Bureau of Mines
Special Publication

LIST OF BUREAU OF MINES PUBLICATIONS AND ARTICLES

January 1, 1980, to December 31, 1984

With Subject and Author Index

Compiled by Staff, Branch of Editorial Services

UNITED STATES DEPARTMENT OF THE INTERIOR

Donald Paul Hodel, Secretary

BUREAU OF MINES

David S. Brown, Acting Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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With Subject and Author Index

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INTRODUCTION

The Bureau of Mines was established in the public interest to conduct inquiries and scientific and technologic investigations concerning mining and the preparation, treatment, and utilization of mineral substances; to promote health and safety in the mineral industries; to conserve material resources and prevent their waste; to further economic development; to increase efficiency in the mining, metallurgical, quarrying, and other mineral industries; and to inquire into the economic conditions affecting those industries. The organic act of the Bureau, as amended by Congress and approved February 25, 1913, made it the province and duty of the Bureau of Mines to "disseminate information concerning these subjects in such manner as will best carry out the purposes of this Act."

In accordance with this directive, the Bureau reports the findings of its research and investigations in its own series of publications and also in articles that appear in scientific, technical, and trade journals; in proceedings of conventions and seminars; in reference books; and in other non-Bureau publications. The number of these reports, the wide range of subjects they cover, and the variety of mediums in which they appear make the kind of list and index presented in this special publication both necessary and valuable.

This issue of the Bureau of Mines List of Publications and Articles describes reports and articles published during the period January 1, 1980, to December 31, 1984. It supplements the 50-year list of Bureau publications issued from July 1, 1910, to January 1, 1960;[1] the 50-year list of articles by Bureau authors published outside the Bureau from July 1, 1910, to January 1, 1960;[2] the 5-year lists of publications and articles from January 1, 1960, to December 31, 1964,[3] from January 1, 1965, to December 31, 1969,[4] from January 1, 1970, to December 31, 1974,[5] and from January 1, 1975, to December 31, 1979;[6] and the annual lists of Bureau publications and articles from January 1 to December 31, 1980,[7] from January 1 to December 31, 1981,[8] from January 1 to December 31, 1982,[9] and from January 1 to December 31, 1983.[10]

[1]Available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, telephone 703-487-4650. NTIS publication number PB 295 062.
[2]Available from NTIS, publication number PB 295 432.
[3]Available from NTIS, publication number PB 295 481.
[4]Available from NTIS, publication number PB 198 112.
[5]Available from NTIS, publication number PB 252 843.
[6]Available from NTIS, publication number PB 82-145400.
[7]Available from NTIS, publication number PB 82-257502.
[8]Available from NTIS, publication number PB 83-178293.
[9]Available from NTIS, publication number PB 84-151232.
[10]Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. GPO Stock No. 024-004-02136-5. $5.50.

BUREAU PUBLICATIONS

Some Bureau of Mines publications, including most Bulletins and the Minerals Yearbook, are sales publications; other series may contain both free and sales publications. Because the price of sales publications varies, the price is indicated in the individual listing of any publication for which a charge is made.

Sales publications of the Bureau of Mines must be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, to whom orders should be sent directly. Sales publication purchases may be made by check or money order payable to the Superintendent of Documents, charged to a deposit account at the U.S. Government Printing Office, or charged to a valid VISA or MasterCard account. Payment for orders going to foreign countries should be made by International Postal Money Order, by draft on a United States or Canadian bank (in U.S. dollars), or by UNESCO Coupons. Orders received with postage stamps, International Response Coupons, or foreign money are not acceptable and will be returned unprocessed. No charge is made for postage on publications mailed within the United States or its possessions. There is a special handling charge on orders mailed to other countries; the charge is one-fourth of the current selling price of the publication(s) ordered. There is a minimum charge of $1 for each mail order.

Free publications of the Bureau of Mines may be obtained from Publication Distribution, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236. Because of the limited editions, only 1 copy of any publication can be sent to the person applying and a maximum of 10 titles to any 1 applicant.

The following types or series of publications are issued by the Bureau of Mines.

Bulletins report the results of broad and significant projects or programs of scientific, historical, or economic research, or other investigations, including comprehensive and important mineral resource studies and compilations. Bulletins are usually prepared after all laboratory and field work has been completed, but they sometimes report a major phase of a larger or continuing investigation or research study. Bulletins rarely represent the first public report on the subject. As a rule, Bulletins encompass published work together with essential unpublished data and details.

Mineral Facts and Problems, issued every 5 years, is the Bureau's only periodic Bulletin. It contains comprehensive information on all important metals and minerals. Each commodity chapter covers industry patterns, technology, reserves, supply-demand relationships, consumption patterns, economic factors, environmental considerations, possible advances in technology, alternative future mineral supply-demand relationships, and future uses of commodities. Chapters are issued separately as preprints or reprints. Updates, issued when necessary within the 5-year cycle, appear as *Mineral Commodity Profiles*.

Handbooks are instruction or information manuals designed to improve efficiency in the mineral industries or to promote the wise use of mineral resources. Based on research and the practical experience of Bureau and contractor personnel, Handbooks cover a wide range of subjects such as mine electric power systems.

Reports of Investigations present the results of process research and investigations conducted by the Bureau at its research centers or laboratories, or in mines, quarries, smelters, plants, and other non-Bureau properties. Research conducted under contract to the Bureau that is deemed worthy of publication by the Bureau may be published in the Reports of Investigation series. Reports of Investigations differ from Bulletins in that they describe the principal features and results of individual experiments (single or multiple), minor research projects, or a significant coordinated phase of a major research project or program.

Information Circulars are concerned primarily with Bureau economic reviews and analyses and with projects that are not process research by the Bureau. Information Circulars also cover surveys of mineral resources and related mining and operating activities, guides to marketing of mineral commodities, compilations of historical or statistical and economic data on minerals, summaries of scientific and technical meetings and symposia, bibliographies, descriptions of new instrumentation and techniques, and descriptions of new industrial mining methods and metallurgical processes (as distinguished from those developed by the Bureau). Work done under contract to the Bureau that is worthy of publication by the Bureau can be published in the Information Circular series.

Technical Progress Reports are expanded factsheets giving the technical background and details necessary to supplement a press release that reports important progress in an area of Bureau activity meriting widespread public interest. The Technical Progress Report series was discontinued on September 23, 1983. Information that would have been reported in Technical Progress Reports were presented in Reports of Investigations after that date.

Special Publications include the Annual List of Bureau of Mines Publications and Articles and popular-type pamphlets prepared for the general public and distributed in response to requests for information on specific subjects. Special Publications also include certain long and detailed publications that do not belong in any of the other series.

Mineral Perspectives are issued to inform the Bureau's audience of developments in the mineral industries and markets of a foreign country or region of the world.

Technology News is a simple factsheet discussing new technologic developments from Bureau of Mines research programs that are of interest to the minerals industry. Technology News is issued as the need arises. For a free subscription to Technology News, write to Technology Transfer Group, Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

Mineral Issues are reports that identify and evaluate mineral policy issues to assist Government and private sector analysts and decisionmakers. Mineral Issues present mineral information in an analytically convenient form for the support of policy formulation and analysis; assess options to achieve mineral-related policy goals and provide an assessment of their economic, social, and environmental effects; examine specific issues of mineral economics using an accepted economics or operations research methodology; and/or assess the impact of Federal and State mineral-related policies.

Minerals Yearbooks summarize annually, on a calendar-year basis, the significant economic and technologic developments in the mineral industries. Three separate volumes are issued each year—Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; and Volume III, Area Reports: International. Volume I presents, by mineral commodity, the salient statistics on production, trade, consumption, and other pertinent data. Volume II reviews the U.S. mineral industry by State and island possessions. Volume III presents the latest available mineral statistics for more than 150 countries and areas together with a review of the role of minerals in the economies of these nations. Chapters in these volumes are issued separately as preprints before the bound volumes are available.

Mineral Industry Surveys contain timely statistical and economic data on minerals. The surveys are designed

to keep Government agencies and the public, particularly the mineral industry and business community, regularly informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the need for current data. Most of the reports are issued monthly, quarterly, or annually. Preliminary annual data are published as soon as possible after the close of each calendar year and comprise statistics that are later printed in permanent form in the Minerals Yearbook. Preliminary annual area reports also contain data on mineral production by State, and final figures are published in Volume II of the Minerals Yearbook.

Mineral Commodity Summaries, an up-to-date annual summary of about 85 nonfuel mineral commodities, is the earliest Government publication to furnish estimates covering the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics.

Research 84, the 1984 edition of the Bureau of Mines research annual report, covers significant developments in Bureau programs. Each project appears as a profile accompanied by the names of the principal investigators, who may be consulted if further information is desired. Research 84 also includes a list of principal officials, a location map of field facilities, and a selected bibliography of publications and patents issued on Bureau developments during the past 3 years.

Minerals and Materials—A Bimonthly Survey provides timely information on selected commodities. Data and analyses are presented that are germane to policy issues of current interest. Brief narratives are supplemented by statistical graphs and tables. An economic analysis of the status of the mineral industry and articles focusing on major mineral issues are presented in each issue.

Computer tapes and printouts are occasionally available containing mineral data.

LISTS OF BUREAU OF MINES PUBLICATIONS, JOURNAL ARTICLES, AND MOTION PICTURES

New Publications of the Bureau of Mines is a monthly report that gives titles and abstracts of publications, open file reports, and journal articles by Bureau authors. The list also tells where the reports can be obtained or inspected, and indicates the cost of the publication if it is for sale by the Superintendent of Documents at the U.S. Government Printing Office or by the National Technical Information Service.

Annual and 5-Year Lists of Bureau of Mines Publications and Articles. The annual list includes titles and abstracts of most reports, along with subject and author indexes. Every 5 years, the preceding four annual listings are combined with the fifth-year listing into a 5-year list, complete with information on the various series, depository libraries, open file reports, outside publications, patents, and reprints, along with subject and author indexes. The annual and 5-year lists are sales publications; for instructions on ordering previous editions, see the footnotes on page 1 of this publication.

Bureau of Mines 1983–84 Films is a film catalog listing educational motion picture films made in cooperation with industrial firms and organizations. Most of the films depict mining and metallurgical operations and related manufacturing processes. Some show where minerals are found and how they are extracted from the earth, refined or manufactured into useful everyday products, and utilized. Others deal with mineral and other natural resources in a comprehensive manner, emphasizing the importance of these resources in the growth and development of several States. A central library for the distribution of all films is maintained by the Bureau of Mines in Pittsburgh, PA. Films are sent from Pittsburgh free of charge with outgoing postage prepaid; the borrower pays the return postage only. In addition, for the convenience of borrowers, copies of certain films are distributed by cooperating centers in various sections of the United States, Single copies of the film catalog are available from the Office of Technical information, Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

ASSOCIATED DOCUMENTS

Although the material in the categories that follow is not published by the Bureau of Mines, it is listed and indexed in this publication as a service to those who may be interested.

Cooperative Publications result from investigations conducted cooperatively by the Bureau of Mines and another Government or outside organization. Although usually written either wholly or in part by Bureau personnel, they are published by the other organization. Cooperative publications include monographs and joint reports.

Open File Reports are unpublished Bureau of Mines manuscripts, reports prepared for the Bureau under contracts, or material not in manuscript form, which the Bureau makes available for consultation at Bureau facilities; in the Natural Resources Library, U.S. Department of the Interior, Washington, DC; and/or for sale through the National Technical Information Service.

Mineral Land Assessments, a special open file report series, presents results of mineral investigations of areas studied by the Bureau of Mines. The results of these mineral investigations are to be incorporated in joint reports with the U.S. Geological Survey to provide information essential for determining the suitability of land for inclusion in the National Wilderness Preservation System.

Outside Publications are journal articles, papers in proceedings and transactions of symposia and society meetings, and other non-Bureau publications published by technical and trade journals, scientific organizations, and publishing houses.

Patents issued to the Bureau during the calendar year are listed, with instructions on how to apply for permission to use such patents.

Reprints of Bureau of Mines publications that have been made available for purchase from the National Technical Information Service, U.S. Department of Commerce, are listed in the section "Reports Available From the National Technical Information Service."

DEPOSITORY LIBRARIES

Under the Depository Library Program established by Congress, Government publications are made available to designated depository libraries located in each State and congressional district to provide the general public with greater access to Government publications. There are currently over 1,350 depository libraries. Of this number, 50 have been designated as Regional Depository Libraries. The Regional Depository Libraries receive and retain one copy of nearly every Federal Government publication, either in printed or microfilm form, for use by the general public. The Regional Depository Libraries assume the responsibility of permanently retaining depository material and of providing interlibrary loan and reference service for their regions. They also assist selective depository libraries with the disposal of unwanted material. Copies of documents no longer available through the Government Printing Office can usually be found in Regional Depository Libraries.

Many of the depository libraries also receive publications of the Bureau of Mines, particularly Reports of Investigations and Information Circulars, which are distributed mainly by the Bureau. Depository libraries maintaining a file of Bureau of Mines publications are a source for reports published by the Bureau when the publications are out of print or copies are no longer available from the Superintendent of Documents or the Bureau.

The following list contains the names and locations of depository libraries receiving various series of reports and documents issued by the Bureau of Mines. The figures in parentheses following the names of the libraries indicate the types of Bureau publications generally received on a regular basis by each library.

(1) Reports of Investigations and Information Circulars
(2) Bulletins
(3) Minerals Yearbooks

Each Regional Depository Library is listed and indicated by an asterisk (*).

ALABAMA

Alexander City—Alexander City State Junior College, Thomas D. Russell Library (3).
Auburn—Auburn University, Ralph Brown Draughton Library (1, 2, 3).

ALABAMA—Continued

Birmingham—Birmingham Public Library (1, 2, 3).
Birmingham-Southern College Library (2, 3).
Miles College (3).
Samford University, Harwell G. Davis Library (3).
Enterprise—Enterprise State Junior College (3).
Fayette—Brewer State Junior College Library (1, 2, 3).
Florence—University of North Alabama, Collier Library (3).
Gadsden—Gadsden Public Library (3).
Huntsville—University of Alabama in Huntsville Library (3).
Jacksonville—Jacksonville State University Library (3).
Mobile—Mobile Public Library (1, 3).
University of South Alabama Library (1, 2, 3).
Montgomery—Air University Library (3).
Alabama Public Library Service (3).
*Auburn University at Montgomery Library (1, 2, 3).
Normal—Alabama Agricultural and Mechanical University, Drake Memorial Library (3).
Troy—Troy State University Library (3).
University—*University of Alabama Library (1, 3).

ALASKA

Anchorage—Anchorage Municipal Libraries, Z. J. Loussac Public Library (3).
U.S. Department of the Interior, Alaska Resources Library (1, 2, 3).
University of Alaska, Anchorage Library (1, 2, 3).
Fairbanks—University of Alaska, Elmer E. Rasmuson Library (1, 2, 3).
Juneau—Alaska State Library (3).

ARIZONA

Coolidge—Central Arizona College, Instructional Materials Center (3).
Flagstaff—Northern Arizona University Library (1, 2, 3).
Mesa—Mesa Public Library (3).
Phoenix—*Arizona State Library (1, 2, 3).
Grand Canyon College, Fleming Library (3).
Phoenix Public Library (1, 2, 3).
Prescott—Yavapai College Learning Resource Center (2, 3).
Tempe—Arizona State University Library (1, 2, 3).
Arizona State University, College of Law Library (3).
Tucson—Tucson Public Library (3).
*University of Arizona Library (1, 2, 3).
Yuma—Yuma City-County Library (2, 3).

ARKANSAS

Arkadelphia—Ouachita Baptist University, Riley Library (2, 3).
Batesville—Arkansas College, Mabee Learning Resources Center (3).
Conway—Hendrix College, Olin C. Bailey Library (3).
Fayetteville—University of Arkansas Library (1, 2, 3).
Little Rock—*Arkansas State Library (1, 2, 3).
Central Arkansas Library System (3).
University of Arkansas at Little Rock Library (3).
University of Arkansas at Little Rock, School of Law and Pulaski County Law Library (3).
Magnolia—Southern Arkansas University, Magale Library (2, 3).
Monticello—University of Arkansas at Monticello Library (3).
Pine Bluff—University of Arkansas at Pine Bluff, Watson Memorial Library (3).

Russellville—Arkansas Tech University, Tomlinson Library (3).
State University—Arkansas State University, Dean B. Ellis Library (2, 3).
Walnut Ridge—Southern Baptist College, Felix Goodson Library (3).

CALIFORNIA

Anaheim—Anaheim Public Library (3).
Arcadia—Arcadia Public Library (3).
Arcata—Humboldt State University Library (1, 2, 3).
Bakersfield—California State College at Bakersfield Library (2, 3).
Kern County Library (1, 2, 3).
Berkeley—University of California at Berkeley, General Library (1, 2, 3).
Carson—California State University at Dominquez Hills, Educational Resources Center (3).
Carson Regional Library (3).
Chico—California State University, Chico Library (3).
Claremont—Claremont College, Honnold Library (1, 2, 3).
Compton—Compton Library (3).
Culver City—Culver City Library (3).
Davis—University of California at Davis Library (1, 2, 3).
Downey—Downey City Library (3).
Fresno—California State Library at Fresno Library (2, 3).
Fresno County Free Library (1, 2, 3).
Fullerton—California State University at Fullerton Library (2, 3).
Garden Grove—Garden Grove Regional Library (3).
Gardena—Gardena Public Library (3).
Hayward—California State University at Hayward Library (2, 3).
Huntington Park—Huntington Park Library, San Antonia Region (3).
Inglewood—City of Inglewood Public Library (2, 3).
Irvine—University of California at Irvine Library (1, 2, 3).
La Jolla—University of California at San Diego Library (3).
Lakewood—Angelo Iacoboni Public Library (3).
Lancaster—Lancaster Regional Library (3).
Long Beach—California State University at Long Beach Library (1, 2, 3).
Long Beach Public Library (1, 2, 3).
Los Angeles—California State University at Los Angeles, John F. Kennedy Memorial Library (1, 2, 3).
Los Angeles County Law Library (2).
Los Angeles Public Library (1, 2, 3).
Loyola Marymount University, Charles Von Der Ahe Library (3).
Loyola University School of Law Library (3).
Occidental College, Mary Norton Clapp Library (1, 2, 3).
Southwestern University, School of Law Library (3).
University of California at Los Angeles Library (1, 2, 3).
University of Southern California, Doheny Memorial Library (1, 2, 3).
Menlo Park—U.S. Geological Survey Library (1, 2, 3).
Montebello—Montebello Library (3).
Monterey—U.S. Naval Postgraduate School (3).
Monterey Park—Bruggemeyer Memorial Library (3).
Northridge—California State University at Northridge, Oviatt Library (2, 3).
Norwalk—Norwalk Public Library (3).
Oakland—Oakland Public Library (1, 2, 3).
Ontario—Ontario Public Library (2, 3).
Palm Springs—Palm Springs Public Library (3).
Pasadena—California Institute of Technology, Millikan Memorial Library (1, 2, 3).
Pasadena Public Library (1, 2, 3).
Pleasant Hill—Contra Costa County (3).
Redding—Shasta County Library (2, 3).
Redlands—University of Redlands, Armacost Library (2, 3).
Redwood City—Redwood City Public Library (3).

Reseda—West Valley Regional Branch Library (3).
Richmond—Richmond Public Library (3).
Riverside—Riverside City and County Public Library (2, 3).
University of California at Riverside Library (1, 2, 3).
Sacramento—*California State Library (1, 2, 3).
California State University at Sacramento Library (1, 2, 3).
Sacramento Public Library (2).
San Bernardino—San Bernardino County Library (1, 2, 3).
San Diego—San Diego County Library (3).
San Diego Public Library (1, 2, 3).
San Diego State University, Malcolm A. Love Library (1, 2, 3).
University of San Diego, School of Law Library (3).
San Francisco—Hastings College of Law Library (3).
Mechanics Institute Library (3).
San Francisco Public Library (1, 2, 3).
San Francisco State University Library (1, 2, 3).
U.S. Court of Appeals Library (3).
University of San Francisco, Gleeson Library (2, 3).
San Jose—San Jose State University Library (1, 2, 3).
San Leandro—San Leandro Community Library (3).
San Luis Obispo—California Polytechnic State University Library (1, 2, 3).
San Rafael—Marin County Free Library (3).
Santa Ana—Santa Ana Public Library (2, 3).
Santa Barbara—University of California at Santa Barbara Library (1, 2, 3).
Santa Clara—University of Santa Clara, Michel Orradre Library (3).
Santa Cruz—University of California at Santa Cruz Library (1, 2, 3).
Santa Rosa—Santa Rosa-Sonoma County Library (2, 3).
Stanford—Stanford University, Jonsson Library (1, 2, 3).
Stanford University, Robert Crown Law Library (3).
Stockton—Stockton and San Joaquin County Public Library (2, 3).
Thousand Oaks—California Lutheran College Library (2, 3).
Torrance—Torrance Public Library (3).
Turlock—California State College at Stanislaus Library (3).
Valencia—Valencia Library (3).
Vallejo—Solano County Library (2, 3).
Ventura—Ventura County Library (3).
Walnut—Mount San Antonio College Learning Resources Center (1, 2, 3).
West Covina—West Covina Library (3).
Whittier—Whittier College, Bonnie Bell Wardman Library (3).

COLORADO

Alamosa—Adams State College Learning Resources Center (1, 2, 3).
Aurora—Aurora Public Library (3).
Boulder—*University of Colorado Libraries (1, 2, 3).
Colorado Springs—Colorado College, Charles Leaming Tutt Library (2, 3).
U.S. Air Force Academy (3).
Denver—Auraria Libraries (2, 3).
*Denver Public Library (1, 2, 3).
University of Denver, Penrose Library (1, 2, 3).
University of Denver, Westminster Law Library (3).
Water and Power Resources Service Library (2, 3).
Fort Collins—Colorado State University Libraries (1, 2, 3).
Golden—Colorado School of Mines, Arthur Lakes Library (1, 2, 3).
Grand Junction—Mesa County Public Library (1, 2, 3).
Greeley—University of Northern Colorado, James A. Michener Library (3).
Gunnison—Western State College of Colorado, Leslie J. Savage Library (1, 2, 3).
Lakewood—Jefferson County Public Library (3).
Pueblo—Pueblo Regional Library (1, 2, 3).
University of Southern Colorado Library (1, 2, 3).

CONNECTICUT

Bridgeport—Bridgeport Public Library (1, 2, 3).
University of Bridgeport, Law Library (3).
Danbury—Western Connecticut State College, Ruth A. Haas Library (1, 3).
Enfield—Enfield Central Library (2, 3).
Hartford—*Connecticut State Library (1, 2, 3).
Hartford Public Library (3).
Trinity College Library (3).
University of Connecticut, School of Law Library (3).
Middletown—Wesleyan University, Olin Memorial Library (1, 2, 3).
New Britain—Central Connecticut State College Library (2, 3).
New Haven—Southern Connecticut State College, Hilton C. Buley Library (2, 3).
Yale University Library (2, 3).
New London—Connecticut College Library (3).
U.S. Coast Guard Academy (3).
Stamford—Ferguson Library (3).
Storrs—University of Connecticut, Wilbur Cross Library (1, 2, 3).
Waterbury—Post College, Traurig Library (3).
Silas Bronson Library (3).
West Haven—University of New Haven Library (3).

DELAWARE

Dover—Delaware State College, William C. Jason Library (3).
Georgetown—Delaware Technical and Community College (3).
Newark—University of Delaware, Morris Library (1, 2, 3).
Wilmington—Wilmington Institute and New Castle County Library (2, 3).

DISTRICT OF COLUMBIA

Washington—American University, Washington College of Law Library (3).
District of Columbia Public Library (3).
Catholic University, Robert J. White Law Library (3).
Federal Energy Regulatory Commission Library (1, 3).
Federal Mine Safety and Health Review Commission (1, 2).
Federal Reserve System Research Library (3).
General Accounting Office Library (2, 3).
General Services Administration Library (3).
George Washington University, Gelman Library (3).
Georgetown University Library (2, 3).
Library of Congress, Congressional Research Services (1, 2, 3).
National Defense University Library (3).
Office of Management and Budget Library (3).
Pentagon, Army Library (3).
U.S. Department of Commerce Library (3).
U.S. Department of Energy Library (3).
U.S. Department of Health and Human Services Library (3).
U.S. Department of Housing and Urban Development Library (3).
U.S. Department of the Interior, Natural Resources Library (1, 2, 3).
U.S. Department of Justice, Main Library (3).
U.S. Department of Labor Library (1, 3).
U.S. Department of State Library (3).
U.S. Department of Transportation Library (3).
U.S. Department of Treasury Library (2, 3).
U.S. Senate Library (3).
U.S. Supreme Court Library (3).

FLORIDA

Boca Raton—Florida Atlantic University, S. E. Wimberly Library (1, 2, 3).
Clearwater—Clearwater Public Libary (3).

FLORIDA—Continued

Daytona Beach—Volusia County Public Library (3).
De Land—Stetson University, DuPont-Ball Library (2, 3).
Fort Lauderdale—Broward County Main Library (2, 3).
Nova University, Law Center Library (3).
Fort Pierce—Indian River Community College (3).
Gainesville—*University of Florida Libraries (1, 2, 3).
Jacksonville—Jacksonville Public Library System, Haydon Burns Library (1, 2, 3).
Jacksonville University, Swisher Library (3).
University of North Florida Library (3).
Lakeland—Lakeland Public Library (3).
Melbourne—Florida Institute of Technology (3).
Miami—Florida International University, North Miami Campus Library (3).
Florida International University Library (2, 3).
Miami-Dade Public Library System (3).
University of Miami Library (1, 2, 3).
Opa Locka—Biscayne College (3).
Orlando—University of Central Florida Library (1, 2, 3).
Palatka—St. James River Community College Library (3).
Panama City—Bay County Public Library (3).
Pensacola—University of West Florida, John C. Pace Library (3).
Pompano Beach—Broward County Division of Libraries (3).
Port Charlotte—Charlotte County Library System (3).
Punta Gorda—Charlotte City Library System (3).
St. Petersburg—St. Petersburg Public Library (3).
Sarasota—Selby Public Library (3).
Tallahassee—Florida Agricultural and Mechanical University, Coleman Memorial Library (2, 3).
Florida State Library, R. A. Gray Building (3).
Florida State University, Robert Manning Strozier Library (1, 2, 3).
Tampa—Tampa Public Library (1, 2, 3).
University of South Florida Library (1, 2, 3).
University of Tampa, Merl Kelce Library (3).
Winter Park—Rollins College, Mills Memorial Library (3).

GEORGIA

Albany—Albany Dougherty Public Library (3).
Americus—Georgia Southwestern College, James Earl Carter Library (1, 2, 3).
Athens—*University of Georgia Libraries (1, 2, 3).
Atlanta—Atlanta Public Library (2, 3).
Atlanta University (3).
Emory University, Robert W. Woodruff Library (2, 3).
Georgia Institute of Technology, Price Gilbert Memorial Library (1, 2, 3).
Georgia State Library (3).
Georgia State University (1, 2, 3).
Augusta—Augusta College, Reese Library (1, 2, 3).
Brunswick—Brunswick-Glynn County Regional Library (3).
Carrollton—West Georgia College Library (2, 3).
Columbus—Columbus College, Simon Schwob Memorial Library (3).
Dahlonega—North Georgia College, Stewart Library (2, 3).
Dalton—Dalton Junior College Library (3).
Decatur—DeKalb Community College, South Campus Learning Resources Center (3).
Macon—Mercer University, Walter F. George School of Law Library (3).
Marietta—Kennesaw College Library (3).
Milledgeville—Georgia College at Milledgeville, Ina Dillard Russell Library (3).
Mount Berry—Berry College, Memorial Library (3).
Savannah—Chatham-Effingham-Liberty Regional Library (3).
Statesboro—Georgia Southern College (1, 2, 3).
Valdosta—Valdosta State College Library (3).

HAWAII

Hilo—University of Hawaii at Hilo Libraries (3).
Honolulu—Hawaii State Library System (3).

*University of Hawaii Library (1, 2, 3).
Laie—Brigham Young University-Hawaii Campus, Joseph F. Smith Library (3).

IDAHO

Boise—Boise Public Library and Information Center (1, 2, 3).
Boise State University Library (1, 2, 3).
Idaho State Law Library (3).
Idaho State Library (1, 2, 3).
Caldwell—College of Idaho, Terteling Library (2, 3).
Moscow—*University of Idaho, College of Law Library (3).
University of Idaho Library (1, 2, 3).
Nampa—Northwest Nazarene College, Riley Library (1, 2, 3).
Pocatello—Idaho State University Library (1, 2, 3).
Rexburg—Ricks College, David O. McKay Library (1, 2, 3).
Twin Falls—College of Southern Idaho Library (3).

ILLINOIS

Carbondale—Southern Illinois University at Carbondale, Morris Library (1, 2, 3).
Southern Illinois University, School of Law Library (3).
Carlinville—Blackburn College, Lumpkin Library (3).
Carterville—Shawnee Library System (3).
Champaign—University of Illinois Law Library (3).
Charleston—Eastern Illinois University, Booth Library (3).
Chicago—Chicago Public Library (1, 2, 3).
Chicago State University Library (3).
De Paul University Law Library (3).
Field Museum of Natural History Library (1, 2, 3).
Illinois Institute of Technology, Kemper Library (2, 3).
Illinois Institute of Technology, Kent College of Law Library (3).
John Crerar Library (2, 3).
Loyola University of Chicago, E. M. Cudahy Memorial Library (3).
Northeastern Illinois University Library (3).
University of Chicago Law Library (3).
University of Chicago Libraries (1, 2, 3).
University of Illinois at Chicago Circle Library (1, 2, 3).
Decatur—Decatur Public Library (3).
De Kalb—Northern Illinois University, Founders Memorial Library (1, 2, 3).
Edwardsville—Southern Illinois University, Lovejoy Memorial Library (1, 2, 3).
Elsah—Principia College, Marshall Brooks Library (3).
Evanston—Northwestern University Library (1, 2, 3).
Freeport—Freeport Public Library (3).
Galesburg—Galesburg Public Library (3).
Jacksonville—MacMurray College, Henry Pfeiffer Library (3).
Kankakee—Olivet Nazarene College, Benner Library (3).
Lake Forest—Lake Forest College, Donnelley Library (2, 3).
Lebanon—McKendree College, Holman Library (3).
Lisle—Illinois Benedictine College, Theodore Lownik Library (3).
Macomb—Western Illinois University Library (1, 2, 3).
Moline—Black Hawk College Learning Resource Center (3).
Monmouth—Monmouth College, Hewes Library (2, 3).
Mount Carmel—Wabash Valley College Library (1, 2, 3).
Mount Prospect—Mount Prospect Public Library (3).
Normal—Illinois State University, Milner Library (1, 2, 3).
Oak Park—Oak Park Public Library (3).
Oglesby—Illinois Valley Community College, Jacobs Memorial Library (3).
Palos Hills—Moraine Valley Community College Library (3).
Park Forest—Governors State University Library (3).
Peoria—Bradley University Library (1, 2, 3).
Peoria Public Library (1, 2, 3).

River Forest—Rosary College, Rebecca Crown Library (3).
Rockford—Rockford Public Library (3).
Romeoville—Lewis University Library (3).
Springfield—*Illinois State Library (1, 2, 3).
Streamwood—Poplar Creek Public Library (2, 3).
Urbana—University of Illinois Library (1, 2, 3).
Wheaton—Wheaton College Library (3).
Woodstock—Woodstock Public Library (3).

INDIANA

Anderson—Anderson College, Charles E. Wilson Library (3).
Anderson Public Library (3).
Bloomington—Indiana University Law Library (3).
Indiana University Libraries (1, 2, 3).
Crawfordsville—Wabash College, Lilly Library (1, 2, 3).
Evansville—Evansville and Vanderburgh County Public Library (1, 2, 3).
Indiana State University at Evansville Library (2, 3).
Fort Wayne—Indiana University-Purdue University at Fort Wayne Library (3).
Public Library of Fort Wayne and Allen County (1, 2, 3).
Gary—Gary Public Library (3).
Indiana University, Northwest Library (1, 2, 3).
Greencastle—DePauw University, Roy O. West Library (1, 2, 3).
Hammond—Hammond Public Library (2, 3).
Hanover—Hanover College Library (3).
Huntington—Huntington College (3).
Indianapolis—Butler University, Irwin Library (2, 3).
*Indiana State Library (1, 2, 3).
Indiana University at Indianapolis School of Law Library (3).
Indiana University-Purdue University at Indianapolis Library (2, 3).
Indianapolis-Marion County Public Library (1, 3).
Kokomo—Indiana University at Kokomo Library (3).
Lafayette—Purdue University Library (1, 2).
Muncie—Ball State University Library (2, 3).
Muncie-Center Township Public Library (3).
New Albany—Indiana University Southeast Library (2).
Notre Dame—University of Notre Dame, Memorial Library (1, 2, 3).
Rensselaer—St. Joseph's College Library (2, 3).
Richmond—Earlham College, Lilly Library (2, 3).
Wayne Township Library, Morrisson-Reeves Library (3).
South Bend—Indiana University at South Bend Library (3).
Terre Haute—Indiana State University, Cunningham Memorial Library (2, 3).
Valparaiso—Valparaiso University, Moellering Memorial Library (1, 2, 3).

IOWA

Ames—Iowa State University Library (1, 2, 3).
Cedar Falls—University of Northern Iowa Library (3).
Council Bluffs—Free Public Library (3).
Iowa Western Community College, Hoover Media Library (3).
Davenport—Davenport Public Library (1, 2, 3).
Des Moines—Drake University, Cowles Library (2, 3).
Iowa State Library Commission (2, 3).
Public Library of Des Moines (3).
Dubuque—Carnegie-Stout Public Library (3).
Fayette—Upper Iowa University, Henderson-Wilder Library (3).
Grinnell—Grinnell College Library (3).
Iowa City—University of Iowa Law Library (3).
*University of Iowa Libraries (1, 2, 3).
Lamoni—Graceland College, Frederick Madison Smith Library (3).
Mason City—North Iowa Area Community College Library (3).

Mount Vernon—Cornell College, Russell D. Cole Library (1, 2, 3).
Orange City—Northwestern College, Ramaker Library (3).
Sioux City—Sioux City Public Library (3).

KANSAS

Atchison—Benedictine College, North Campus Library (3).
Baldwin City—Baker University Library (3).
Colby—Colby University Community College, H. F. Davis Memorial Library (3).
Emporia—Emporia State University, William Allen White Library (2, 3).
Fort Scott—Fort Scott Community College (3).
Hays—Fort Hays State University, Forsyth Library (1, 2, 3).
Hutchison—Hutchison Public Library (3).
Lawrence—*University of Kansas Library (1, 2, 3).
University of Kansas School of Law Library (3).
Manhattan—Kansas State University Library (1, 2, 3).
Pittsburg—Pittsburg State University Library (2, 3).
Salina—Kansas Wesleyan University, Memorial Library (3).
Shawnee Mission—Johnson County Library (3).
Topeka—Kansas State Historical Society Library (3).
Kansas State Library (3).
Washburn University of Topeka, School of Law Library (3).
Wichita—Wichita State University Library (2, 3).

KENTUCKY

Ashland—Ashland Public Library (3).
Barbourville—Union College, Abigail E. Weeks Memorial Library (3).
Bowling Green—Western Kentucky University, Helm-Cravens Library (2, 3).
Danville—Centre College of Kentucky, Grace Doherty Library (3).
Fort Mitchell—Thomas More College Library (3).
Frankfort—Kentucky Department of Library and Archives (3).
Kentucky State University, Blazer Library (2).
State Law Library (3).
Highland Heights—Northern Kentucky University, W. Frank Steeley Library (1, 2, 3).
Hopkinsville—Hopkinsville Community College Library (2, 3).
Lexington—*University of Kentucky Library (1, 2, 3).
University of Kentucky Law Library (3).
Louisville—Louisville Free Public Library (1, 2, 3).
University of Louisville, Ekstrom Library (2, 3).
Morehead—Morehead State University, Johnson Camden-Julian Carroll Library (1, 2, 3).
Murray—Murray State University Library (1, 2, 3).
Owensboro—Kentucky Wesleyan College Library (3).
Richmond—Eastern Kentucky University, John Grant Crabbe Library (1, 2, 3).

LOUISIANA

Baton Rouge—Louisiana State Library (3).
*Louisiana State University, Middleton Library (1, 2, 3).
Southern University Library (1).
Eunice—Louisiana State University at Eunice, LeDoux Library (1, 2, 3).
Hammond—Southeastern Louisiana University, Linus A. Sims Memorial Library (3).
Lafayette—University of Southwestern Louisiana Libraries (1, 2).
Lake Charles—McNeese State University, Frazer Memorial Library (1, 2, 3).
Monroe—Northeast Louisiana University, Sandel Library (2, 3).

Natchitoches—Northwestern State University of Louisiana, Watson Memorial Library (2, 3).
New Orleans—Loyola University Library (3).
New Orleans Public Library (2, 3).
Southern University in New Orleans (3).
Tulane University of Louisiana, Howard-Tilton Memorial Library (1, 2, 3).
Pineville—Louisiana College, Norton Memorial Library (3).
Ruston—*Louisiana Tech University, Prescott Memorial Library (1, 2, 3).
Shreveport—Louisiana State University in Shreveport Library (1, 2, 3).
Shreve Memorial Library (1, 2, 3).
Thibodaux—Nicholls State University, Ellender Memorial Library (1, 2, 3).

MAINE

Augusta—Maine State Library (2, 3).
Brunswick—Bowdoin College Library (2, 3).
Castine—Marine Maritime Academy, Nutting Memorial Library (3).
Lewiston—Bates College Library (2, 3).
Orono—*University of Maine at Orono, Raymond H. Fogler Library (1, 2, 3).
Portland—Portland Public Library (2, 3).
University of Maine Law Library (3).
Presque Isle—University of Maine at Presque Isle Library (3).
Springvale—Nasson College Library (3).
Waterville—Colby College Library (2, 3).

MARYLAND

Annapolis—Maryland State Law Library (3).
U.S. Naval Academy, Nimitz Library (2, 3).
Baltimore—Enoch Pratt Free Library (1, 2, 3).
Goucher College, Julia Rogers Library (3).
Johns Hopkins University, Milton S. Eisenhower Library (1, 3).
Morgan State College, Soper Library (3).
Towson State University, Cook Library (3).
University of Baltimore, Langsdale Library (3).
University of Maryland, Baltimore County Library (3).
University of Maryland, School of Law Library (3).
Bel Air—Harford Community College Library (3).
Beltsville—U.S. Department of Agriculture, National Agricultural Library (2, 3).
College Park—*University of Maryland, McKeldin Library (1, 2, 3).
Frostburg—Frostburg State College Library (1, 2, 3).
Rockville—Montgomery County Department of Public Libraries (2, 3).
Salisbury—Salisbury State College, Blackwell Library (2, 3).
Westminster—Western Maryland College Library (3).

MASSACHUSETTS

Amherst—Amherst College Library (2, 3).
University of Massachusetts at Amherst, Goodell Library (1, 2, 3).
Boston—Belmont Memorial Library (3).
Boston College, Bapst Library (2, 3).
Boston College, Thomas P. O'Neill, Jr., Library (2, 3).
*Boston Public Library (1, 2, 3).
Northeastern University, Dodge Library (2, 3).
State Library of Massachusetts (3).
Suffolk University Law Library (3).
Brookline—Public Library of Brookline (3).
Cambridge—Harvard College Library (3).
Massachusetts Institute of Technology Libraries (1, 2, 3).
Chicopee—College of Our Lady of the Elms (3).
Lowell—University of Lowell, Alumni-Lydon Library (3).
Lynn—Lynn Public Library (3).

Marlborough—Marlborough Public Library (3).
Medford—Tufts University Library (2, 3).
New Bedford—New Bedford Free Public Library (3).
Southeastern Massachusetts University (2, 3).
North Dartmouth—Southeastern Massachusetts University Library (1).
North Easton—Stonehill College, Cushing-Martin Library (3).
Springfield—Springfield City Library (3).
Western New England College Law Library (3).
Waltham—Brandeis University Library (3).
Wellesley—Wellesley College Library (3).
Williamstown—Williams College Library (3).
Worcester—Worcester Public Library (3).

MICHIGAN

Albion—Albion College, Stockwell Memorial Library (1, 2, 3).
Allendale—Grand Valley State College Library (1, 2, 3).
Ann Arbor—Great Lakes Basin Commission Library (3).
University of Michigan, Harlan Hatcher Library (1, 2, 3).
Bloomfield Hills—Cranbrook Institute of Science Library (3).
Dearborn—Dearborn Department of Libraries, Henry Ford Centennial Library (3).
Henry Ford Community College Library (3).
Detroit—*Detroit Public Library (1, 2, 3).
Mercy College of Detroit Library (3).
University of Detroit Library (3).
University of Detroit, Law Library (3).
Wayne State University, G. Flint Purdy Library (1, 2, 3).
Dowagaic—Southwestern Michigan College (3).
East Lansing—Michigan State University Library (1, 2, 3).
Escanaba—Michigan State Library, Upper Peninsula Branch (3).
Farmington—Oakland Community College, Martin L. King Learning Resources Center (3).
Flint—Flint Public Library (3).
University of Michigan at Flint Library (3).
Grand Rapids—Calvin College and Seminary Library (3).
Grand Rapids Public Library (3).
Houghton—Michigan Technological University Library (1, 2, 3).
Jackson—Jackson District Library (3).
Kalamazoo—Kalamazoo Public Library (3).
Western Michigan University, Dwight B. Waldo Library (1, 2, 3).
Lansing—*Michigan State Library (1, 2, 3).
Livonia—Schoolcraft College Library (3).
Madison Heights—Madison Heights Public Library (3).
Marquette—Northern Michigan University, Olson Library (1, 2, 3).
Mount Clemens—Macomb County Library (3).
Mount Pleasant—Central Michigan University Library (2, 3).
Muskegon—Hackley Public Library (3).
Olivet—Olivet College Library (3).
Port Huron—St. Clair County Library System (3).
Rochester—Oakland University, Kresge Library (3).
Royal Oak—Royal Oak Public Library (3).
Saginaw—Hoyt Public Library (3).
Sault Sainte Marie—Lake Superior State College (3).
Traverse City—Northwestern Michigan College, Mark Osterlin Library (3).
University Center—Delta College Library (3).
Ypsilanti—Eastern Michigan University Library (1, 2, 3).

MINNESOTA

Bemidji—Bemidji State University, A. C. Clark Library (3).
Blaine—Anoka County Library (3).
Collegeville—St. John's University, Alcuin Library (3).
Cottage Grove—Washington County Library (3).
Duluth—Duluth Public Library (1, 2, 3).
Eagen—Dakota County Library (3).

Edina—Southdale Hennepin Library (2, 3).
Mankato—Mankato State University Library (1, 2, 3).
Minneapolis—Minneapolis Public Library (1, 2, 3).
*University of Minnesota, Wilson Library (1, 2, 3).
Moorhead—Moorhead State University Library (3).
Morris—University of Minnesota at Morris Library (3).
Northfield—Carleton College Library (2, 3).
St. Olaf College, Rolvaag Memorial Library (3).
St. Cloud—St. Cloud State University Library (1, 3).
St. Paul—Hamline University, School of Law Library (3).
Minnesota Historical Society Library (3).
St. Paul Public Library (2, 3).
University of Minnesota, St. Paul Campus Library (3).
St. Peter—Gustavus Aldophus College Library (3).
Stillwater—Stillwater Public Library (3).
Willmar—Crow River Regional Library (3).
Winona—Winona State University, Maxwell Library (3).

MISSISSIPPI

Cleveland—Delta State University, W. B. Roberts Library (3).
Clinton—Mississippi College School of Law Library (3).
Columbus—Mississippi University for Women, J. C. Fant Memorial Library (3).
Hattiesburg—University of Southern Mississippi Library (1, 2, 3).
Jackson—Millsaps College, Millsaps-Wilson Library (3).
Mississippi College, School of Law (3).
Mississippi Library Commission (3).
Mississippi State Law Library (3).
Lorman—Alcorn State University Library (2, 3).
Mississippi State—Mississippi State University, Mitchell Memorial Library (1, 2, 3).
University—*University of Mississippi Library (1, 2, 3).
University of Mississippi School of Law Library (1, 2, 3).

MISSOURI

Cape Girardeau—Southeast Missouri State University, Kent Library (2, 3).
Columbia—University of Missouri at Columbia Library (1, 2, 3).
Fayette—Central Methodist College (3).
Fulton—Westminster College, Reeves Library (3).
Jefferson City—Missouri State Library (3).
Joplin—Missouri Southern State College Library (3).
Kansas City—Kansas City Public Library (2, 3).
University of Missouri at Kansas City Library (1, 2, 3).
Kirksville—Northeast Missouri State University, Pickler Memorial Library (3).
Liberty—William Jewell College Library (2).
Maryville—Northwest Missouri State University, Wells Library (1, 2, 3).
Rolla—University of Missouri at Rolla Library (1, 2, 3).
St. Joseph—St. Joseph Public Library (2, 3).
St. Louis—Maryville College Library (2).
St. Louis County Library (2, 3).
St. Louis Public Library (1, 2, 3).
St. Louis University, Pius XII Memorial Library (1, 2, 3).
University of Missouri at St. Louis, Thomas Jefferson Library (1, 2, 3).
Washington University, John M. Olin Library (1, 2, 3).
Springfield—Southwest Missouri State University Library (1, 2, 3).
Drury College, Walker Library (3).
Warrensburg—Central Missouri State University, Ward Edwards Library (1, 2, 3).

MONTANA

Billings—Eastern Montana College Library (1, 2, 3).
Bozeman—Montana State University Library (1, 2, 3).

Butte—Montana College of Mineral Science and Technology Library (1, 2, 3).
Havre—Northern Montana College (3).
Helena—Carroll College Library (1, 3).
Montana Historical Society Library (3).
Montana State Library (1, 2, 3).
Missoula—*University of Montana, Mansfield Library (1, 2, 3).

NEBRASKA

Blair—Dana College, C. A. Dana-Life Library (3).
Fremont—Midland Lutheran College Library (3).
Kearney—Kearney State College, Calvin T. Ryan Library (2, 3).
Lincoln—*Nebraska Library Commission (1, 2, 3).
University of Nebraska, D. L. Love Memorial Library (1, 2, 3).
Omaha—Creighton University, Alumni Memorial Library (3).
Omaha Public Library, W. Dale Clark Branch (1, 2, 3).
University of Nebraska at Omaha Library (1, 3).
Wayne—Wayne State College, U.S. Conn Library (3).

NEVADA

Carson City—Nevada State Library (1, 2, 3).
Las Vegas—Clark County Library District (3).
University of Nevada at Las Vegas, James R. Dickinson Library (1, 2, 3).
Reno—Nevada State Historical Society (3).
*University of Nevada Library (1, 2, 3).
Washoe County Library (2, 3).

NEW HAMPSHIRE

Concord—Franklin Pierce Law Center Library (3).
New Hampshire State Library (1, 2, 3).
Durham—University of New Hampshire (1, 2, 3).
Hanover—Dartmouth College, Baker Memorial Library (1, 2, 3).
Henniker—New England College Library (3).
Manchester—Manchester City Library (2, 3).
New Hampshire College, Shapiro Library (3).
Nashua—Nashua Public Library (3).

NEW JERSEY

Bayonne—Bayonne Free Public Library (2, 3).
Bloomfield—Bloomfield Public Library (2, 3).
Bridgeton—Cumberland County Library (3).
Camden—Rutgers University at Camden Library (3).
East Brunswick—East Brunswick Public Library (3).
East Orange—East Orange Public Library (3).
Elizabeth—Elizabeth Public Library (2, 3).
Glassboro—Glassboro State College, Savitz Learning Resource Center (2, 3).
Hackensack—Johnson Free Public Library (3).
Irvington—Irvington Public Library (3).
Jersey City—Jersey City Public Library (3).
Jersey City State College, F. A. Irwin Library (3).
Lawrenceville—Rider College Library (3).
Madison—Drew University, Rose Memorial Library (3).
Mahwah—Ramapo College of New Jersey Library (3).
Mount Holly—Burlington County Library (3).
New Brunswick—New Brunswick Free Public Library (3).
Rutgers University Library (1, 2, 3).
Newark—*Newark Public Library (1, 2, 3).
Rutgers University, State University of New Jersey, John Cotton Dana Library (1, 2, 3).
Passaic—Passaic Public Library (3).
Plainfield—Plainfield Free Public Library (2, 3).
Pomona—Stockton State College Library (1, 2, 3).
Princeton—Princeton University Library (2, 3).
Randolph Township—County College of Morris, Masten Learning Resource Center (3).

Red Bank—Monmouth County Library, Eastern Branch (3).
Rutherford—Fairleigh Dickinson University, Messler Library (3).
South Orange—Seton Hall University, McLaughlin Library (3).
Teaneck—Fairleigh Dickinson University, Teaneck Campus Library (2, 3).
Toms River—Ocean County College Learning Resources Center (2, 3).
Trenton—New Jersey State Library (3).
Trenton Free Public Library (3).
Union—Kean College of New Jersey, Nancy Thompson Library (3).
Upper Montclair—Montclair State College, Harry S. Sprague Library (3).
Wayne—Wayne Public Library (3).
West Long Branch—Monmouth College, Guggenheim Library (3).
Woodbridge—Free Public Library of Woodbridge (3).

NEW MEXICO

Albuquerque—University of New Mexico, School of Law Library (3).
*University of New Mexico, Zimmerman Library (1, 2, 3).
Hobbs—New Mexico Junior College, Pannell Library (3).
Las Cruces—New Mexico State University Library (1, 2, 3).
Las Vegas—New Mexico Highlands University, Donnelly Library (2, 3).
Portales—Eastern New Mexico University Library (1, 2, 3).
Santa Fe—*New Mexico State Library (1, 2, 3).
New Mexico Supreme Court Law Library (3).
Silver City—Western New Mexico University, Miller Library (1, 3).
Socorro—New Mexico Institute of Mining and Technology Library (1, 2, 3).

NEW YORK

Albany—*New York State Library (1, 2, 3).
State University of New York at Albany Library (2, 3).
Auburn—Seymour Library (3).
Binghamton—State University of New York at Binghamton Library (1, 2, 3).
Brockport—State University of New York College at Brockport, Drake Memorial Library (1, 2, 3).
Bronx—Fordham University Library (3).
Herbert H. Lehman College Library (3).
New York Public Library, Mott Haven Branch (3).
State University of New York Maritime College Library (3).
Brooklyn—Brooklyn College Library (3).
Brooklyn Public Library (2, 3).
Polytechnic Institute of New York, Spicer Library (3).
Pratt Institute Library (3).
Buffalo—Buffalo and Erie County Public Library (1, 2, 3).
State University of New York at Buffalo, Charles B. Sears Law Library (2, 3).
State University of New York at Buffalo, Lockwood Library (1, 3).
Canton—St. Lawrence University, Owen D. Young Library (1, 2, 3).
Corning—Corning Community College, Arthur A. Houghton, Jr., Library (3).
Cortland—State University of New York College at Cortland, Memorial Library (3).
Delhi—State University Agricultural and Technical College Library (3).
Douglaston—Cathedral College of the Immaculate Conception Library (2).
East Islip—East Islip Public Library (2, 3).
Elmira—Elmira College, Gannett-Tripp Learning Center (3).
Farmingdale—State University of New York Agricultural and Technical College at Farmingdale Library (2, 3).

Flushing—Queens College Library (3).
Queensborough Community College Library (3).
Garden City—Adelphi University Library (2, 3).
Genesco—State University of New York College at Genesco, Milne Library (1, 2, 3).
Great Neck—U.S. Merchant Marine Academy Library (3).
Greenvale—C. W. Post Center of Long Island University, B. Davis Swartz Memorial Library (1, 2, 3).
Hamilton—Colgate University Library (1, 2, 3).
Hempstead—Hofstra University Library (3).
Ithaca—Cornell Law Library (3).
Cornell University Library (1, 2, 3).
State University of New York, College of Agriculture and Life Sciences at Cornell University, Albert R. Mann Library (3).
Jamaica—Queens Borough Public Library (1, 2, 3).
St. John's University Library (3).
Mount Vernon—Mount Vernon Public Library (3).
New Paltz—State University of New York College at New Paltz Library (2, 3).
New York—Benjamin N. Cardozo Law School Library (3).
City University of New York, City College Library (1, 2, 3).
Columbia University Libraries (1, 2, 3).
Cooper Union Library (3).
New York Law Institute Library (3).
New York Public Library, Astor Branch (1, 2, 3).
New York Public Library, Lenox Branch (1, 2, 3).
New York University Law Library (3).
New York University Library (2, 3).
Yeshiva University, Pollack Library (3).
Newburgh—Newburgh Free Library (3).
Niagara Falls—Niagara Falls Public Library (3).
Oakdale—Dowling College Library (3).
Oneonta—State University of New York, College at Oneonta, James M. Milne Library (2, 3).
Oswego—State University of New York, Penfield Library (2, 3).
Plattsburgh—State University of New York College at Plattsburgh, Benjamin F. Feinburg Library (2, 3).
Potsdam—Clarkson College of Technology Library (1, 2, 3).
State University of New York College at Potsdam Library (3).
Poughkeepsie—Vassar College Library (3).
Purchase—State University of New York College at Purchase Library (3).
Rochester—Rochester Public Library (3).
University of Rochester Library (1, 2, 3).
St. Bonaventure—St. Bonaventure University, Friedsam Memorial Library (3).
Saratoga Springs—Skidmore College Library (3).
Schenectady—Union College, Shaffer Library (2, 3).
Southampton—Southampton College Library of Long Island University (3).
Sparkhill—St. Thomas Aquinas College (3).
Staten Island—Wagner College, Horrmann Library (2, 3).
Stony Brook—State University of New York at Stony Brook, Main Library (1, 2, 3).
Syracuse—Syracuse University Library (1, 2, 3).
Onondaga County Public Library System (3).
Troy—Troy Public Library (1, 2, 3).
Uniondale—Nassau Library System (1, 2, 3).
Utica—State University of New York College of Technology, Utica-Rome Library (3).
Utica Public Library (3).
West Point—U.S. Military Academy Library (3).
White Plains—Pace University Law Library (3).
Yonkers—Sarah Lawrence College Library (3).
Yonkers Public Library (3).
Yorktown Heights—Mercy College (3).

NORTH CAROLINA

Asheville—University of North Carolina at Asheville, D. Hiden Ramsey Library (3).

Boiling Springs—Gardner-Webb College Library (3).
Boone—Appalachian State University Library (1, 2, 3).
Buies Creek—Campbell College, Carrie Rich Memorial Library (3).
Chapel Hill—University of North Carolina Law Library (2).
*University of North Carolina Wilson Library (1, 2, 3).
Charlotte—Public Library of Charlotte and Mecklenburg County (3).
University of North Carolina at Charlotte, Atkins Library (1, 2, 3).
Cullowhee—Western Carolina University, Hunter Library (2, 3).
Davidson—Davidson College Library (3).
Durham—Duke University, William R. Perkins Library (1, 2, 3).
North Carolina Central University, James E. Shepard Memorial Library (3).
Elon College—Elon College Library (3).
Greensboro—North Carolina Agricultural and Technical State University, F. D. Bluford Library (2, 3).
University of North Carolina at Greensboro, Walter Clinton Jackson Library (2, 3).
Greenville—East Carolina University Library (1, 2, 3).
Laurinburg—St. Andrews Presbyterian College, DeTamble Library (3).
Murfreesboro—Chowan College, Whitaker Library (3).
Pembroke—Pembroke State University, Mary H. Livermore Library (1, 3).
Raleigh—North Carolina Department of Cultural Resources State Library (3).
North Carolina State University, D. H. Hill Library (1, 2, 3).
Wake County Public Library (3).
Rocky Mount—North Carolina Wesleyan College Library (3).
Salisbury—Catawba College Library (3).
Wilmington—University of North Carolina at Wilmington, William M. Randall Library (1, 2, 3).
Wilson—Altantic Christian College Library (3).
Winston-Salem—Forsyth County Public Library (3).
Wake Forest University, Z. Smith Reynolds Library (3).

NORTH DAKOTA

Bismarck—North Dakota Historical Society (3).
North Dakota State Library (3).
Veterans Memorial Public Library (3).
Dickinson—Dickinson State College Library (3).
Fargo—Fargo Public Library (3).
North Dakota State University Library (1, 2, 3).
Grand Forks—*University of North Dakota, Chester Fritz Library (3).
Minot—Minot State College, Memorial Library (1, 2, 3).
Valley City—Valley City State College Library (3).

OHIO

Ada—Ohio Northern University, J. P. Taggart Law Library (3).
Akron—Akron Public Library (1, 2, 3).
University of Akron, Bierce Library (1, 2, 3).
Alliance—Mt. Union College Library (1, 2, 3).
Ashland—Ashland College Library (3).
Athens—Ohio University Library (1, 2, 3).
Batavia—University of Cincinnati, Clermont General and Technical College Library (3).
Bluffton—Bluffton College, Musselman Library (3).
Bowling Green—Bowling Green State University Library (2, 3).
Canton—Malone College, Everett L. Cattell Library (3).
Chardon—Geauga County Public Library (3).
Cincinnati—Public Library of Cincinnati and Hamilton County (1, 2, 3).
University of Cincinnati Library (1, 2, 3).

Cleveland—Case Western Reserve University, Freiberger Library (1, 2, 3).
Cleveland Heights-University Heights Public Library (3).
Cleveland Public Library (1, 2, 3).
Cleveland State University, Cleveland Marshall College of Law Library (2).
Cleveland State University Library (1, 2, 3).
John Carroll University, Grasselli Library (3).
Columbus—Capital University Library (2, 3).
*Ohio State Library (1, 2, 3).
Ohio State University Library (1, 2, 3).
Public Library of Columbus and Franklin County (3).
Dayton—Dayton and Montgomery County Public Library (1, 2, 3).
University of Dayton, Roesch Library (2, 3).
Wright State University Library (2, 3).
Delaware—Ohio Wesleyan University, L. A. Beeghly Library (3).
Elyria—Elyria Public Library (2, 3).
Findlay—Findlay College, Shafer Library (3).
Gambier—Kenyon College Library (3).
Granville—Denison University Library (3).
Kent—Kent State University Library (1, 2, 3).
Marietta—Marietta College, Dawes Memorial Library (1, 2, 3).
Marion—Marion Public Library (3).
Middletown—Miami University-Middletown, Gardner-Harvey Library (2, 3).
New Concord—Muskingum College Library (3).
Oberlin—Oberlin College Library (2, 3).
Oxford—Miami University Library (1, 2, 3).
Portsmouth—Portsmouth Public Library (1).
Rio Grande—Rio Grande College, Jeanette Albiez Davis Library (1, 3).
Springfield—Warder Public Library (3).
Steubenville—Public Library of Steubenville and Jefferson County (3).
Tiffin—Heidelberg College, Beeghly Library (3).
Toledo—Toledo Public Library (1, 2, 3).
University of Toledo Library (1, 2, 3).
Westerville—Otterbein College, Courtright Memorial Library (3).
Wooster—College of Wooster, Andrews Library (2, 3).
Youngstown—Public Library of Youngstown and Mahoning County (3).
Youngstown State University Library (2, 3).

OKLAHOMA

Ada—East Central State University, Linscheid Library (3).
Alva—Northwestern Oklahoma State University Library (3).
Bethany—Bethany Nazarene College, R. T. Williams Library (3).
Durant—Southeastern Oklahoma State University Library (3).
Edmond—Central State University Library (1, 3).
Enid—Enid Public Library (3).
Muskogee—Muskogee Public Library (3).
Norman—University of Oklahoma Law Library (3).
University of Oklahoma Libraries (1, 2, 3).
Oklahoma City—Metropolitan Library System (1, 2, 3).
Oklahoma City University Library (3).
*Oklahoma Department of Libraries (1, 2, 3).
Shawnee—Oklahoma Baptist University (3).
Stillwater—*Oklahoma State University Library (1, 2, 3).
Tahlequah—Northeastern Oklahoma State University, John Vaughan Library (1, 3).
Tulsa—Tulsa City-County Library (1, 2, 3).
University of Tulsa, McFarlin Library (1, 2, 3).
Weatherford—Southwestern Oklahoma State University, Al Harris Library (3).

OREGON

Ashland—Southern Oregon State College (2, 3).
Corvallis—Oregon State University (1, 2, 3).
Eugene—University of Oregon (1, 2, 3).
Forest Grove—Pacific University (3).
Klamath Falls—Oregon Institute of Technology (3).
La Grande—Eastern Oregon State College (3).
McMinnville—Linfield College, Northrup Library (3).
Monmouth—Western Oregon State College (3).
Portland—Bonneville Power Administration Library (3).
Lewis and Clark College (3).
Library Association of Portland (1, 2, 3).
*Portland State University (1, 2, 3).
Salem—Oregon State Library (1, 2, 3).
Willamette University (3).

PENNSYLVANIA

Allentown—Muhlenberg College (3).
Altoona—Altoona Public Library (3).
Bethel Park—Bethel Park Public Library (3).
Bethlehem—Lehigh University (1, 2, 3).
Bradford—University of Pittsburgh (3).
Carlisle—Dickinson College, Boyd Lee Spahr Library (2, 3).
Dickinson School of Law, Sheely-Lee Law Library (3).
Cheyney—Cheyney State College, Leslie Pinckney Hill Library (3).
Collegeville—Ursinus College, Myrin Library (3).
East Stroudsburg—East Stroudsburg State College, Kemp Library (3).
Erie—Erie Public Library (3).
Greenville—Thiel College, Langenheim Memorial Library (1, 2, 3).
Harrisburg—*State Library of Pennsylvania (1, 2, 3).
Haverford—Haverford College (3).
Hazleton—Hazleton Public Library (2, 3).
Indiana—Indiana University of Pennsylvania, Rhodes R. Stabley Library (3).
Johnstown—Cambria County Library System, Glosser Memorial Library (1, 2, 3).
Lancaster—Franklin and Marshall College (1, 2, 3).
Lewisburg—Bucknell University, Ellen Clarke Bertrand Library (2, 3).
Mansfield—Mansfield State College (1, 2, 3).
Meadville—Allegheny College, Pelletier Library (1, 2, 3).
Millersville—Millersville State College, Ganser Library (2, 3).
Monesson—Monesson Public Library (3).
New Castle—New Castle Public Library (3).
Newtown—Bucks County Community College (3).
Norristown—Montgomery County-Norristown Public Library (3).
Philadelphia—Drexel University (1, 2, 3).
Free Library of Philadelphia (1, 2, 3).
Temple University, Paley Library (1, 2, 3).
University of Pennsylvania (1, 2, 3).
Pittsburgh—Carnegie Library of Pittsburgh (1, 2, 3).
Carnegie Library of Pittsburgh, Allegheny Regional Branch (2, 3).
La Roche College, John J. Wright Library (3).
U.S. Bureau of Mines (2, 3).
University of Pittsburgh, Hillman Library (1, 2, 3).
Pottsville—Pottsville Free Public Library (2, 3).
Reading—Reading Public Library (2, 3).
Scranton—Scranton Public Library (3).
Shippensburg—Shippensburg State College, Ezra Lehman Memorial Library (3).
Slippery Rock—Slippery Rock State College (1, 2, 3).
Swarthmore—Swarthmore College (3).
University Park—Pennsylvania State University (1, 2, 3).
Villanova—Villanova University Law Library (3).
Warren—Warren Library Association (3).
Waynesburg—Waynesburg College (2, 3).
West Chester—West Chester State College, Francis Harvey Green Library (2, 3).
Wilkes-Barre—King's College (2, 3).

Williamsport—Lycoming College (3).
York—York College of Pennsylvania Library (3).
Youngwood—Westmoreland County Community College (3).

RHODE ISLAND

Newport—U.S. Naval War College Library (3).
Providence—Brown University (1, 2, 3).
Providence College, Phillips Memorial Library (3).
Providence Public Library (3).
Rhode Island College, James P. Adams Library (3).
Wakefield—University of Rhode Island (1, 2, 3).
Warwick—Warwick Public Library (3).
Westerly—Westerly Public Library (3).

SOUTH CAROLINA

Charleston—College of Charleston (3).
The Citadel Library (1, 3).
College of Charleston Library (3).
Clemson—Clemson University Library (1, 2, 3).
Columbia—South Carolina State Library (1, 3).
University of South Carolina (1, 2, 3).
Conway—University of South Carolina, Coastal Carolina College, Kimbel Library (3).
Due West—Erskine College, McCain Library (3).
Florence—Florence County Library (3).
Francis Marion College, James A. Rogers Library (3)
Greenville—Furman University (1, 2, 3).
Greenville County Library (3).
Greenwood—Lander College, Larry A. Jackson Library (3).
Rock Hill—Winthrop College, Dacus Library (3).
Spartanburg—Spartanburg County Public Library (3).

SOUTH DAKOTA

Aberdeen—Northern State College (3).
Brookings—South Dakota State University, H. M. Briggs Library (2, 3).
Pierre—South Dakota State Library (3).
Rapid City—Rapid City Public Library (3).
South Dakota School of Mines and Technology Library (1, 2, 3).
Sioux Falls—Augustana College, Mikkelsen Library (3).
Sioux Falls Public Library (3).
Spearfish—Black Hills State College (2, 3).
Vermillion—University of South Dakota, I. D. Weeks Library (3).

TENNESSEE

Bristol—King College (3).
Chattanooga—Chattanooga-Hamilton County Bicentennial Library (1, 2, 3).
Tennessee Valley Authority Technical Library (1, 3).
Clarksville—Austin Peay State University, Woodward Library (1, 2, 3).
Cleveland—Cleveland State Community College (3).
Cookeville—Tennessee Technological University, Jere Whitson Memorial Library (1, 2, 3).
Jefferson City—Carson-Newman College (3).
Johnson City—East Tennessee State University, Sherrod Library (1, 2, 3).
Knoxville—Knoxville-Knox County Public Library (2, 3).
University of Tennessee at Knoxville (1, 2, 3).
Martin—University of Tennessee at Martin (3).
Memphis—Memphis-Shelby County Public Library (1, 2, 3).
Memphis State University (1, 2, 3).
Murfreesboro—Middle Tennessee State University (3).
Nashville—Public Library of Nashville and Davidson County (3).
Tennessee State Library and Archives (2, 3).
Tennessee State University Library (3).
Vanderbilt University Library (1, 2, 3).
Vanderbilt University, Vanderbilt Law Library (3).

Sewanee—University of the South, Jessie Ball DuPont Library (2, 3).

TEXAS

Abilene—Abilene Christian University, Margaret and Herman Brown Library (2, 3).
Hardin-Simmons University (3).
Arlington—Arlington Public Library (3).
University of Texas (1, 2, 3).
Austin—*Texas State Library (1, 2, 3).
University of Texas, Perry-Castenada Library (1, 2, 3).
University of Texas, Lyndon B. Johnson School of Public Affairs Library (2, 3).
University of Texas Law Library (3).
Beaumont—Lamar University, Gray Library (1, 2, 3).
Brownwood—Howard Payne University, Walker Memorial Library (3).
Canyon—West Texas State University Library (1, 2, 3).
College Station—Texas A & M University (1, 2, 3).
Commerce—East Texas State University (2, 3).
Corpus Christi—Corpus Christi State University (3).
Dallas—Bishop College, Zale Library (3).
Dallas Baptist College (3).
Dallas Public Library (1, 2, 3).
Southern Methodist University, Fondren Library (1, 2, 3).
Denton—North Texas State University (2, 3).
Edinburg—Pan American University (3).
El Paso—El Paso Public Library (1, 2, 3).
University of Texas (1, 2, 3).
Fort Worth—Fort Worth Public Library (1, 2, 3).
Texas Christian University, Mary Couts Burnett Library (1, 2, 3).
Galveston—Rosenburg Library (3).
Houston—Houston Public Library (1, 2, 3).
North Harris County College (3).
Rice University, Fondren Library (1, 2, 3).
South Texas College of Law (3).
University of Houston (1, 2, 3).
University of Houston, Clear Lake City Library (3).
Huntsville—Sam Houston State University (1, 2, 3).
Irving—Irving Public Library System (3).
Kingsville—Texas A & I University (1, 2, 3).
Laredo—Laredo Junior College, Harold R. Yeary Library (3).
Longview—Nicholson Memorial Public Library (3).
Lubbock—Texas Tech University Law Library (3).
*Texas Tech University Library (1, 2, 3).
Marshall—Wiley College, Cole Library (3).
Nacogdoches—Stephen F. Austin State University, Steen Library (1, 2, 3).
Richardson—University of Texas at Dallas Library (1, 2, 3).
San Angelo—Angelo State University Library (3).
San Antonio—St. Mary's University, Academic Library (2, 3).
St. Mary's University, Law Library (3).
San Antonio College (3).
San Antonio Public Library (1, 2, 3).
Trinity University (1, 2, 3).
University of Texas (1, 2, 3).
San Marcos—Southwest Texas State University (3).
Victoria—Victoria College-University of Houston (3).
Waco—Baylor University (2, 3).
Wichita Falls—Midwestern State University, Moffett Library (3).

UTAH

Ephraim—Snow College (3).
Logan—*Utah State University, Merrill Library (1, 2, 3).
Ogden—Weber State College (2, 3).
Provo—Brigham Young University, Law Library (2, 3).
Brigham Young University, Lee Library (1, 2, 3).
Salt Lake City—University of Utah, Law Library (2, 3).
University of Utah, Marriott Library (1, 2, 3).
Utah State Library (3).

VERMONT

Burlington—University of Vermont, Bailey Library (1, 2, 3).
Castleton—Castleton State College, Calvin Coolidge Library (3).
Johnson—Johnson State College, John Dewey Library (3).
Lyndonville—Lyndon State College, Samuel Reed Hall Library (3).
Middlebury—Middlebury College Library (2, 3).
Montpelier—Vermont Department of Libraries (3).
Northfield—Norwich University (3).
South Royalton—Vermont Law School Library (3).

VIRGINIA

Arlington—George Mason University, Law Library (3).
Blacksburg—Virginia Polytechnic Institute and State University Library (1, 2, 3).
Charlottesville—*University of Virginia, Alderman Library (1, 2, 3).
Chesapeake—Chesapeake Public Library (3).
Emory—Emory and Henry College Library (2, 3).
Fairfax—George Mason University Library (1, 2, 3).
Fredericksburg—Mary Washington College, E. Lee Trinkle Library (3).
Hampden-Sydney—Hampden-Sydney College, Eggleston Library (3).
Harrisonburg—James Madison University, Madison Memorial Library (3).
Hollins College—Hollins College, Fishburn Library (3).
Lexington—Virginia Military Institute, Preston Library (2, 3).
Washington and Lee University (2, 3).
Norfolk—Armed Forces Staff College (1, 3).
Norfolk Public Library (3).
Old Dominion University Library (2, 3).
Petersburg—Virginia State College, Johnston Memorial Library (3).
Quantico—U.S. Marine Corps Schools, James Carson Breckinridge Library (3).
Reston—U.S. Geological Survey Library (1, 2, 3).
Richmond—University of Richmond, Boatwright Memorial Library (2, 3).
Virginia Commonwealth University, James Branch Cabell Library (2, 3).
Virginia State Library (1, 2, 3).
Salem—Roanoke College Library (3).
Springfield—National Technical Information Service (1, 3).
Williamsburg—College of William and Mary, Swem Library (1, 2, 3).
Wise—Clinch Valley College, John Cook Wyllie Library (1, 2, 3).

WASHINGTON

Bellingham—Western Washington University, Wilson Library (1, 2, 3).
Cheyney—Eastern Washington University Library (1, 2, 3).
Ellensburg—Central Washington University Library (1, 2, 3).
Everett—Everett Public Library (3).
Midway—Highline Community College (3).
Olympia—Evergreen State College (3).
*Washington State Library (1, 2, 3).
Port Angeles—North Olympic Library System (2, 3).
Pullman—Washington State University (1, 2, 3).
Seattle—Seattle Public Library (1, 2, 3).
University of Washington (1, 2, 3).
Spokane—Gonzaga University School of Law Library (3).
Spokane Public Library (1, 2, 3).
Tacoma—Tacoma Public Library (1, 2, 3).
University of Puget Sound, Collins Memorial Library (2, 3).
Vancouver—Fort Vancouver Regional Library (3).
Walla Walla—Whitman College, Penrose Memorial Library (2, 3).

WEST VIRGINIA

Athens—Concord College Library (3).
Bluefield—Bluefield State College (1, 3).
Charleston—Kanawha County Public Library (3).
West Virginia Library Commission (1, 2, 3).
West Virginia Supreme Court Law Library (1, 2).
Elkins—Davis and Elkins College (3).
Fairmont—Fairmont State College (2, 3).
Glenville—Glenville State College, Robert F. Kidd Library (3).
Huntington—Marshall University Library (1, 2, 3).
Institute—West Virginia College of Graduate Studies Library (3).
West Virginia State College (2, 3).
Morgantown—*West Virginia University (1, 2, 3).
Salem—Salem College Library (1, 2, 3).
Shepherdstown—Shepherd College (3).

WISCONSIN

Appleton—Lawrence University, Seeley G. Mudd Library (2, 3).
Beloit—Beloit College (3).
Eau Claire—University of Wisconsin, William D. McIntyre Library (2, 3).
Fond du Lac—Fond du Lac City-County Library Service (1, 3).
Fond du Lac—Fon du Lac City-County Library Service (1, 3).
Green Bay—University of Wisconsin (1, 2, 3).
La Crosse—La Crosse Public Library (3).
University of Wisconsin, Murphy Library (2, 3).
Madison—Madison Public Library (2, 3).
*State Historical Society Library (1, 2, 3).
University of Wisconsin Memorial Library (3).
Milwaukee—*Milwaukee Public Library (1, 2, 3).
Mount Mary College Library (3).
University of Wisconsin (1, 2, 3).
Oshkosh—University of Wisconsin, Forrest R. Polk Library (1, 2, 3).
Platteville—University of Wisconsin (1, 2, 3).
Racine—Racine Public Library (1, 2, 3).
Ripon—Ripon College (3).
River Falls—University of Wisconsin, Chalmer Davee Library (3).
Sheboygan—Mead Public Library (3).
Stevens Point—University of Wisconsin (1, 2, 3).
Superior—Superior Public Library (3).
University of Wisconsin, Jim Dan Hill Library (2, 3).
Waukesha—Waukesha Public Library (3).
Wausau—Marathon County Public Library (3).
Whitewater—University of Wisconsin (2, 3).

WYOMING

Casper—Natrona County Public Library (1, 2, 3).
Cheyenne—*Wyoming State Library (1, 2, 3).
Gillette—Campbell County Public Library (1, 2, 3).
Laramie—University of Wyoming, Coe Library (1, 2, 3).
University of Wyoming, Law Library (3).
Riverton—Central Wyoming College Library (1, 3).
Rock Springs—Western Wyoming Community College (2, 3).
Sheridan—Sheridan College, Griffith Memorial Library (1, 2, 3).

GUAM

Agana—Guam Public Library, Nieves M. Flores Memorial Library (3).
Mangilao—University of Guam, Robert F. Kennedy Memorial Library (3).

PUERTO RICO

Mayaguez—University of Puerto Rico (1, 2, 3).

PUERTO RICO—Continued

Ponce—Catholic University of Puerto Rico Library (3). Catholic University of Puerto Rico School of Law Library (1).
San Juan—University of Puerto Rico (1, 2, 3).

TRUST TERRITORIES OF THE PACIFIC ISLANDS

Ponape—Community College of Micronesia (2, 3).

VIRGIN ISLANDS

St. Thomas—College of the Virgin Islands, Ralph M. Paiewonsky Library (3).

HANDBOOKS

Application for free publications should be made to—
Publication Distribution
Bureau of Mines
Cochrans Mill Rd., P.O. Box 18070
Pittsburgh, PA 15236
or call 412–675–4338.

Handbooks are instruction or information manuals designed to improve efficiency in the mineral industries or to promote the wise use of mineral resources. Based on research and the practical experience of Bureau and contractor personnel, they give specific instructions on various subjects.

1981

HB 1–81. Application Notes: Mine Electric Power Systems, by Staff, Bureau of Mines. 1981. 83 pp. 63 figs. These application notes on mine electric power systems are based on work done under contract to the Bureau of Mines. The notes are intended to provide ready reference to mine maintenance engineers. The subject covered in the first notes are (1) the measurement of earth resistivity, (2) measurement of ground bed resistance, (3) cable fault location using time domain reflectometry instruments, (4) cable fault location, (5) common splicing errors and how to avoid them, and (6) learning from failed splices. Because this is an active area of research, the Bureau of Mines plans to issue new and updated notes and to distribute them to the holders of the original publication. Additional application notes will include electric transient suppression and additional items on trailing cable splicing. (*Out of print.*)

HB 2–81. Guidelines for Carrier Phone Systems: Installation, Maintenance, and Improvement, by James C. Cawley. 1981. 69 pp. 24 figs. This Bureau of Mines Handbook describes the installation and maintenance of carrier phone systems in underground coal mines. Detailed information is also presented on specific ways to improve existing carrier phone systems.

1983

HB 1–83. Techniques for Constructing Concrete Block Stoppings, by Robert J. Timko and Edward D. Thimons. 1983. 29 pp. 24 figs. The Bureau of Mines has evaluated several techniques that will enhance the airtightness of concrete block permanent stoppings used in mines for airflow control. These techniques have been combined to create three distinct stopping types, each with its own utility. This handbook describes the three types of stoppings and includes illustrated step-by-step instructions for their construction. (*Out of print.*)

HB 2–83. Mining Machinery Noise Control Guidelines, 1983, by Roy C. Bartholomae and Robert P. Parker. 1983. 87 pp. 42 figs. The Mine Health and Safety Act of 1977 seeks to protect miners by regulating their exposure to excessive noise in the mining environment. When a worker's exposure is found to be excessive, the utilization of existing engineering noise control measures are required to abate the noise. Over the past decade, the Bureau of Mines has undertaken a number of noise control programs aimed at establishing a technology base that can be used by industry to effect solutions to noise problems. Many of these hardware-oriented programs have provided the development and demonstration of retrofit noise control treatments for mining machinery. The purpose of this Handbook is to synthesize evolving and available noise control information and disseminate it within the mining industry.

1984

HB 1–84. Splicing Mine Cables, compiled by Staff, Bureau of Mines. 1984. 92 pp. 32 figs. This Handbook combines the chapters from the Bureau of Mines Mine Handbook Electric Power Systems (HB 1–81) that cover splicing mine cables. Topics include common splicing errors and how to avoid them; learning from failed splices; the advantages of correctly made splices; trailing cable splices, including cable preparation, rejoining the conductors, and finishing the splice; and procedures for splicing low-voltage shielded trailing cables.

HB 2–84. Battery Safety Procedures for Surface-Mining Equipment, by James C. Mitchell. 1984. 54 pp. 11 figs. Recent mine accident data compiled by the Mine Safety and Health Administration indicate a need for better understanding by operators and mechanics of the hazards of lead-acid storage batteries and proper safety precautions to be observed when working with such batteries. This publication will familiarize the miner with lead-acid battery terminology and procedures for safe and proper battery installation, storage, inspection, testing, servicing, and jump starting of engines. These procedures are presented as a guide for assuring battery safety associated with surface mining equipment.

MINERAL INDUSTRY SURVEYS

Mineral Industry Surveys are processed reports that contain statistical and economic data on various mineral commodities. These reports are issued at regular intervals so that information on mineral commodities may be made available quickly and in a convenient form. Most of the data contained in these reports appear in permanent form in the Bureau of Mines Minerals Yearbook. Single copies of Mineral Industry Surveys may be obtained from Publication Distribution, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236. Mineral Industry Surveys dealing with various mineral commodities will be forwarded regularly if application stating in detail the need for certain reports is made to the Branch of Editorial Services, Bureau of Mines, 2401 E Street, NW., Washington, DC 20241. The following Mineral Industry Surveys are published by the Bureau of Mines on various mineral commodities. Mineral Industry Surveys are also published annually that contain preliminary data on mineral production for each State.

MONTHLY

Aluminum.
Cement.
Chromium.
Cobalt.
Copper.
Gold and Silver.
Gypsum.
Iron and Steel Scrap.
Iron Ore.
Lead.
Lime.
Manganese.
Molybdenum.
Nickel.
Phosphate Rock.
Silicon.
Sodium Compounds.
Sulfur.
Tin.
Tungsten.
Vanadium.
Zinc.

QUARTERLY

Antimony.
Bauxite.
Bismuth.
Cadmium.
Copper Sulfate.
Fluorspar.
Magnesium.
Mercury.
Platinum-Group Metals.
Selenium.
Titanium.

ANNUALLY

Abrasive Materials.
Asbestos.
Barite.
Boron.
Bromine.
Cement.
Clays.
Columbium and Tantalum.
Diamond, Industrial.
Diatomite.
Feldspar.
Ferroalloys.
Garnet.
Gem Stones.
Graphite, Natural.
Gypsum.
Iodine.
Iron and Steel.
Kyanite and Related Materials.
Lime.
Lithium.
Mica.
Molybdenum.
Peat.
Perlite.
Phosphate Rock.
Potash.
Pumice and Pumicite.
Quartz Crystal.
Salt.
Sand and Gravel.
Sodium Compounds.
Stone (Crushed and Dimension).
Strontium.
Sulfur.
Talc and Pyrophyllite.
Tungsten.
Vermiculite.

SPECIAL MINERAL COMMODITY PUBLICATIONS

The following publications are issued to assist producers and consumers of mineral commodities, policymakers, mineral industry experts, and the general public to keep abreast of developments in the mineral industries. The publications provide brief summaries or tabulations of significant information from various sources. Single copies of these publications may be obtained from Publication Distribution, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236.

Mineral and Materials—A Bimonthly Survey provides timely information on selected commodities. Data and analyses are presented that are germane to policy issues of current interest. Brief narratives are supplemented by statistical graphs and tables. An economic analysis of the status of the mineral industry and articles focusing on major mineral issues are presented in each issue. To be placed on a mailing list to receive copies of Minerals and Materials on a regular basis, write to U.S. Department of the Interior, Bureau of Mines, Mineral Data Analysis, 2401 E Street, NW., Washington, DC 20241.

Mineral Commodity Summaries, an annual publication, is the earliest Government publication to furnish estimates of the previous year's nonfuel mineral industry data. Most of the estimates are based on 9 months data. The publication contains information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for a number of minerals and metals.

MINERALS YEARBOOK

The Minerals Yearbook, published in three volumes, discusses the performance of the worldwide minerals industry during the year and provides background information to assist in interpreting developments during the year being reviewed. The complete volumes are available for the prices indicated from—

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Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1980. 75 ch. 1066 pp. Available from NTIS, publication number PB 81–152274.

Volume II, Area Reports: Domestic, prepared by the staff of the Bureau of Mines. 1981. 52 ch. 665 pp. Available from NTIS, publication number PB 82–105248.

Volume III, Area Reports: International, prepared by the staff of the Bureau of Mines. 1981. 93 ch. 1243 pp. Available from NTIS, publication number PB 82–208265

1978–79 MINERALS YEARBOOK

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Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1981. 72 ch. 950 pp. Available from NTIS, publication number PB 82–180027.

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Volume III, Area Reports: International, prepared by the staff of the Bureau of Mines. 1982. 92 ch. 1367 pp. Available from NTIS, publication number PB 82–220906.

1981 MINERALS YEARBOOK

Volume I, Metals and Minerals. Centennial Edition 1981, prepared by the staff of the Bureau of Mines. 1982. 73 ch. 968 pp. Available from NTIS, publication number PB 83–177568.

Volume II, Area Reports: Domestic. Centennial Edition 1981, prepared by the staff of the Bureau of Mines. 1983. 53 ch. 561 pp. Available from NTIS, publication number PB 83–213975.

Volume III, Area Reports: International. Centennial Edition 1981, prepared by the staff of the Bureau of Mines. 1983. 90 ch. 1413 pp. Available from NTIS, publication number PB 83–213983.

1982 MINERALS YEARBOOK

Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1984. 73 ch. 961 pp. Available from GPO, GPO Stock No. 024–004–02124–1. $16.

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B 670. Comminution by the Attrition Grinding Process, by Martin H. Stanczyk and I. L. Feld. 1980. 43 pp. 36 figs. As part of its mission to advance minerals technology, the Federal Bureau of Mines has conducted investigations to determine the feasibility of producing subsieve-size material by an attrition grinding method. The Bureau-patented technique involves the intense agitation of a slurry composed of the material to be ground, a granular grinding medium, and a suspending fluid. Investigations were made to determine the efficiency of the method in grinding numerous industrial minerals, metals, and ceramic materials. The research has demonstrated the feasibility of the process for comminuting a variety of materials to extremely fine particle sizes. Transfer of this technology to industry has been achieved, and commercial-scale units currently are being used in the paper-coating clay and titania pigment industries. Research at the Tuscaloosa Research Center is carried out under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama. (*Out of print.*)

B 671. Mineral Facts and Problems, 1980 Edition, by Staff, Bureau of Mines. 1981. 1060 pp. This one-volume encyclopedia comprising 80 commodity chapters and an explanatory introduction contains comprehensive information on metals, nonmetals, and industrial gases. Commodity chapters cover such topics as industry structure, reserves and resources, uses, technology, supply-demand relationships, byproducts and coproducts, strategic considerations, economic factors and problems, operating factors and problems, and outlook and forecasts to 2000. Preprints of the individual chapters are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. GPO Stock No. 024-004-02072-5. $23.

B 672. Thermodynamic Properties of Elements and Oxides, by L. B. Pankratz. With a section on Process Applications, by R. V. Mrazek. 1982. 509 pp. Thermodynamic data on the elements and oxides were reviewed, evaluated, and compiled at the Bureau of Mines Albany Research Center. Values for $C_p°$, $S°$, $H° - H°_{298}$, $-(G° - H°_{298}) / T$, $\Delta Hf°$, $\Delta Gf°$, and log K are given in tabular form. $C_p°$, $H° - H°_{298}$, $\Delta Hf°$, and $\Delta Gf°$ are also expressed algebraically. Examples of calculations using these data are given. A short statement of some fundamental ideas of thermodynamics and several examples of their use are included. The examples illustrate several alternate methods of calculation using both the tabulated values and the equations. Comparisons are also made on the bases of ease of calculation and accuracy of results. GPO Stock No. 024-004-02101-2. $17.

B 673. The Inductoslag Melting Process, by P. G. Clites. 1982. 32 pp. 35 figs. This bulletin summarizes the results of Bureau of Mines research on the development of the inductoslag melting process. Inductoslag melting is an induction melting technique using a segmented, water-cooled, copper crucible. The process was developed as part of the Bureau's work on effective utilization of reactive metal scrap, and the process has been applied to melting Ti, Zr, Cr, Co, Fe, Ni, and V. Construction details are given for the segmented crucibles and for both an ingot furnace and a casting furnace. The melting process is described, and results of tests conducted with a variety of reactive metals are given.

B 674. Thermodynamic Properties of Halides, by L. B. Pankratz. 1984. 826 pp. Thermodynamic data on the halides were reviewed, evaluated, and compiled at the Bureau of Mines Albany Research Center. The values for heat capacities, high-temperature relative enthalpies, enthalpies of formation, and Gibbs energies of formation are given in both tabular and equation forms. The tables include entropy, Gibbs energy functions, and logarithms (base 10) of the equilibrium constants. Where possible, all phases of a halide are presented in a single table. Temperatures of transformation and thermodynamic properties at these temperatures are included in the table. Immediately below the table the natures of transformations are given along with their associated enthalpies. GPO Stock No. 024-004-02136-6. $20.

B 676. Conventional Versus Developing Processes of Phosphatic Clay Disposal: A Technical Evaluation, by Jerry T. McLendon, James R. Boyle, Jr., and John W. Sweeney. 1984. 28 pp. 47 figs. The proper disposition of phosphatic clays has been the subject of research and debated for years by phosphate producers, State and Federal research agencies, regulatory authorities, and environmentalists. To date, no "universal" solution exists for the ultimate disposal of phosphatic clays. This Bureau of Mines report examines the state of conventional clay disposal technology and reviews the technical progress of innovative alternatives. Twenty impoundment sites were investigated by the Bureau of Mines using geotechnical methods and laboratory analysis of cored samples. In addition, quasi-static cone penetrometer soundings were conducted to define clay and/or sand-clay interfaces en masse. Samples of the top, middle, and bottom hole segments were obtained at each station for laboratory studies of clay densities, pore fluids, plasticity, and mineralogical properties. The results of this study support the continued use of *initial* clay settling impoundments but emphasize the need for "in-line" systems to reduce the initial volumes of plant-generated phosphatic clays. The effective use of sand tailings is also encouraged to promote further consolidation of clays via self-weight stressing, sand-clay admixtures, and/or surcharging sand caps. This research was carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the Florida Institute of Phosphate Research. GPO Stock No. 024-004-02135-7. $2.

COOPERATIVE PUBLICATIONS

WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY

EPA 1–82. Environmental Considerations for Emerging Copper-Winning Processes, by H. Dolezal, M. Hayashi, G. Potter, and J. O. Burckle. 1982. 6 pp. EPA–600/S2–82–058.

WITH THE STATE OF FLORIDA DEPARTMENT OF NATURAL RESOURCES BUREAU OF GEOLOGY

FBG 1–81. The Hawthorn Formation of Central Florida. Part I—Geology of the Hawthorne Formation in Central Florida, by Thomas M. Scott and Peter L. MacGill. **Part II—Characterization, Evaluation, and Beneficiation of Central Florida Phosphate-Bearing Hawthorn Formation,** by W. H. Eddy, B. E. Davis, and G. V. Sullivan. Fla. Bureau of Geol. RI 91. 1981. 107 pp. 10 figs.

FBG 1–83. The Hawthorn Formation of Northeastern Florida. Part I—The Geology of the Hawthorn Formation of Northeastern Florida, by Thomas M. Scott. **Part II—Characterization and Beneficiation of the Northeastern Florida Phosphate-Bearing Hawthorn Formation,** by B. E. Davis, G. V. Sullivan, and T. O. Llewellyn. Fla. Bureau Geol. RI 94. 1983. 90 pp.

WITH THE FLORIDA INSTITUTE OF PHOSPHATE RESEARCH

FIPR 1–84. State-of-the-Art of Phosphatic Clay Dewatering Technology and Disposal Techniques (In Two Parts). 1. A Review of Phosphatic Clay Dewatering Research, by W. E. Pittman, Jr., and J. W. Sweeney. Sept. 1983. 41 pp. FL Inst. Phosphate Res. Pub. 02–017–021.

WITH THE GEOLOGICAL SURVEY U.S. DEPARTMENT OF THE INTERIOR

The Wilderness Act (Public Law 88–577, September 3, 1964) and the Conference Report on Senate Bill 4, 88th Congress, direct the Geological Survey and the Bureau of Mines to make mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System. Areas classified as "primitive" were not included in the Wilderness System, but the act provided that each should be studied for incorporation into the Wilderness System. The act also directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more and every roadless island within the national wildlife refuges and game ranges under the Secretary's jurisdiction, and to report the suitability or nonsuitability of each area or island for preservation as a wilderness. The mineral surveys of the primitive areas, wildlife refuges, and game ranges are one aspect of the suitability studies.

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GS 1–80. Geology and Mineral Resources of the North Absaroka Wilderness and Vicinity, Park County, Wyoming, by Willis H. Nelson, Harold J. Prostka, and Frank E. Williams. With sections on mineralization of the Sunlight mining region and geology and mineralization of the Cooke City mining district, by James E. Elliott, and a section on aeromagnetic survey, by Donald L. Peterson. 1980. 101 pp. 22 figs. 2 pl. Geol. Survey Bull. 1447. GPO Stock No. 024–001–03271–6. $4.50.

GS 2–80. Mineral Resources of the Indian Peaks Study Area, Boulder and Grand Counties, Colorado, by Robert C. Pearson and U.S. Bureau of Mines. With a section on interpretation of aeromagnetic data, by Gordon Johnson. 1980. 109 pp. 12 fig. 2 pl. Geol. Survey Bull. 1463. GPO Stock No. 024–001–03303–8. $5.50.

GS 3–80. Mineral Resources of the Sturgeon River Wilderness Study Area, Houghton and Baraga Counties, Michigan, by W. F. Cannon, Elizabeth R. King, James J. Hill, and Peter C. Mory. 1980. 49 pp. 18 figs. Geol. Survey Bull. 1465. GPO Stock No. 024–001–03259–7. $3.25.

GS 4–80. Mineral Resources of the Dolly Sods Wilderness Area, Grant, Randolph, and Tucker Counties, West Virginia, by Kenneth J. Englund, Ralph C. Warlow, James J. Hill, Peter C. Mory, Bradford B. Williams, and Maynard L. Dunn, Jr. With sections on peat resources, by Cornelia C. Cameron, geochemical survey, by Frank G. Lesure, and oil and gas potential, by William J. Perry, Jr. 1980. 52 pp. 19 figs. 3 pl. Geol. Survey Bull. 1483–A. GPO Stock No. 024–001–03340–2. $3.75.

1981

GS 1–81. Mineral Resources of the Scotchman Peak Wilderness Study Area, Lincoln and Sanders Counties, Montana, and Bonner County, Idaho, by the U.S. Geological Survey and U.S. Bureau of Mines. With sections on geology, by Robert L. Earhart; aeromagnetic and gravity studies, by M. Dean Kleinkopf and Dolores M. Wilson; geological and geochemical evaluation of the mineral resources, by David J. Grimes and Robert L. Earhart; and economic appraisal, by Nicholas T. Zilka. 1981. 73 pp. 17 figs. 2 pl. Geol. Survey Bull. 1467. GPO Stock No. 024–001–03379–8. $4.75.

GS 2–81. Mineral Resources of the Galiuro Wilderness and Contiguous Further Planning Areas, Arizona, by S. C. Creasey, J. E. Jinks, F. E. Williams, and H. C. Meeves. With a section on aeromagnetic survey and interpretation, by W. E. Davis. 1981. 94 pp. 16 figs. 2 pl. Geol. Survey Bull. 1490. GPO Stock No. 024–001–03438–7. $4.75.

GS 3–81. Mineral Resources of the Lone Peak Wilderness Study Area, Utah and Salt Lake Counties, Utah, by Calvin S. Bromfield and Lowell L. Patten. With a section on interpretation of aeromagnetic data, by Don R. Mabey. 1981. 117 pp. 40 figs. 2 pl. Geol. Survey Bull. 1491. GPO Stock No. 024–001–03423–9. $7.

GS 4–81. Mineral Resources of the Cranberry Wilderness Study Area, Webster and Pocahontas Counties, West Virginia, by Charles R. Meissner, Jr., John F. Windolph, Jr., Peter C. Mory, and Donald K. Harrison. With sections on peat resources, by Cornelia C. Cameron and Andrew E. Grosz; oil and gas potential, by William J. Perry, Jr.; and geochemical survey, by Frank G. Lesure. 1981. 61 pp. 19 figs. 3 pl. Geol. Survey Bull. 1494. GPO Stock No. 024–001–03389–5. $4.25.

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GS 6–81. Mineral Resources of the Strawberry Mountain Wilderness and Adjacent Areas, Grant County, Oregon, by Thomas P. Thayer, James E. Case, and Ronald B. Stotelmeyer. 1981. 67 pp. 13 figs. 2 pl. Geol. Survey Bull. 1498. GPO Stock No. 024–001–03445–0. $5.50.

GS 7–81. Mineral Resources of the Rincon Wilderness Study Area, Pima County, Arizona, by Charles H. Thorman, Harold Drewes, and Michael E. Lane. 1981. 62 pp. 1 fig. 2 pl. Geol. Survey Bull. 1500. GPO Stock No. 024–001–03454–9. $6.

GS 8–81. Mineral Resources of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana, by the U.S. Geological Survey and U.S. Bureau of Mines. 1981. 77 pp. 19 figs. 2 pl. Geol. Survey Bull. 1501. GPO Stock No. 024–001–03393–3. $4.50.

GS 9–81. Mineral Resources of the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area, Bayfield County, Wisconsin, by W. F. Cannon, Cornelia C. Cameron, Andrew E. Grosz, Maynard L. Dunn, Jr., Gertrude C. Gazdik, and James J. Hill. 1981. 19 pp. 8 figs. 1 pl. Geol. Survey Bull. 1511. GPO Stock No. 024–001–03455–7. $3.75.

GS 10–81. Mineral-Resource Evaluation of the Round Lake Wilderness Study Area, Price and Vilas Counties, Wisconsin, by William F. Cannon, Cornelia C. Cameron, John S. Klasner, Andrew E. Grosz, and Bradford B. Williams. 1981. 23 pp. 9 figs. 1 pl. Geol. Survey Bull. 1512. GPO Stock No. 024–001–03416–6. $4.

1982

GS 1–82. Mineral Resources of the Boulder-Pioneer Wilderness Study Area, Blaine and Custer Counties, Idaho, by the U.S. Geological Survey and U.S. Bureau of Mines. With sections on geology, by J. H. Dover; aeromagnetic studies, by D. R. Mabey; geological and geochemical evaluation, by F. S. Simons; and economic appraisal, by E. T. Tuchek and James Ridenour. 1981. 303 pp. 66 figs. 5 pl. Geol. Surv. Bull. 1497. $15.

GS 2–82. Mineral Resources of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California, by the U.S. Geological Survey and U.S. Bureau of Mines. With sections on geology and geologic and geochemical evaluation, by J. G. Evans; aeromagnetic studies, by Leroy Pankratz; economic appraisal of Sheep Mountain Wilderness Study Area, by James Ridenour, S. W. Schmauch, and N. T. Zilka; and economic appraisal of Cucamonga Wilderness and additions, by N. T. Zilka and S. W. Schmauch. 1982. 92 pp. 2 pl. Geol. Surv. Bull. 1506–A–E. $5.50.

GS 3–82. Mineral Resources of Proposed Additions to the Salmon-Trinity Alps Primitive Area, California, by Preston E. Hotz, Robert C. Greene, Terry J. Close, and Robert K. Evans. 1982. 54 pp. 21 figs. 1 pl. Geol. Surv. Bull. 1514. $4.25.

GS 4–82. Mineral Resources of the Craggy Mountain Wilderness Study Area and Extension, Buncombe County, North Carolina, by F. G. Lesure, A. E. Grosz, B. B. Williams, and G. C. Gazdik. 1982. 27 pp. 6 figs. 1 pl. Geol. Surv. Bull. 1515. $4.

GS 5–82. Mineral Resources of the Minarets Wilderness and Adjacent Areas, Madera and Mono Counties, California, by the U.S. Geological Survey and U.S. Bureau of Mines. With sections on regional setting, geology, and geochemical studies, by N. King Huber; geophysical studies, by Howard W. Oliver; geothermal-resource evaluation, by Roy A. Bailey; and economic-mineral appraisal, by Horace K. Thurber, Michael S. Miller, C. Thomas Hillman, David S. Lindsey, and Richard W. Morris. 1982. 159 pp. 55 figs. 3 pl. Geol. Surv. Bull. 1516–A–D. $7.50.

GS 6–82. Mineral Resources of the Big Frog Wilderness Study Area and Additions, Polk County, Tennessee, and Fannin County, Georgia, by John F. Slack, Gertrude C. Gazdik, and Maynard L. Dunn, Jr. 1982. 25 pp. 8 figs. Geol. Surv. Bull. 1531. $2.50.

1983

GS 1–83. Mineral Resources of the Cougar Lakes-Mount Aix Study Area, Yakima and Lewis Counties, Washington. Part A. Geology of the Cougar Lakes-Mount Aix Study Area, by G. C. Simmons, with a section on interpretation of aeromagnetic data, by W. E. Davis. **Part B. Mines, Prospects, and Mineralized Areas, and Geochemistry**

of the Cougar Lakes-Mount Aix Study Area, by R. M. Van Noy, N. T. Zilka, and G. C. Simmons. 1983. 81 pp. Geol. Surv. Bull. 1504. $4.

GS 2–83. Mineral Resources of the North Absaroka Wilderness Study Area, Park and Sweet Counties, Montana. Part A. Geological and Geochemical Investigations of the North Absaroka Wilderness Study Area, by J. E. Elliot, D. L. Gaskill, and W. H. Raymond. **Part B. Geophysical Interpretations,** by D. L. Peterson. **Part C. Economic Appraisal of the North Absaroka Wilderness Study Area,** by R. B. Stotelmeyer, F. L. Johnson, D. S. Lindsey, James Ridenour, and S. W. Schmauch. **Part D. Geothermal Resource,** by N. T. Zilka. 1983. 251 pp. Geol. Surv. Bull. 1505. $15.

GS 3–83. Mineral Resources of the Mill Creek, Mountain Lake, and Peters Mountain Wilderness Study Areas, Craig and Giles Counties, Virginia, and Monroe County, West Virginia, by F. G. Lesure, B. B. Williams, and M. L. Dunn, Jr. With a section on oil and gas potential, by W. J. Perry, Jr. 1982. 76 pp. Geol. Surv. Bull. 1510. $7.50.

GS 4–83. Mineral Resources of the Rock River Canyon Wilderness Study Area, Alger County, Michigan, by J. W. Whitlow, P. J. Geraci, and P. C. Mory. With a section on geophysical-data interpretation, by E. R. King. 1983. 43 pp. Geol. Surv. Bull. 1549. $3.75.

GS 5–83. Mineral Resources of the Caney Creek Wilderness, Polk County, Arkansas, by G. E. Erickson, S. H. Patterson, M. L. Dunn, Jr., and D. K. Harrison. 1983. 42 pp. Geol. Surv. Bull. 1551. $4.

1984

GS 1–84. Mineral Resources of the Tracy Arm-Fords Terror Wilderness Study Area and Vicinity, Alaska, by U.S. Geological Survey and U.S. Bureau of Mines. With sections on geology, by D. A. Brew and D. Grybeck; aeromagnetic data interpretation, by R. C. Jachens; gravity data interpretation, by D. F. Barnes; geochemistry, by D. Grybeck, B. R. Johnson, and C. J. Nutt; mineral deposits and occurrences, by A. L. Kimball, J. C. Still, and J. L. Rataj; and mineral resource evaluation, by A. L. Kimball, D. A. Brew, and J. C. Still. 1984. 308 pp. 3 pl. Geol. Surv. Bull. 1525. $15.

GS 2–84. Mineral Resources of the Citico Creek Wilderness Study Area, Monroe County, Tennessee, by J. F. Slack, E. R. Force, P. T. Behum, and B. B. Williams. 1984. 32 pp. 2 pl. Geol. Surv. Bull. 1552. $3.50.

GS 3–84. Contributions to the Geology of Mineral Deposits. Part A. Exploration for Porphyry Metal Deposits Based on Rutile Distribution; a Test in Sumatera, by E. R. Force, S. Djaswadi, and T. V. Leeuwen. **Part B. Titanium Mineral Resources of the United States; Definitions and Documentation,** by E. R. Force and L. E. Lynd. 1984. 20 pp. Geol. Surv. Bull. 1558-A, B. $2.

GS 4–84. Wilderness Mineral Potential: Assessment of Mineral-Resource Potential in U.S. Forest Lands Studied in 1964–1984, ed. by S. P. Marsh, S. J. Kropschot, and R. G. Dickinson. 1983. 1183 pp. Geol. Surv. Prof. Pap. 1300. $38.

WITH THE STATE OF NORTH CAROLINA NORTH CAROLINA GEOLOGICAL SURVEY

NCGS 1–82. Clays and Shales of the North Carolina Piedmont, by Eldon P. Allen and Kenneth J. Liles. 1982. 266 pp. NC Geol. Surv. OFR 80–4, $58.

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P 2–80. Removal of Asbestos Fibers From Water. J. E. Schiller and S. E. Khalafalla. U.S. Pat. 4,181,607, Jan. 1, 1980.

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P 21–80. Molybdenite Flotation. J. L. Huiatt, M. D. Shurtz, and G. M. Potter. U.S. Pat. 4,231,859, Nov. 4, 1980.

P 22–80. Recovery of Organic and Aqueous Phases From Solvent Extraction Emulsions. K. W. Moser, R. E. Siemens, and S. C. Rhoads. U.S. Pat. 4,231,866, Nov. 4, 1980.

P 23–80. Recovery of Metal Values From Lead Smelter Matte. R. G. Sandberg and T. L. Hebble. U.S. Pat. 4,231,993, Nov. 4, 1980.

P 24–80. Separation of Zirconium From Hafnium by Solvent Extraction. D. J. MacDonald. U.S. Pat. 4,231,994, Nov. 4, 1980.

P 25–80. Mine Face Ventilation System. E. F. Divers. U.S. Pat. 4,235,163, Nov. 25, 1980.

P 26–80. Recycling Spent Asphaltic Concrete. W. C. McBee and T. A. Sullivan. U.S. Pat. 4,239,547, Dec. 16, 1980.

P 27–80. Removal of Impurities From Clay. J. A. Eisele, D. J. Bauer, and P. R. Bremner. U.S. Pat. 4,239,735, Dec. 16, 1980.

P 28–80. Sorption of Tungsten From Alkaline Solutions. S. R. Borrowman and P. B. Altringer. U.S. Pat. 4,241,028, Dec. 23, 1980.

P 29–80. Electrolytic Stripping Cell. B. W. Dunning, Jr., and D. H. Chambers. U.S. Pat. 4,242,192, Dec. 30, 1980.

P 30–80. Removal of Sodium Sulfate From a Sulfate-Containing Sodium Chloride Solution in a Process for Separating Zirconium and Hafnium. R. A. Guidotti. U.S. Pat. 4,242,312, Dec. 30, 1980.

1981

P 1–81. Extensometer Anchor. Charles Herman, III. U.S. Pat. 4,242,915, Jan. 6, 1981.

P 2–81. Method of In Situ Mining. Roger J. Morrell, William C. Larson, and Robert D. Schmidt. U.S. Pat. 4,249,777, Feb. 10, 1981.

P 3–81. Dust Controlling Method Using a Coal Cutter Bit. Wallace W. Roepke. U.S. Pat. 4,251,109, Feb. 17, 1981.

P 4–81. Impedance Measuring Method of and Apparatus for Detecting Escaping Leach Solution. Daryl R. Tweeton. U.S. Pat. 4,253,063, Feb. 24, 1981.

P 5–81. Link-Loc Chainless Haulage System. Paul J. Guay. U.S. Pat. 4,254,710, Mar. 10, 1981.

P 6–81. Copper Electrowinning and Cr^{+6} Reduction in Spent Etchants Using Porous Fixed Bed Coke Electrodes. David M. Soboroff and Hector O. McDonald. U.S. Pat. 4,256,557, Mar. 17, 1981.

P 7–81. Siliceous Adsorbent for Heavy Metals. Thomas G. Carnahan and Charles M. Flynn, Jr. U.S. Pat. 4,256,587, Mar. 17, 1981.

P 8–81. Preparation and Use of High Surface Area Transition Metal Catalysts. Gary B. Atkinson. U.S. Pat. 4,256,653, Mar. 17, 1981.

P 9–81. Leaching Agglomerated Gold-Silver Ores. Harold J. Heinen, Gene E. McClelland, and Roald E. Lindstrom. U.S. Pat. 4,256,705, Mar. 17, 1981.

P 10–81. Leaching Agglomerated Gold-Silver Ores. Harold J. Heinen, Gene E. McClelland, and Roald E. Lindstrom. U.S. Pat. 4,256,706, Mar. 17, 1981.

P 11–81. Selective Removal of Mercury From Cyanide Solutions. Charles M. Flynn, Jr., Thomas G. Carnahan, and Roald E. Lindstrom. U.S. Pat. 4,256,707, Mar. 17, 1981.

P 12–81. Process for Recovering Ni (II), Cu (II), and Co (II) From an Ammoniacal-Ammonium Sulfate Leach Liquor. Richard E. Siemens, David Nilsen, and Stanley C. Rhoads. U.S. Pat. 4,258,016, Mar. 24, 1981.

P 13–81. Recovery of Chromium From Scrap. Francis J. Hennion, John J. deBarbadillo, and Umar M. U. Ahmad. U.S. Pat. 4,259,296, Mar. 31, 1981.

P 14–81. Decomposition of $AlCl_3 \cdot 6H_2O$ in H_2 Atmosphere. Ishwarlal D. Shah. U.S. Pat. 4,259,311, Mar. 31, 1981.

P 15–81. Production of Alumina From Aluminum Nitrate Solutions. Barlane R. Eichbaum, Judith A. Eisele, and Donald J. Bauer. U.S. Pat. 4,260,589, Apr. 7, 1981.

P 16–81. Portable Airborne Droplet Impactor Sampler and Method. Lung Cheng and Warren G. Cross. U.S. Pat. 4,265,107, May 5, 1981.

P 17–81. Combined Rotating Bed Scrubber and Water Eliminator. Edward F. Divers. U.S. Pat. 4,266,829, May 12, 1981.

P 18–81. Auger Construction Providing Reduced Noise. Thomas J. Retka and Donald W. Schoen. U.S. Pat. 4,266,830, May 12, 1981.

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P 20–81. Automatic Feed and Rotational Speed Control System of a Hydraulic Motor Operated Drill. Michael O. Dressel. U.S. Pat. 4,271,914, June 9, 1981.

P 21–81. Electrowinning of Lead From H_2SiF_6 Solution. Ernest R. Cole, Jr., Agnes Y. Lee, and Danton L. Paulson. U.S. Pat. 4,272,340, June 9, 1981.

P 22–81. Ferric Leaching of Uranium Values From Lignite. Lawrence E. Schultze, Donald J. Bauer, and Michael T. Morimoto. U.S. Pat. 4,272,491, June 9, 1981.

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P 24–81. Metal Hydride Actuation Device. Peter M. Golben. U.S. Pat. 4,282,981, Aug. 11, 1981.

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P 27–81. Recovery of Bismuth From Chloride Process Solutions. Charles M. Flynn, Jr., Thomas G. Carnahan, and Roald E. Lindstrom. U.S. Pat. 4,285,912, Aug. 25, 1981.

P 28–81. Recovery of Lithium From Low-Grade Ores. Charles F. Davidson. U.S. Pat. 4,285,914, Aug. 25, 1981.

P 29–81. High Surface Area Transition Metal Catalysts and Method of Preparing Same. Gary B. Atkinson, Larry J. Nicks, and Donald J. Bauer. U.S. Pat. 4,287,095, Sept. 1, 1981.

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P 35–81. Thorium Oxide-Containing Catalyst and Method of Preparing Same. Gary B. Atkinson, Larry J. Nicks, and Donald J. Bauer. U.S. Pat. 4,301,032, Nov. 17, 1981.

P 36–81. Method for Measuring the Ionic Activities in Water With a Differential Pressure Transducers. Nev A. Gokcen. U.S. Pat. 4,301,676, Nov. 24, 1981.

P 37–81. Open Surface Flotation Method. Dan M. Bass and Fun-Den Wang. U.S. Pat. 4,302,051, Nov. 24, 1981.

P 38–81. Mounting Block to Rotate Coal Cutter Bits. Wallace W. Roepke and Richard J. Wilson. U.S. Pat. 4,302,053, Nov. 24, 1981.

P 39–81. Triangular Shaped Cutting Head for Use With a Longwall Mining Machine. Wallace W. Roepke and Sterling J. Anderson. U.S. Pat. 4,303,277, Dec. 1, 1981.

P 40–81. Dewatering of Slimes. Annie G. Smelley, Robert W. Montgomery, and Bobby J. Hamner. U.S. Pat. 4,303,532, Dec. 1, 1981.

P 41–81. Production of Ferrochromium Alloys. John E. Pahlman and Sanaa E. Khalafalla. U.S. Pat. 4,306,905, Dec. 22, 1981.

P 42–81. Extraction of Metals From Mixtures of Oxides or Silicates. Charles F. Davidson. U.S. Pat. 4,307,066, Dec. 22, 1981.

P 43–81. System for Maintaining High Resonance During Sonic Agglomeration. James E. Dudgeon and Donald A. Stanley. U.S. Pat. 4,307,964, Dec. 29, 1981.

1982

P 1–82. Amine Flotation of Chromite From Acidic Pulps. Gregory E. Smith, Jerry L. Huiatt, and Monte B. Shirts. U.S. Pat. 4,311,584, Jan. 19, 1982.

P 2–82.* Modified Sulfur Cement. William C. McBee and Thomas A. Sullivan. U.S. Pat. 4,311,826, Jan. 19, 1982.

P 3–82. Electrochemical Apparatus for Simultaneously Monitoring Two Gases. Stanley Bruckenstein and John A. Kosek. U.S. Pat. 4,315,753, Feb. 16, 1982.

P 4–82. Multilayer Pressure Vent for Explosion Proof Enclosures. Robert J. Gunderman and Michael W. Riley. U.S. Pat. 4,328,901, May 11, 1982.

P 5–82. Method for Wrought and Cast Aluminum Separation. Dominic Montagna and Harry V. Makar. U.S. Pat. 4,330,090, May 18, 1982.

P 6–82. Separation of Zirconium and Uranium. Helen G. Henry. U.S. Pat. 4,330,509, May 18, 1982.

P 7–82. Instrumentation for Surveying Underground Cavities. Walter G. Krawza and George A. Savanick. U.S. Pat. 4,331,975, May 25, 1982.

P 8–82. Regeneration of Waste Metallurgical Process Liquor. David M. Soboroff, Jerry D. Troyer, and Andrew A. Cochran. U.S. Pat. 4,337,129, June 29, 1982.

P 9–82. Recovery of Platinum-Group Metals From Ores. Edward R. Peasley and John M. Gomes. U.S. Pat. 4,337,226, June 29, 1982.

P 10–82. Recovery of Chromium From Waste Solutions. Hector O. McDonald and Lawrence C. George. U.S. Pat. 4,337,227, June 29, 1982.

P 11–82. Preflush-Lixiviant Process for Solution Mining of Uranium Ore Beds. William M. Breland, Terry R. Guilinger, and Robert S. Schechter. U.S. Pat. 4,340,253, July 20, 1982.

P 12–82.* Concrete Formulation Comprising Polymeric Reaction Product of Sulfur/Cyclopentadiene Oligomer/Dicyclopentadiene. William C. McBee and Thomas A. Sullivan. U.S. Pat. 4,348,313. Sept. 7, 1982.

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P 14–82. Purifying Titanium-Bearing Slag by Promoted Sulfation. Gerald W. Elger and Ruth A. Holmes. U.S. Pat. 4,362,557. Dec. 7, 1982.

P 15–82. Froth Flotation of Rutile. Thomas O. Llewellyn and Gerald V. Sullivan. U.S. Pat. 4,362,-615. Dec. 7, 1982.

1983

P 1–83. Combined Aerosol Monitor and Calibrateable Light Ray Scattering Reference Rod. Jerry J. Klug. U.S. Pat. 4,367,950, Jan. 11, 1983.

P 2–83. Thermally Activated Metal Hydride Sensor/Actuator. Peter M. Golben. U.S. Pat. 4,377,209, Mar. 22, 1983.

P 3–83. Chromium Recovery From Superalloy Scrap by Selective Chlorine Leaching. John A. Thomas, David L. Jones, and Victor A. Ettel. U.S. Pat. 4,377,410, Mar. 22, 1983.

P 4–83. Selective Paging and Intercommunication System. William H. Schiffbauer and Richard A. Watson. U.S. Pat. 4,377,726, Mar. 22, 1983.

P 5–83. Separation of Zirconium and Uranium. David J. MacDonald and Helen G. Henry. U.S. Pat. 4,381,287, Apr. 26, 1983.

P 6–83. Removal of Suspended Solids From Water. Joseph E. Schiller and Sanaa E. Khalafalla. U.S. Pat. 4,385,998, May 31, 1983.

P 7–83. Apparatus and Method for Measuring Low Concentrations of High Molecular Weight Polymers in Solution. Jalna R. Zatko. U.S. Pat. 4,386,518, June 7, 1983.

P 8–83. Continuous Transducer Drift Compensator. George M. Lucich and Charles A. Seitz. U.S. Pat. 4,387,438, June 7, 1983.

P 9–83. Method for Controlled Burnout of Abandoned Coal Mines and Waste Banks. Robert F. Chaiken. U.S. Pat. 4,387,655, June 14, 1983.

P 10–83. **Extraction of Aluminum From Clay.** William G. Gruzensky and Richard S. Olson. U.S. Pat. 4,388,280, June 14, 1983.

P 11–83. **Borehole Gauge for In-Situ Measurement of Stress and Other Physical Properties.** Clarence O. Babcock. U.S. Pat. 4,389,896, June 28, 1983.

P 12–83.* **Modified Sulfur Cement.** William C. McBee and Thomas A. Sullivan. U.S. Pat. 4,391,969, July 5, 1983.

P 13–83. **Method of Hydrospalling.** Martin S. Oudenhoven. U.S. Pat. 4,394,051, July 19, 1983.

P 14–83. **Water Spray Cooler.** Edward D. Thimons, Kenneth S. Heller, John F. McCoy III, and Austin Whillier. U.S. Pat. 4,394,142, July 19, 1983.

P 15–83. **High Temperature Hydrolysis of Aluminum Sulfate Solutions.** Donald E. Shanks. U.S. Pat. 4,394,368, July 19, 1983.

P 16–83. **Recovery of Arsenic From Flue Dust.** Brent W. Madsen, Henry Dolezal, Philip A. Bloom, and Monte B. Shirts. U.S. Pat. 4,401,632, Aug. 30, 1983.

P 17–83. **Open Surface Flotation Method for Extracted Crude Oil.** Dan M. Bass and Fun-Den Wang. U.S. Pat. 4,402,552, Sept. 6, 1983.

P 18–83. **Thermal Decomposition of Aluminum Chloride Hexahydrate.** Eugene Miller and Gerald B. McSweeney. U.S. Pat. 4,402,932, Sept. 6, 1983.

P 19–83. **Readout Circuit for Linear Displacement Transducer.** Michael G. Hughes, Radu R. Tenenbaum, and Al Bugay. U.S. Pat. 4,404,523, Sept. 13, 1983.

P 20–83. **Pressureless Consolidation of Metallic Powders.** James L. Holman, Jr., John F. McIlwain, and L. A. Neumeier. U.S. Pat. 4,407,775, Oct. 4, 1983.

P 21–83. **Recovery of Metals From Grinding Sludges.** James L. Holman, Jr., and Leander A. Neumeier. U.S. Pat. 4,409,020, Oct. 11, 1983.

* This patent, although developed by Bureau of Mines personnel, is being licensed by the U.S. Department of Commerce. For details, contact National Technical Information Service, Office of Government Inventions and Patents, U.S. Department of Commerce, P.O. Box 1423, Springfield, VA 22151.

P 22–83. **Recovery of Tungsten From Brines.** S. Ralph Borrowman, Paulette B. Altringer, and Parkman T. Brooks. U.S. Pat. 4,409,189, Oct. 11, 1983.

P 23–83. **Recovery of Metal Values From Complex Sulfides.** Gary A. Smyres and Philip R. Haskett. U.S. Pat. 4,410,496, Oct. 18, 1983.

P 24–83. **Selective Recovery of Base Metals and Precious Metals From Ores.** Elizabeth G. Baglin and John M. Gomes. U.S. Pat. 4,423,011, Dec. 27, 1983.

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P 1–84. **Apparatus for Lifting a Flexible Cable.** George J. Conroy and Melvin N. Ackerman. U.S. Pat. 4,423,852, Jan. 3, 1984.

P 2–84. **Concentrating and Reclaiming Magnetic Fluids.** George W. Reimers and Sanaa E. Khalafalla. U.S. Pat. 4,435,302, Mar. 6, 1984.

P 3–84. **Extraction of Metal Ions From Aqueous Solution.** Richard W. Baker. U.S. Pat. 4,437,994, Mar. 20, 1984.

P 4–84. **Power Supply for an Intrinsically Safe Circuit.** James C. Cawley, Michael D. DiMartino, Thomas J. Fisher, Roger L. King, and Marcus H. Uhler. U.S. Pat. 4,438,473, Mar. 20, 1984.

P 5–84. **Selective Recovery of Base Metals and Precious Metals From Ores.** Elizabeth G. Baglin and John M. Gomes. U.S. Pat. 4,442,072, Apr. 10, 1984.

P 6–84. **Production of Metal Powder.** Robert B. Worthington. U.S. Pat. 4,445,931, May 1, 1984.

P 7–84. **Remote Sequential Gas Sampler for Blasting Areas.** Anthony T. Iannacchione, David H. Lawhead, and John H. Perry. U.S. Pat. 4,468,973, Sept. 4, 1984.

P 8–84. **Pullcord Lockout Device for a Conveyor System.** Richard J. Wilson. U.S. Pat. 4,470,501, Sept. 11, 1984.

P 9–84. **Method of Enhancing the Removal of Methane Gas and Associated Fluids From Mine Boreholes.** Michael A. Trevits, Roger L. King, and Gerald L. Finfinger. U.S. Pat. 4,474,409, Oct. 2, 1984.

P 10–84. **Formation of Tungsten Monocarbide From a Molten Tungstate-Halide Phase by Gas Sparging.** John M. Gomes, Andrea E. Raddatz, and Elizabeth G. Baglin. U.S. Pat. 4,489,044, Dec. 18, 1984.

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1980

SP 1–80. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1978. With Subject and Author Index, compiled by Shelby Z. Palya. 1980. 125 pp. This compilation supplements the 5-year list of Bureau publications issued from January 1, 1970, to December 31, 1974, the annual list issued from January 1 to December 31, 1975, the annual list issued from January 1 to December 31, 1976, and the annual list issued from January 1 to December 31, 1977. The list summarizes publications by Bureau authors published in the regular Bureau of Mines series; in scientific, technical, or trade journals; or in other media. Those available from the Bureau of Mines are indicated. Patents issued to Bureau personnel are also listed, and instructions are given on how to apply for permission to use them. An outstanding feature of this Special Publication is an exhaustive subject and author index. (*Out of print.*)

SP 2–80. Bureau of Mines Research 79. A Summary of Significant Results in Mining, Metallurgy, and Mineral Economics, by Staff, Bureau of Mines. 1980. 112 pp. 50 figs. Minerals are vital to the economic well-being of our society. We depend on automobiles, metal containers, glass, gypsum wallboard, copper wire, steel and concrete buildings, and countless other goods, all of them requiring the processing of minerals. The demand for the mineral raw materials necessary to create these products is rising rapidly, creating unprecedented worldwide competition. It is now more important than ever to recover minerals from lower grade ores, recycle mineral materials, and substitute abundant materials for scarce ones. Yet, the economic aspects of our mineral resources are not the only factors to be considered. We are more aware than ever of the environmental impact of mineral production, and more determined than ever to minimize its adverse effects. The health and safety of workers in the mineral industries continue to be of prime importance. We also recognize that social, political, or economic situations in distant countries can affect our supplies of essential mineral commodities. During the past year, the Bureau of Mines underwent intensive examination to determine how it could best meet these challenges. It was recognized that such complex issues require rapid, comprehensive analysis of mineral-related issues and policies, along with research and development programs that are responsive and efficiently conducted. The internal organization of the Bureau was restructured to combine this type of analysis with an ongoing program planning effort more responsive to today's rapid change. Research 79, the ninth in this annual series, reflects the Bureau's new emphasis and renewed commitment. Research 79 highlights significant research conducted during the past year under contract or at the Bureau's research facilities throughout the United States. Readers who desire more information about the projects and studies reviewed are encouraged to contact the researchers whose names appear with each summary. A directory and a listing of publications authored by Bureau personnel in the past 3 years appear at the end of the publication. (*Out of print.*)

SP 3–80. Mining Research Review, by Staff, Bureau of Mines. February 1980. 93 pp. 72 figs. The Bureau of Mines mining research activities are mission oriented and are directed towards the conservation of our Nation's mineral resources, the protection of the miner from health and safety hazards, and the control of social and economic costs to help assure a viable mining industry in the United States. Research efforts are conducted on mining health and safety, production, and environmental control. The largest of these areas, health and safety, has been the agency's major mining research responsibility since the Bureau was established in 1910. For administrative purposes this research is subdivided into (1) coal health, (2) coal safety, and (3) metal and nonmetal health and safety. The annual Mining Research Review provides an overview of current mining research project activities. (*Out of print.*)

1981

SP 1–81. Bureau of Mines Research 80. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Janice D. Burket. 1980. 127 pp. 65 figs. The Bureau of Mines is responsible for a broad spectrum of programs for meeting the diverse and changing mineral resource needs of the Nation. Bureau program activities are classified into two major functions: (1) Developing new and improved technology that will make the production and processing of minerals more efficient, safer and more healthful for mineral workers and the public, and more compatible with a quality environment. (2) Acquiring statistical and economic knowledge related to mineral materials, their availability, production, and use, and performing mineral problem and policy analysis. Research 80, the 10th in an annual publication series, reflects the scope of the Bureau's mission and the success with which that mission is being pursued. (*Out of print.*)

SP 2–81. Federal Land Status in the Overthrust Belt of Idaho, Montana, Utah, and Wyoming, 1979, by Otto L. Schumacher, Andrew W. Berg, Fred V. Carrillo, Ronald A. Pense, and Robert B. Davis. 1980. 22 pp. 6 figs. The Overthrust Belt in portions of Montana, Idaho, Utah, and Wyoming, an area that has contributed generously to the Nation's mineral supply, is one of the few remaining oil and gas frontiers on the North American Continent. Determination of the oil and gas potential and develop-

ment of mineral resources of the area have been affected by a variety of land withdrawals and other restrictions. The purpose of this study is to determine the extent of these wihdrawals and restrictions and to discuss the mineral resource potential within the study area. Satistics in this report refer to land status on January 1, 1979. At that time, of the 27.3 million acres of Federal mineral lands within the study area, applications for Federal oil and gas leases for more than 4.4 million acres (about 16 percent) were pending; the average length of time was 2 years. Federal oil and gas leases covering 8.8 million acres were also on record. Although drilling has occurred on some of these leases, others are subject to restrictions that discourage or prevent development. Some in fact contain stipulaions disallowing any development. As of January 1, 1979, special restrictions ranging from complete prohibition of mineral development to restrictions having slight effect on mineral development, were in effect for 18.2 million acres (67 percent of the Federal mineral estate, or 39 percent of the entire study area). Since the survey of land status was completed, release of RARE II and Bureau of Land Management (BLM) roadless areas determined to be unsuitable for Wilderness has reduced this acreage by 5.9 million acres and has reduced the total acreage restricted for Wilderness reasons by 8.9 million acres. However, part of this released acreage is now covered by other restrictions imposed by management policy. Restricted lands include wilderness areas, proposed wilderness areas, RARE II lands, BLM roadless areas, and national parks. Also included are restrictions imposed by management policy for protection of key wildlife habitat, recreation or scenic values, watershed, and research uses. Mineral leasing outside these areas can also be affected by incomplete land-use plans, legal restraints, and uncertainty concerning habitat for endangered and threatened wildlife. The report contains 14 over-size maps. (*Out of print.*)

SP 3–81. Mineral Dependency Versus Mineral Vulnerability, by Lindsay D. Norman. Pres. at 83d Nat. Western Min. Conf., Denver, Colo., February 1980. 8 pp. America's increasing mineral dependency on foreign sources of supply has become a major issue. In many cases, however, the trend toward increased imports that many characterize as "dependency" is a natural outcome of post-World War II international prosperity, and of America's vigorous participation in world trade. We should distinguish between mere dependency and true vulnerability, a distinction that may not always be easy to make without a careful analysis of the situation for a given mineral. The Bureau of Mines is expanding its capacity to make such analyses, as the basis for policy formulation, and to conduct research toward technologies that can increase our mineral self-sufficiency as necessary. (*Out of print.*)

SP 4–81. Capital and Operating Cost Estimating System Manual for Mining and Beneficiation of Metallic and Nonmetallic Minerals Except Fossil Fuels in the United States and Canada, by George K. Clement, Jr., Robert L. Miller, Philip A. Seibert, Louis Avery, and Harold Bennett. 1981. 149 pp. 129 figs. The Bureau of Mines is establishing a computerized mineral inventory system to help the Federal Government appraise its mineral position and prepare programs insuring against critical shortages of materials. This system, called the Minerals Availability System (MAS), is a component of the Bureau's minerals intelligence function designed to conduct and maintain an inventory of minerals important to the Nation. The MAS defines the physical and commercial availability of the mineral resources. Known resources are evaluated and classified by deposit for entry into a computer storage and retrieval system. An integral concern of these evaluations is the cost of obtaining and beneficiating the ore contained in specific deposits. To meet this concern, a cost handbook was developed as an aid to preparing feasibility-type estimates for capital and operating costs of mining and primary beneficiation of various types of mineral occurrences. Cost data, obtained from U.S. and Canadian companies, were used as the basis of this handbook. The handbook presents cost curves and equations for each component of the mining and beneficiation process. Factors for each cost component are also given, thereby allowing the updating of cost for time, geographic location, labor rates, and mining and milling conditions. Included in the latter conditions are items such as the length of haul, need for rock bolts, and a rock work index for ores and rocks of various hardnesses. GPO Stock No. 024-004-02015-6. $5.50.

SP 5–81. Creating a Safer Environment in U.S. Coal Mines. The Bureau of Mines Methane Control Program, 1964–79, by Milford L. Skow, Ann G. Kim, and Maurice Duel. 1980. 50 pp. 45 figs. This report summarizes the principal activities and results of 15 years of research by the Bureau of Mines, U.S. Department of the Interior, on methane control in coal mines. This research has investigated fundamental factors regarding the occurrence and movement of methane in coalbeds, removal of methane prior to mining, and control of methane during mining. The report includes a bibliography listing the more than 150 publications resulting from the Bureau's methane control program as well as numerous other references, a section on methane recovery and use, a look at the upcoming Bureau of Mines research program, and a brief review of methane drainage practices in other coal-producing countries. (*Out of print.*)

SP 6–81. List of Bureau of Mines Publications and Articles, January 1, 1975, to December 31, 1979. With Subject and Author Index, compiled by Shelby Z. Palya. 1981. 568 pp. This publication lists and summarizes publications by Bureau authors published in the regular Bureau of Mines series, in scientific, technical, or trade journals, or in other media; those available from the Bureau of Mines are indicated. Patents issued to Bureau personnel are also listed, and instructions are given on how to apply for permission to use them. One of the outstanding features of this Special Publication is an exhaustive subject and author index. (*Out of print.*)

SP 7–81. Technical Highlights: Health and Safety Research, 1970–80, by Staff, Bureau of Mines. 1981. 181 pp. 236 figs. Under provisions of the Federal Coal Mine Health and Safety Act of 1969, and the Amendments Act of 1977, the Bureau of Mines is conducting research to improve the health and safety of workers in the minerals industries. This document presents an overview of selected accomplishments implemented through the Bureau's Minerals Health and Safety Program.

SP 8–81. Bureau of Mines Research 81. A Summary of Significant Results in Mineral Technology and Economics, compiled by Jerald R. Pederson. 1981.

148 pp. 118 figs. The Bureau of Mines is responsible for a broad spectrum of programs for meeting the diverse and changing mineral resource needs of the Nation. Bureau program activities are classified into two major functions: (1) Developing new and improved technology that will make the production and processing of minerals more efficient, safer and more healthful for mineral workers and the public, and more compatible with a quality environment. (2) Acquiring statistical and economic knowledge related to mineral materials, their availability, production, and use, and performing mineral problem and policy analysis. Research 81, the 11th annual summary of significant results in mineral technology and economics, reflects the scope of the Bureau's mission, and the success with which that mission is being pursued. (*Out of print.*)

1982

SP 1–82. Mineral Commodity Summaries 1982, by Staff, Bureau of Mines. 1982. 183 pp. This report is the earliest Government publication to furnish estimates covering 1981 nonfuel mineral industry data. Most of the estimates are based on 9 months data. These data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 86 individual minerals and metals. World resource data appearing in the statements have been provided by the Geological Survey. (*Out of print.*)

SP 2–82. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1980. With Subject and Author Index, compiled by Staff, Branch of Editorial Services. 1982. 131 pp. This compilation supplements the 5-year list of Bureau publications issued from January 1, 1975, to December 31, 1979. The list summarizes publications by Bureau authors published in the regular Bureau of Mines series; in scientific, technical, or trade journals; or in other media. Those available from the Bureau of Mines are indicated. Patents issued to Bureau personnel are also listed, and instructions are given on how to apply for permission to use them. An outstanding feature of this Special Publication is an exhaustive subject and author index. (*Out of print.*)

SP 3–82. Bureau of Mines Research 82. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Jerald R. Pederson. 1982. 140 pp. 87 figs. Minerals, and the adequacy of America's mineral supply, are subjects of growing national concern in the 1980's. They have been subjects of concern to the Bureau of Mines for most of this century. The Bureau's mission is to help assure an adequate and dependable flow of minerals at reasonable costs. That mission is pursued through the acquisition and analysis of minerals data on a worldwide basis, and through research to make mining and mineral processing safer, more productive, and more compatible with the effective use of all the Nation's resources. Research 82 is the 12th annual summary of significant developments in Bureau programs. It reflects both the scope of the Bureau's mission, and the success with which that mission is being pursued. GPO Stock No. 024–004–02106–3. $6.50.

SP 4–82. Improving Dust Control Technology for U.S. Mines. The Bureau of Mines Respirable Dust Research Program, 1969–82, by John A. Breslin and George E. Niewiadomski. 1982. 40 pp. 43 figs. This report summarizes the principal activities and significant results of the Bureau of Mines respirable dust research program since passage of the Federal Coal Mine Health and Safety Act of 1969 and the Federal Mine Safety and Health Amendments Act of 1977. This program has investigated new and improved techniques and equipment to reduce or prevent the formation of dust during the cutting cycle; to dilute, suppress, or collect airborne dust generated during mining, handling, and processing; and to improve the measurement of dust levels for evaluation of engineering controls and for enforcement of Federal dust standards. The report is intended for mining industry dust control specialists and other interested parties. It includes a brief summary of the program to date, a section on future research plans and goals, and a list of publications resulting from the Bureau's respirable dust program. GPO Stock No. 024–004–02103–9. $4.75.

SP 5–82. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1981. With Subject and Author Index, compiled by Staff, Branch of Editorial Services. 1982. 152 pp. The list summarizes publications by Bureau of Mines authors published in the regular Bureau series; in scientific, technical, or trade journals; or in other media. Those available from the Bureau of Mines are indicated. The list includes abstracts of open file reports—reports prepared for the Bureau under contracts, or material not in manuscript form—and gives information on their availability. Patents issued to the Bureau of Mines for work done by Bureau personnel or under contracts with the Bureau are listed, and instructions are given on how to apply for permission to use them. An additional feature of this Special Publication is an extensive subject and author index. (*Out of print.*)

1983

SP 1–83. Mineral Commodity Summaries 1983, by Staff, Bureau of Mines. 1983. 183 pp. This report is the earliest Government publication to furnish estimates covering 1982 nonfuel mineral industry data. Most of the estimates are based on 9 months data. These data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 86 individual minerals and metals. World resource data appearing in the statements have been provided by the Geological Survey.

SP 2–83. The Domestic Supply of Critical Minerals, by the White House Staff and the Bureau of Mines. 1983. 49 pp. 38 figs. This report summarizes, primarily in graphic form, the major factors that govern the adequacy of national mineral supply. The complexity of mineral issues is well demonstrated, and the reader will gain appreciation for the international as well as the domestic aspects of some of the mineral supply and demand problems facing the United States. GPO Stock No. 024–004–02112–8. $5.50.

SP 3–83. Bureau of Mines Research 83. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Jerald R. Pederson. 1983. 173 pp. 93 figs. Minerals, and the adequacy of America's mineral supply, are subjects of growing national concern in the 1980's. They have been subjects of concern to the Bureau of Mines for most of

this century. The Bureau's mission is to help assure an adequate and dependable flow of minerals at reasonable costs. That mission is pursued through the acquisition and analysis of minerals data on a worldwide basis, and through research to make mining and mineral processing safer, more productive, and more compatible with the effective use of all the Nation's resources. Research 83 is the 13th annual summary of significant developments in Bureau programs. It reflects both the scope of the Bureau's mission, and the success with which that mission is being pursued. GPO Stock No. 024–004–02123–3. $5.50.

SP 4–83. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1982. With Subject and Author Index, compiled by Staff, Branch of Editorial Services. 1983. 169 pp. This issue of the Bureau of Mines List of Publications and Articles describes reports and articles published during the period January 1 to December 31, 1982. This publication supplements the 50-year list of Bureau publications issued from July 1, 1910, to January 1, 1960; the 50-year list of articles by Bureau authors published outside the Bureau from July 1, 1910, to January 1, 1960; the 5-year lists of publications and articles, from January 1, 1960, to December 31, 1964, from January 1, 1965, to December 31, 1969, from January 1, 1970, to December 31, 1974, and from January 1, 1975, to December 31, 1979; and the annual lists of publications and articles from January 1 to December 31, 1980, and from January 1 to December 31, 1981. (*Out of print.*)

1984

SP 1–84. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1983. With Subject and Author Index, compiled by Staff, Branch of Editorial Services. 1984. 167 pp. This issue of the Bureau of Mines List of Publications and Articles describes reports and articles published during the period January 1 to December 31, 1983. This publication supplements the 50-year list of Bureau publications issued from July 1, 1910, to January 1, 1960; the 50-year list of articles by Bureau authors published outside the Bureau from July 1, 1910 to January 1, 1960; the 5-year lists of publications and articles from January 1, 1960, to December 31, 1964, from January 1, 1965, to December 31, 1969, from January 1, 1970, to December 31, 1974, and from January 1, 1975, to December 31, 1979; and the annual lists of publications and articles from January 1 to December 31, 1980, from January 1 to December 31, 1981, and from January 1 to December 31, 1982. GPO Stock No. 024–004–02136–5. $5.50.

SP 2–84. Bureau of Mines Research 84. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Jerald R. Pederson. 1984. 138 pp. 82 figs. Minerals, and the adequacy of America's mineral supply, are subjects of growing national concern in the 1980's. They have been subjects of concern to the Bureau of Mines for most of this century. The Bureau's mission is to help assure an adequate and dependable flow of minerals at reasonable costs. That mission is pursued through the acquisition and analysis of minerals data on a worldwide basis, and through research to make mining and mineral processing safer, more productive, and more compatible with the effective use of all the Nation's resources. Research 84 is the 14th annual summary of significant developments in Bureau programs. It reflects both the scope of the Bureau's mission, and the success with which that mission is being pursued. GPO Stock No. 024–004–02133–1. $5.

TECHNICAL PROGRESS REPORTS

Technical Progress Reports make known new or improved systems and techniques in mining and metallurgy developed by the Bureau of Mines.

TPR 110. Long-Term Response of a Coal Mine Roof to Time Lapse Between Exposure and Support, by Daryl E. Radcliffe and Raymond M. Stateham. 1980. 12 pp. 7 figs. The Bureau of Mines, as part of an agreement with the Bear Coal Co., Somerset, Colo., evaluated the response of a coal mine roof to time lapse. Time lapse, the interval between exposure and support of the roof, was studied using both instrumentation and statistics. Instrumentation studies were designed to equate displacement and rates of displacement with areas of roof left unsupported from 15 minutes to more than 4 days. A statistical study was completed to compare roof fall occurrence with time lapse intervals encountered during normal room-and-pillar mining. Results from this investigation show time lapse, in the Bear mine, to be insignificant with respect to roof stability after installation of permanent support.

TPR 111. Reducing Dust at Longwall Shearers by Confining the Dust Cloud to the Face, by Fred Kissell, Natesa Jayaraman, Charles Taylor, and Robert Jankowski. 1981. 21 pp. 15 figs. The Bureau of Mines has developed the shearer-clearer—a new type of dust control system for longwall shearers. The system partitions the airflow around the shearer into a clean split and a contaminated split. The dust cloud is confined to the vicinity of the coal face, while the shearer operators remain in the clean split on the gob side of the machine. The shearer-clearer operates on the principle that each water spray moves air like a small fan and can be positioned to direct the duty air towards the face. The hardware is inexpensive and can be installed in a single shift. It consists of several strategically mounted water sprays and one or more passive barriers. Laboratory testing indicates reductions in shearer operator dust exposure as high as 97 pct. Preliminary results from an underground demonstration in one mine also indicate that considerable dust reductions at the shearer may be obtained. In conjunction with the development of the shearer-clearer, dust surveys were conducted in three other mines to determine if some shearer spray systems currently in use partition the flow in a manner similar to the shearer-clearer, and if so, whether this partially accounts for markedly cleaner conditions on some longwalls. Results from these surveys indicate this to be the case. A feature of the cleaner longwalls was a downwind orientation of their water sprays, which is a key element of the shearer-clearer system. The shearer-clearer system described in this report was designed for an Eickhoff EDW 300 shearer working a 7-foot coal seam. The testing to date has concentrated on cutting directions counter to the primary airflow. The development effort continues for different mining equipment and conditions. It is expected that different systems will be required to accommodate the range of conditions occurring underground. Application of the system presented here to conditions different than those described is not likely to produce the same results.

TPR 112. New Twin Scrubber Installation for Continuous Mining Machines, by Edward F. Divers, John C. LaScola, and Gerald J. Hundman. 1981. 10 pp. 4 figs. This Bureau of Mines report describes a new type of scrubber (dust collector) and ventilation system built into the auger support frame (boom) of a Jeffrey 120L continuous mining machine. With this twin scrubber arrangement, one scrubber is mounted into each side of the boom. Each scrubber includes a 2,500-cfm fan, a flooded fibrous-bed scrubber panel, and a water droplet eliminator. The system was designed for minimum size and adds only a few inches to machine height. Exhaust duct design allows flexibility with various airflow configurations to suit both blowing and exhaust face ventilation systems and brattice distances ranging up to 20 feet. Full-scale tests with exhaust ventilation were conducted at a Mine Safety and Health Administration surface facility at Bruceton, Pa., to determine the scrubbers' methane dilution capability. Several configurations of the twin scrubber-ventilation system produced striking improvements in face methane dilution when compared with conventional systems.

TPR 113. Convergence Measurements for Squeeze Monitoring: Instrumentation and Results, by Eric R. Bauer and Gregory J. Chekan. 1981. 9 pp. 9 figs. The magnitude and rate of advance of an in-mine coal squeeze was determined by measuring roof-to-floor convergence on a regular basis. A dial-gage tube extensometer was used to collect data. Using these measurements, Bureau of Mines employees drew contour maps and graphs to show the direction and rate of squeezing. Information on the rate of squeeze advance was used to determine whether steps should be taken to prevent roof and/or floor movement from closing an entire section of the mine and if alteration of mining plans was necessary to prevent further squeeze development. Data analysis revealed that the squeeze was decelerating; thus there was no need to strengthen support in the areas of the mine that were studied. Mining plans were altered, however, as a result of the findings of this investigation.

TPR 114. The Water Spray Cooler — An Update, by Edward D. Thimons and J. Harrison Daniel. 1981. 9 pp. 4 figs. The water spray cooler is a direct-contact air-to-water heat exchanger designed to cool the hot working areas of deep mines. This cooler was originally developed by the Bureau of Mines. Recent tests with water spray coolers at the Homestake gold mine in South Dakota proved their thermal performance to be superior to that of the conventional finned-coil coolers in use at the mine. Testing has also shown that water spray coolers require little maintenance, whereas finned-coil coolers need maintenance for dust removal every 2 weeks.

TPR 115. Electric Arcing at High Voltage During Methane-Air Explosions Inside Explosion-Proof Enclosures, by Lawrence W. Scott and Joseph G. Dolgos. 1982. 9 pp. 7 figs. The problem of electric arcing at high voltage during methane-air explosions in explosion-proof enclosures was investigated by the Bureau of Mines, with the following conclusions: (1) the mixture at which arcing is most likely to occur is approximately 9.8 pct methane-air at any given voltage and conductor spacing; (2) arcing will occur before there is any appreciable pressure build-up; and (3) conductor spacings presently required in normal atmosphere are not sufficient when there is the possibility of a methane-air explosion. This report presents information on the clearances between energized conductors, which, in a series of experiments, did prevent arc discharges from occurring as methane-air explosions took place in an explosion-proof enclosure.

TPR 116. Dust Deposition in Coal Mine Airways, by Welby G. Courtney, John Kost, and Jay Colinet. 1982. 15 pp. 6 figs. The Bureau of Mines conducted an exploratory field survey to determine the amount of airborne coal dust, the size distribution of the dust, and the rate of dust deposition in coal mine airways. The survey was taken at eight underground locations in operating coal mines. The rate of dust deposition in the airways depended upon the concentration of airborne dust and decreased exponentially with distance from the dust source. The rate was seemingly independent of the size of the airborne dust particles. The rate of deposition, along a return, for the coal dust from a face being mined with a continuous mining machine closely matched the rate for the rock dust from a trickle duster. A sample rock-dusting schedule for that return is presented; that is, the trickle duster should be operated for 3½ hours after every five shifts to protect the average deposit of new float coal dust in the return, but operation after every three shifts is preferred, to protect an occasional heavier deposit.

TPR 117. A New Sonic Velocity-Logging Technique and Results in Near-Surface Sediments of Northeastern New Mexico, by James J. Snodgrass. 1982. 24 pp. 16 figs. A new technique was used to obtain detailed sonic logging data in drill holes above the water table at a coal mine site in northeastern New Mexico. The equipment was developed under contract to the Bureau of Mines and the U.S. Department of Energy to indirectly evaluate the in situ structural properties of coal and overburden. The system comprises a hydraulically operated, wall-clamping downhole probe compatible with standard four-conductor logging cable, and a surface control module. Resolution of layering is 0.6 meter (2.0 ft), and a redundancy of data from separate receivers provides accurate timing measurements. Preliminary results in the settled overburden of an excavated longwall panel indicated a low average velocity zone, extending approximately 18 meters (60 ft) into the immediate roof of the coal seam. Subsequent measurements improved the field and recording procedures to produce high-quality waveforms from which both P and S arrivals may be visually interpreted. Over a representative section of interbedded sandstone, siltstone, shale, and coal, V_P and V_S varied considerably even within lithologic units. Compressional wave velocity in the coal seam, V_P = 1,740 m/sec (5,700 ft/sec), was in the range of variability of published data.

TPR 118. Evaluation of a Sheathed Permissible Explosive Charge for Open Shooting in Flammable Atmospheres, by Richard J. Mainiero and J. Edmund Hay. 1982. 9 pp. 6 figs. The Bureau of Mines has developed a prototype nonincendive explosive rock-breaker charge that can be fired unconfined in underground bituminous coal mines without the danger of igniting a flammable atmosphere that might be present. At present, unconfined shooting in underground coal mines is prohibited, but there are situations where the use of such shots would yield an overall improvement in safety. The charge consists of 1-1/2 lb of permissible water gel explosive in the form of a short cylinder 7 inches in diameter and 7/8 inches high, surrounded by a 1/2-inch-thick layer of damp salt, and encased in latex rubber reinforced with cheese cloth. The latex rubber housing provides a charge package that is strong enough to resist rough handling yet is pliable enough to conform to an irregular stone surface. A charge of this shape was found to be more effective at breaking rock than charges with lined or unlined cavities. Incendivity tests in a gallery have shown that the prototype charge will not ignite a flammable methane-air atmosphere when fired. Rockbreaking tests made with limestone boulders indicate that the charge will satisfactorily break stone slabs weighing 1 to 2 tons, and that two or more charges might be effective for slabs weighing up to 10 tons. In cooperation with the Mine Safety and Health Administration (MSHA), a test protocol for the certification of these charges as "permissible" for use in flammable atmospheres is being developed.

TPR 119. Field Test of an Automated Temporary Roof Support (ATRS) on a Low-Coal, Single Fixed-Head Roof-Bolting Machine (Squirmer), by Charles T. Chislaghi and Thomas E. Marshall. 1982. 11 pp. 10 figs. An economical, remotely operated (automated), temporary roof support (ATRS) has been developed by the Bureau of Mines for use on a single, fixed-head roof-bolting machine (squirmer) that operates in low coal seams (less than 42 inches thick). The ATRS eliminates the need for squirmer operators and helpers to go under unsupported roof to set or remove temporary support prior to or during the roof-bolting cycle—a task that annually accounts for approximately 20 pct of all roof fall fatalities. The ATRS can be adapted to any squirmer used in the U.S. low coal fields. A prototype ATRS was field tested at Imperial Colliery Co.'s Mine No. 20 in Eskdale, W. Va. The Mine No. 20 amended roof-control plan, which requires the use of the Bureau's ATRS as temporary support during face bolting, has been approved by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor.

TPR 120. A Microwave System for the Acid Dissolution of Metal and Mineral Samples, by S. A. Matthes, R. F. Farrell, and A. J. Mackie. 1983. 9 pp. 4 figs. This Bureau of Mines report describes a system for the dissolution of metal and mineral samples using a microwave heat source. Samples and an acid mixture are placed in sealed polycarbonate vessels. The vessel contents are heated using microwaves, digested for 2 min, and quickly cooled. After the solution is brought to a final volume, the vessel contents are heated an additional 2 min in the microwave oven. Using this method, a slag, a feldspar, and a Ni-Cu alloy were dissolved and analyzed by atomic absorption spectroscopy. Values obtained for Na, K, Cu, Ni, Si, Mg, Mn, Ca, Al, and Fe agreed with certified values and had an average relative standard deviation of 1 pct. This system results in a significant savings in time and expense over traditional methods of sample dissolution, and is ideal for preparing solutions for analysis by atomic absorption, plasma optical emission, or X-ray spectroscopy.

TPR 121. Bit Ignition Potential With Worn Carbide Tips, by Wallace W. Roepke and Bruce D. Hanson. 1983. 7 pp. 4 figs. The Bureau of Mines has a well-established health and safety research effort directed to fundamental studies of the mine cutting system. This report describes the ignition danger of using cutting bits with flat wear area on still-intact carbide inserts.

TPR 122. Cl_2-O_2 Leaching of Massive Sulfide Samples From the Southern Juan de Fuca Ridge, North Pacific Ocean, by D. L. Sawyer, Jr., G. A. Smyres, J. J. Sjoberg, and T. G. Carnahan. 1983. 8 pp. 5 figs. Aqueous Cl_2-O_2 leaching procedures developed by the Bureau of Mines to produce zinc chloride from

zinc sulfide bulk concentrates were effective in extracting 99 pct of the zinc and 97 pct of the silver contained in samples of massive seafloor sulfides from the southern Juan de Fuca Ridge. Zinc sulfide (sphalerite and wurtzite) mineralization comprised 55 and 88 pct of two specimens provided by the U.S. Geological Survey for this study. Minor occurrences of galena, chalcopyrite, and other minerals in the sulfides permitted the recovery of pregnant liquors that were low in metal values other than zinc, which were successfully purified by a two-step cementation procedure using zinc dust.

MINERAL PERSPECTIVES

The "Mineral Perspectives" series reports on the mineral resources, industries, and related infrastructure of those foreign sources (individual countries or regions of the world) that assume major importance to our Nation's mineral needs.

MP. Mineral Industries of Latin America, by Orlando Martino, Doris Hyde, and Pablo Velasco. 1981. 116 pp. 32 figs. This Bureau of Mines report presents a summary review of the mineral industries of about 34 countries and areas in the Latin American region of the Western Hemisphere. Mineral reserves, production, international mineral trade, and the role of minerals within each country and in terms of world supply are reviewed in text and tables. The principal mining companies are listed, and basic information is presented on labor, energy, and transportation, relative to the mineral industries. Base maps for each country or area show the location of major mines, oilfields and gasfields, and plant facilities—including iron and steel works, nonferrous smelters and refineries, and cement plants. Maps also show major roads, pipelines, railways, and ports that are important to mineral transportation and trade. (*Out of print.*)

MP. Zimbabwe, by E. Shekarchi, G. Morgan, P. Clarke, and S. Ambrosio. 1981. 62 pp. 9 figs. This Bureau of Mines paper investigates the current status of the mineral industry of Zimbabwe, formerly the British colony of Southern Rhodesia. It also forecasts the expected future position of the country's chromium industry, which is of strategic interest to the United States and the other industrialized countries of the West. In analyzing the capabilities of the mineral industry, the influences of Government policy, current economic conditions, labor supply, energy supply, and transport system are evaluated. Zimbabwe produces over 40 different minerals, the most valuable of which are gold and asbestos. The most important mineral to the West from a strategic point of view is chromite. Zimbabwe has almost one-third of the world's chromite resources but produces less than 10 percent of the total world output. The competitive position of the chromium industry in Zimbabwe has been weakened since the widespread adoption by Western countries of the argon-oxygen-decarburization process for making stainless steel. (*Out of print.*)

MP. Namibia, by G. Coakley, S. Ambrosio, P. Clarke, M. Ellis, and E. Shekarchi. 1983. 57 pp. 7 figs. Namibia, the former Territory of South-West Africa, has a large and diversified mining industry, which supplies approximately 45% of its gross domestic product and 70% of its foreign exchange earnings. It is one of the world's largest producers of gem diamonds and uranium and also produces a substantial quantity of base metals, including copper, lead, and zinc. Several of the world's largest multinational mining companies are or have been actively involved in producing minerals in Namibia. This Bureau of Mines report provides an in-depth look at the structure, production history, and resource position of Namibia's mineral industry. The study points to uranium as having the greatest potential for sustaining long-term growth in the mining sector, while diamond and base metal production appear to have peaked and may decline in the short to medium term. The report also describes the administrative and economic dependence of Namibia on the Republic of South Africa and analyzes those aspects of mineral policy, labor, and water and energy resources that will affect future development of Namibia's mineral resources. (*Out of print.*)

MP. Mineral Industries of Africa, by George J. Coakley and Staff, Branch of Africa and the Middle East, Division of Foreign Data. 1984. 153 pp. 24 figs. This Bureau of Mines report presents a summary review of the mineral industries of 52 countries in Africa. Mineral reserves, production, international mineral trade, and the role of minerals within the economy of each country and in terms of world supply are reviewed in text and tables. The major operating mining companies are listed, along with their locations and capacities. Basic information is presented on trade with the United States, on local mineral policy, and on labor, energy, and infrastructure as it relates to the mineral industries. An outlook section briefly assesses the future prospects for the mineral industry in each country. Base maps show the generalized locations of major mines, oil and gas fields, and processing plant facilities including iron and steel works, nonferrous smelters and refineries, and cement plants. The maps also show major roads, pipelines, railways, and ports important to mineral transportation and trade. GPO Stock No. 024-004-02131-4. $5.50.

MP. Mineral Industries of Europe and the U.S.S.R., by Staff, Bureau of Mines. 1984. 143 pp. 12 figs. This Bureau of Mines report presents a summary review of the mineral industries of 26 European countries and the U.S.S.R. Mineral production, international mineral trade, and the role of minerals within each country and in terms of world supply are reviewed in text and tables. The principal mining companies are listed, along with their locations and capacities. Basic information is presented on labor, energy, and infrastructure relative to the mineral industries. Maps for each country show the generalized locations of major mineral deposits, petroleum resources, and processing or refining plants. The maps also show major roads, railways, pipelines, and ports that are important to mineral transportation and trade. GPO Stock No. 024-004-02139-0. $5.

REPORTS OF INVESTIGATIONS

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RI 8405. Electrochemical Determination of Gibbs Energies of Formation of MoS_2 and WS_2, by Seth C. Schaefer. 1980. 17 pp. 4 figs. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology, the Gibbs energies of formation of MoS_2 (molybdenite) and WS_2 (tungsten disulfide) were determined with high-temperature galvanic cells employing stabilized ZrO_2 (zirconia) as the electrolyte. A third-law analysis of the present data yielded a standard enthalpy of formation $\Delta H^\circ_{298}f$ of -67.36 ± 0.60 kcal/mole of MoS_2. Experimental entropy and enthalpy data are needed to extend the present Gibbs energy of formation data to wider temperature ranges and derive a standard enthalpy of formation of WS_2.

RI 8409. Enthalpies of Formation α- and β-Magnesium Sulfate and Magnesium Sulfate Monohydrate, by H. C. Ko and G. E. Daut. 1980. 8 pp. As part of the Federal Bureau of Mines effort to provide thermodynamic data for the advancement of minerals technology, energy conservation, and environmental preservation, the standard enthalpies of formation of α-magnesium sulfate, β-magnesium sulfate, and magnesium sulfate monohydrate were determined by hydrochloric acid solution calorimetry. The values of the standard enthalpies of formation in kcal per mole at 298.15 K are -307.95 ± 0.14 for α-$MgSO_4$, -307.03 ± 0.13 for β-$MgSO_4$, and 384.72 ± 0.13 for $MgSO_4 \cdot H_2O$.

RI 8410. Thermodynamic Properties of Potassium Metasilicate and Disilicate by R. P. Beyer, M. J. Ferrante, R. R. Brown, and G. E. Daut. 1980. 21 pp. 2 figs. The Bureau of Mines has measured the low-temperature heat capacities and high-temperature enthalpies of crystalline $K_2Si_2O_5$ as part of a program for advancing mineral resources technology with energy economy. High-temperature enthalpies of glassy and liquid $K_2Si_2O_5$ and crystalline K_2SiO_3 were also measured. An adiabatic calorimeter operation over the range 5 to 308 K was used for the heat capacity measurements for $K_2Si_2O_5$ from which the standard entropy at 298.15 K, $S^\circ_{298} = 45.55 \pm 0.05$ cal/deg-mole, was calculated. Tabulated values of C°_p, S°, $-(G^\circ-H^\circ_0)/T$, and $H^\circ-H^\circ_0$ from 5 to 300 K are given for $K_2Si_2O_5$. A copper-block drop calorimeter was used in the enthalpy measurements, operating from 298.15 to 1,198 K for K_2SiO_3 and from 298.15 to 1,453.8 K for $K_2Si_2O_5$. No transitions were found for K_2SiO_3. The $K_2Si_2O_5$ showed two reversible first-order transitions, one at 510 K with a heat of transition of 0.29 kcal/mole and one at 867 K with a heat of transition of 0.38 kcal/mole. The heat of fusion for $K_2Si_2O_5$ was calculated to be 8.42 kcal/mole. Relative enthalpies are given in equation form, and high-temperature values are tabulated for C°_p, S°, $-(G^\circ-H^\circ_{298})/T$, and $H^\circ-H^\circ_{298}$. Also tabulated are ΔH°, ΔG°, and log K for formation of K_2SiO_3 and $K_2Si_2O_5$ from both the elements and the oxides.

RI 8411. Iron-Based Alloys Strengthened by Ternary Laves Phases, by J. S. Dunning. 1980. 13 pp. 9 figs. A primary goal of the Federal Bureau of Mines is to minimize the requirements for scarce mineral commodities through conservation and substitution of more abundant elements, such as iron and molybdenum. One example of this is the research effort to devise substitute materials for specialty alloys, thereby conserving nickel and chromium in high-volume stainless steels. As a possible substitute for the solid solution strengthening of chromium and nickel, the precipitation hardening characteristics of a number of binary iron-based systems in which Laves phase precipitates, such as Fe_2Mo, are formed were investigated. Several hardening responses were observed, but none were ideal. The Fe-Ta binary system had the highest magnitude of hardening, even with low alloy additions, and the Fe-Mo system had unique stability at temperature. Accordingly, the Fe-Mo-Ta system was selected for study to determine if a ternary Laves phase could combine hardening with long-term stability at elevated temperature. Hardening and stability were reflected in excellent elevated temperature, tensile, and stress rupture strengths. Future research will study ternary systems based on more abundant resource materials, such as the Fe-Mo-Ti system, together with additions, such as aluminum and minimal chromium, to provide oxidation resistance.

RI 8412. Development Testing and Analysis of Steel-Fiber-Reinforced Concrete Mine Support Members. Support System Design and Results of Laboratory Investigation and Full-Scale Testing, by G. L. Anderson and T. W. Smelser. 1980. 38 pp. 13 figs. This Federal Bureau of Mines report presents the design analysis, laboratory testing, full-scale crib testing, and analysis of results of steel-fiber-reinforced concrete mine support members developed at the Spokane (Wash.) Research Center. The objective of the work was to design and laboratory-test fiber-reinforced concrete mine support members for best configuration, fiber material, fabrication method, handling, strength, stiffness, and cost. The results indicate the steel-fiber-reinforced concrete (SFC) support members that were developed offer significant improvements in stiffness and strength in compression compared with wood supports, yet they avoid the brittle or catastrophic compressive failure mode of plain concrete. The results also indicate SFC support members may offer significant cost savings compared with wood supports.

RI 8413. Development of a Method To Detect Geologic Faults and Other Linear Features From LANDSAT Images, by Richard D. Burdick and Robert A Speirer.

1980. 74 pp. 16 figs. Methods of detecting geologic faults and other linear features by means of processed LANDSAT satellite images have gained prominence during the past several years. There have been numerous programs written to pick these "lineaments," but they have been almost universally tailored to large computers. This Bureau of Mines report describes a detection method developed for use with a minicomputer. The method comprises a suite of programs that scans an image for all "potential" lineaments. From this partially analyzed data, the final lineaments are picked by another routine. The method was field tested in an area of south-central Wyoming, and results indicated good agreement between computer-picked lineaments and ground features. Most of the known geologic faults in the area were picked by the method. Such features as roads and trails were also picked but were easily distinguished from faults during field inspection. The method is relatively new but promises to be a viable reconnaissance technique for the mining industry in geologic structure analysis.

RI 8414. Least Squares Calculation of Horizontal Stresses From More Than Three Diametral Deformations in Vertical Boreholes, by Wilbur I. Duvall and James R. Aggson. 1980. 12 pp. The borehole deformation gage and overcoring techniques developed by the Bureau of Mines form one of the primary methods of determining in situ rock stress. This report describes a least squares method of calculating the average rock stress components in the horizontal plane from more than three diametral deformation measurements in a vertical borehole. This least squares analysis provides a means of determining the multiple correlation coefficient, the variance, and the scatter for a set of deformation measurements. From this information, confidence limits can be calculated for the secondary horizontal principal stresses and their directions. The material presented in this report can be used as a guide to the development of least squares solutions for stress measurement techniques other than the borehole deformation method. Since the statistical information that results from the least squares method is extremely useful in the interpretation of results, it is recommended that a least squares analysis be used on stress measurement data whenever possible.

RI 8415. Laboratory Corrosion Studies in Low- and High-Salinity Geobrines of the Imperial Valley, Calif., by S. D. Cramer and J. P. Carter. 1980. 30 pp. 12 figs. Corrosion research is being conducted by the Federal Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. As part of this research, the corrosion resistance of 31 iron-, nickel-, aluminum-, copper-, titanium-, and molybdenum-base alloys was characterized and evaluated in laboratory corrosion studies in low- and high-salinity geobrines representative of those found in the Imperial Valley, Calif. General, crevice, pitting, weld, and stress corrosion were measured at 105° and 232° C in deaerated brines and brines containing dissolved O_2, CO_2, and CH_4. General corrosion rates in deaerated brines at 105° and 232° C were usually below 5 mpy for the alloys tested except carbon steel, the low-alloy steels, Monel 400, 70–30 cupronickel, and the aluminum-base alloys. Dissolving carbon dioxide and methane in the brines at 232° C did not markedly alter these results. However, the introduction of oxygen, which can enter the brine during process operations, seriously degraded the corrosion resistance of many alloys by increasing the incidence of stress corrosion cracking, crevice corrosion and, except for the titanium-base alloys, pitting. In deaerated brine at 232° C, the general corrosion rates for carbon steel and the low-alloy steels were relatively unaffected by pH in the range of 6.1 to 3.0. However, general corrosion rates increased sharply below pH 3.0. In deaerated brine at 232° C, welds in several iron-, nickel-, and titanium-base alloys corroded at rates comparable to the general corrosion rates of the alloys, but the addition of oxygen to the brine increased corrosion rates for welds in Inconel 625 and E-Brite 26–1. Alloys exhibiting good corrosion resistance in the deaerated Salton Sea KGRA-type brine at 232° C were E-Brite 26–1, Inconel 625, Hastelloy S, Hastelloy G, Hastelloy C-276, TiCode-12, Ti-0.2Pd, Ti-2Ni, Ti-1.7W, and TZM. The alloys most resistant to corrosion in oxygenated Salton Sea KGRA-type brine at 232° C were the titanium-base alloys. These alloys appear the most suitable for use in the construction of geothermal resource recovery plants. Carbon steel and the low-alloy steels are unsatisfactory for high-temperature, high-salinity brines and alternative low-cost materials with improved corrosion resistance should be sought.

RI 8416. Development of a Mechanical Roof Breaker for Ground Control in Longwall Operations Under Massive Roof, by Sathit Tandanand. 1980. 20 pp. 9 figs. Massive roof overlying the working seam in longwall operations can cause hazards if it does not cave readily behind the face supports. The overhang thus formed can overload the supports and endanger personnel when it collapses suddenly as a large rock mass. This Bureau of Mines report proposes the use of a concentrated load, either strip or point loading, applied onto the roof with the help of the upward thrust of the face supports. An experiment was conducted in the laboratory to obtain information about break characteristics and the values of significant parameters of three sedimentary rocks. The results were used to determine the breaking load requirements for a strong roof possibly encountered in typical longwall operations. The results show that the roof slab of moderate thickness can be fractured within the load capacity of off-the-shelf powered supports.

RI 8417. A Rapid-Set Cement Suitable as a Molding Sand Binder for Small Ferrous Castings, by S. D. Sanders, E. D. Scott, and G. V. Sullivan. 1980. 16 pp. 11 figs. Goals of the Bureau of Mines include utilizing readily available minerals as substitutes for scarce mineral commodities and minimizing occupational hazards associated with mineral processing occupations. Therefore, the Tuscaloosa Research Center investigated using rapid-set cement as a suitable molding sand binder for small ferrous castings; currently petroleum-based binders are used. Substitution of a rapid-set cement would eliminate organic vapors associated with the petroleum-based binders; these vapors constitute occupational hazards and environmental pollutants. A binder containing 60 percent white portland cement (WPC) and 40 percent calcium aluminate (CA) would be an acceptable and economic substitute for petroleum-based binders where the foundry requirements are compatible with its limitations. It produced a set time and a pattern strip time of less than 1 hour. Cement, sand, and water mixtures developed compressive strengths from about 40 to 75 psi after 2 hours and from 120 to 130 psi after 24 hours. Tensile strengths of 18 to 22 psi were obtained after 2 hours, increasing to 30 to 35 psi after 24 hours.

The addition of about 1 percent polyphosphate to the sand-cement-water mixture doubled the compressive strength and increased the tensile strength about 50 percent after 4 hours, but also increased the set time from 30 minutes to 1 to 1-½ hours. Polyvinylacetate (PVA) resin latex additions resulted in rapid strength development. When castings were poured into the cement-bonded molds, the surface finish was fair to good on gray iron castings, but some areas of burn-on were present on steel castings. Using a graphite wash on the cement-bonded molds produced good surfaces on gray iron castings. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8418. High-Temperature Enthalpy and X-Ray Powder Diffraction Data for ZrI_4, by M. J. Ferrante and R. A. McCune. 1980. 8 pp. 1 fig. New data on zirconium tetraiodide (ZrI_4) have resulted from high-temperature enthalpy and X-ray powder diffraction studies conducted by the Bureau of Mines. These studies were undertaken as part of the Bureau's efforts to provide important thermodynamic data essential to the advancement of mineral resources technologies that can be employed with minimal energy requirements and minimal environmental degradation. Enthalpies were measured with a copper-block drop calorimeter. No transitions or other anomalies were found. Tabulated values are given from 298.15 to 772 K for relative enthalpy, heat capacity, entropy, and Gibbs energy function. Enthalpies are expressed in equation form and combined with data from the literature to calculate values of the standard enthalpy of formation and the Gibbs energy of formation. X-ray powder diffraction data indicate that ZrI_4 is primitive cubic with a lattice parameter of 11.79 A and is isostructural with stannic iodide (SnI_4).

RI 8419. Solvent Extraction of Cobalt From Laterite-Ammoniacal Leach Liquors, by D. N. Nilsen, R. E. Siemens, and S. C. Rhoads. 1980. 23 pp. 13 figs. The Bureau of Mines is developing a method to recover Ni, Co, and Cu from laterites containing less than 1.2 pct Ni and 0.25 pct Co. The method consists of the following basic unit operations: (1) reduction roasting, (2) leaching, (3) solvent extraction, and (4) electrowinning. The method reflects three Bureau of Mines objectives: (1) recovery of critical minerals that are domestically in short supply from low-grade domestic laterites, (2) lower processing energy requirements, and (3) solution recycling. This report deals with the extraction of cobalt and the preparation of a suitable cobalt electrolyte by solvent extraction from liquor produced by this method. Nickel and copper are coextracted with LIX64N from an ammoniacal ammonium sulfate leach liquor containing about 1.00 g/l Ni, 0.30 g/l Co, 0.03 g/l Cu, and 0.02 g/l Zn. Cobalt (III) in the nickel-copper barren raffinate is reduced to cobalt (II) with cobalt metal. Reduction of cobalt (III) to cobalt (II) greatly aids subsequent extraction. Commercially available XI-51 extracts about 94 pct of the cobalt from the treated raffinate in one stage in a laboratory mixer-settler continuous circuit. Ammonia loaded on the solvent is removed in two washing steps. About 94 pct of the cobalt then is stripped from the XI-51 in one stage with spent cobalt electrolyte containing about 77 g/l Co and 18 g/l sulfuric acid (H_2SO_4). Electrolytes containing less H_2SO_4 also may be used. Preliminary data indicate that coextracted zinc may be removed from pregnant cobalt electrolyte containing 3 g/l or less H_2SO_4 with di-(2-ethylhexyl) phosphoric acid (D2EHPA).

RI 8420. Thermodynamic Properties of Ferric Oxychloride and Low-Temperature Heat Capacity of Ferric Trichloride, by J. M. Stuve, M. J. Ferrante, D. W. Richardson, and R. R. Brown. 1980. 14 pp. 3 figs. This Bureau of Mines investigation measured the low-temperature heat capacities of FeOCl(c) and $FeCl_3$(c) in the temperature ranges of 6 to 305 K and 4.6 to 300 K, respectively. The standard entropies (S°, 298.15 K) of FeOCl(c) and $FeCl_3$(c) were derived as 19.73±0.03 cal/deg-mole and 35.33 ±0.07 cal/deg-mole. A large lambda transition was observed in the heat capacity of $FeCl_3$(c) at 8.4 K The standard enthalpy of formation ($\Delta H°f$, 298.15 K) of FeOCl(c) was determined to be -98.23±0.22 kcal/mole by HCl solution calorimetry. High-temperature enthalpy measurements ($H - H_{298.15}$) of FeOCl(c) were determined to 700 K by precision drop calorimetry. Standard thermodynamic formation data and related functions were tabulated at various temperatures for FeOCl(c) and $FeCl_3$(c).

RI 8421. Evaluating Clay Resources From Clay County, Ga., for Structural Clay Products, by K. J. Liles and H. Heystek. 1980. 28 pp. 23 figs. To encourage the development and conservation of the Nation's ceramic raw materials, the Bureau of Mines, U.S. Department of the Interior, under an agreement with the Georgia Department of Natural Resources, evaluated samples from a clay resource located in Clay County, Ga., for use as a raw material for lightweight aggregate. The physical properties of clay samples, taken from 5-foot increments of drill cores from 11 holes, were determined. Raw materials were plasticized and extruded to produce ½-inch by 1-inch pieces and fired in a rotary kiln to produce lightweight aggregate samples. The resulting expanded material had excellent loose pour weights ranging from 30 to 37 lb/cu ft. The expanded test materials were crushed, sized, and used as aggregate to form concrete cylinders. The unit weight and compressive strength of the cylinders averaged 106 lb/cu ft and 3,350 lb/sq in, respectively; these values meet American Society for Testing and Materials specifications for structural concrete. The clay from the drill cores was also used to make test bars that were evaluated for building brick. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8422. Two-Measurement Methods for Working-Level Determinations of Radon Daughters, A Theoretical Study, by Robert F. Holub. 1980. 47 pp. 42 figs. The Bureau of Mines has evaluated four working-level radiation-measurement methods and optimized them from the inherent and statistical error standpoint. Optimization with respect to various sampling and measurement times yielded no marked improvement over the existing methods. However when appropriate approximations are made and evaluated, these two-measurement methods can be reduced to simple formulas, eliminating a need to use nomograms. These modified methods also have improved inherent error characteristics. A new method—a combination of two existing methods—with improved inherent and statistical errors has been suggested. All the pertinent equations are given, together with

the computer program, so that any two-measurement method can be readily evaluated.

RI 8423. A Proportional Temperature Controller With Automatic Shutoff, by George M. Lucich and Philip W. Holland. 1980. 8 pp. 4 figs. This report describes a sensitive, proportional temperature controller developed by the Bureau of Mines that is useful in the temperature range from 40° to 400° C with an accuracy of ±0.1° C. A temperature controller of this kind is potentially useful for regulating temperatures in air chambers, liquid baths, furnaces, and reaction vessels, and for other applications. This instrument was developed to control the duration and temperature of the heating cycle of a charcoal-filled adsorber that is part of a special helium analyzer used by the Bureau. The controller was made from commercially available parts, and can be easily modified to provide continuous temperature control. The circuit is solid-state and employs no electromechanical devices. Over a 2-year period of use as a component of the special helium analyzer, this temperature controller performed successfully and required no maintenance.

RI 8424. A Fail-Safe Control System for a Mine Methane Pipeline, by M. C. Irani, F. F. Kapsch, P. W. Jeran, and S. J. Pepperney. 1980. 11 pp. 7 figs. The Bureau of Mines has designed and put into operation a fail-safe control system for use in underground coal mines equipped with methane drainage pipelines. This control system can detect certain unsafe conditions and respond by automatically shutting off the flow of methane from the degasification borehole to the drainage pipeline. Methane flow is shut off when the methane content in the return airways reaches a predetermined level (typically 1.5 pct), when the methane drainage pipeline is ruptured by roof fall, or when there is an electric power failure. The fail-safe control system was designed using commercially available components and a methane analyzer system previously developed by the Bureau. The fail-safe system consists of a unit that combines a shutoff valve and pneumatic valve actuator, and electronic and mechanical equipment designed to detect hazards and effect shutdown. The fail-safe control system was designed to meet regulatory requirements issued by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor, and State regulatory bodies for the same operation of underground methane pipelines used for mine degasification. MSHA has inspected and tested this system and permitted its use in two mines. The Bureau installed the fail-safe system in two working coal mines, where successful performance has been demonstrated.

RI 8425. Electrochemical Corrosion of Iron-Chromium Alloys Under Ultra-High-Purity Conditions, by Murray Rosen. 1980. 66 pp. 30 figs. This Bureau of Mines study used rigorously maintained, ultra-high-purity electrochemical systems for in situ characterization of Fe-18Cr surfaces for corrosion studies in well-defined aqueous environments that heretofore were unavailable by normal or conventional laboratory techniques. Contrary to data in the literature, Fe-18Cr does *not* spontaneously corrode in 1*N* H_2SO_4 solutions of ultra-high-purity; instead, it forms a state that is dependent on the deaerating gas. In He-saturated solution the behavior is one of long-term inactivity at potentials that are usually associated with passivity. In H_2-saturated solution a steady-state, open-circuit potential is spontaneously formed that is within -1 mv of the reversible hydrogen electrode potential for that solution. This noncorroding state in H_2-saturated solution is termed "stability" because even though corrosion is thermodynamically possible at -1 mv, the electrode is kinetically stable and exhibits, over a narrow potential range, equilibrium behavior that is associated with the H^+/H_2 exchange reaction. In situ electrochemical measurements of the Fe-18Cr solution interface indicated that stability was dependent not on the presence of surface metal-oxygen species, but on the absence of corrosion-inducing species. Without altering the ultra-high purity of an H_2-saturated solution, it was determined that corrosion could be induced and stability restored by in situ electrochemical control of the surface concentration of hydrogen atoms. A mechanism has been proposed to account for the hydrogen atom dependency. The spontaneous behavior of Fe-18Cr in these ultra-high-purity solutions in combination with the electrochemical techniques makes it possible to specifically measure the synergistic effects of individual components of a metallurgical environment. By first establishing this stable state, and then making controlled additions of selected chemical species, one can obtain a fundamental understanding of corrosion-inducing species.

RI 8426. Development of Analytical Reference Materials for Refuse-Derived Fuels, by Stephen L. Law, Benjamin W. Haynes, and William J. Campbell. 1980. 11 pp. Municipal solid waste (MSW), presently a major disposal problem, represents a significant source of metals and glass together with a combustible fraction that could be used to supplement coal and oil and in generating heat and electricity. This combustible fraction represents ~70 weight-percent MSW; therefore, effective utility of this fraction is an essential part of the Bureau of Mines program to conserve and increase the Nation's mineral and fuel supply through recycling of urban waste. Because of the increasing national interest in this important fuel supplement, the U.S. Department of the Interior, Bureau of Mines prepared a refuse-derived fuel material as a proposed reference material for use by other laboratories to evaluate their analytical procedures. This reference material was prepared by combining MSW light combustibles from Tampa, Fla., Montgomery County, Md., and Tulsa, Okla., then shredding, milling, and blending the composite material. Homogeneity of the refuse-derived fuel reference material (RDFRM) appears to be acceptable based on analytical values for replicate analyses. Concentration data for major, minor, and trace elements together with proximate analyses are provided in this report. Aliquots of the RDFRM are available to interested laboratories upon request.

RI 8427. Adsorption of Heavy Metal Ions by Xanthated Sawdust, by C. M. Flynn, Jr., T. G. Carnahan, and R. E. Lindstrom. 1980. 12 pp. 3 figs. The Bureau of Mines prepared and investigated xanthated sawdust adsorbents to determine their effectiveness in removing heavy metal ions from dilute aqueous solutions, mine-drainage waters, and brines. Stripping of the metal values from the metal-laden adsorbent was also investigated. The treated sawdusts had an adsorption capacity of 0.3 to 0.4 meq/g dry adsorbent for Mn, Co, Ni, Cu, Ag, Zn, Cd, Hg, or Pb from feed solutions with pH 5 to 6. The feed solutions tested included mine-drainage waters and geothermal brine. Effluent metal concentrations as low as 0.05 to 0.1 mg/l were obtained at effluent pH values of 6 to 9. The order of

affinity of metals for the sawdust adsorbent is Na<<Ca~Mg~Mn<Zn<Ni<Cd<Pb~Cu. The presence of Ca, Mg, or Na in concentrations as high as 2 g/l does not seriously impair the heavy-metal adsorption. Metals were desorbed from the metal-laden adsorbent by elution with dilute mineral acids, sodium cyanide, or salts of ethylenediaminetetraacetic acid.

RI 8428. Recovery of Silver From Chloride Leach Solutions by Iodide Precipitation, by T. G. Carnahan, C. M. Flynn, Jr., and R. F. Lindstrom. 1980. 9 pp. 3 figs. The Federal Bureau of Mines investigated, on a laboratory scale, a technique for recovery of silver from pregnant solutions generated in the hydrometallurgical treatment of complex base-metal sulfide concentrates with oxidizing chloride media. This technique provides a means for recovery and simplified reduction of accessory silver to metal from chloride solutions. The method consists of adding NaI or KI to the solution to precipitate AgI, which is then contacted with Na_2S to produce Ag_2S and to regenerate the iodide salt solution. Silver recoveries range from 99 pct with 20 pct excess iodide precipitant, to 92 pct when the theoretical stoichiometric amount of precipitant is employed The Ag_2S product can be reduced to silver metal by contact with aluminum chips in NaOH solution followed by purification with conventional fire refining techniques. (*Out of print.*)

RI 8429. Pilot-Scale Studies on the Composition and Characteristics of Urban Refuse, by R. S. DeCesare, F. J. Palumbo, and P. M. Sullivan. 1980. 32 pp. 9 figs. Operation of the Bureau of Mines raw refuse continuous separation pilot plant is described, including modifications made to plant equipment for improved performance. Products recovered from refuse, many of which have been evaluated by other laboratories and private firms are discussed. Sampling procedures used in the pilot plant and detailed data obtained from processing refuse from 13 municipalities are presented in appendixes. Fuel evaluations made on combustible fractions of refuse from the various municipalities are also presented. Information and data obtained at the pilot plant have been used to assist many municipalities in solving their urban refuse problems.

RI 8430. High-Temperature Corrosion Resistance of Alumina Refractories to Lignite Ash Slags, by J. E. Pahlman, C. F. Anderson, and S. E. Khalafalla. 1980. 20 pp. 11 figs. As part of its goal to minimize the requirements for mineral commodities through conservation and substitution, the Bureau of Mines is conducting research to determine the resistance of alumina refractories to corrosion by alkali-containing slags that could result from burning of the abundant Western lignites in metallurgical operations. Static corrosion tests were performed at 1,000° to 1,350° C and dynamic tests were performed at 1,400° to 1,600° C to investigate the stability of refractory specimens in slag environments. In general, the degree of refractory attack increased with decreasing alumina content in the refractory and with increasing alkali content of the lignite ash. The parabolic kinetics observed in static tests suggested that a reaction product layer is formed through which ionic diffusion must occur to sustain the reaction with the refractory material. The linear kinetics observed in dynamic tests in high-viscosity slags indicated a shearing of the reaction product layer by viscous slags. The observed lesser attack of refractories by low-viscosity slags can be explained on this basis. Two 99-percent-alumina refractories and two 90-percent alumina refractories formed an expanded protective layer with the more viscous slags but not with the less viscous slags. Corrosion of 90-percent-alumina refractories increased exponentially with temperature. In refractories with the same nominal alumina content, those that contain a combination of α-Al_2O_3 and mullite ($3Al_2O_3 \cdot 2SiO_2$) have better corrosion resistance than those containing a combination of α-Al_2O_3, cristobalite (SiO_2 mineral), and mullite. In alkali environments (1,300° to 1,400° C), 90- to 99-percent-alumina refractories are recommended for use as furnace linings.

RI 8431. Electrochemical Corrosion Behavior of Alloys Formed by Ion Implantation, by B. S. Covino, Jr., B. D. Sartwell, G. R. Conner, and P. B. Needham, Jr. 1980. 20 pp. 8 figs. The Bureau of Mines, U.S. Department of the Interior, is conducting research to devise substitute corrosion-resistant materials by using ion implantation to form alloyed regions near the surfaces of metals. These alloys were prepared by implanting 25-kev Cr^+ and/or Ni^+ ions into iron. Their resistance to corrosive attack was evaluated by determining their anodic polarization behavior under potentiodynamic conditions in a solution containing sodium chloride, boric acid, and sodium borate. These electrochemical studies have shown that the general corrosion resistance of ion-implanted alloys was comparable to nominally equivalent bulk alloys. The pitting-corrosion resistance of the ion-implanted alloys was superior to that of iron, although not as good as that of most of the bulk alloys tested.

RI 8432. Extracting Lithium From Clays by Roast-Leach Treatments, by J. T. May, D. S. Witkowsky, and D. C. Seidel. 1980. 16 pp. 3 figs. The Federal Bureau of Mines investigated the extraction of lithium from hectorite-type clay deposits found on the Nevada-Oregon border. Two clay samples were used in the investigation; one contained 0.36 pct Li and the second contained 0.64 pct Li. The purpose of this laboratory-scale research was to determine how these clays responded to different extraction techniques. Extraction techniques investigated were sulfuric acid leach, sulfuric acid bake-water leach, and roast-water leach procedures with cholorides, sulfates, carbonates, and combinations of these reagents. The processing characteristics of the clay samples showed significant variations, and no one technique was effective for both materials. Lithium extractions near 90 pct were achieved during these exploratory studies.

RI 8433. Spectrophotometric Determination of Uranium Using Dibenzoylmethane, by M. M. Jones, J. S. Macduff, and A. B. Whitehead. 1980. 12 pp. 2 figs. A procedure for the spectrophotometric determination of uranium has been developed in support of minerals research being conducted by the Bureau of Mines. Uranium is separated from the sample by tributylphosphate extraction from acid solution containing added aluminum nitrate and (ethylene dinitrilo)-tetraacetic acid solutions. The colored uranium-dibenzoylmethane complex is developed in the organic phase by adding an ethanol solution of dibenzoylmethane buffered with triethanolamine. Absorbance is measured at 410 nanometers, and the response is linear up to at least 100 micrograms U_3O_8 in the aqueous aliquot taken for analysis. Aliquots containing as little as 8 micrograms U_3O_8 may be analyzed with relative errors no

greater than ±5 percent. For aliquots containing at least 35 micrograms U_3O_8, relative standard deviation at the 95-percent confidence level is about ±2.2 percent. Appropriate procedures are given for analyzing a wide variety of samples.

RI 8434. Characterization of Alloys Formed by Ion Implantation, by B. D. Sartwell, A. B. Campbell III, B. S. Covino, Jr., and P. B. Needham, Jr. 1980. 29 pp. 13 figs. The formation of alloyed regions near the surface of metals using ion implantation is being investigated by the Bureau of Mines as a means of providing corrosion resistance using much smaller amounts of the strategic alloying metals. Two ion implantation systems that can implant low-energy chromium, nickel, or aluminum ions into low-cost substrate materials such as iron or carbon steel have been designed and constructed. The development of the ion source, ion beam acceleration stage, mass analysis system, and target chamber are described in detail. The ion-implanted alloys have been characterized using proton-induced X-ray emission to give the total number of atoms implanted and to determine the extent of any surface contamination introduced by the ion implantation process. Research conducted at other laboratories on metallurgical applications of ion implantation is given.

RI 8435. Shaft Design in the Coeur d'Alene Mining District, Idaho—Results of In Situ Stress and Physical Property Measurements, by Michael J. Beus and Samuel S. M. Chan. 1980. 39 pp. 19 figs. This Bureau of Mines report describes field investigations conducted in the Coeur d'Alene mining district of Idaho to obtain data on rock stress and physical properties. The resulting information has been utilized as input to detailed finite-element analyses to establish structural design criteria for deep-vein mine shafts. Measurement techniques include the Council for Scientific and Industrial Research biaxial and triaxial strain cells, the U.S. Geological Survey solid-inclusion probe, and the Colorado School of Mines dilatometer. Physical property testing was conducted in the laboratory on core obtained from each test site. Limited in situ physical property tests were also conducted. Reasonable success was obtained with the CSIR equipment, which was considered the most suitable for stress measurement in the study area. Test sites ranged in depth from 1,200 to 7,700 feet and are described in detail. The stress data were reduced by least-squares linear regression techniques to enable prediction of vertical and horizontal stresses to 7,500 feet. Ratios between the horizontal stresses as utilized for shaft design varied considerably, and a hydrostatic condition is the exception, based on Bureau measurements. Physical properties also varied widely, due to the complex geologic structure. Analyses of the data in terms of the tectonic history of the area show reasonable correlation. Data from previous rock mechanics investigations from the Coeur d'Alene district were also compiled and presented as part of this report to justify any generalizations regarding stress conditions and physical properties of the district as a whole.

RI 8436. Synergism in Polyethylene Oxide Dewatering of Phosphatic Clay Waste, by A. G. Smelley and B. J. Scheiner. 1980. 18 pp. 10 figs. As part of research conducted in its mission to effect pollution abatement, the Bureau of Mines, U.S. Department of the Interior, is developing a dewatering technique that allows for disposal of phosphatic clay wastes, for reuse of water now lost with clays, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer (PEO) that has the ability to flocculate and dewater phosphatic clay wastes. A synergistic flocculation study was made to determine whether a portion of PEO could be replaced by other reagents. Several groups of reagents were tested: (1) those that increased the zeta potential of the phosphatic clay wastes; (2) those capable of hydrogen bonding; and (3) those which flocculated the phosphatic clay waste. Reduction in PEO consumption occurred only with addition of those reagents able to flocculate the slime. The use of natural guar gums resulted in a lower PEO requirement and also yielded a dewatered product of higher solids content, 43 to 45 percent, versus 33 to 35 percent obtained with PEO alone. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8437. A Continuous Dielectric Separator for Mineral Beneficiation, by C. E. Jordan, G. V. Sullivan, B. E. Davis, and C. P. Weaver. 1980. 18 pp. 9 figs. Under its program of advancing minerals technology, the Federal Bureau of Mines has invented a laboratory apparatus for continuous separation of minerals based on differences in dielectric properties. The separator consists of a rotating drum electrode and a wire screen electrode positioned 3 mm apart. A high voltage applied across the electrodes that are immersed in a dielectric fluid produces a high-gradient electric field. The high-dielectric-constant (K) minerals are attracted to and conveyed through the separator by the rotating drum electrode, while the low K minerals settle through the screen electrode. Several design and operating parameters, such as electrode configurations, the dielectric liquid and its dielectric constant, electrical voltage and frequencies, feed rates, and particle sizes were studied. In addition, 28 different mineral mixtures were tested with the dielectric separator. In typical tests, a sample of rutile and quartz gangue containing 10-percent rutile was concentrated to 62-percent rutile with 94-percent rutile recovery. A second-stage dielectric separation of the rutile concentrate produced a 92-percent-rutile concentrate. The overall rutile recovery for the two-stage dielectric separation was 86 percent. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8438. An Environmental Evaluation of Polyethylene Oxide When Used as a Flocculant for Clay Wastes, by Jalna R. Zatko. 1980. 13 pp. 6 figs. The Bureau of Mines, U.S. Department of the Interior, has developed a novel method of flocculation dewatering of phosphatic clay wastes using polyethylene oxide as the flocculant. Research was conducted to determine whether ethylene oxide gas was present in the air in the vicinity of disposed waste materials which had been flocculated with polyethylene oxide. Samples of clay waste materials containing polyethylene oxide were prepared in stoppered glass bottles in simulated disposal environments. Gaseous samples, removed over a 75-day period using an airtight syringe, were injected into a gas chromatograph that was capable of separating ethylene oxide from air. The presence of ethylene oxide gas was not detected in any sample. To determine possible

degradation products of polyethylene oxide, the properties and reactions of ethylene oxide and its polymers were reviewed. Based upon the literature survey and experimental study, it was concluded that adverse environmental effects were not likely to result from the use of polyethylene oxide for flocculating phosphatic clay waste products. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8439. Reinforcement Mechanisms of Untensioned Full-Column Resin Bolts. by August J. Kwitowski and Lewis V. Wade. 1980. 37 pp. 31 figs. This Bureau of Mines report describes how the reinforcement mechanisms of untensioned, full-column resin bolts were determined during one underground study. Both axial and transverse shear loadings were identified for two instrumented resin bolts that replaced standard resin bolts in an operating room-and-pillar mining section. The strain responses of resin bolt steel cores to local axial and transverse shear loadings are described. This information was obtained from laboratory testing of resin bolts installations; it was also used to analyze the data from the underground test.

RI 8440. Stress Distribution Around Resin-Grouted Bolts, by Daryl E. Radcliffe and Raymond M. Stateham. 1980. 39 pp. 33 figs. Ninety-seven roof bolts were instrumented with strain gages and resin-grouted in three areas of the Bear coal mine, Somerset, Colo., by the Bureau of Mines. Measurements taken with these instruments indicate roof support is achieved through a combination of point suspension and resistance to vertical and horizontal stresses caused by localized shearing in the roof. The localized shearing results in bending of the bolts, yielding due to high vertical stresses, and the transfer of high loads to the bolt head or plate.

RI 8441. Slimes Consolidation at the Henderson Mine, by R. H. Sprute and D. J. Kelsh. 1980. 20 pp. 9 figs. Underground accumulations of slimes in the Henderson mine are routed to two large collection pits where they are dewatered and consolidated by application of direct current. Densified material is then removed to ore cars by rubber-tired front-end loaders and transported out of the mine. This Bureau of Mines report describes the electrical dewatering installation and compares its efficiency of operation with that predicted from preliminary laboratory studies performed by the Bureau. Direct current from a 150-kw rectifier (applied for 44 hours at 400 amperes and 65 to 70 volts) converted slimes containing 25.3 percent solids to material ranging from 44 to 65 percent solids. Better results can be expected if the ramp and front sections of the pits are treated separately, using higher current density.

RI 8442. Low-Temperature Heat Capacities and High-Temperature Enthalpies of Chiolite ($Na_5Al_3F_{14}$), by J. M. Stuve and M. J. Ferrante. 1980. 8 pp. 2 figs. Low-temperature heat capacities of chiolite ($Na_5Al_3F_{14}$) were determined by adiabatic calorimetry in the temperature range 5.8 to 300 K. The derived standard entropy (S°, 298.15) was 115.6 ± 0.2 cal/deg-mole. High temperature enthalpies relative to 298.15 K were obtained by precision drop calorimetry up to 1,000 K. Tables of experimental data and related thermodynamic functions are given for the temperature range of experimental observations.

RI 8443. Shape-Casting Titanium in Olivine, Garnet, Chromite, and Zircon Rammed and Shell Molds, by R. K. Koch and J. M. Burrus. 1980. 33 pp. 18 figs. In seeking substitutes for such critical metals as chromium, cobalt, and nickel, the Bureau of Mines investigated techniques for shape-casting titanium in rammed sand molds. Castings were made in olivine, garnet, chromite, and, for comparison, zircon. It was found that commercial-grade castings up to 31 lb (maximum capacity of furnace) could be made in zircon or olivine molds if a zirconia mold wash was used. Castings up to 4 lb could be made in chromite molds, but heavier castings suffered from some mold-metal reaction. Garnet molds were found to be unsatisfactory for castings of all sizes because of gas blows and rough surfaces. In other tests shell castings of acceptable quality were produced in water-glass-bonded zircon and olivine molds up to weights of 8 lb, but chromite molds were unsatisfactory because rough casting surfaces were caused by mold-metal reaction. Unlike the currently used commercial processes, neither the rammed-sand nor the shell-molding processes developed by the Bureau of Mines generate noxious fumes at any step.

RI 8444. Helium—Its Relationship to Geologic Systems and Its Occurrence With the Natural Gases, Nitrogen, Carbon Monoxide, and Argon, by Claude A. Tongish. 1980. 176 pp. 9 figs. This Federal Bureau of Mines report presents information on the accumulation and distribution of helium in U.S. natural gas reservoirs. The investigation concerns the relationship or association of helium with geographic location, geologic age, reservoir depth, nitrogen, carbon dioxide, and argon. Although helium is a minor constituent in natural gas, these data show that certain conditions make some reservoirs satistically more favorable than others for the accumulation of helium. The report is based on gas analysis information collected by the Bureau from 1917 to 1974 from 10,086 gas samples, representing 6,455 reservoirs in 35 States. The occurrence of helium in the reservoirs was 11.5 percent with less than 0.005 percent of helium, 70.9 percent with 0.005 through 0.29 percent of helium, and 17.6 percent with 0.30 percent or more of helium in the gas. Results of the various correlations are presented in tables and charts. Relationships have also been determined quantitatively by measures of correlation. The statistical data can be used to determine the environment under which reservoirs with high-helium contents are most likely to occur. These data can be used with other information for predicting the future helium resources of the United States.

RI 8445. Preparing Rare Earth-Silicon-Iron-Aluminum Alloys, by J. D. Marchant, E. Morrice, B. P. Herve, and M. M. Wong. 1980. 10 pp. 1 fig. As part of its mission to assure the maximum recovery and use of the Nation's mineral resources, the Bureau of Mines investigated an improved procedure for producing rare earth-silicon alloys. For example, a charge consisting of 681 grams of mixed rare-earth oxides, 309 grams of ferrosilicon (75 wt-pct Si), and 182 grams of aluminum metal along with a flux consisting of 681 grams of CaO and 45 grams of MgO was reacted at 1,500° C in an induction furnace. Good slag-metal separation was achieved. The alloy product contained, in weight-percent, 53 RE, 28 Si, 11 Fe, and 4 Al with a rare earth recovery of 80 pct. In current industrial practice rare earth recoveries are usually about 60 pct in alloy products that contain approximately 30 wt-pct each of rare earths and silicon. Metallurgical evaluations showed

the alloys prepared in this investigation to be as effective in controlling the detrimental effect of sulfur in steel and cast iron as the commercial rare earth-silicon-iron alloys presently used in the steel industry.

RI 8446. Experimental Processing of Salt Slags From an Aluminum Dross Furnace, by Michael J. Magyar, Robert S. Kaplan, and Harry V. Makar. 1980. 26 pp. 10 figs. The Federal Bureau of Mines has developed a hydrometallurgical method to recover aluminum, aluminum oxide, and fluxing salts from aluminum salt slags. The slag is leached with water at room temperature to produce a saturated brine slurry. Screening of the slurry yields an aluminum-rich fraction that can be returned to the dross furnace. The remaining slurry is vacuum filtered, yielding a clear brine solution and an aluminum oxide filter cake. Evaporation of the clear filtrate produces a high-purity fluxing salt for reuse in the dross furnace. Over 80 pct of the metallic aluminum is recovered in the aluminum-rich oversize fraction, while essentially all the fluxing salts are recovered by evaporation. This report contains the final results of an investigation on a process research unit scale, an economic evaluation of the method, and recommendations to further improve the process. (*Out of print.*)

RI 8447. Atmospheric Corrosion Resistance of Steels Prepared From the Magnetic Fraction of Urban Refuse, by Stephen D. Cramer, John P. Carter, and Bernard S. Covino, Jr. 1980. 32 pp. 13 figs. The Bureau of Mines conducted a study in which the magnetic fraction of urban refuse was used as melting stock in the preparation of high-strength, low-alloy and carbon steel. Product steels, made from incinerated steel can scrap, nonincinerated-nondetinned steel can scrap, nonincinerated-detinned steel can scrap, and dilutions of these scraps with No. 1 heavy melting scrap, were used in continuing tests in industrial, rural, and marine environments to determine the effect of residual elements and atmospheric pollutants on their atmospheric corrosion resistance. The respective commercial steels were exposed at the same time to establish baseline corrosion data for the test sites. Weight-loss data are reported for atmospheric exposures of 0.5, 1.0, 1.5, and 3.8 years. The marine environment was the most corrosive; the industrial environment was the least corrosive. The atmospheric corrosion resistance of the carbon steel was improved 25 pct by using incinerated scrap and nonincinerated-nondetinned scrap in the steelmaking process. In no case was the atmospheric corrosion resistance of carbon steel degraded by using the magnetic fraction of urban refuse as melting stock. The presence of sulfur in the corrosion film was the most important factor affecting the corrosion resistance of the steels. With increasing sulfur concentration, the rate of the corrosion reaction was reduced and the corrosion film became more protective. The residual elements in the product steels most responsible for improving corrosion resistance were copper and tin. These elements tended to increase the concentration of sulfur in the corrosion film. At the levels present in the product steels, Cr, Ni, and Pb had no observable effect on the corrosion resistance of the steels.

RI 8448. Experiments in Hot-Rolling and Forging of Ductile Cast Iron, by L. A. Neumeier, B. A. Betts, and R. L. Crosby. 1980. 36 pp. 14 figs. The Bureau of Mines investigated hot-rolling and forging characteristics of experimental ductile iron castings, both sand and permanent-mold, made with charges containing up to 70 pct foundry pig iron and 95 pct steelmaking pig iron. Between 1,550° and 1,950° F, most castings could be rolled to 90-pct reduction or forged to 70-pct reduction without serious cracking. Charge and composition have less bearing on workability than on subsequent properties. Permanent mold castings could be worked as readily as sand castings at 1,750° and 1,950° F. Plasticity improved with temperature. Small billets were also forged cold to 50-pct reduction without cracking. With equivalent nodularity, composition affects properties of wrought materials by altering matrix structure and strength. Properties vary with reduction and improve with increasing working temperature. Rolled material has high strength and anisotrophy, and low ductility, particularly in the transverse direction. Annealing reduces strength and improves ductility, but anisotropy persists. At 70-pct reduction, impact resistance in the longitudinal direction is about twice that in the transverse. Annealing roughly doubles impact resistance. Deformation enhances damping capacity. The feasibility of die-forging and bar-rolling of ductile iron was evaluated in trial tests conducted under a Bureau contract. Although workability and ductility of ductile iron are inferior to those of steel, more advantage could be taken of ductile iron's plasticity to work rough shapes to final dimensions.

RI 8449. Scrubbers for Dust Control: A Comparison of Six Medium-Energy Use Types, by Edward F. Divers and Joseph T. Janosik. 1980. 29 pp. 7 figs. This Bureau of Mines report describes the results of a program to develop small, rugged scrubbers with high dust collection efficiency for use in underground coal mines. The Bureau's Pittsburgh (Pa.) Research Center has developed and assisted in the development of several types of improved scrubbers that are especially suitable for various underground mining applications. Research efforts concentrated on reducing the size, power, and water consumption of these scrubbers, while optimizing their dust collection efficiency. Fractional dust collection efficiency, air volumetric range, size, power, water consumption, and application guidelines for each type are described. Air pressure differentials ranged between 2- and 30-inches water column (wc). The dust collection efficiency of six scrubbers—a venturi, two flooded-fibrous-bed, a venturi-impaction plate, a wetted-fan, and a rotating flooded-bed—were compared. The rotating flooded-fibrous-bed and the stationary flooded-fibrous-bed scrubbers showed the highest coal dust collection efficiency. Test results show that these scrubbers can generally achieve respirable size coal dust collection efficiencies in the high 90-pct range required to reduce both long- (8-hour) and short-term coal mine dust concentrations below Federal requirements.

RI 8450. Behavior of Wood Fires in Model Tunnels Under Forced Ventilation Flow. Tests With Untreated Wood, by C. K. Lee, R. F. Chaiken, J. M. Singer, and M. E. Harris. 1980. 58 pp. 37 figs. This Bureau of Mines report presents results from experimental studies on wood fires in a laboratory-scale tunnel network. Experimental measurements include ignition delay time, flame spread rate, ventilation air and gas flow rates, wood temperature, gas temperature, pressure and composition, thermal flux, and smoke particulates. These measurements form a data base for fire-scaling studies and provide information on various fire processes, such as flow interacting between ventilation air and fire, fire throttling and reverse flow, and duct fire energetics. Results show how hazards of duct fires relate to the develop-

ment of (1) asphyxiating and toxic fumes, (2) explosive gas mixtures, (3) throttling of ventilation air, and (4) high-temperature combustion products. Such fire hazards should be carefully considered when testing flammabilities of materials used in a confined underground mine environment.

RI 8451. Thermodynamic Properties of Petalite ($Li_2Al_2Si_8O_{20}$), by K. O. Bennington, J. M. Stuve, and M. J. Ferrante. 1980. 20 pp. 2 figs. The thermodynamic properties of petalite ($Li_2Al_2Si_8O_{20}$) were determined by the Bureau of Mines. The enthalpy of formation was determined by hydrofluoric acid solution calorimetry. The values from the elements and from the oxides are

$$\Delta H°_{f298.15} = 2{,}335.8 \pm 3.0 \text{ kcal/mole},$$

and

$$\Delta H°_{298} \text{ (from oxides)} = -50.60 \pm 1.20 \text{ kcal/mole}.$$

Low-temperature heat capacities were determined by adiabatic calorimetry from 10.69 to 302.11 K. The derived standard entropy is

$$S°_{298.15} = 111.0 \pm 1 \text{ cal/deg-mole}.$$

Enthalpy increments above 298 K were measured by copper block calorimetry from 298 K to 1,193.6 K. The various experimental data were combined with other data from the literature to calculate the Gibbs energies of formation and equilibrium constants of formation over the temperature range of the measurements. Tables of enthalpies of formation and Gibbs energies of formation are given as a function of temperature from the elements and constituent oxides. The Gibbs energy of formation is

$$\Delta G°_{f298.15} = 2{,}203.8 \text{ kcal/mole}.$$

RI 8452. Chemical and Physical Characterization of Amosite, Chrysotile, Crocidolite, and Nonfibrous Tremolite for Oral Ingestion Studies by the National Institute of Environmental Health Sciences, by William J. Campbell, Charles W. Huggins, and Ann G. Wylie. 1980. 63 pp. 33 figs. The Federal Bureau of Mines provided five test materials—amosite, short- and long-fiber chrysotile, crocidolite, and nonfibrous tremolite—to the National Institute of Environmental Health Sciences (NIEHS) for studies on the biological effects of orally ingested asbestos-related materials. An interagency agreement between the Bureau and NIEHS made possible this program to characterize these test materials. The Bureau in turn received support through contracts with the Ontario Research Foundation for the milling of amosite and crocidolite, and with the University of Maryland for microscopic measurements. The five test materials, which were supplied in quantities of 960 to 1,200 pounds each, were characterized by chemical-instrumental analysis for elemental composition, surface area, density, X-ray diffraction, infrared spectroscopy, thermogravimetric analysis, mineralogy, and particle size analyses. Particle size distributions were emphasized because of the current theories relating adverse biological effects to length-width characteristics of durable elongated particles. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the National Institute of Environmental Health Sciences.

RI 8453. Documentation and Analysis of a Massive Rock Failure at the Bautsch Mine, Galena, Ill., by Jack Touseull and Charles Rich, Jr. 1980. 49 pp. 29 figs. On November 15, 1972, the Bautsch mine, a lead-zinc mine in Paleozoic dolomites, experienced a massive rock failure involving 3 to 5 million tons. Because this failure was large and extended to the surface, it was included in the Federal Bureau of Mines investigations on "Massive Rock Failures." Analysis of the rock mechanics and mode of failure revealed that failure at the Bautsch mine was the result of the interrelationship of many factors. Factors related to the failure were found to be external and internal to the mining environment. Unlike internal factors, external factors were not apparent and, therefore, many external factors were investigated; some of which are not normally considered in rock mechanics analyses. External and internal factors determined to be of significant importance were (1) precipitation, (2) fractures, (3) plastic clay layer, (4) topography, (5) rock alteration, (6) bedding, and (7) mining zone dimensions. Because of the conditions at the mine, failure could have been predicted without extensive instrumentation. Application of basic geologic and engineering principles to the internal and external factors could have predicted failure. Alternately, failure would, in all probability, have been delayed by years if, after 1962, mining had been curtailed in the area of failure.

RI 8454. Utilizing the Magnetic Fraction of Raw Refuse With Shredded Automobile Scrap in Cupola Gray Iron, by V. R. Spironello and W. M. Mahan. 1980. 19 pp. 7 figs. The Bureau of Mines is involved in research directed toward the utilization of municipal solid waste. One of the primary objectives is the recycling of the magnetic fraction of municipal solid waste (raw refuse). This is consistent with one of the Bureau's goals, which is to minimize the requirements for mineral commodities by maximizing metals recovery from secondary domestic resources. In this investigation, cupola trials were made using combinations of refuse scrap with shredded automobile scrap under basic and acid slag practices. Furnace operating information and the behavior of alloying and tramp elements was obtained. The research showed that it is possible to utilize up to 60 percent refuse scrap in the cupola under basic practice and 30 percent under acid practice. Aluminum in refuse scrap, present in bimetallic cans, increased the recoveries of silicon and manganese charged to the cupola. Increased use of refuse scrap provided iron of lower sulfur. The alumina resulting from oxidation increased the slag volume. The aluminum and tin contents of the iron increased with increasing levels of refuse scrap in the charge. Lead was not a problem with respect to contamination of the iron. In basic practice, operation of the cupola was satisfactory since all slags were adequately fluid. In acid practice, operation became troublesome above the 45-percent level. Under both practices, the cupola iron melting rate decreased. Particulates in scrubber water and stack condensate samples contained lead, zinc, and tin, and the dust load increased. The tensile and transverse strengths of the iron produced under both practices are reported.

RI 8455. Characterization of Thin Films and Solid Surfaces Using Proton-Induced X-Ray Emission, by Bruce D. Sartwell and Arthur B. Campbell III. 1980. 22 pp. 10 figs. The Bureau of Mines is using characteristic X-rays produced by proton bombardment of a solid surface to provide quantitative compositional analyses of surface layers of metals. An integral X-ray yield equation has been developed that quantitatively relates the measured X-ray yield to the thickness of thin films ranging from less than a monolayer to several thousand angstroms. The use of the integral yield equation is demonstrated

for the growth of a thin film by vacuum evaporation. Results are presented that show how proton-induced X-ray emission (PIXE) has been used to determine the oxidation kinetics of iron that had been implanted with several different species of heavy ions. The sensitivity of PIXE for the measurement of very-thin-film growth kinetics is demonstrated from studies of the effect of fractional monolayer coverages of sulfur on the initial oxidation kinetics of iron. Results are also presented in which PIXE has been used to study the redistribution of alloying elements in components of a gas turbine that had fractured due to corrosion fatigue. By combining PIXE with low-energy ion sputtering, quantitative composition depth profiles of surface layers are obtained. Examples are presented for the profiling of iron samples implanted with 25-kev nickel ions and for a platinum coating on an Fe-5Cr substrate.

RI 8456. Partial Pressures of Gaseous HCl and H_2O Over Aqueous Solutions of HCl, $AlCl_3$, and $FeCl_3$, by N. A. Gokcen. 1980. 18 pp. 18 figs. Equilibrium partial pressures of gaseous HCl and H_2O over aqueous binary and ternary solutions of HCl and $AlCl_3$ were calculated or estimated in the range of 20° to 110° C, and up to saturation with $AlCl_3 \cdot 6H_2O$. The results were extended to solutions containing less than 10 wt-pct $FeCl_3$ by assuming that $FeCl_3$ and $AlCl_3$ are equivalent on the molar basis, since both salts have trivalent cations with a common anion. The ionic activity coefficient of HCl and the equilibrium constant for dissolution of gaseous HCl were also computed. This research is part of the effort by the Bureau of Mines, U.S. Department of the Interior, to provide thermodynamic data to expand the technology base relevant to the extraction of alumina from nonbauxitic domestic raw materials.

RI 8457. Pneumatic Concentration of Mica, by C. E. Jordan, G. V. Sullivan, and B. E. Davis. 1980. 24 pp. 7 figs. The Bureau of Mines is conducting research into the pneumatic recovery of coarse mica and has used this method to produce mica concentrates that contain more than 90 percent mica. This research is being carried out pursuant to the Bureau's objective to develop technology that will help maintain an adequate supply of minerals and metals to meet national economic and strategic needs. Researchers used a Bureau-designed system of crushers, screens, and zigzag air classifiers to concentrate coarse liberated mica particles from mica-bearing materials. This pneumatic system was used to concentrate four mica ores from Arizona, North Carolina, and South Dakota and three waste tailings from Alabama, Georgia, and South Dakota. Using these samples, it was demonstrated that plus 65-mesh size mica can be effectively recovered by the pneumatic method. Not only were the concentrates high in mica content; it was also demonstrated that this method can be used to recover up to 78 percent of the mica that was originally contained in the samples. Because it is a dry concentration method, the pneumatic beneficiation technique may be advantageous in areas where water resources are limited. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8458. Recovery of Gold From Arsenopyrite Concentrates by Cyanidation-Carbon Adsorption, by H. J. Heinen, G. E. McClelland, and R. E. Lindstrom. 1980. 10 pp. 1 fig. The Bureau of Mines investigated a cyanidation-carbon adsorption technique for extracting gold from arsenopyrite concentrates. Agitation leach experiments were conducted on 85-pct minus 35-mesh gravity concentrates containing 21.8 oz gold and 6.4 oz silver per ton. Results obtained in leaching the concentrates showed that 96.9 pct gold and 90.7 pct silver extraction could be achieved in 96 hours of agitation. Gold and silver were recovered from the resulting pregnant solution by exposure to granular activated carbon in a countercurrent system. Carbon loadings of 2,556 oz of gold and 502 oz of silver per ton were achieved. These loadings are significantly higher than heretofore thought practical.

RI 8459. Three Coal Mine Gob Degasification Studies Using Surface Boreholes and a Bleeder System, by S. D. Maksimovic and Fred N. Kissell. 1980. 10 pp. 6 figs. The use of vertical surface degasification boreholes with bleeder systems and the use of a timbered bleeder system to degasify gob areas were studied by the Bureau of Mines. This report describes three gob degasification studies conducted in the Pittsburgh coalbed. One study was conducted to determine the number of panels degasified with one large borehole. The study showed that the borehole provided degasification for three panels. Another study was conducted during the retreat of a 35-acre panel with a single-entry and a two-entry bleeder system and a large surface borehole. A major portion of methane emitted from the panel was carried away by the borehole, leaving the bleeder entries relatively free of methane. The last study was made to determine the effectiveness of a timbered bleeder system. The bleeder entries successfully degasified the gob area when enough entries were available and adequate pressure was available to force the air through roof falls.

RI 8460. Application of Thermal Neutron Capture-Gamma Ray Analysis to Oxidized Taconite Beneficiation Process Slurries, by Franklin B. W. Woodbury. 1980. 71 pp. 17 figs. The Bureau of Mines undertook the development and evaluation of a system to provide a simultaneous, on-line determination of both iron and silica in iron ore beneficiation streams as part of a program to improve the efficiency to mineral separation processes. Californium-252 (252-Cf) was the neutron source used in the system for measuring the amounts of silica and iron in bulk slurries by thermal neutron capture-gamma ray spectra analysis. The theory of thermal neutron capture-gamma ray reactions and their potential application to mineral processing stream analysis is discussed. The prototype system and supporting software developed by the Bureau is described. During the initial phase of the work, both simulated and actual pilot plant slurries were investigated using a 60- to 32-μg 252-Cf neutron source. The percent solids of the slurries ranged from 2 to 40 percent and the silica and iron content ranged from 1.5 to 83 percent and from 10 to 65 percent, respectively. Accuracy of the determination of the components in the solids was dependent upon the percent solids in the slurry.

RI 8461. Monitoring Taconite Process Streams With Thermal Neutron Capture-Gamma Ray Analysis, by Franklin B. W. Woodbury. 1980. 24 pp. 14 figs. The Bureau of Mines, as part of its goal of helping maintain an adequate supply of minerals to meet national economic and strategic needs, is evaluating alternative technologies to treat oxidized taconites. Since process control is an essential element in the application of these process technologies, research was performed on a prototype monitoring system

utilizing a Californium-252 (252-Cf) neutron source and a thermal neutron capture-gamma ray spectra analysis method to measure the amount of iron and percent solids in process slurries. The prototype system was used to monitor the concentrate and tailing streams in a 900-lb/hr flotation pilot plant during continuous around-the-clock tests. The iron content of the process slurries was determined by measuring the total peak areas under the capture spectrum peaks at 7.626–7.632 MeV, the associated escape peaks at 7.136–7.122 and 6.626–6.612 MeV, and the iron doublets at 4.900 and 4.998 MeV. A potential method for determining the percent solids in process slurries using the 2.22-MeV hydrogen capture peak is discussed. Results of this work demonstrate a potential method for providing process control parameters using the data from thermal neutron capture-gamma ray reactions.

RI 8462. Recovery of Rutile From a Porphyry Copper Tailings Sample, by T. O. Llewellyn and G. V. Sullivan. 1980. 18 pp. 3 figs. The Bureau of Mines conducted batch-scale tests on a sample of porphry copper mill tailings as part of a study to determine the feasibility of rutile recovery from this source. The tailings that were tested contained 0.75 percent titanium dioxide (TiO_2), with about two-thirds of the TiO_2 values occurring as rutile. Mineralogical studies indicated that about one-half of the TiO_2 content could be considered recoverable. Beneficiation studies of the tailings showed that best flotation results were obtained when sulfides and carbonates were removed by bulk flotation prior to rutile flotation. Rutile flotation was most effective when a petroleum sulfonate collector was used in an acid circuit. From this basic method of flotation, two alternative procedures were developed. The first procedure was to size and grind the tailings to minus 200 mesh; deslime the total pulp; and then float the sulfides, carbonates, and rutile. The second procedure was the same, except that it did not include sizing and grinding. Flotation of the sized and ground tailings yielded rutile concentrates containing 43.1 percent TiO_2 and 75.7 percent of the recoverable TiO_2. Rutile concentrates floated from the tailings that were deslimed but not ground contained only 34.7 percent TiO_2 and 69.4 percent of the recoverable TiO_2. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8463. Absorption of Radium and Thorium From New Mexico Uranium Mill Tailing Solutions, by H. R. Beard, H. B. Salisbury, and M. B. Shirts. 1980. 14 pp. 1 fig. The Bureau of Mines investigated the absorption of radium and thorium from waste uranium leach liquor by clays and other materials. This work was conducted in support of the Bureau's goal of minimizing the environmental conflicts, impacts, and occupational hazards associated with mining and milling operations. Tailing and soil samples from New Mexico were evaluated for their potential to absorb radium and thorium from tailing liquors. Absorption ranged from 0 to 97 pct for radium and 0 to 60 pct for thorium. Some samples that readily absorbed radium were contacted with various salt solutions that could be present in tailing solutions to determine whether desorption would be a potential problem. The desorption of radium ranged from 0 to 75 pct. An alpha spectrometric method was used to determine the radium and thorium concentrations in the solutions and solids.

RI 8464. Practical Ignition Problems Related to Intrinsic Safety in Mine Equipment. Four Short-Term Studies, by E. L. Litchfield, T. A. Kubala, T. Schellinger, F. J. Perzak, and D. Burgess. 1980. 18 pp. 10 figs. Four short-term studies of practical ignition problems were undertaken and completed during the course of the Bureau of Mines project "Development of Specifications for Intrinsically Safe Equipment." Conclusions were as follows: (1) the most easily ignitible mixture of propane-air in a PTB break flash apparatus is approximately 5.2 percent propane; (2) miniature lamp bulbs to be used in intrinsically safe circuits are about as incendive to coal dust-air as to methane-air and should be tested in gas mixtures containing about 7.0 to 7.5 percent methane; (3) the sodium amalgam contained in high-pressure sodium lamps does not present an ignition hazard for coal dust or methane, where the lamps contain no more than 30 milligrams of amalgam; (4) the maximum allowable surface temperature of permissible electrical enclosures should remain at 150° C despite efforts by industry groups to raise the value to 200° C.

RI 8465. Well Engineering and Sampling Variables in the Evaluation of Geobrines, by W. D. Riley, R. P. Walters, F. X. McCawley, G. R. Conner, and P. B. Needham, Jr. 1980. 20 pp. 12 figs. The U.S. Department of the Interior, Bureau of Mines, has been conducting minerals recovery research in support of the Nation's geothermal program since 1974. The Bureau's program of laboratory and field studies has focused on determining the materials of construction for geothermal resource recovery plants and on the recovery of mineral values from the geobrines. An analytical program has been conducted at the Avondale Research Center to determine the chemical constituents of some high- and low-salinity geobrines found in the Imperial Valley of California. Data are reported for the early stages of brine production of four geothermal wells—the low-salinity, medium-enthalpy brines from the East Mesa Known Geothermal Resource Area (KGRA), Mesa 6–1, and 6–2, and the high-salinity, high-enthalpy brine from the Salton Sea KGRA, Magmamax 1 and Woolsey 1. The reported results indicate the importance of the operating and engineering history, the operating parameters during sampling, and the method of sampling in order to evaluate the chemical analyses.

RI 8466. Effect of Additives on Sintering of Silicon Nitride-Alumina Compositions, by B. W. Jong. 1980. 16 pp. 2 figs. As part of the Bureau of Mines program to develop substitute or improved performance refractory materials for metallurgical applications, the Tuscaloosa Research Center has evaluated the effect of additives on sintering and strength properties of sialon (silicon aluminum oxynitride) compositions fabricated by a conventional powder metallurgy technique. Additions of Y_2O_3, Gd_2O_3, CeO_2, MgO, ZrO_2, $ZrSiO_4$, and $MgAl_2O_4$ to a sialon composition containing 70 pct β-Si_3N_4 + 30 pct α-Al_2O_3 increased sintered densities by as much as 50 pct over densities of undoped material. The studies also indicated that sintered densities reached a maximum between 20 and 30 mole-pct α-Al_2O_3 when a series of sialon compositions of α-Si_3N_4, having 6.7 to 57.9 pct α-Al_2O_3, were doped with Y_2O_3, Gd_2O_3, and MgO. In studies to establish the effect of the crystalline phase of the silicon nitride and alumina used, tests were made using α- and β-Si_3N_4 and α- and γ-Al_2O_3 as starting materials. The tests indicated that when using an addition of 5 wt-pct Y_2O_3, best results were

obtained with a sialon composed of 74.4 mole-pct α-Si_3O_4 and 25.6 mole-pct γ-Al_2O_3. In other tests made with this sialon composition modulus of rupture values of 28,120 and 29,500 psi at 25° C, and 23,520 and 16,850 psi at 1,400° C, were obtained when doping with 5 wt-pct $ZrSiO_4$ and ZrO_2, respectively. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8467. Correlation of the Fibrous Aerosol Monitor With the Optical Membrane Filter Count Technique, by Steven J. Page. 1980. 21 pp. 6 figs. The Bureau of Mines used fiber-laden air to test two identical fibrous aerosol monitors (FAM) in order to establish the FAM-optical count correlation. The FAM is a unique instrument developed by GCA Corp. (GCA) to measure real-time fibrous aerosol concentrations. It will also respond to particulates that have sufficient shape irregularities to possess fiber characteristics such as the 3:1 length:diameter (L:D) aspect ratio. Results of the Bureau's laboratory tests showed that the FAM response is linearly correlated to concentration data obtained using the optical membrane filter count technique approved by the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare. A plot of the FAM-optical count correlation showed that FAM concentration readings are generally well within ±25 pct of the optical membrane filter count. Initial tests to estimate the best ratio control setting of the FAM for 5-μm fiber-length discrimination were performed using one instrument only (the ratio control setting determines the minimum threshold fiber length that will be detected by the FAM). The estimated setting was then used to correlate both FAM units. The result was a 65-pct difference in correlation between the two units. It appears that the major factor responsible for this difference was the internal adjustment of the photomultiplier detector sensitivity for each of the two FAM units.

RI 8468. A Laboratory Test To Evaluate the Resistance of Refractories to Molten Slags, by J. R. Cobble and L. Y. Sadler III. 1980. 13 pp. 7 figs. As part of the Federal Bureau of Mines project to develop new or improved materials for metallurgical furnace applications, the Tuscaloosa (Ala.) Research Center has conducted research to develop a reproducible laboratory test for evaluating the resistance of refractories to molten slags. Tests were conducted with a slag representative of slag used to produce mineral wool. A rotating cylindrical furnace was lined with the brick being tested, and it was operated at temperatures up to 1,660° C for periods ranging from 8 to 32 hours. The effects of such variables as slag temperature, rotational velocity, charge rate, and contact time on refractory erosion were determined. The research demonstrated the reproducibility of the test procedure developed. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8469. The Theory of Flammability Limits. Conductive-Convective Wall Losses and Thermal Quenching, by Martin Hertzberg. 1980. 25 pp. 5 figs. The concept of limit burning velocities, formulated in an earlier Bureau of Mines report (RI 8127) is applied to the problem of flame propagation through tubes of finite size. The limit burning velocity for conductive-convective wall-loss quenching (process b) is $(S_u)_b = \frac{\alpha Pe}{2r_o}$, where the proper choice of critical Peclet constant, Pe, is determined mainly by the ratio of contact-perimeter loss area to flame-zone cross-sectional area. This ratio of loss area to propagation area relates to the shape of the flame front and its control by buoyancy and by boundary conditions. The comparison of $(S_u)_b$ with previously defined limit velocities for systems mixed by natural convection allows one to assess the influence of tube dimensions and boundary constraints on the "true" or earthly limits for the three directions of propagation. The flame quenching caused by inert powders is shown to be similarly described in terms of a limit burning velocity, $(S_u)'_b$. The tube's surface-to-volume ratio ($\sim 1/r_o$) is simply replaced by the powder's surface area per unit volume of the flammable mixture. Thermal loss quenching by these "internal walls" occurs at a critical Peclet constant somewhat higher than that observed for tubes, and the problem is complicated by the finite heat capacities of the powders and particle lag effects in the flame front.

RI 8470. Iron-Base Alloys Strengthened by Laves Phases as Substitutes for Stainless Steels, by J. S. Dunning, M. L. Glenn, and W. L. O'Brien. 1980. 24 pp. 9 figs. One Federal Bureau of Mines research goal, to minimize requirements for domestically scarce mineral commodities through conservation and substitution, can be accomplished by utilizing more abundant elements such as iron, molybdenum, and titanium. An example of this research is the study of precipitation-hardening, iron-base alloys containing molybdenum and titanium, as substitutes for the high-tonnage stainless steels that are high in imported nickel and chromium. The precipitation-hardened iron-base alloys are strengthened by a dispersion of the ternary Laves phase, $Fe_2(Mo, Ti)$. Aluminum and chromium additions changed the solid solubility limits of molybdenum and titanium in α-iron and affected the composition of precipitating phases. A baseline composition of Fe-7Mo-2Ti was selected to study the effects of aluminum and chromium additions on the precipitation-hardening mechanism and microstructure and was also used in studies of mechanical properties and oxidation resistance. The study yielded workable, precipitation-hardening alloys, with elevated temperature strengths equivalent to or superior to types 304 and 316 stainless steels. Chromium and aluminum additions in combination were more effective in providing oxidation resistance than either addition was alone.

RI 8471. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Central and Southern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. 1980. 20 pp. 5 figs. The Bureau of Mines has investigated the occurrence and recovery of byproduct heavy minerals from sand and gravel operations as a means of assessing the Nation's resources. Sand samples from 63 locations in central and southern California were treated to yield heavy-mineral concentrates. The mineral compositions of the concentrates were characterized by chemical and mineralogical examinations. Additional large quantities of concentrates were prepared from selected deposits that contained significant quantities. Beneficiation studies were performed on these concentrates to recover individual mineral products. Gold was recovered by amalgamation; platinum-group metals and radioactive minerals by flotation; magnetite, ilmenite, and chromite by magnetic and high-tension separation techniques. (*Out of print.*)

RI 8472. Electrolytic Reduction of Chromium (VI) and Copper Using Coke Electrodes, by H. O. McDonald, D. M. Soboroff, and A. A. Cochran. 1980. 8 pp. 3 figs. Solutions containing Cr^{6+} and sulfuric acid are used in a number of surface-finishing operations. Substantial quantities of chromium and copper are lost and pollution problems are created when the spent solutions are discarded. To minimize the undesirable environmental effects while improving secondary resource recovery technology, the Bureau of Mines is conducting research to detoxify and recover metals from these solutions. Spent etchants are treated to remove copper and reduce Cr^{6+} to Cr^{3+} in an electrolytic cell. The anodes and cathodes are granulated coke. The spent solution is continuously pumped through the electrodes. Hexavalent chromium is reduced to trivalent chromium, and copper is recovered at the cathode. Reoxidation of Cr^{3+} at the anode was not observed. The removal and recovery of copper and reduction of Cr^{6+} lessen chemical demand and increase efficiency in waste treatment operations associated with the use of these solutions.

RI 8473. Face Ventilation Measurement With Sulfur Hexafluoride (SF_6), by Robert P. Vinson, Fred N. Kissell, John C. LaScola, and Edward D. Thimons. 1980. 16 pp. 21 figs. The face ventilation measurement method developed by the Bureau of Mines involves releasing a small volume of tracer gas (SF_6) on the off-curtain side of the working face at the start of the mining cycle. At the same time, gas bottle samples are taken in the immediate return airway. The gas samples are analyzed, and a curve is drawn of SF_6 concentration versus time. From this curve, the percentage of gas removed per time is calculated. A curve showing a high percentage of the tracer gas removed in a short period would represent a well-ventilated face. The face ventilation measurement method was tested in a full-scale mine entry model. Subsequently it was used underground to evaluate the spray-fan ventilation system and in an MSHA test facility to test machine-mounted scrubbers. The method was shown to be a simple and effective way of evaluating face ventilation systems.

RI 8474. Spontaneous Combustion Susceptibility of U.S. Coals, by J. M. Kuchta, V. R. Rowe, and D. S. Burgess. 1980. 37 pp. 18 figs. The chemical and thermal criteria used for predicting the spontaneous combustion hazard are briefly reviewed and data are presented to characterize the gas desorptions and self-heating tendencies of 29 U.S. coals. Closed vessel desorption experiments showed that CO, CO_2, and CH_4 are the main gases evolved and that the CO, $CO/\Delta O_2$ index, and O_2 absorption rate increase with decreasing rank and increasing oxygen content of the coal. In this Bureau of Mines report, the effects of temperature, moisture, and other variables are discussed together with the application of the data to the complex conditions encountered in a mining environment. An important finding is that the presence of CO alone in a mine is not necessarily an indication of a self-heating reaction of the coal. Based upon experiments conducted in an adiabatic-type calorimeter, the self-heating temperatures of lignite and subbituminous coals can be as low as 30° C, whereas the bituminous coals require a temperature of about 60° C or more. The self-heating hazard is greatest when the coals are dried and exposed to a high humidity condition, apparently as a result of the "heat-of-wetting." Generally, the hazard is greatest with the western coals of the United States.

RI 8475. Recovery of Potash Feldspar From Molybdenite Tailings, by W. H. Eddy and G. V. Sullivan. 1980. 22 pp. 10 figs. The Bureau of Mines used several laboratory batch flotation schemes combined with magnetic separation to investigate the feasibility of recovering potash feldspar and glass sands from molybdenite tailings. Four molybdenite tailings or prospective tailings were used as test samples. Feldspar concentrates containing from 10.7 pct to 12.0 pct K_2O were recovered from three of the four samples. The alkali content of the fourth sample met the grade for a mixed feldspar. All the feldspar concentrates contained iron in excess of the 0.10-pct-Fe_2O_3 specification for most uses. Electron-beam microprobe examination of the feldspar concentrates showed the presence of an iron-bearing potash feldspar in quantities that were excessive with respect to most iron specifications. However, a high-quality glass sand was produced from all of the samples. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8476. Producing Alumina From Clay by the Hydrochloric Acid Process, A Bench-Scale Study, by J. A. Eisele. 1980. 21 pp. 4 figs. The Bureau of Mines conducted bench-scale cyclic tests to determine the composition of recycled leach liquor in the Bureau's proposed clay/HCl leach/HCl sparge process for producing Al_2O_3 from clay. The data developed from these tests make it possible to synthesize leach liquors for predetermined steady-state operating conditions when conducting large-scale crystallization tests. The results of two sparge tests were compared. One was a 20-cycle test with a 36-pct-HCl concentration in the mother liquor; the other was a 10-cycle test with a 26-pct-HCl concentration in the mother liquor. The effect of impurity concentrations in the leach liquor on the purity of aluminum chloride ($AlCl_3 \cdot 6H_2O$) crystals was determined, but there was poor correlation between these data and results that have been obtained from miniplant-scale work.

RI 8477. Silver Recovery From Aircraft Scrap, by D. Harry Chambers and B. W. Dunning, Jr. 1980. 23 pp. 9 figs. The Bureau of Mines, through a memorandum of agreement with the Department of Defense, conducted research to recover silver from aircraft scrap. Silver was recovered by an electrolytic method from stainless steel honeycomb sections separated from the aircraft. These sections had been constructed by sandwiching a stainless steel honeycomb core between stainless steel sheets and then brazing the assembly with a silver alloy. Over 300 pounds of silver was used in the B-58 bomber, concentrated in certain honeycomb sections of the aircraft. Following shredding of the aircraft parts, an average of 95 percent (ranging 67 to 100 percent) of the silver was recovered in a single electrorefining step. After the electrorefined product was magnetically cleaned, purity of the recovered silver was greater than 99.3 percent. (*Out of print.*)

RI 8478. Controlled Burnout of Wasted Coal on Abandoned Coal Mine Lands, by Robert F. Chaiken. 1980. 23 pp. 8 figs. A novel approach to eliminating environmental and public safety hazards that are associated with fires in abandoned coal mines and waste banks involves the use of in situ combustion technology developed by the Federal Bureau of Mines to accelerate the burning of the wasted coals in place. This technology would be used under

exhaust ventilation control conditions that would allow for total management of the hot gases produced. Combustion stoichiometries would be optimized to minimize unburnt combustibles and to maximize the heat content of the gas products, which will be exhausted at one or more fan locations. When necessary, scrubber systems would be employed to remove air pollutants, such as sulfur dioxide; heat utilization systems (process heat, steam, and electricity) would also be employed to offset operational costs. Ultimately, complete burnout would solve the fire and acid water formation problems of the abandoned coal mine or waste bank. Pertinent technical data for burnout control are derived and discussed in terms of the important material and operational parameters. In general, it is believed feasible to operate a burnout system in an existing abandoned mine or waste bank fire at thermal power levels in the range of 10 to 100 Mw, and at exhaust gas temperatures of 1,000° C (1,830° F).

RI 8479. Computer Modeling of Fluid Flow During Production and Environmental Restoration Phases of In Situ Uranium Leaching, by Robert D. Schmidt. 1980. 70 pp. 16 figs. This Bureau of Mines report describes the development and application of a computer model for simulating the hydrological activity associated with in situ leaching. The model is intended to provide uranium resource developers with a description of the flow behavior of leachants and ground water during the development, production, and restoration phases of a leaching operation involving an arbitrary pattern of injection and recovery wells. Different aquifer environments are modeled, using a closed-form solution to the partial differential equation that describes three-dimensional changes in piezometric head as a result of pumping from leachant injection and recovery wells. The computer program can model a maximum of 50 arbitrarily located wells. Numerical techniques involving difference quotients and Taylor expansions about time points are used to derive time, velocity, areal sweep, and fluid volume parameters associated with leaching hydraulics. These parameters are output by the program in graphic and tabular formats. Other numeric methods insure that the program running time is minimized without significantly affecting the accuracy of results.

RI 8480. A Simple, Low-Cost Method for the Dissolution of Metal and Mineral Samples in Plastic Pressure Vessels, by R. F. Farrell, S. A. Matthes, and A. J. Mackie. 1980. 14 pp. 2 figs. A goal of the U.S. Department of the Interior, Bureau of Mines, is the advancement of minerals technology through the development of improved metals and minerals processing. In support of this goal, the Bureau of Mines has developed a general method for preparing solutions from a wide range of metal and mineral samples for chemical analysis. The development of the method from current knowledge of vessel material, pressure dissolution techniques, and the fluoride-boric acid reaction is given. The method uses 7 ml of a mixture of HCl-HNO_3-HF acids in a ratio of 3.5:2:1.5 sealed in plastic bottles that act as pressure vessels when heated in a boiling water bath. A final volume of 100 ml is obtained by the addition of 93 ml of a 1.5-pct H_3BO_3 solution to the bottles, which are reheated; precipitated fluorides as well as sample residue are dissolved by the fluoride-boric acid reaction. A copper slag and a steelmaking slag treated using this method were analyzed by atomic absorption, spectroscopy, yielding values for Si, Mg, Ca, Al, Fe, Mn, Na, As, Pb, Sb, and Zn very close to certified values with an average relative standard deviation of 2.13 pct. The low cost, reduction in preparation time, ease and safety of sample handling, conservation of reagents, and ability to dissolve volatile materials without loss make this method superior to traditional wet digestion techniques for many materials, and ideal for use with atomic absorption, and optical emission or X-ray emission spectroscopy.

RI 8481. Cladding of Metals to Iron by Vacuum Rolling, by R. Blickensderfer. 1980. 25 pp. 22 figs. Maintaining an adequate supply of minerals and metals to meet national economic and strategic needs is the overall goal of the Bureau of Mines, U.S. Department of the Interior. One method of achieving this goal is to conserve scarce metals by cladding a plentiful base metal, such as iron, with a scarcer metal. To investigate cladding, a vacuum-rolling mill capable of rolling bimetal specimens at temperatures to 1,300° C in a residual gas pressure of 2×10^{-5} torr was established. Metals that were successfully bonded to iron included stainless steels, chromium, nickel, nickel alloys, copper, and several refractory metals including molybdenum and titanium. The effects of the rolling temperature, reduction in thickness, rolling speed, and residual air pressure on bonding strength and bend ductibility of the bimetals were determined. Optimum rolling conditions produced bimetals with bond shear strength essentially equal to that of the iron base metal.

RI 8482. Selective Flocculation and Flotation of a Mesabi Range Hematitic-Goethitic Taconite, by H. D. Jacobs and A. F. Colombo. 1980. 11 pp. 3 figs. The Bureau of Mines undertook a research program to insure an adequate supply of iron raw materials for future iron and steelmaking needs. A sample was obtained of oxidized taconite from the western Mesabi Range in Minnesota, and the metallurgical response of the taconite to beneficiation by a process that included selective flocculation-desliming-cationic flotation was evaluated. The sample contained 35.3 pct iron and represented approximately 2 billion tons of crude material. Selective flocculation and flotation were evaluated in a pilot plant with a feed rate of 900 lb/hr. Concentrates averaging 61.7 pct iron and 5.1 pct silica were obtained, with an accompanying iron recovery of 67.2 pct. About 83 pct of the process water requirements were reclaimed from the slime and froth tailing and then recycled.

RI 8483. Surface Charge Measurements of Amphibole Cleavage Fragments and Fibers, by J. E. Schiller and S. L. Payne. 1980. 23 pp. 12 figs. The Bureau of Mines has investigated the surface charge of amphibole asbestos fibers and nonasbestiform cleavage fragments, as part of the Bureau's fundamental studies to provide new knowledge on the physical and chemical properties of the amphibole minerals. Microelectrophoresis was used to measure the electrophoretic mobilities, in water, of particles from six asbestiform amphiboles and seven nonasbestiform amphiboles over the pH range of 5 through 9. The particles generally ranged in size from 2 to 5 μm wide by 10 to 30 μm long. The isoelectric point was determined for four of the minerals, and values were found to be between pH 3.5 and pH 5. The minerals studied had zeta potentials that generally ranged from -25 to -50 mv in neutral solution. Attachment of colloidal positively charged AgI was also studied as a means of determining surface charge. Scanning electron microscopy of amphibole particles that had been in contact with aqueous

AgI showed equal attachment of AgI to asbestos fibers and to cleavage fragments; the extent of AgI coating was the same for both. The electrophoretic mobilities of asbestos fibers were essentially the same as those of elongated cleavage fragments of the same aspect ratio (particle length divided by width). Blocky particles from both asbestiform and nonasbestiform specimens had lower mobilities.

RI 8484. Rapid, Low-Cost Analysis of a Copper Slag for 13 Elements by Flame Atomic Absorption Spectroscopy, by S. A. Matthes. 1980. 8 pp. 2 figs. This Bureau of Mines report describes analysis of a copper slag for 13 elements from a single sample solution by flame atomic absorption spectroscopy. Samples are dissolved with 7 ml of an HCl-HF-HNO_3 (3:1.5:2) mixture in heated plastic pressure vessels. A 1.5-pct boric acid solution is added to dissolve precipitated fluorides and to reduce matrix effects that interfere with atomic absorption analysis. Preparation time is less than 1 hour per batch of 10 samples. Total analysis time is less than 6 person-hours for 130 determinations with an average relative standard deviation of 1.83 pct for the 13 elements. Simple acid standards were used for all determinations. Values obtained by this method are in excellent agreement with values obtained by slower, more costly procedures.

RI 8485. Structure Response and Damage Produced by Airblast From Surface Mining, by David E. Siskind, Virgil J. Stachura, Mark S. Stagg, and John W. Kopp. 1980. 111 pp. 48 figs. The Bureau of Mines studied airblast from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Research results obtained from direct measurements of airblast-produced structure responses, damage, and analysis of instrument characteristics were combined with studies of sonic booms and human response to transient overpressures. Safe levels of airblast were found to be 134 dBL (0.1 Hz), 133 dBL (2 Hz), 129 dBL (6 Hz), and 105 dBL C-slow. These four airblast levels and measurement methods are equivalent in terms of structure response, and any one could be used as a safe-level criterion. Of the four methods, only the 0.1-Hz high-pass linear method accurately measures the total airblast energy present; however, the other three were found to adequately quantify the structure response and also represent techniques that are readily available to industry. Where a single airblast measuring system must be used, the 2-Hz linear peak response is the best overall compromise. The human response and annoyance problem from airblast is probably caused primarily by wall rattling and the resulting secondary noises. Although these will not entirely be precluded by the recommended levels, they are low enough to preclude damage to residential structures and any possible human injury over the long term.

RI 8486. Electrochemical Determination of Gibbs Energies of Formation of MnS and $Fe_{0.9}S$, by Seth C. Schaefer. 1980. 17 pp. 6 figs. As part of the Bureau of Mines effort to provide thermodynamic data for advancement of mineral resources technology, the standard Gibbs energies of formation ($\Delta G°f$) of MnS (manganese sulfide) and $Fe_{0.9}S$ (pyrrhotite) were investigated with a high-temperature galvanic cell employing stabilized ZrO_2 (zirconia) as the electrolyte.

RI 8487. Effects of Additives on Methanation Activity of Raney Nickel Catalysts, by James H. Russell, Laurance L. Oden, and Jack L. Henry. 1980. 21 pp. 2 figs. The Bureau of Mines, U.S. Department of the Interior, in cooperation with the Department of Energy, has attempted to increase the activity of nickel catalysts for converting synthesis gas, derived from coal, to a substitute natural gas. This report describes the effects of low-level additions of B, Ca, Ce, Co, Mn, Mo, Pd, Re, Ti, Y, Zn, and Zr on the methanation activity of Raney nickel. The methanation rate at 320° C and the resistance to poisoning by 2 ppm H_2S were used to compare catalysts. The effects of the additions were small, and the experimental variances were large, necessitating the use of statistical methods to identify significant effects. Co, Ti, Y, and Zn improved the resistance to H_2S poisoning, but only Co improved the methanation rate. In some individual catalysts containing Ca, Mo, or Mn, both the methanation rate and resistance to H_2S poisoning were improved. The work upon which this report is based was done under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the U.S. Department of Energy.

RI 8488. Partial Replacement of Coke in Cupola Operation, by V. R. Spironello and W. M. Mahan. 1980. 19 pp. 1 fig. The Bureau of Mines is involved in research directed toward the conservation of important raw materials and the utilization of solid waste. Two of the objectives are to conserve high-quality coking coals used for foundry coke and to utilize waste materials of marginal quality but of high calorific value. These objectives are consistent with Bureau goals. Pilot plant cupola trials were made to evaluate the adequacy of various alternative fuels, and to determine to what extent they could replace the foundry coke in cupola charges. Information was obtained on furnace performance, metal and slag chemistry, environmental questions, and the properties of castings. It was shown that anthracite or bituminous coals can partially replace charge coke up to the 40-pct level. Briquetted materials prepared from fuel fines, and waste products or byproducts of high calorific value, all tend to break down on heating in a cupola so that their use must be restricted to below 20 pct replacement. In cases where pitch-bonded coal fines or petroleum coke were used, carbon pickup by the iron was inadequate for gray iron specifications. Although emphasis during this work was placed on basic slag practice, some acid practice results are included.

RI 8489. Recycling Spent Chrome Refractories From Steelmaking Furnaces, by E. Martin and A. V. Petty, Jr. 1980. 12 pp. 3 figs. In Bureau of Mines research on recycling chrome refractory wastes, used refractories from argon-oxygen decarburization and electric steelmaking furnaces were beneficiated, concentrates were reformed into briquets, and modulus of rupture tests were conducted at 1,350° C. The test results indicated that the beneficiated minus 6-mesh material could be used for producing magnesia-chrome refractories. Research at the Tuscaloosa Research Center is carried out under a memorandum of understanding between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8490. Electronic Ore-Sorting Tests on Native Copper Ore, by Jon K. Ahlness and James C. Kirchner. 1980. 36 pp. 13 figs. The Bureau of Mines, in cooperation with the Institute of Mineral Research of Michigan Technological University, and the Upper Great Lakes Regional Commission, conducted an

investigation of electronic sorting of native copper ore from Upper Michigan. This report is based on research by the Institute of Mineral Research under contract to the Bureau. The test program evaluated the use of belt and rotary sorters on various size and grade fractions of ore. Both plant-scale sorting and lab sorting tests were run. The plant sorting objectives were to determine the sortability of different ores and the efficiency of the electronic ore sorters. High- and low-grade ores from both conglomerate and amygdaloid types were separated into four size fractions. The two larger sizes were sorted on belt sorters and the two smaller ones on rotary sorters. Copper recoveries ranged from 20.0 pct from a feed grade of 0.40 pct to 80.3 pct from a feed grade of 1.08 pct. Lab sorting tests of conglomerate ore were run to determine the efficiency of a belt sorter equipped with a second sensing coil located above the belt and to determine the sorting characteristics of larger ore size fractions than those used in the plant sorting. Copper recoveries from the combined feed sizes ranged from 47.0 pct from a feed grade of 0.13 pct to 96.8 pct from a feed grade of 4.87 pct. For all the ore types except one, it was found that the copper recovery increased with the feed size.

RI 8491. Constructing Ventilation Bulkheads With Shotcreted Wire Panel, by K. Robert Dorman and Jan G. Patricio. 1980. 24 pp. 19 figs. This Bureau of Mines report describes laboratory and field experimentation in building mine ventilation stoppings, air-door frames, and fan bulkheads with a civil construction technique. Shotcrete is applied to a free-standing, three-dimensional wire-truss panel, which is easily cut and rapidly erected. In mines where shotcrete equipment is available, this technique should be faster and cheaper than conventional block-and-mortar or monolithic concrete construction.

RI 8492. Uranium Ion Exchange From Low-Grade Acidic Solutions in a Fluidized System, by G. R. Palmer, I. L. Nichols, and D. C. Seidel. 1980. 20 pp. 13 figs. Using a fluidized, countercurrent multiple-compartment ion-exchange (MCIX) column previously developed by the Bureau of Mines, Bureau researchers have successfully extracted uranium from a simulated acidic in situ leach liquor that contained 150 ppm U_3O_8. This successful demonstration of the MCIX system is reported, and the effects of varying the operating conditions on the performance of the system are also examined. Operating the MCIX system with a flow rate of 15 gpm/ft^2 and an aqueous-to-resin flow ratio of 200:1, more than 90 percent of the uranium was extracted, and a resin containing approximately 28 grams U_3O_8 per liter was produced. The absorption column used to investigate the operating variables was approximately 18 feet long with a 2-inch ID and was divided into compartments that were 1 foot long.

RI 8493. Behavior of Arsenic in a Static Bed During Roasting of Copper Smelter Feed, by Arne Landsberg, J. E. Mauser, and J. L. Henry. 1980. 18 pp. 17 figs. Accessory metals, although valuable resources, present possible environmental concern in the smelting of base metals. The Bureau of Mines, U.S. Department of the Interior, has undertaken research to define the chemistry involving these metals. Arsenic in copper smelting is the first to be investigated. Roasting, the first step in many copper smelters, was chosen for initial investigation because of the potential for arsenic removal in this primary process. Simple, static-bed, vaporization experiments were devised to obtain the data in this study. Ancillary transpiration and mass spectrometry were also used to delineate conditions necessary for arsenic volatilization from a roaster feed. For nearly complete arsenic removal, a temperature of 650°-700° C, a reducing atmosphere including carbon monoxide, and a source of sulfur were found to be essential.

RI 8494. Inorganic Cement for Mine Roof-Bolt Grouting, by R. E. Simpson, J. E. Fraley, and D. J. Cox. 1980. 32 pp. 16 figs. Beginning in 1972, fully grouted resin bolts were used in underground mines. An estimated 20 million resin bolts will be installed in 1980 owing to their apparent support improvement in most roof-bolt applications. Inorganic cements were tested to replace the resin at a lower cost while retaining the advantages of a grouted bolt. Although other inorganic materials were considered, all but portland and gypsum cements were rejected for reasons of availability, performance, or cost. Portland and gypsum-type cements were tested by the Bureau of Mines to select a fast-hardening, low-cost material that would anchor a roof bolt adequately to meet safety standards. An alpha-gypsum cement, accelerated with potassium sulfate, was selected as the best material because it had adequate pull strength at a desired set time of less than 5 minutes and was readily available.

RI 8495. Cladding Metals by Continuous Strip Rolling in Vacuum, by Robert Blickensderfer. 1980. 11 pp. 9 figs. Equipment and procedure for the continuous roll bonding of metal strips are described. The reels, mill rolls, and furnace were located within a vacuum chamber capable of operation at a residual gas pressure of 1 x 10^{-4} to 1 x 10^{-5} torr. Several metals were successfully clad at rolling temperatures of 930° to 1,050° C in lengths up to 120 ft. The bimetals that were clad included stainless steel to carbon steel, molybdenum, and nickel to stainless steel and carbon steel, and titanium to carbon steel. Bend tests of bond integrity are described, and microstructures of the interfaces are presented. The amounts of brittle intermetallic phases formed at the interface are minimized by this cladding method.

RI 8496. A Breathing Metabolic Simulator for Testing Respiratory Protective Equipment, by Anthony W. Sparks, Richard L. Stein, and Jerry W. Stengel. 1980. 18 pp. 14 figs. The Bureau of Mines conducted tests designed to compare its breathing metabolic simulator (BMS) with other methods that are currently used to evaluate the performance of respiratory protective equipment. The BMS is a commercially developed device that uses a piston cylinder to stimulate breath movement. Using a propane furnace that consumes oxygen and forms CO_2, the BMS also simulates the respiratory metabolism of humans. The breathing and metabolic subsystems of the BMS are described in detail in this report. Results are compared from tests that used the BMS to evaluate respiratory equipment and from tests that used human subjects for the same purpose. The BMS was also tested against a pulsatile breathing machine (PBM) previously designed by the Bureau. Both machines were used to test respiratory equipment, and the test results are compared in this report. To illustrate typical applications of the BMS,

the report briefly describes how the BMS was used to test two different types of closed-circuit respiratory apparatus, and the test results are presented. This research showed that BMS test results compared more closely to the results of tests that used human subjects than did results obtained using the PBM.

RI 8497. Preparation and Chlorination of Titanium Carbide From Domestic Titaniferous Ores, by G. W. Elger, W. L. Hunter, and J. E. Mauser. 1980. 20 pp. 10 figs. The Bureau of Mines conducted laboratory and larger scale studies on samples of domestic perovskite and ilmenite ore concentrates to devise a procedure for recovering TiC from these ores. From the concentrates, mixtures of titanium and calcium carbides were produced. The carbides were then ground and reacted with water. This reaction decomposed the CaC_2 to acetylene and hydrated lime and simultaneously liberated the TiC. Using a combination of elutriation and gravity-separation techniques to separate the hydrated lime, approximately 93 pct of the titanium was subsequently recovered as purified carbide containing 54 to 70 pct titanium with CaO content as low as 0.6 pct. This combination of techniques can be used to separate more than 90 pct of the CaO from the TiC. Therefore, this carbiding procedure is a viable method for treating titaniferous materials, including perovskite, that contain more than 20 pct CaO. Tests made in a static-bed reactor showed that for the reaction of TiC with elemental chlorine to produce titanium tetrachloride ($TiCl_4$), a temperature of at least 940° F is desirable to achieve a suitable extraction of titanium in a laboratory chlorination reactor. In fluidized-bed tests at 840° F, 98 pct of the titanium contained in TiC was extracted.

RI 8498. Dewatering of Industrial Clay Wastes, by Annie G. Smelley, Bernard J. Scheiner, and Jalna R. Zatko. 1980. 13 pp. 3 figs. As a part of research conducted in its mission to effect pollution abatement, the Bureau of Mines, U.S. Department of the Interior, is developing a dewatering technique that allows for disposal of clay wastes, for reuse of water now lost with clays, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer (PEO) that has the ability to flocculate and dewater materials containing clay wastes. In laboratory experiments, coal-clay waste, potash-clay brine slurry, phosphatic clay waste, uranium tailings, and talc tailings were successfully consolidated. Coal-clay waste was consolidated from 3.6 to 57 percent; potash-clay brine slurry was consolidated from 3.8 to 35 percent; phosphatic clay waste from 15.6 to 49 percent; uranium tailings from 15.4 to 67 percent; tailings from talc production from 9.7 to 53 percent; and an acidic TiO_2 slurry from 1.68 to 30 percent. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8499. Characterization of Pre-1957 Avionic Scrap for Resource Recovery, by B. W. Dunning, Jr., and F. Ambrose. 1980. 20 pp. 1 fig. This paper describes studies conducted by the Bureau of Mines to achieve its goal of developing methods for increased recovery and utilization of valuable constituents in a wide variety of domestic and industrial wastes. In this particular study, 36 units of obsolete electronic equipment from military aircraft were disassembled into their modular components by hand to determine materials distribution. Further modular disassembly into individual parts was used to identify metal composition. After identifying the metals in some of the more difficult to dismantle modules, similar modules were grouped together, shredded, mechanically separated, and using metal composition data from hand separation, classified along with the hand-separated materials. Although this equipment is normally classified as low-value iron-bearing aluminum, data were obtained that indicated the potential for moderately higher value classification. The electronic units were classified as to precious metals, copper, iron, and aluminum contents, and scrap values were estimated.

RI 8500. Preparation of Platinum-Palladium Flotation Concentrate From Stillwater Complex Ore, by J. Bennetts, E. Morrice, and M. M. Wong. 1981. 18 pp. 9 figs. As part of its mission to develop technology that will help increase the supply of critical and strategic minerals from domestic resources, the Bureau of Mines has investigated methods for beneficiating platinum-group metal ores from the Stillwater complex, Montana. This report presents the result of a bench-scale study employing froth flotation to recover a sulfide concentrate containing platinum-palladium values from a mineralized gabbro. Best results were obtained with a flotation scheme utilizing a mercaptobenzothiazone collector and sulfuric acid. Rougher concentrates containing approximately 11 oz Pt-Pd/ton and 90 pct of the metal values in the ore were obtained. Subsequently, cleaner concentrates containing approximately 26 oz Pt-Pd/ton and between 80 to 85 pct of the Pt-Pd values in the ore were prepared.

RI 8501. Characterization of Residues From Selected Coal Conversion Processes, by E. Martin and G. V. Sullivan. 1980. 13 pp. 3 figs. As part of the Bureau of Mines subactivity in secondary resource recovery and to expand the Nation's mineral base, the Tuscaloosa Research Center made characterization and preliminary beneficiation studies of the waste residues from various coal-conversion processes: from pilot plant tests of the Synthane process for coal gasification, the Synthoil process for coal liquefaction, and the solvent-refined coal (SRC) process for sulfur removal from coal. Those coal conversion processes selected for this study were based on the availability of pilot plant samples. Physical, chemical, and mineralogical examinations of the wastes made to determine the mineral content prior to physical beneficiation tests indicated that in addition to significant quantities of carbon, some trace elements offer potential for concentration.

RI 8502. Amine Flotation of Chromite Ores From the Stillwater Complex, Mont., by G. E. Smith, J. L. Huiatt, and M. B. Shirts. 1981. 12 pp. 2 figs. The Bureau of Mines, U.S. Department of the Interior, devised a flotation technique for upgrading chromite in chromium ores and gravity concentrates. The technique consisted of cationic flotation of chromite from a slime-free pulp acidified to pH 2.5 or lower using H_2SO_4 modifier. Flotation results showed that ore containing serpentine as the primary gangue mineral was more amenable to concentration by this technique than ore containing the readily floatable olivine as the primary gangue mineral. Rougher flotation of a chromite ore containing abundant serpertine increased the grade form 19 to 41 percent Cr_2O_3 at a chromite recovery of 89.6 percent. Rougher flotation of ore containing

abundant olivine upgraded the chromite from 23.4 to 29.6 percent Cr_2O_3 at a recovery of 89.4 percent. The technque was also applied to chromite gravity concentrates to further upgrade chromite and to reject silicates. Flotation of a gravity concentrate containing 40.9 percent Cr_2O_3 and 4.4 percent SiO_2 recovered 90 percent of the chromite in cleaner products containing 44.9 percent Cr_2O_3 and 0.63 percent SiO_2. The combined recovery by gravity and flotation was 87 percent. An economic evaluation of this technique will be undertaken to determine its feasibility for commercial use.

RI 8503. Autogenous Attrition Microgrinding of Calcium Carbonate Minerals, by J. P. Hansen, E. G. Davis, and G. V. Sullivan. 1981. 15 pp. 8 figs. To help assure an adequate domestic supply of minerals essential to the Nation's economy and security by developing more efficient minerals extraction technologies, the Bureau of Mines' Tuscaloosa Research Center examined the application of autogenous microgrinding to calcium carbonate minerals. Treatment of minus 8-mesh Alabama marble resulted in a product 80 pct minus 5 micrometers (μm) at a power consumption of 70 to 80 kwhr/ton. This study shows that coarse particles of calcium carbonate minerals are effective as the grinding media for the autogenous attrition grinding of these minerals. The minus 8- plus 30-mesh fraction is an effective grinding medium (sand) for particles smaller than 30 mesh. A 40-pct-solids slurry and a sand-marble ratio of 2.5 appeared to be near optimum. For residence times above 13 minutes, products were greater than 80 pct minus 5 μm and greater than 54 pct minus 2 μm. Power consumption was uniformly low, ranging from 50 to 100 kwhr/ton of product depending upon the feed rate. One marble sample from Georgia was shown to be the most persistent grinding medium, with losses of less than half those of the other materials tested.

RI 8504. Corrosion of Materials and Scaling in Low-Salinity East Mesa Geothermal Brines, by F. X. McCawley, S. D. Cramer, W. D. Riley, J. P. Carter, and P. B. Needham, Jr. 1981. 17 pp. 10 figs. The Bureau of Mines, in pursuing its goal of extending the life span of strategic materials, conducted field corrosion studies at the East Mesa Known Geothermal Resources Area (KGRA) in the Imperial Valley, Calif., to determine the optimum materials of construction for use in geothermal mineral energy resource recovery plants. These studies included characterization of geothermal environments and in situ corrosion testing. The corrosion resistance of 10 alloys exposed to 5 brine and steam process environments was evaluated using the low-salinity, high-temperature brine from geothermal well Mesa 6–1. Of these alloys, Hastelloy C-276, Hastelloy S, Inconel 625, titanium-2nickel, and 316 L stainless steel had excellent resistance to corrosion in all of the process environments; E-Brite 26–1 and 430 stainless steel had fair resistance. Although general corrosion rates for 4130 steel and 1020 carbon steel were substantially higher than those of the other iron-base alloys, these two alloys could prove useful in low-salinity process environments because of their low cost. Aluminum alloy 5005 was the least corrosion resistant alloy and pitted severely. Scales formed on all of the alloys in every process environment. Calcite, aragonite, and an amorphous silicate were the major components of the scales.

RI 8505. Cationic Flotation of a Hematitic Oxidized Taconite, by H. D. Jacobs and A. F. Colombo. 1981. 11 pp. 3 figs. The Federal Bureau of Mines, as part of a program to insure future raw material needs for the iron and steel industry, undertook research to beneficiate the oxidized taconites from the western Mesabi range in Minnesota. The data presented were obtained by applying the Bureau-developed selective-flocculation / cationic-flotation process to the second of three oxidized taconite samples. These three samples are representative of an estimated 10 billion tons of ore analyzing 30 to 40 pct iron. The experimental work was performed in a 900-lb/hr pilot plant. Treating the ore sample (36.1 pct Fe) with the Bureau's process produced commercially acceptable concentrates averaging 63.5 Fe and 4.3 pct SiO_2, with an average iron recovery of 84.6 pct.

RI 8506. Measurement of Blast-Induced Ground Vibrations and Seismograph Calibration, by Mark S. Stagg and Alvin J. Engler. 1980. 62 pp. 44 figs. Blast-induced ground vibrations from surface coal mine, quarry, and construction blasting were measured and analyzed for frequency content and duration characteristics. Eighteen commercially available ground vibration measurement systems were evaluated in the field and laboratory for linearity, accuracy, and crosstalk. Buried, surface, and sandbagged transducer placement methods were compared, along with peak and vector-sum measurements. The recommended minimum frequency ranges for ground vibration instrumentation are 2 to 150 Hz for coal mine and quarry blasting, and 5 to 200 Hz for construction and excavation blasting. When higher or lower frequency vibrations are possible, as in construction blasting or for a quarry shot close to a residence, care should be taken to insure proper choices of instrumentation and vibration criteria. Several instruments operating in these ranges are available, and all but one of the seismographs tested fell within ±3-dB accuracy limits (+41 pct, -29 pct). Waveform recordings of all three ground vibration components are recommended as the peak amplitude and frequency may vary among the three. Peak or vector-sum readings are adequate if only amplitude levels are desired. The soil density matched box should be anchored or buried, particularly for high-frequency, high-amplitude construction blasting.

RI 8507. Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting, by D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding. 1980. 74 pp. 68 figs. The Bureau of Mines studied blast-produced ground vibration from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Direct measurements were made of ground-vibration-produced structure responses and damage in 76 homes for 219 production blasts. These results were combined with damage data from nine other blasting studies, including the three analyzed previously for Bureau of Mines Bulletin 656. Safe levels of ground vibration from blasting range from 0.5 to 2.0 in/sec peak particle velocity for residential-type structures. The damage threshold values are functions of the frequencies of the vibration transmitted into the residences and the types of construction. Particularly serious are the low-frequency vibrations that exist in soft foundation materials and/or result from long blast-to-residence distances. These vibrations produce not only structure resonances (4 to 12 Hz for whole structures and 10 to 25 Hz for midwalls) but also excessive levels of displacement and strain. Threshold damage was defined as the occurrence of

cosmetic damage; that is, the most superficial interior cracking of the type that develops in all homes independent of blasting. Homes with plastered interior walls are more susceptible to blast-produced cracking than modern gypsum wallboard; the latter are adequately protected by a minimum particle velocity of approximately 0.75 in/sec for frequencies below 40 Hz. Structure response amplification factors were measured; typical values were 1.5 for structures as a whole (cracking) and 4 for midwalls, at their respective resonance frequencies. For blast vibrations above 40 Hz, all amplification factors for frame residental structures were less than unity. The human response problem from ground vibration is aggravated by wall rattling, secondary noises, and the presence of airblast. Approximately 5 to 10 pct of the neighbors will judge peak particle velocity levels of 0.5 to 0.75 in/sec as "less than acceptable" (that is, unacceptable) based on direct reactions to the vibration. Even lower levels cause psychological response problems, and thus social, economic, and public relations factors become critical for continued blasting.

RI 8508. Airblast Instrumentation and Measurement Techniques for Surface Mine Blasting, by Virgil J. Stachura, David E. Siskind, and Alvin J. Engler. 1981. 53 pp. 40 figs. The Bureau of Mines has investigated techniques and instrumentation that measure accurately the airblast overpressures from surface mine blasting. The results include equivalencies between broadband research instrumentation and commercially available impulse precision sound level meters measuring: root-mean-square, peak, fast, slow, impulse, A and C weighting, C-weighted sound exposure level (CSEL), and "linear" (flat) response. These values were obtained from field measurements and broadband FM tape recordings of production blasts at area and contour coal mines, limestone quarries, and iron mines. Frequency response was determined for 14 commercial systems.

RI 8509. Flotation Responses of Two Duluth Complex Copper-Nickel Ores, by R. B. Schluter and W. H. Mahan. 1981. 24 pp. 12 figs. The Bureau of Mines investigated the flotation responses of two copper-nickel ore samples from the Duluth Complex with the objective of recovering bulk sulfide concentrates. One of the ores studied was taken from a test pit; the other was taken from a test shaft. The samples were quite similar except that the pit sample analyzed 0.35 pct Cu and 0.11 pct Ni and the shaft sample analyzed 0.69 pct Cu and 0.14 pct Ni. Flotation responses were studied in both laboratory and pilot plant tests. Pilot plant flotation responses were similar for both samples resulting in grades of 12.2 pct Cu and 2.5 pct Ni for the pit sample and 12.2 pct Cu and 2.1 pct Ni for the shaft sample. Weight recoveries were 2.5 pct for the pit sample and 5.2 pct for the shaft sample. Copper and nickel recoveries for the pit sample were 87 and 62 pct, respectively, and 92 and 73 pct for the shaft sample. Both concentrates contained small but significant values of cobalt and precious metals. Cobalt recoveries were low—less than 40 pct for both concentrates. Precious metals contents of the concentrates were 1.59 oz/ton for the pit sample and 0.99 oz/ton for the shaft sample. Silver was the predominant precious metal by weight, but platinum and palladium represented the highest values.

RI 8510. Determination of Antimony in Smelter Flue Dusts by Atomic Absorption Spectrometry, by K. R. Farley, K. W. Sheetz, and A. B. Whitehead. 1981. 9 pp. 1 fig. A simplified method for the atomic absorpton determination of antimony is described. Samples are dissolved in hydrobromic acid and diluted to volume with water. Solutions can be ready for analysis in about 10 minutes and are stable for at least 24 hours. The spectral line at 231 nanometers is used, and there is no effect on absorption resulting from the presence of any concentration of HBr. Absorbance is linear with antimony concentrations up to 120 micrograms per milliliter. Sensitivity is 1.48 micrograms per milliliter per 0.0044 absorbance. Relative errors on National Bureau of Standards Standard Reference Materials were 3 percent or less, and relative standard deviations on 12 determinations of each of three flue dust samples were 4 percent or less (95-percent confidence limit).

RI 8511. Electric-Arc Furnace Processing of Domestic Titaniferous Materials, by R. H. Nafziger, R. R. Jordan, and W. L. Hunter. 1981. 35 pp. 1 fig. The Bureau of Mines evaluated 18 domestic titaniferous materials with widely varying compositions, mineralogy, and physical properties in electric-arc furnaces. Techniques were devised to recover both the titanium and iron values contained in these materials so that the reliance of the United States on foreign sources of higher grade ilmenites and rutile might be decreased. Most of the tested titaniferous materials responded well to lower grade or byproduct reductants, such as bituminous coals, charcoal, and coke breeze. Sufficient slag fluidity was realized by maintaining from 8 to 12 wt-pct iron in the slags; no contaminating fluidizers were required. Fluid slags containing up to 79, 70, and 54 wt-pct TiO_2 were realized from east coast ilmenites, a rock ilmenite, and a titaniferous magnetite ore, respectively. A carbon-lined furnace shell is recommended for minimum slag contamination. Good results also were obtained during extended submerged-arc furnace tests.

RI 8512. Effectiveness of Wet Cutter Bars in Reducing Salt Mine Dust, by Steven J. Page, Charles W. Urban, and Jon C. Volkwein. 1981. 10 pp. 2 figs. Responding to the increasing concern for dust control in metal and nonmetal mining, the Bureau of Mines investigated typical dust reduction efficiencies of wet bar cutter machines as they are presently being used in salt mines. Wet bar techniques have previously been used in coal mines, achieving dust reduction efficiencies ranging from 11 to 60 pct. Two different wet bar techniques, namely, the front spray and the water trickle, have been studied as they are currently being used in two salt mines. Preliminary results show that the dust reduction efficiencies have a large variation (0 to 66 pct), as is the case for wet bars used in coal. However, whereas wet bars in coal required 3 to 4 gpm water consumption, wet bars in salt obtained similar efficiencies with only 0.1 to 0.4 gpm. The most reliable data obtained during this study show that the front spray system consistently performs at efficiencies between 41 and 66 pct, with an average of 54 pct. The results indicate that, although wet bar cutter techniques in salt mines are a relatively simple and inexpensive means of dust control with a minimum of water consumption, further investigation should be performed to fully evaluate and optimize wet bar cutter dust reduction efficiencies.

RI 8513. Effects of CO_2-Absorbent Canister Design on LiOH Efficiency in Closed-Circuit Breathing Apparatus, by Nicholas Kyriazi. 1981. 13 pp. 15 figs. It is of interest to know how to obtain as high an absorption efficiency as possible from a CO_2-absorp-

tion canister used in closed-circuit breathing apparatus. In this study the Bureau of Mines found that varying the bed depth and the cross-sectional area of a canister changes it absorption characteristics. In tests using four, rectangular, variable-depth canisters with different cross-sectional areas, the Bureau found that, given a constant weight of the chemical absorbent, LiOH, and a constant CO_2 input, the canisters with a greater cross-sectional area reached CO_2 levels of 0.5 volume-percent in the effluent gas sooner than did the canisters with a greater bed depth. However, resistance to flow through the canister increases with bed depth, and a trade-off is inevitable. It was anticipated that the efficiency of a canister would increase with increasing intergranular air space approaching the tidal volume of the breathing waveform and then level off at some point under 100 percent. This postulation was partiallv substantiated. Cylindrical and radial canisters were also tested and compared. It appears that shape is not as important a factor in absorption efficiency as bed depth, since neither canister differed significantly from the rectangular canisters with regard to absorption efficiency values.

RI 8514. Method for Preparing Ferrochromium Alloys by Vacuum Reduction and Simple Melting of Reduced Products, by J. E. Pahlman, M. L. Boucher, S. L. Payne, and S. E. Khalafalla. 1981. 22 pp. 11 figs. As part of its effort to reduce the need for strategic minerals through conservation and to reduce the capital and energy requirements of mineral processing, the Bureau of Mines has investigated a method for preparing ferrochromium alloys containing less than 2 percent carbon. This method will conserve chromium and should reduce the capital and energy requirements for chromite reduction. Reduced products containing less than 2 wt-pct C and as low as 0.01 wt-pct C were obtained by reacting pellets of chromite and carbonaceous reductant mixtures at pressures of 0.1 to 1 torr and temperatures of 1,230° to 1,320° C. The extent of reduction increased with increased temperature and decreased pressure; however, operating conditions were limited due to the onset of significant chromium vaporization at higher temperatures and lower pressures. Foundry coke, anthracite, and carbon black were found to be superior to graphite as reductants. The reduction of chromite to metallics was found to proceed via the carbide intermediates $(Fe,Cr)_7C_3$ and $(Fe,Cr)_{23}C_6$. No evidence of carbide intermediates Fe_3C or Cr_3C_2 was found. Buttons of ferrochrome alloys were made by melting a mixture of reduced products with CaO and SiO_2 at 1,700° C for 20 minutes in an induction furnace.

RI 8515. Direct Method Determination of the Gas Content of Coal: Procedures and Results, by W. P. Diamond and J. R. Levine. 1981. 36 pp. 9 figs. The explosion hazard of methane-air mixtures has become an increasingly serious mine planning problem, and an advance assessment of methane gas potential can therefore be essential for a safe and economic mine development program. As part of its coal mine health and safety program, the Bureau of Mines has developed a simple, inexpensive test to measure the methane content of coal samples obtained from exploration cores. The gas content of coal per unit weight as determined by the direct method test can be used as a basis for a preliminary estimate of mine ventilation requirements, and to determine if degasification of the coalbed in advance of mining should be considered. Since the Bureau began measuring the gas content of coal samples in 1972, experience has led to equipment and procedural changes, the most significant of which has been the development of a ball mill for crushing the coal sample to release the residual gas at the end of the desorption test period. This revised procedure replaces the crushing box and graphical methods described in earlier Bureau publications. The results of 583 direct method tests are summarized in tabular form. These results include data on the gas content of 125 coalbeds in 15 States. (*Out of print.*)

RI 8516. Development of a Continuous Flotation Process for Removal of Insoluble Slimes From Potash Ore, by Philip Thompson and J. L. Huiatt. 1981. 21 pp. 7 figs. The Bureau of Mines investigated a selective flocculation-flotation technique to remove insoluble slimes from low-grade potash ore in a continuous 45-kilogram-per-hour (100-pound-per-hour) process investigation unit (PIU). This research is part of the Bureau's program to improve resource recovery from low-grade ores. Results showed that 84 percent of the insoluble slimes were removed from an ore containing 5.5 percent water-insolubles and 14 percent K_2O using a Bureau-developed, cationic flocculant-glycol ester-diesel oil reagent. Subsequent potash flotation recovered 75 percent of the potash in a cleaner concentrate assaying 56 percent K_2O. Concentrate leaching upgraded the product to market specifications of 60 percent K_2O. An economic evaluation by the Bureau suggested that the rate of return on investment, after taxes, should be about 20 percent for such an enterprise.

RI 8517. Thermal Degradation Products of Solvents and Hydraulic Fluids Used in Mining, by Theodore Christos and David R. Forshey. 1981. 14 pp. The Bureau of Mines sponsored an investigation of the thermal oxidative degradation characteristics of certain solvents and hydraulic fluids used in underground mining operations. The following halogenated solvents were studied in view of their usefulness and their flame retardant property: tetrachloroethylene, $Cl_2C = CCl_2$; 1, 1, 2-trichloroethane, ClH_2CCHCl_2; and trichloroethylene, $Cl_2C = CHCl$. The hydraulic fluids studied were representative of five groups approved by the Mine Safety and Health Administration for underground operation, namely: glycol-water solutions, mineral oil-water emulsions, synthetics other than phosphate esters, synthetic phosphate esters, and mixures of phosphate esters with mineral oils and other ingredients. It was observed that the partially halogenated solvents present a greater potential toxic hazard than the fully halogenated materials, due not only to the easy production of hydrogen chloride but also to their ease of oxidation leading to the formation of phosgene and carbon monoxide. The pure phosphate esters exhibited the best thermal oxidative stability of the five groups of hydraulic fluids tested. A fluid containing phosphate esters mixed with mineral oils and other unidentified ingredients appeared to be the most hazardous on the basis that it produced very toxic acrolein and phosphine.

RI 8518. Selective Extraction of Metals From Pacific Sea Nodules With Dissolved Sulfur Dioxide, by S. E. Khalafalla and J. E. Pahlman. 1981. 26 pp. 7 figs. In support of its goal to maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines has investigated a novel hydrometallurgical system with sulfur dioxide. Differential leaching with dissolved SO_2 of

manganese, nickel, and cobalt from their hydrous oxides was found to be very rapid and efficient—almost instantaneous and quantitative. In this method a given weight of mixed oxides previously ground to minus 200-mesh is slurried with a leach solution containing a specified quantity of dissolved SO_2 for 10 minutes at room temperature and ambient pressure. An empirical leaching parameter, R, is defined as the ratio of the number of SO_2 moles in the leaching solution to the weight of the metal oxide charge. Plots of the variation of metal extraction with the ratio R generate a series of sigmoidal-shaped curves, each of which is characteristic of a specific metal extraction. A threshold value of R is required to initiate the leaching of a given metal from the mixed oxides. Once this threshold is reached, the metal recovery can increase to more than 95 pct in very short times.

RI 8519. Effects of Humidity on Salt Mine Dust: A Preliminary Report, by J. C. Volkwein, R. P. Vinson, and E. D. Thimons. 1981. 9 pp. 3 figs. A preliminary study was conducted by the Bureau of Mines to determine the effect of humidity on salt mine airborne dust levels. Results showed less dust where the humidity was elevated. Dust reductions appeared to be dependent on the equilibrium between humidity and salt.

RI 8520. Alternative Methods for Copper Recovery From Dump Leach Liquors, by B. W. Madsen and R. D. Groves. 1981. 17 pp. 7 figs. The Bureau of Mines conducted large-scale laboratory copper ore leaching tests to enable improving copper recovery from large dump-leaching operations. This was done by comparing leaching progress when copper was recovered from recycled leach liquor either by cementation or by solvent extraction. Copper was leached from 7-ton ore samples at room temperature using pH 2 ferric sulfate solutions. With ore samples containing 11 percent minus 0.5-inch fines, no marked advantage in using either of the copper recovery methods was evident after 416 days of leaching. With ore containing 32 percent minus 0.5-inch fines, solvent extraction of copper was advantageous in that 60 percent of the copper was extracted after 568 days, whereas only 48 percent of the copper was extracted when cementation was used. Less acid was consumed during leaching when solvent extraction, rather than cementation, was used for copper recovery. Iron, contributed by cementation with scrap iron, plugged the ore bed containing 32 percent fines.

RI 8521. Fire Resistance Test Method for Conveyor Belts, by M. J. Sapko, K. E. Mura, A. L. Furno, and J. M. Kuchta. 1981. 27 pp. 8 figs. A moderately scaled apparatus was developed by the Bureau of Mines to determine the fire resistance characteristics of mine conveyor belts and similar type materials. The design of the apparatus was based upon data obtained in full-scale fire tests and features a radiant panel to preheat the belt and a methane-oxygen ribbon burner to ignite the sample under ventilating conditions in a rectangular duct. The test method overcomes the limitations of existing laboratory-scale methods and provides a measure of both ignitability and flammability in quantitative terms. Flame propagation depended upon such variables as air velocity, ignitor heat flux, and belt width and height in the test chamber. Data are presented for nine belt materials and fire resistance ratings are proposed in terms of the flame spread rate, heat release rate, and the critical ignitor heat flux. The ratings discriminate between the fire hazard posed by different fire-resistant belts and tend to be in reasonable agreement with those obtained in full-scale fire tests.

RI 8522. Low-Pressure Leaching of Duluth Complex Matte, by L. A. Haas, R. B. Schluter, and R. H. Nafziger. 1981. 12 pp. 9 figs. The Bureau of Mines conducted bench-scale leaching tests with recycled spent copper electrolytes and copper-nickel mattes produced from the Minnesota Duluth Complex concentrates. This report describes the first stage of an overall two-stage leach operation. The objective of this research was to determine the matte-leach technology required to convert spent copper elecrolyte into an enriched nickel liquor suitable for a nickel refinery and therefore essentially free of copper, iron, and sulfuric acid. The experimental variables investigated were matte composition, particle size, spent electrolyte content, pulp concentration, oxygenation, temperature, and time. The time required to produce an enriched purified nickel liquor decreased with increasing pulp concentration, temperature, and oxygenation, but increased with increasing particle size and electrolyte copper and acid content. Nickel-rich (about 50 g/l) liquors at a pH of about 4 and containing less than 1 g/l of copper and iron were produced at 70° C by leaching minus 325-mesh low-iron (less than 5 pct) matte for 8 hours with spent electrolyte containing 22.4 g/l Cu, 28.9 g/l Ni, less than 0.1 g/l Fe, and 50 g/l H_2SO_4 at a pulp concentration of 1 kg of matte per liter of spent electrolyte. Varying the nickel content of the spent electrolyte from 11 to 101 g/l appeared to have no appreciable influence on the matte leaching characteristics.

RI 8523. Recovery of Lithium From Clay by Selective Chlorination, by C. F. Davidson. 1981. 19 pp. 12 figs. The Bureau of Mines studied the extraction of lithium from lithium-containing clays by chlorination with hydrogen chloride (HCl). In bench-scale laboratory investigations, HCl-H_2O mixtures were used to selectively chlorinate lithium, but not calcium or magnesium, in lithium-containing clays. The addition of calcium carbonate to the clay was found to improve the lithium recovery. Reaction conditions found to affect the lithium recovery were ratio of clay to carbonate, reaction temperature, and HCl concentration. The best conditions for selective chlorination of the lithium were 2:1 clay-carbonate, 750° C, and 20 wt-pct HCl. The experimental results and trends in lithium extraction are explained using thermodynamic relationships.

RI 8524. Electrowinning Zinc From Zinc Chloride in Monopolar and Bipolar Fused-Salt Cells, by S. D. Hill, D. L. Pool, and G. A. Smyres. 1981. 24 pp. 16 figs. To help insure the continued viability of the minerals and materials sector of the U.S. economy, the Bureau of Mines is conducting research and disseminating technology that will result in more efficient minerals extraction. As part of this effort, a process is being investigated that involves an aqueous chlorine-oxygen leaching procedure to treat complex sulfide concentrates to produce $ZnCl_2$. Subsequent fused-salt electrolysis of the $ZnCl_2$ produces high-purity zinc metal. Previous reports described preliminary, small-scale research on the chlorine-oxygen leaching system and fused-salt electrolysis of $ZnCl_2$. This report discusses the details of design, construction, and long-term, continuous operation of both monopolar and biopolar fused-salt cells. The effects of temperature, electrode gap, current density, electrolyte composition,

and electrode configuration on current efficiency and energy consumption were determined for a $ZnCl_2$-KCl-NaCl electrolyte system. Zinc metal was produced at the rate of about 50 lb/day in a monopolar cell which was operated continuously for 60 days with current efficiencies from 85.8 to 98.6 pct and an average power consumption of 2.1 kwhr/lb. Bipolar cells with several different electrode configurations were operated for 90 days. A current efficiency of about 70 pct and power consumption of about 1.7 kwhr/lb of zinc were achieved using a three-electrode-pair, bipolar assembly with a chlorine gas lift pump to circulate electrolyte.

RI 8525. Assessing the Methane Hazard of Gassy Coals in Storage Silos, by John C. LaScola, Joseph E. Matta, and Fred N. Kissell. 1981. 9 pp. 5 figs. The Bureau of Mines investigated coal storage silos to determine how gassy coal must be for methane accumulations in a silo to become hazardous and where such accumulations are likely to occur. Methane concentrations were measured in the open space above the stored coal pile, in the pile, and in the reclaiming area. No methane layering was found in closed-top silos. Reclaiming areas were as gassy as the top part of the silos. Coal samples were collected from the conveyors entering the silos in order to assess the gassiness of the coal. No simple correlation was found between the gassiness of the coal stored and the measured methane concentrations. However, at mines where the average 24-hour gas emissions from the conveyor belt samples was 14 ft^3/ton or more, fans or open tops were used. It appears that a large fraction of the methane released during storage remains in the void space between the coal particles.

RI 8526. High-Temperature Enthalpy and X-Ray Powder Diffraction Data for Aluminum Sulfide (Al_2S_3), by M. J. Ferrante and R. A. McCune. 1981. 10 pp. 1 fig. High-temperature enthalpy and X-ray powder diffraction studies were conducted on aluminum sulfide (Al_2S_3) as part of the Bureau of Mines effort to provide new data for the advancement of mineral technology consistent with environmental preservation and energy conservation Relative enthalpies were measured with a copper-block calorimeter from 298.15 to 879 K. Tabulated values are listed for heat capacity, entropy, Gibbs energy functions, and relative enthalpies between 298.15 and 900 K. Enthalpies were also given in the form of an equation and combined with published data to calculate standard enthalpies of formation and Gibbs energies of formation for reactions of crystalline aluminum with crystalline, liquid, and gaseous diatomic sulfur. The hexagonal, rhombohedral, and cubic phases of Al_2S_3 were identified by X-ray powder diffraction studies, and the indexed powder diffraction patterns of these phases are given. The hexagonal phase was stable to about 852 K and was partially converted to the rhombohedral form at 879 K.

RI 8527. SF_6 Tracer Gas Tests of Bagging-Machine Hood Enclosures, by Robert P. Vinson, Jon C. Volkwein, and Edward D. Thimons. 1981. 10 pp. 10 figs. This Bureau of Mines report presents the results of tracer gas studies conducted at three facilities where bagger hoods had been installed several years ago to remove airborne silica dust from the vicinity of the bagging operator. The studies indicated that for optimum benefits makeup air must be evenly dispersed, the hood enclosures and duct systems must be as airtight as possible, the average intake air velocity of each hood should be at least 200 fpm, and the hoods and duct systems must be properly maintained.

RI 8528. Feed Grade Versus Extraction Correlations on Uranium Ores From New Mexico, by P. L. Placek, A. G. Lawrence, I. L. Nichols, and D.C. Seidel. 1981. 52 pp. 18 figs. Correlations were made on experimental data for four New Mexico ore series to determine relationships between ore grade and uranium extraction during leaching operations. Such relationships provide information needed to predict the long-range supply of minerals to meet national economic and strategic needs. Results show that other ore constituents and gangue materials in addition to uranium grade influence uranium extraction. In general, tailing grades decrease and uranium extraction increases as both H_2SO_4 and $NaClO_3$ concentrations increase. Terminal emf and terminal pH also were studied. Similar trends appeared for all ores; however, specific combinations of results also were observed for individual ores and ore series. Experimental results indicate that uranium extractions are higher for lower uranium feed grades than predicted by other estimates.

RI 8529. Dewatering Florida Phosphatic Clay Wastes With Moving Screens, by L. W. Brandt. 1981. 16 pp. 8 figs. The Bureau of Mines, as part of its mission to effect pollution abatement, conducted research to study various means of dewatering Florida phosphatic clay wastes and reclaiming mined lands. The work was done in cooperation with 10 Florida phosphate companies. During this work, a novel technique to effectively dewater phosphatic clay wastes was developed. The solids contained in the clay waste slurry are slowly compressed by moving wire mesh screens through the system. In a typical application, the screens were moved downward, compressing solids ahead of the screens. The rate of movement of the screens is an important variable in the process. It is believed that the moving screens distort the gel structure of the phosphatic clay system and cause the release of water. Samples of 18 clay wastes, including a high-grade attapulgite from beneficiation plants of the Florida phosphate field, were studied using the method. Typical samples were concentrated from initial solids of 4.7 and 11.9 percent to 16.8 and 25.2 percent, respectively, in 3-1/2 days. The high-grade attapulgite sample was dewatered from 2.7 percent solids to 13 percent solids in the same period.

RI 8530. An Evaluation of Used Aluminum Smelter Potlining as a Substitute for Fluorspar in Cupola Ironmelting, by V. R. Spironello and R. H. Nafziger. 1981. 14 pp. 3 figs. The Bureau of Mines is conducting studies of the slags related to ferrous technology to evaluate acceptable substitutes for the auxiliary flux, mineral fluorspar, in foundry operations. This work is directed toward the Bureau's goal of minimizing the Nation's dependence on scarce and critical minerals. Comparative basic practice cupola (18-inch-ID) trials were made to evaluate a waste material called "used potlining," which contains significant levels of fluorine, sodium, and aluminum in various compounds. Used potlining is recovered from alumina reduction cells after its useful life, and was supplied by the Aluminum Co. of America (Alcoa) to the Bureau for evaluation. The material in the lump and pelletized form (with limestone) provided extremely fluid slags based on visual observation during cupola operation. No adverse effects were found on cupola performance, metal and slag chemistry, the environment, or

mechanical properties of the castings produced. Fluorine recovery in the slag was equal to, or higher than, that of fluorspar; fluorine losses to the scrubber water and solids were lower. The acidity of the scrubber water was somewhat neutralized. No difference was observed in furnace-refractory attack, as determined by the level of magnesia in the slag and visual inspection. The recovery of sodium in the slag, presumably as the oxide, significantly increased slag fluidity, suggesting that less than equivalent fluorine may be required. There was no contamination of the gray iron by the aluminum from the used potlining. Used potlining was completely satisfactory as a substitute for fluorspar in cupola ironmelting.

RI 8531. Insoluble Anodes for Electrowinning Zinc and Other Metals, by E. R. Cole, Jr., and T. J. O'Keefe. 1981. 25 pp. 8 figs. This Bureau of Mines investigation was prompted by the need for a stable anode for electrowinning metals, particularly zinc and copper, from acid solutions. The polarization behavior of Pb-Ag (1 pct Ag) anodes in H_2SO_4 and fluoride solutions was determined as the first step in the development of such an anode. A Luggin capillary, dc power supply, high-impedence voltmeter, and other equipment standard to an electrochemical laboratory were used in this study. It was determined that during polarization, a relatively hard, stable coating of PbO_2 was formed on the surface of the lead-silver anode and the rate of formation of this coating was considerably enhanced by the presence of fluoride ions in solution. Subsequent investigations at the Bureau of Mines Rolla Research Center resulted in the development of a PbO_2-coated titanium (PbO_2-Ti) anode. Results of this effort were presented in Bureau of Mines Report of Investigations 8111. Additional data resulting from extensive testing of the PbO_2-Ti anodes, as well as process improvements and innovations, are included in this report. The anodes were considered generally unsatisfactory for zinc electrowinning because of lower conductivity, higher oxygen overvoltages, and shorter in-cell life as compared with the Pb-Ag anodes now being used in industry. However, the PbO_2-Ti anodes were used successfully to oxidize waste chromium solutions and to electrowin copper.

RI 8532. Beneficiation With Magnetic Fluids, by S. E. Khalafalla and G. W. Reimers. 1981. 21 pp. 8 figs. The Bureau of Mines has used colloidal solutions of magnetite in a magnetic field to segregate nonmagnetic materials such as nonferrous scrap metals and to concentrate precious minerals. Conventional magnetic separation relies on the inherent magnetic susceptibility of the material to be separated and may be designated as magnetic separation of the first kind. When the medium of separation rather than the separated particles are made magnetizable, a new system of gravity separation results. In this new magnetic separation of the second kind, a magnetic fluid rather than air or water acts as the separation medium. The same force that attracts magnetic objects in separations of the first kind also attracts the entire separation medium in separations of the second kind, thereby creating a reactionary force of equal magnitude in the opposite direction. This force, sometimes called the levitation force, can be made to segregate nonmagnetic particles in a flowing stream according to their specific gravity. The technique has been applied to segregate nonferrous metals from automobile and appliance shredders and mixed scraps. The system has also been used to upgrade diamondiferous jig concentrates from certain river gravels in order to facilitate the sorting and recovery of their diamond content.

RI 8533. Laboratory Investigation of Sulfurous Acid Leaching of Kaolin for Preparing Alumina, by A. E. Raddatz, J. M. Gomes, and M. M. Wong. 1981. 15 pp. 4 figs. In an attempt to develop technology to use domestic resources in place of imported bauxite, the Bureau of Mines investigated sulfurous acid leaching to extract alumina from kaolin. The process consists of leaching the calcined kaolin with a 30 wt-pct SO_2 solution at 60° C and 160 psig for 17 hours, filtering the leach slurry, precipitating monobasic aluminum sulfite from the filtrate at 110° C and 60 psig, and decomposing the sulfite in the spent liquid at 150° C and 55 psig to produce crude alumina. Purification of the crude alumina was accomplished using a modified Bayer process. Results from closed-circuit tests employing the sulfurous acid process showed that overall extraction of alumina from kaolin was 67 pct. Production of 1 ton of alumina would require 3.6 tons of calcined kaolin, 0.7 ton of sulfur dioxide, and 8.4 tons of water. After purification by a modified Bayer process, the alumina product contained the following impurities, expressed in weight-percent: Fe_2O_3, 0.009; S, 3.6; SiO_2, 0.07; TiO_2, 0.002; K_2O, 0.017; and P_2O_5, 0.03.

RI 8534. Direct Preparation of Phosphoric Acid From Intermediate-Grade Western Phosphatic Shale, by Philip C. Good, T. N. Goff, and C. B. Daellenbach. 1981. 12 pp. 2 figs. The Bureau of Mines investigated the feasibility of utilizing low-grade phosphatic shale as a feed for phosphoric acid production. Present practice in the phosphate mining operations of southeastern Idaho is to remove and either stockpile or waste low-grade phosphatic shales as the high-grade phosphate beds are selectively mined. Acid digestion studies were performed on uncalcined shale and on shale calcined to remove free carbon to determine phosphoric acid quality, yield, and amenability to filtration. The untreated shale, containing 21.4 pct P_2O_5, was digested with sulfuric acid in a single-tank reactor to yield phosphoric acid and gypsum residue. Although 96 pct P_2O_5 recovery was attained in digesting uncalcined shale, only the calcined product gave satisfactory filtration rates. Calcined shale yielded phosphoric acid recovery of about 93 pct of the contained P_2O_5. It was higher in impurities than commercially prepared acid derived from high-grade western phosphate rock. An acid filtration rate of 745 lb P_2O_5/ft²/day was attained. This value is lower than the rate of 900 lb P_2O_5/ft² that is generally considered to be acceptable in industrial production of phosphoric acid from high-grade phosphate rock.

RI 8535. Treatment of Florida Surface Waters for Use in Phosphate Beneficiation, by D. A. Stanley, B. J. Scheiner, and P. Brown. 1981. 10 pp. 3 figs. The Bureau of Mines conducted laboratory-scale experiments to determine whether or not surface waters with high organic content could be purified sufficiently to be used to replace the natural high-quality deep well water currently being used in the silica flotation step of phosphate rock beneficiation. Waters abundant in organic matter were collected from two central Florida streams, flocculated with a cationic polyethylenimine polymer, and processed in a sand filter. This treatment removed most of the organic materials from the water. Untreated sur-

face water, treated surface water, and distilled water were used to compare the flotation response of the acid insolubles in an amine flotation circuit. Surface water treated with PEI-1000 was shown to be as effective as distilled water for the acid-insoluble-flotation step. Flocculation and filtration can therefore produce water suitable for amine flotation of quartz, which would permit substitution of surface water for deep well water. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8536. High-Pressure Shrouded Water Sprays for Dust Control, by N. I. Jayaraman, F. N. Kissell, W. Cross, J. Janosik, and J. Odoski. 1981. 16 pp. 13 figs. High-pressure shrouded sprays were first tested on a bench to determine air-moving capability and dust collection efficiency. The bench-scale tests indicated that at 500 psi and above, the dust collection efficiency, when sampled downstream of a water eliminator, was about 99 pct for two types of nozzles. However, for the same water flow, the induced airflow was about three times greater in one type than in another. Since the only difference in the nozzles was the spray angle, this factor was important in air movement through a shrouded spray. Full-scale model mine tests were then conducted to determine the reduction in dust concentration behind the line curtain and at the operator position produced by high-pressure sprays in a shroud. The shroud was mounted on top of the boom of a model continuous miner, and high-pressure (greater than 500 psi) sprays were installed inside the shroud. The inlet of dusty air to the shroud was open toward the face and the outlet toward the exhaust line curtain. The high-pressure sprays were compared with conventional sprays mounted at the head of the continuous miner and directing water toward the face. The difference at the operator position (opposite side of brattice) was significant in that, under certain conditions, with conventional sprays an increase in respirable dust concentration of 471 pct was noticed compared with dry operation due to rollback from face. High-pressure shrouded sprays, on the other hand, decreased the dust concentrations at the operator position (opposite side of brattice) by 28.2 pct.

RI 8537. Wear Properties of Electrodeposited Titanium Diboride Coatings, by D. R. Flinn, J. A. Kirk, M. J. Lynch, and B. G. Van Stratum. 1981. 30 pp. 13 figs. A newly developed chemical conditioning technique, which greatly simplifies the preparation of plating baths for the electrodeposition of titanium diboride (TiB_2) coatings, is described in this report. The new plating technique was used to prepare samples of titanium diboride (TiB_2) coatings on three types of substrate materials. These samples were then evaluated in both low- and high-speed wear-test programs to determine the wear resistance, microhardness, and adhesion of the coatings. In general, it was found that the wear resistance of the coatings is independent of substrate. Scanning electron micrographs have shown that the coating wear surfaces are very smooth, suggesting slow and continuous removal of the coating during the wear test (that is, adhesive wear). Adhesion between the coating and all substrates was excellent. Microhardness results show that the TiB_2 coating is harder than alumina, with a hardness value exceeding 5,000 kg/mm^2 measured in one test. The results of the wear tests show that TiB_2 coatings have relatively poor wear resistance compared with alumina in low-speed unlubricated sliding environments, but exhibit wear properties comparable with alumina in high-speed unlubricated sliding environments.

RI 8538. Suppression of Coal Dust Explosion by Water Barrier in a Conveyor Belt Entry, by I. Liebman and J. K. Richmond. 1981. 27 pp. 10 figs. The Bureau of Mines conducted experiments on coal dust explosion suppression. The investigation took place on a beltway in the double-entry of the Bureau's Experimental Mine. Using conditions that simulate those in a working mine, the investigation showed that a coal dust explosion can be readily initiated in a conveyor belt entry. Also, the explosion can spread into adjacent entries through opened crosscuts (stopping destroyed by explosion) to propagate for long distances even though the adjacent entries are rock dusted in compliance with regulations. Passive water barriers (water-filled tubs) were found to be effective in suppressing explosions on a beltway; however, barrier efficiency was reduced by opened crosscuts. The study indicated that the beltway barrier should be the distributed type consisting of continuous rows of water-filled tubs covering long distances along the entry. A plan is outlined for the installation of a water barrier system in a working coal mine for the protection of a beltway.

RI 8539. Hydrogen Sulfide Generation by Reaction of Natural Gas, Sulfur, and Steam, by S. R. Crane, Laird Crocker, and W. I. Nissen. 1981. 54 pp. 17 figs. One Bureau of Mines goal is to minimize the undesirable environmental impacts associated with industrial plants emitting waste gases containing SO_2. To help meet this goal, a regenerable flue gas desulfurization process was developed. This process, known as the citrate process, uses a buffered weak acid solution to absorb SO_2 from the waste gas. The absorbed SO_2 is reacted with H_2S to precipitate elemental sulfur and regenerate the solution for recycle. The H_2S feedstock for the process, if not otherwise available, may be produced by reacting two-thirds of the recovered elemental sulfur with natural gas and steam. Laboratory investigations and pilot plant operations were conducted by the Bureau to determine if H_2S from the natural gas, sulfur, and steam reaction was suitable for the citrate process. The laboratory investigations, in which an H_2S generator was integrated with other citrate process operations, provided a basis for design and operation of the pilot plant. The objective of the pilot plant was primarily to provide H_2S for the citrate process pilot plant at the Bunker Hill Co. lead smelter in Kellogg, Idaho. The design capacity of the pilot plant was 0.4 to 1.25 tons of H_2S per day. The operation demonstrated that (1) a 77- to 79-dry-volume-percent H_2S product could be produced from pilot-plant product sulfur, natural gas, and steam; (2) the product H_2S regenerated the SO_2-loaded citrate solution; and (3) under certain conditions over 95 percent of the natural gas could be converted to H_2S.

RI 8540. The Chemical Reactions of Sulfur in the Citrate Process for Flue Gas Desulfurization, by W. N. Marchant, S. L. May, B. W. Moore, and W. W. Simpson. 1981. 23 pp. 7 figs. The Bureau of Mines performed chemical research to elaborate details of sulfur chemistry pertaining to the citrate flue gas desulfurization process in which sulfur dioxide (SO_2), absorbed (as bisulfite ion) in a buffered

sodium citrate solution, is reduced by hydrogen sulfide (H_2S) according to the overall reaction $2H_2S+HSO_3^-+H^+ \rightarrow 3S+3H_2O$. The rate-limiting step in the process was shown to be the reduction by H_2S of thiosulfate ($S_2O_3^{2-}$) that is formed as an intermediate. Pseudo first-order kinetic measurements were made at room temperature to retard the reaction sufficiently that adequate analysis was possible.

RI 8541. An Investment Mold for Titanium Casting, by E. D. Calvert. 1981. 35 pp. 16 figs. The Bureau of Mines, in its effort to promote greater utilization of domestically abundant materials, conducted research on an alternate mold material that has commercial potential for titanium investment casting. Using variations of the conventional lost wax molding process, investment shell molds were formed entirely of fused, calcia-stabilized ZrO_2 and a ZrO_2-forming binder. Optimization of binder/slurry properties, stucco grain size and distribution, and curing practices resulted in a structurally sound investment shell that was distortion free and thermally stable. Small titanium castings, weighing up to 10 pounds, were prepared in unheated molds by both static and centrifugal casting techniques. Microstructural examination of the castings revealed that mold fill and surface quality were enhanced by centrifugal casting, although good results also were obtained from the statically poured molds. Microstructural and electron microprobe examinations showed that excessive, brittle case formation could be avoided by curing the dried shell molds in air for at least 2 hours at 1,400° C. Increasing curing temperature and time above these levels yielded added benefits. Molds fired in vacuum at 1,500° C for 4 hours yielded castings essentially free of case formation. The tensile properties of as-cast test specimens (no surface conditioning performed) and the chemical composition of representative metal samples showed that castings produced were comparable to Grades C-1 and C-2 unalloyed titanium. This indicated that no significant degradation of metal properties resulted from mold/metal interaction.

RI 8542. Three Bureau of Mines Optical Dust Probes, by Kenneth L. Cashdollar, Israel Liebman, and Ronald S. Conti. 1981. 26 pp. 19 figs. This report describes three types of optical dust probes that have been designed, built, and tested by the Bureau of Mines. Each of the probes measures dust cloud concentrations by the attenuation of light. The first is a single-path-length probe, the second is a double-path-length probe, and the third is a single-path-length probe that employs jets of air to keep the windows of the light source and detector free from dust coating. The theory of operation and the calibration procedures for each of the probes are described. The results of the Bureau's laboratory, mine, and field tests of the probes are also reported.

RI 8543. Behavior of Cadmium During Roasting of Zinc Concentrate, by Arne Landsberg, D. H. Yee, H. W. Leavenworth, Jr., and J. L. Henry. 1981. 17 pp. 10 figs. The Bureau of Mines has undertaken research to elucidate the chemistry involved in the efficient recovery and control of minor elements in base metal smelting operations. These elements should be effectively recovered not only because they have commercial value, but also because of their potential hazard to workers' health and the environment, if they are not controlled during processing. Cadmium, a minor metal in zinc ores, is the subject of this report. The roasting step of the complex zinc-smelting process was chosen for investigation because of the high potential for removing cadmium by volatilization during this primary stage. Commercial roaster feed materials were used to determine the sequence of reactions and the effect of these reactions on the volatilization of cadmium. Electron microprobe examination of both the commercial roaster product and oxidized sulfide solid solutions prepared in the laboratory showed that oxidized iron was of prime importance in preventing cadmium volatilization. The mechanism by which iron prevents cadmium volatilization is proposed, and a preheating technique is recommended for more effectively recovering cadmium prior to roasting.

RI 8544. Design Parameters for Oil Shale Waste Disposal Systems, by R. A. Bloomfield and B. M. Stewart. 1981. 38 pp. 17 figs. This report summarizes Bureau of Mines contract research on the disposal of retorted oil shale. A data base has been developed describing the physical-chemical properties, geotechnical engineering properties, and natural cementation characteristics of spent shale. Results of field compaction tests and seepage pond tests are presented, along with results of a partially saturated finite element seepage model used to predict infiltration and seepage rates. Preliminary engineering analyses are presented for underground disposal systems, which include material transport methods, and for a surface disposal system, which includes stability analyses.

RI 8545. Modified-Sulfur Cements for Use in Concretes, Flexible Pavings, Coatings, and Grouts, by W. C. McBee, T. A. Sullivan, and B. W. Jong. 1981. 24 pp. 12 figs. A family of modified-sulfur cements has been developed by the Bureau of Mines for the preparation of construction materials with improved properties. Various types of sulfur cements were prepared by reacting sulfur with mixtures of dicyclopentadiene (DCPD) and oligomers of cyclopentadiene (CPD). Durable cements were prepared with structural characteristics ranging from rigid to flexible. These cements were used to prepare corrosion-resistant materials for use in a wide variety of industrial applications where resistance to acidic and salt conditions is needed. These materials were prepared as rigid concretes, flexible pavings, spray coatings, and grouts. Production of modified-sulfur cements in a commercial-size plant was demonstrated.

RI 8546. Effect of Additives on Sintering of Silicon Nitride-Alumina-Aluminum Nitride Compositions, by B. W. Jong and H. Heystek. 1981. 14 pp. 4 figs. As part of the Bureau of Mines program to develop substitutes for critical and strategic materials for metallurgical applications, the Tuscaloosa Research Center has evaluated the effects of additives and starting materials on the sintering and strength properties of sialon (silicon-aluminum-oxynitride) compositions fabricated by conventional pressing and sintering techniques. Sintering and MOR (modulus of rupture) data were developed for sialon compositions produced from three components, Si_3N_4, Al_2O_3, and AlN. When doped with Y_2O_3 to aid in sintering, the highest MOR values were obtained with compositions containing between 20 and 30 mole-pct (Al_2O_3 + AlN). The effect of the crystalline phase of the Si_3N_4 and Al_2O_3 used in the three-component system on MOR was investigated. Alpha-Si_3N_4 and γ-Al_2O_3 were found to be the best starting

materials. A sialon composed of 67.4 mole pct α-Si_3N_4 plus 32.6 mole-pct (γ-Al_2O_3 + AlN), doped with 5 wt-pct Y_2O_3, had MOR values at 25°, 1,200°, and 1,400° C of 40,300, 40,300, and 31,100 psi, respectively. Samples of this composition doped with Gd_2O_3, MgO, ZrO_2, and $ZrSiO_4$ also were evaluated. The $ZrSiO_4$-doped sialon had higher MOR values than Gd_2O_3-, MgO-, and ZrO_2-doped materials but lower MOR values than the Y_2O_3-doped sialon. The MOR values of $ZrSiO_4$-doped sialons were 25,000 and 25,900 psi, respectively, at 25° and 1,400° C.

RI 8547. A Mixed Kinetics Dump Leaching Model for Ores Containing a Variety of Copper Sulfide Minerals, by B. W. Madsen and M. E. Wadsworth. 1981. 44 pp. 14 figs. To help maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines developed a mathematical model that describes acidic ferric sulfate leaching of copper from sulfide ores The leaching model can aid in maximizing minerals and metals recovery from primary sources by giving operators and management a better understanding of the copper leaching process. This will aid in improving dump leaching operations. The model is based on a steady-state approximation of the continuity equation for diffusion of ferric ions in the rock pores and the intrinsic leaching kinetics of the various sulfide mineral particles. Ore characteristics included in the model were ore particle-size distribution, particle shape, grade, mineral content, mineral particle size, porosity, and tortuosity. The continuity equation was used with ferric ion concentration gradients and a fixed value for the diffusion coefficient. Except for effective diffusivity, each of these factors was either measured experimentally or estimated from theoretical considerations. The effective diffusivities were determined by fitting calculated leaching curves with experimental leaching data. Vertical variations in leach solution composition and temperature within a dump are not considered in this model. The model accurately predicted copper extractions for several large-scale tests during nearly 500 days of leaching.

RI 8548. An Apparatus and Procedure for Calibrating a Water Vapor Analyzer in the 0.1- to 15-ppm Range, by Harold L. Rhodes. 1981. 8 pp. 5 figs. The Bureau of Mines has developed a quantitative method to determine water vapor in helium in the range of 0.1 to 15 ppm by volume. This method uses the quantitative chemical reaction of H_2O with CaH_2, which produces 1 mole of hydrogen for each mole of H_2O in the sample. A gas chromatograph is then used to determine the concentration of hydrogen in the product. The precision of the H_2O analysis is ± 0.05 ppm at a concentration of 1 ppm. This method is used to calibrate a commercial platinum-phosphorus pentoxide (Pt-P_2O_5) electrolytic water vapor analyzer that has an improved inlet system and digital voltmeter readout. Research at the Tuscaloosa Research Center is carried out under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8549. Reduction Roasting and Beneficiation of a Hematitic-Geothitic Taconite, by R. E. Peterson and A. F. Colombo. 1981. 20 pp. 6 figs. A reduction roasting-magnetic separation-flotation process for beneficiating oxidized taconite from the western Mesabi iron range in Minnesota was evaluated in a Bureau of Mines research program to insure an adequate supply of raw materials for future ironmaking and steelmaking needs. The research was performed on a sample containing 35.4 pct iron and representing a deposit of approximately 2 billion tons of raw materials. An average of 1,419 lb of oxidized taconite and 37 lb of lignite reductant per hour were fed to a 35-foot rotary kiln in which the iron oxides were converted to artificial magnetite. The kiln was heated with pulverized lignite and natural gas. Most of the dust collected from the kiln exhaust was pelletized and recycled to the kiln. Magnetic separation and cationic flotation of the roasted material in a 900-lb/ft pilot plant produced a concentrate analyzing 67.9 pct iron and 4.9 pct silica and containing 69.2 pct of the iron in the kiln feed.

RI 8550. Recovery of Aluminum Hydroxy Sulfate From Aluminum Sulfate Solution by High-Temperature Hydrolysis, by D. E. Shanks, J. A. Eisele, and D. J. Bauer 1981. 10 pp. 4 figs. As part of its program to lessen dependence on foreign bauxite as the Nation's primary source of cell-grade alumina, the Bureau of Mines is investigating sulfuric acid (H_2SO_4) leaching procedures for the recovery of alumina from domestic aluminous materials. The successful application of a H_2SO_4 leaching process depends on the recovery of the aluminum values in an easily washed and filtered form, containing a minimum of water to be driven off in the subsequent calcination step. This goal was met by the high-temperature hydrolysis of simulated aluminum sulfate [$Al_2(SO_4)_3$] leach liquor. Crystalline, insoluble aluminum hydroxy sulfate [Al(OH)SO_4], which had a water-to-alumina mole ratio of 1:1, was produced. Eighty-six percent of a solution containing 127 g of $Al_2(SO_4)_3$ per liter and 76 pct of a solution containing 336 g of $Al_2(SO_4)_3$ per liter was hydrolyzed to insoluble aluminum hydroxy sulfate by autoclaving for 1 hr at 320° C and rapidly quenching to room temperature. Higher operating temperatures were precluded by corrosion of the autoclave. The yield of aluminum in the hydrolysis product increased with the increasing hydrolysis temperature and decreasing $Al_2(SO_4)_3$ concentration.

RI 8551. Structure Study of a CF_2BR_2-Inhibited Methane Flame. Effect of CF_2BR_2 on Composition, Net Reaction Rates, and Rate Coefficients, by J. F. Papp, C. P. Lazzara, and J. C. Biordi. 1981. 32 pp. 22 figs. The microstructures and a CF_2Br_2-inhibited methane flame and its uninhibited analog have been determined using molecular beam-mass spectrometry. The slightly lean flames were stabilized on a cooled porous plug burner at reduced pressure. Composition profiles of stable, intermediate, and radical species and temperature profiles revealed the following inhibition effects; a shift of the primary reaction zone to higher temperatures, a higher maximum flame temperature, an increase in the CH_3 concentration, and a reduction in the H_2CO, H, O, and OH concentrations. Kinetic analyses of the data yielded rate coefficients at flame temperatures for the reactions $H + CH_4 \rightarrow CH_3 + H_2$, $H + O_2 \rightarrow OH + O$, $CO + OH \rightarrow CO_2 + H$, and $CH_3 + O \rightarrow H_2CO + H$. CF_2Br_2 is judged to decay by thermal decomposition and abstraction reactions.

RI 8552. Beneficiation of Western Mesabi Range Oxidized Taconites. A Comparison of the Anionic and Cationic Flotation Systems and an Evaluation of Potential Iron Ore Reserves, by Howard D. Jacobs. 1981. 21 pp. 6 figs. A bulk sample of oxidized taconite taken from the western Mesabi Range was evaluated by the Bureau of Mines using the Bureau-developed

selective flocculation-desliming-cationic (or anionic) flotation process. The raw ore sample containing 32.3 pct Fe was treated by both cationic and anionic flotation. Using the cationic system the concentrates averaged 37.2 wt-pct of the feed and contained 62.8 pct Fe and 4.7 pct SiO_2 with an iron recovery of 72.3 pct. With the anionic system, concentrates averaged 37.7 wt-pct of the feed and contained 63.0 pct Fe and 5.3 pct SiO_2 with an iron recovery of 73.5 pct. A comparison of reagent costs showed that the cationic process cost 144.1 cents per long ton of crude ore and the anionic process 178.7 cents per long ton of crude ore. Reclaimed water comprised 86 pct of the total water requirement for anionic flotation and 88 pct for cationic flotation. The ore used in this study was one of three samples representing about 3.25 billion tons of oxidized taconite containing from 32 to 36 pct feed iron. Previous study had indicated that selective flocculation-desliming-cationic flotation would produce concentrates from the other two samples of 61.7 pct Fe and 5.1 pct SiO_2 at 67-pct Fe recovery, and 63.5 pct Fe and 4.3 pct SiO_2 at 85-pct Fe recovery. By developing a successful treatment for these ores, the Bureau has insured the availability of technology for processing an amount of raw iron ore which, by itself, would supply U.S. iron needs for 50 to 75 years at expected consumption rates.

RI 8553. Beneficiation of Potential Platinum Resources From Southeastern Alaska, by D. C. Dahlin, A. R. Rule, and L. L. Brown. 1981. 14 pp. 2 figs. The Bureau of Mines conducted laboratory batch beneficiation tests on samples from four potential platinum resources in southeastern Alaska to concentrate platinum and other precious metals. This investigation was done as part of the mission of the Bureau to insure an adequate supply of minerals to meet the Nation's needs. Petrographic studies and beneficiation methods including gravity concentration, froth flotation, and magnetic separation were used to determine mineral association and to attempt to concentrate the platinum values with a primary mineral value such as chromite, copper sulfide, or magnetite. A high-graded sample from the Salt Chuck copper sulfide deposit yielded the best platinum-group metal concentrate; the maximum grade attained was 0.04 oz Pt and 1.5 oz Pd per ton of high-grade copper sulfide concentrate. The other samples yielded low-grade mineral concentrates with low platinum-group values, and/or the platinum-group metals did not concentrate with the primary mineral value.

RI 8554. Copper Recovery From Primary Smelter Dusts, by W. E. Anable, J. I. Paige, and D. L. Paulson. 1981. 19 pp. 8 figs. The Bureau of Mines researched methods for recovering copper from cyclone and electrostatic-precipitator dusts of primary copper smelters as part of its program to maximize minerals and metals recovery from primary and secondary domestic resources. Small-scale studies showed that use of 110 pct stoichiometric sulfur and 123 pct stoichiometric carbon, based on producing a 40-pct copper-iron matte, resulted in the recovery of 95 pct of the copper contained in the dust. Typical mattes contained less than 10 pct of the arsenic, 30 pct of the bismuth, and 45 pct of the antimony and tin contained in the dust. Matte was converted to blister copper by injecting up to 200 pct of the stoichiometric oxygen requirement over a period of 2 to 3 hours. Up to 76 pct of the copper contained in the dust was recovered as a crude blister copper containing about 2 pct arsenic, 0.5 pct antimony, and less than 0.1 pct bismuth and tin. A matte-white metal product resulted from carbothermically reducing dust with coal, lime, and silica. Up to 95 pct of the copper was recovered in the combined product.

RI 8555. The Geologic Character of Some Coal Wants at the Westland Mine in Southwestern Pennsylvania, by Noel N. Moebs. 1981. 25 pp. 25 figs. The coal wants at the Westland Mine in southwestern Pennsylvania consist chiefly of elongated, sandstone-filled channels with slickensided basal contacts. Tentatively identified as washouts, these channels are about 1,000 feet long and 300 feet wide, are erratic in occurrence and trend, and are difficult to delineate from the customary core drilling pattern. Roof conditions are hazardous adjacent to the washout contact, but roof stability is generally unaffected greater than 30 feet away.

RI 8556. Consolidation of an Iron-Base Superalloy by Powder Metallurgy Techniques, by J. F. McIlwain, and L. A. Neumeier. 1981. 22 pp. 16 figs. As part of its goal to minimize the requirements for critical materials, the Federal Bureau of Mines has investigated the consolidation of an iron-base superalloy (20 pct Cr, 5 pct each Ni and Mn, 1 pct each C, W, Mo, and Cb, and the balance Fe) and its modifications by powder metallurgy (P/M) techniques. Vacuum-atomized, prealloyed powder was used. Consolidation was by sintering of cold-pressed alloy powder, or by forging plus rolling or extrusion of canned powder. Several commercial lubricants were evaluated in the pressing operation. At 50-tsi compacting pressure with up to 3 wt-pct lubricant, green strengths did not exceed 1,000 psi. Powder sintered just below the solidus temperature attained a tensile strength of 69,000 psi and 4 pct elongation. Liquid-phase sintering produced higher densities, lower tensile strengths, and nil ductibility. Canned powder was forged and rolled at 1,200° C, yielding a 100-hr rupture strength of 9,800 psi at 815° C and a room-temperature tensile strength of >130,000 psi at 6 pct elongation. Heat treatment of modified P/M iron-base alloy containing 0.63 pct C resulted in a 100-hr ruptured strength of 17,000 psi. Oxidation resistance at 805° to 815° C of the forged and rolled P/M iron-base alloy was similar to that of the cast iron-base alloy and superior to conventional stainless steels.

RI 8557. Ceramic Mold Inserts for Use in Ferrous Diecasting, by E. G. Davis and G. V. Sullivan. 1981. 27 pp. 16 figs. A research program to evaluate the use of ceramic die inserts for ferrous diecasting was initiated by the Bureau of Mines at its Tuscaloosa Research Center. Data were compiled from the literature to characterize selected ceramic materials with respect to thermal properties, thermal-shock resistance factors, chemical reactions with molten metals, and processes required to form die components. With this information and a computer model developed for predicting temperature and stress patterns induced in ceramic materials during simulated ferrous diecasting operations, 27 candidate materials were evaluated. After evaluation, only 15 were considered for testing in an apparatus constructed to immerse the ceramic specimens in molten cast iron. Of these, 13 were tested in a modified testing unit in which cast iron was poured onto the specimens. These tests resulted in the selection of three materials for further testing: boron carbonitride (50 pct B_4C:50 pct BN), boron nitride-grade M (BN-M, 40 pct BN, 60 pct SiO_2), and pyrolytic

boron nitride (PBN). Tests in a gravity-flow die unit showed that PBN was thermal-shock resistant and could be used in diecasting of ferrous metals. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8558. Evaluation of Synthetic Fluorspar in BOF Slags, by H. W. Kilau, V. R. Spironello, I. D. Shah, and W. M. Mahan. 1981. 28 pp. 9 figs. The Bureau of Mines evaluated synthetic fluorspars as substitutes for natural fluorspar in basic oxygen steelmaking using a high-temperature rotational viscometer and a quarter-ton basic oxygen furnace (BOF). Considerable variation in stability and BOF slag fluidizing properties were found when using the initial synthetic products, but improved synthesis methods produced synthetic fluorspars that were generally comparable to natural fluorspar in laboratory testing. Trials in the furnace showed the synthetic products to be operationally the equivalent of natural fluorspar. Higher sulfur and phosphorus contents in some of the synthetic materials did not adversely affect the steel chemistry. Analyses of wet scrubber samples showed evidence that the pelletized synthetic fluorspars experienced greater physical and chemical disintegration than did natural fluorspar. It was also found that operation of a BOF without fluorspar is possible when making low-carbon steels because iron oxide is intrinsically generated as the slag fluidizer.

RI 8559. Polymeric Concentration Determined by Drag Reduction, by Jalna R. Zatko. 1981. 11 pp. 6 figs. The Bureau of Mines has developed and constructed an apparatus that is capable of measuring concentrations of high-molecular-weight polymers in solution at 10 ppm and less. A means for determining low concentrations of polymeric solutions was devised that was independent of slight fluctuations in solvent quality in order to measure polymers in effluent prior to recycling of the recovered solution. The concentrations of polymers are related to a measured pressure drop observed during turbulent flow of the solution. Low concentrations of polymers of ethylene oxide and acrylamide (frequently used as flocculants for clay waste systems) in aqueous and salt solutions have been successfully measured on the apparatus constructed by the Bureau. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8560. The Removal of Iron From Aluminum Chloride Leach Liquor by Solvent Extraction, by Roy T. Sorensen, Earle B. Amey III, and Dwight L. Sawyer. 1981. 28 pp. 12 figs. As part of its mission to maintain an adequate supply of minerals to meet national needs and maximize mineral production from domestic sources, the Bureau of Mines is investigating the recovery of alumina by hydrochloric acid leaching of kaolinitic clay. Most iron impurities are leached from the clay along with the alumina and must be removed before or during crystallization to aluminum chloride hexahydrate. The thermal decomposition step then provides an alumina product of acceptable iron analysis. Miniplant studies of a Bureau-developed solvent extraction technique, using a tertiary amine in kerosine diluent, have demonstrated that the iron content in aluminum chloride leach liquors can be reduced to levels of less than 0.007 wt-pct (7 ppm), expressed as Fe_2O_3. Entrained and dissolved organic matter in the purified pregnant leach liquor from the solvent extraction circuit can be reduced to less than 2 ppm by using a fabric-packed coalescer and subsequent activated carbon treatment. Investigators discovered that a steady buildup of zinc accumulated in the solvent phase within the extraction circuit, proportional to the amount of leach liquor treated. The solvent phase zinc analysis increased by 0.01 wt-pct ZnO for each 1,000 gal of pregnant leach liquor purified.

RI 8561. Recovery of Copper and Associated Precious Metals From Electronic Scrap, by H. B. Salisbury, L. J. Duchene, and J. H. Bilbrey, Jr. 1981. 16 pp. 8 figs. As a part of a research program designed to help minimize national requirements for new mineral commodities by maximizing recovery of metals from domestic secondary resources, the Bureau of Mines investigated the development of economic methods for recovering copper and associated metals from complex electronic scrap. Three types were selected for research: (1) multiple-pin plugs and connectors, (2) obsolete aircraft radio assemblies, and (3) the magnetic fraction of shredded electronic scrap furnished by the Bureau's Avondale Research Center. The plugs and connectors, after incineration to remove plastic components and melting, yielded a brittle ingot, as did the internal portion of the radio assemblies. The brittle ingots were ground to minus 35-mesh for processing, and the magnetic material was used in the as-received condition. A process using pretreated or raw scrap as a copper precipitant in various concentrations of acidulated copper sulfate solution was developed as a means of effecting an initial separation and upgrading in the form of high-grade cement copper containing all or most of the precious metals.

RI 8562. Characterization and Beneficiation of Phosphate-Bearing Rocks From Northern Michigan, by L. L. Brown, A. R. Rule, and C. B. Daellenbach. 1981. 16 pp. 10 figs. As part of the Federal effort to help maintain an adequate supply of fertilizer materials, the Bureau of Mines conducted research to characterize complex low-grade Michigan phosphate materials and to devise methods for recovering fertilizer-grade phosphate concentrates. The rock is from middle Precambrian sedimentary formations in the Marquette Range located in the central part of the Upper Peninsula of Michigan. Occurrence of phosphate-bearing sediments in Precambrian rocks is rare. This deposit, containing 12 to 15 pct P_2O_5, is believed to be the richest Precambrian phosphate deposit in the United States. Petrographic examination showed that the conglomeritic rock contains crystalline apatite both in "black pebbles" and in quartz matrix. Attrition scrubbing and sizing tests showed that there is no tendency for phosphate to concentrate in any of the sized fractions. In beneficiation tests, which included grinding to minus 325 mesh followed by phosphate mineral flotation using a fatty acid-fuel oil collector, a phosphate concentrate was obtained that had a grade of 30 pct P_2O_5 and a P_2O_5 recovery of 72 pct. This concentrate should be suitable for fertilizer manufacture.

RI 8563. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Oregon and Washington, by G. M. Martinez, J. M. Gomes, and M. M. Wong. 1981. 14 pp. 4 figs. The Bureau of Mines has investigated methods for the recovery of byproduct heavy minerals from sand and gravel operations in Oregon and Washington. These heavy

minerals are not currently recovered except for gold in a few areas. The recovery of byproduct heavy minerals would provide a domestic source of minerals presently imported, and a more efficient use of domestic resources would be accomplished. Samples from more than 40 locations were treated by gravity separation to yield heavy mineral concentrates (black sands). Magnetite, ilmenite, zircon, rutile, chromite, platinum-group minerals, radioactive minerals, and gold were identified in the concentrates. Individual zircon, ilmenite, chromite, magnetite, and gold products were recovered from selected concentrates by low- and high-intensity magnetic, high-tension, and heavy-medium separation techniques. The recovery for the individual mineral products ranged from 67 to 95 pct.

RI 8564. Factor of Safety Charts for Estimating the Stability of Saturated and Unsaturated Tailings Pond Embankments, by D. R. Tesarik and P. C. McWilliams. 1981. 97 pp. 173 figs. The factor of safety, the traditional measure of stability for earth embankments, is graphically presented in factors of safety charts in this Bureau of Mines report. Factor of safety contours are drawn for homogeneous earth embankments for two contrasting situations: (1) no phreatic surface and (2) a phreatic surface that assumes 10-pct freeboard. The factor of safety can be read directly from the charts if the physical properties of the soil and the geometry of the embankment are known. The curves provide a quick first approximation of the "most stable" and "least stable" condition of the embankment. The Simplified Bishop Method was used for the safety factor calculations, and a sequence of least squares curve fitting steps was used to present the factor of safety in final chart form.

RI 8565. Corrosion Resistance of Materials in the Aqueous Hydrochloric Acid Environments Associated With the Recovery of Aluminum From Kaolinitic Clays, by B. S. Covino, Jr., M. Rosen, and W. D. Riley. 1981. 28 pp. 10 figs. The Bureau of Mines has conducted a laboratory and field corrosion testing program to determine materials of construction for the leaching and gas-sparging crystallization environment of the clay-HCl process in order to more fully utilize the alumina from domestically available kaolinitic clays. Laboratory tests were used to determine the corrosion rates of 22 metals and alloys by weight-loss measurements in these two environments of the process. The results of this laboratory study were used both to suggest metals and alloys for field testing and to determine the effect of the individual solution components on the corrosion behavior of the metals and alloys. Results from the field tests were used to recommend Ta, Ta-2.5W, and Ta-10W for construction of the agitators for the leaching process. The metals and alloys recommended for construction of the gas-sparging crystallizer heat exchangers were Ta, Ta-2.5W, Ta-10W, Nb, Nb-1Zr, Nb-3Zr, Nb-28Ta-10W-1Zr, Nb-10Hf-1Ti, and Zr for the first stage and Ta, Ta-2.5W, Ta-10W, Nb-28Ta-10W-1Zr, Nb, Nb-10Hf-1Ti, and Zr for the second stage.

RI 8566. An Algorithm for Determining Debye Temperatures, by R. P. Beyer. 1981. 5 pp. As part of its thermodynamic investigations of mineral compounds, the Bureau of Hines has written an algorithm based on Newton's method for solving for the characteristic Debye temperature of a compound, from heat capacity and temperature data. A listing of a FORTRAN IV program based on this algorithm, for calculating Debye temperatures given heat capacities or for calculating heat capacities given Debye temperatures, is available from the author upon request.

RI 8567. Evaluation of the Seismic System for Locating Trapped Miners, by John Durkin and Roy J. Greenfield. 1981. 55 pp. 33 figs. This report discusses the configuration and system deployment for the postdisaster surface seismic system for detecting and locating trapped miners. It analyzes the results of 15 field tests to define a signal model, background noise levels, and subarray performance. A waveform modeling procedure is described and compared with observed waveforms. The resulting similarity indicates that the major factors affecting the signal amplitude, waveform, and spectral character are understood. A model is presented which gives the signal amplitude as a function of source type, source depth, and horizontal offset between source and receiver. Using this model a curve is presented which gives the range at which a signal will be detected for different signal and noise levels. Finally, and most important relative to the mission of the system, the ability of the system to detect signals on one or more subarrays is put into a probabilistic framework. For a strong source it is almost certain that a subarray directly over the source will detect the signal. After signal processing, it is highly likely that signals will be detected on sufficient subarrays to locate the trapped miner. Location errors have been found to be less than 100 ft in the majority of cases. Techniques have been used that can reduce the location errors to this level even when soil layer variation between subarrays is severe.

RI 8568. Automatic and Continuous Transducer-Drift Compensator for Endpoint Detection Systems, by Charles A. Seitz and George M. Lucich. 1981. 9 pp. 5 figs. This Bureau of Mines report describes an automatic and continuous transducer-drift compensator. The compensator formed a part of the instrumentation used to indicate the saturation by hydrogen of a cryogenic, adsorption column. It has a variable delayed-response characteristic and will respond only to signals having rise times faster than component drift times. Zero drift due to varying ambient conditions and component aging is nullified. Equations relating the output as a function of the input signal are given.

RI 8569. Water Jet Perforation, A New Method for Completing and Stimulating In Situ Leaching Wells, by G. A. Savanick and W. G. Krawza. 1981. 30 pp. 18 figs. The Bureau of Mines has designed, fabricated, and field tested a water jet cutting device capable of perforating nonmetallic well casings for the purpose of completing or stimulating in situ uranium leaching wells. The device is lowered into the wellbore, where it issues a high-velocity water jet that penetrates either a polyvinyl chloride or fiberglass casing, cement, and from 1 to 4 feet into the surrounding uraniferous sandstone. The resulting perforations allow leaching solution to pass between the sandstone and the wellbore. This report describes the water jet perforator, tells how it is used, presents cost data, and discusses the results of laboratory and field tests. The tests were designed to (1) determine the optimum operating conditions for water jet perforation, (2) assess the effects of changes in these conditions, (3) evaluate the performance of the water jet perforator under actual conditions, and (4) compare this method with other

methods of well completion. These tests showed that water jet perforation is superior to conventional well completion methods for selectively achieving communication between the wellbore and adjacent sand while maintaining sand control, for restoring permeability lost through wellbore damage, for stimulating poorly performing wells for completing wells with casings that have inside diameters as small as 2 inches, and for extending the effective well diameter.

RI 8570. Process for Recovering Chromium and Other Metals From Superalloy Scrap, by J. J. deBarbadillo, J. K. Pargeter, and H. V. Makar. 1981. 73 pp. 27 figs. This Bureau of Mines report describes a process for recovering chromium and other metals from superalloy scrap. Laboratory-scale experiments were conducted to test a complex flowsheet utilizing a wide range of extractive metallurgical operations. The novel basis for the process is the formation of a sulfide matte in which chromium is concentrated in a discrete chromium sulfide phase. Mineral processing and hydrometallurgical procedures are used to separate chromium sulfide from the other matte constituents. The products of the process are a chromium-nickel alloy suitable for reuse in the superalloy industry, electrolytic nickel, electrolytic cobalt, and iron-molybdenum residue. Recovery of the principal elements contained in the scrap is chromium—93 percent, nickel—99 percent, cobalt—96 percent, and molybdenum—92 percent.

RI 8571. Pyrometallurgical Recovery of Chromium From Scrap Metals: Laboratory Studies, by Charles L. Kusik, Krishna Parameswaran, David J. Kinneberg, and Harry V. Makar. 1981. 41 pp. 10 figs. As part of an effort to establish processes that could be exploited in case of adverse changes in international chromium production and trading patterns, this study was sponsored by the Federal Emergency Management Agency (formerly the Federal Preparedness Agency) through the Bureau of Mines, to experimentally determine the feasibility of recovering chromium from critical scrap metals containing significant quantities of this element. Based on a conceptual pyrometallurgical chromium recovery flowsheet developed at Arthur D. Little, Inc., the experimental program described in this report demonstrated key process steps for the recovery of chromium as ferrochromium in a batch process. The process involves oxidation of chromium into a slag phase, subsequent separation of the slag phase from the remaining metal, followed by reduction of chromium from the slag phase to produce ferrochromium.

RI 8572. Beneficiation of a Hematitic Taconite by Reduction Roasting, Magnetic Separation, and Flotation, by R. E. Peterson and A. F. Colombo. 1981. 13 pp. 5 figs. The Bureau of Mines has undertaken beneficiation investigations on samples representing large tonnages of oxidized taconites in order to develop and evaluate applicable technologies for producing iron oxide concentrates from these materials. Information derived from the investigations can be used to expand the domestic iron raw-materials base and to establish the impact these taconite deposits may have on future national iron ore requirements. This report describes a process that includes reduction roasting, magnetic separation, and flotation, applied to a western Mesabi Range sample taken near Coleraine, Minn. The sample contained 36.8 pct iron and 46.0 pct silica, and represented 0.5 to 1 billion tons of crude material. An average of 962 lb/hr of oxidized taconite was roasted with 33 lb/hr of lignite in a 35-foot-long rotary kiln. Pulverized lignite and natural gas maintained the kiln operating temperature at 850° C. The roasted taconite was beneficiated by magnetic separation and cationic flotation in a 900-lb/hr pilot plant and yielded a product analyzing 68.1 pct iron and 4.6 pct silica, and containing 82.4 pct of the iron in the kiln feed.

RI 8573. Modification of a Commercial Atomic Absorption Spectrophotometer for Cold-Vapor Determination of Mercury, by Joseph A. Perry, Raymond F. Farrell, and Alick J. Mackie. 1981. 11 pp. 4 figs. One goal of the Bureau of Mines is to develop technology to insure a dependable supply of minerals to the United States. To support this goal, the Bureau's Albany Research Center has modified a commercial atomic absorption spectrophotometer to rapidly determine trace levels of mercury by cold-vapor atomic absorption spectrophotometry. Such diverse materials as ores, mill products, stream water, sediments, and flue dust have been analyzed. A very high dynamic range of 0.2 ng/ml to 1 μg/ml of mercury in solutions is routinely analyzed by this instrument.

RI 8574. A Pyrometallurgical Method for Processing Ni-Cd Scrap Batteries, by Donald A. Wilson and Harry V. Makar. 1981. 14 pp. 3 figs. As part of a continuing effort to maximize metal recovery from domestic secondary resources, the Bureau of Mines investigated a process for recovering the metallic portion of scrap alkaline batteries. A pyrometallurgical method for recovering nickel and cadmium from Ni-Cd scrap batteries previously developed on a laboratory scale, was scaled up to 25- and 43-pound charges. The method employed reduction and/or decomposition in a retort using a minimum of 2.5 percent carbon as a reductant. Metallic cadmium was distilled at atmospheric pressure and a minimum of 900° C. Purity of the recovered cadmium was 99.8 percent minimum and the nickel-iron residue contained less than 0.02 percent cadmium.

RI 8575. Geologic Factors in Predicting Coal Mine Roof-Rock Stability in the Upper Kittanning Coalbed, Somerset County, Pa., by A. T. Iannacchione, J. P. Ulery, D. M. Hyman, and F. E. Chase. 1981. 41 pp. 28 figs Roof-rock instability in advancing sections of underground coal mines is a major contributing factor to accidents resulting in fatalities and injuries. Such roof-rock conditions can also result in loss of production due to additional cleanup time and increased amounts of reject material. The Bureau of Mines is investigating fundamental geologic factors affecting coal mine roof-rock instability in order to develop techniques to predict zones of potential unstable roof-rock. Two distinct directional trends of unstable shale roof-rock in a mine working the Upper Kittanning Coalbed are delineated: one trend is associated with the sandstone-shale transition zone, the other with a fault system. The unstable shale roof-rock associated with the transition zone, a consequence of differential compaction, is comprised of slickensided roof-rock. Whereas, the unstable shale roof-rock associated with the fault system, a consequence of structural deformation of the strata, is comprised of fault planes. These faults, small in comparison to the sandstone-shale transition zone, are difficult to delineate with a standard drilling program. Trends of the transition zone associated with the sedimentary facies change are projected into unmined portions of the coalbed with the aid of exploration core data.

RI 8576. Fluorine and Uranium in Phosphate Rock Processing and Waste Materials, by Benjamin W. Haynes, Gary W. Kramer, and July A. Jolly. 1981. 17 pp. 3 figs. Materials from phosphate rock mining and processing were analyzed for fluorine and uranium content as part of the Bureau of Mines program to more effectively recover resources from mining and mineral processing reject materials. The analysis of both feed and waste materials generated in the beneficiation and acidulation of phosphate rock was performed to obtain information on the disposition and concentration of these elements in phosphate rock processing streams. Fluorine was determined by a distillation-titration method and by ion chromatography. Uranium was determined by the dibenzoylmethane (DBM) method, the reliability being confirmed by roundrobin analysis of samples within Bureau of Mines research centers. National Bureau of Standards (NBS) Standard Reference Material (SRM) 120b-Phosphate Rock was also analyzed for fluorine and uranium to verify procedures and results. Fluorine values ranged from 0.3 wt-pct in gypsum filter cake to 3.7 wt-pct in phosphate rock concentrate. Uranium ranged from less than 5 $\mu g/g$ in gypsum filter cake to 200 $\mu g/g$ in a dried clay slime.

RI 8577. Methane Draining Study Using an Underground Pipeline, Marianna Mine 58, by L. J. Prosser, Jr., G. L. Finfinger, and J. Cervik. 1981. 29 pp. 26 figs. The Bureau of Mines has completed an underground degasification project in which an underground piping system was used to transport methane from the coalbed to the surface. In a 10-month period four horizontal holes were drilled to an average depth of 1,450 feet. All four holes were surveyed vertically and azimuthally. In 991 days of degasification, 255 MMcf of gas was drained from the coalbed. The underground piping system proved to be a safe and effective means of transporting methane from the coalbed to the surface.

RI 8578. A Method for Determining Helium in Water, by Philip W. Holland. 1981. 17 pp. 4 figs. The Bureau of Mines has developed a method for determining helium in water for use in sampling and analyzing surface and subsurface waters for geochemical survey work. The accuracy of the analytical method is within ± 10 percent for samples containing above 20×10^{-8} cm^3 He (STP)/cm^3 H_2O. The minimum detectable helium-in-water concentration is calculated to be 2×10^{-8} cm^3 He (STP)/cm^3 water. Water samples are collected in 500-cm^3 stainless steel cylinders. The dissolved gases are extracted into a cylinder of equal volume containing a known quantity of neon. The resulting gas mixture is subsequently analyzed for helium and neon-21 by mass spectrometry. The volume of helium in the sample is calculated from the mass spectrometric determination of the helium-to-neon-21 ratio, the known quantity of neon used, and the extraction efficiency of helium.

RI 8579. Analysis of Pillar Stability on Steeply Pitching Seam Using the Finite Element Method, by Nicholas P. Kripakov. 1981. 33 pp. 18 figs. The U.S. Bureau of Mines examined the applicability of existing material models to solve practical geotechnical mining-related problems by solving a yielding pillar stability problem considering confining effects on strength. Numerical difficulties normally encountered with modeling strain softening behavior were eased with a simplified computational procedure using a quasi-elastic approach to account for residual strength after initial failure. Although in agreement with a confined-core pillar design method using actual mine conditions that include mine layout geometry, overburden geology, and rock properties of the deposit and surrounding structure, the results cannot be verified because measured field data are not available at this writing.

RI 8580. Extracting Uranium From Carbonaceous Ores, by L. E. Schultze, D. J. Bauer, and M. T. Morimoto. 1981. 12 pp. 3 figs. As part of its goal of maintaining an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines devised a processing sequence for recovering uranium from carbonaceous ores. Uranium extractions of 97 pct were obtained by contacting the ore with a solution containing 400 grams of ferric sulfate hydrate in 200 ml water for 3 hr at boiling temperature (96° C). Uranium was recovered from the leaching solution by solvent extraction with tri-issooctyl amine. The barren ferric sulfate solution was recycled to the leaching system. The leaching process resulted in no detectable dissolution of carbonaceous material from the ore. Work on the project was terminated in 1978 because of a transfer of responsibility to the U.S. Department of Energy.

RI 8581. Fine Coal-Refuse Slurry Dewatering, by R. R Backer and R. A. Busch. 1981. 18 pp. 11 figs. The Bureau of Mines, in cooperation with Washington Irrigation and Development Co. (WIDCO), evaluated the dewatering of fine coal-refuse slurry using chemicals and various types and combinations of drains in natural earth impoundments. About 40 lb of lime and 2 lb of polymer per ton of dry solids were mixed with the underflow from the preparation-plant thickener. Clear, free water was immediately liberated from the slurry. The percent solids by weight of the slurry increased from about 17 to 30 immediately, and after 5 days increased to 45 wt-pct. This indicates a threefold reduction in total volume after 5 days from 172 cu ft/ton solids originally to 56 cu ft/ton solids.

RI 8582. Recovery of Principal Metal Values From Electrolytic Zinc Waste, by T. L. Hebble, V. R. Miller, and D. L. Paulson. 1981. 12 pp. 7 figs. The Bureau of Mines investigated a hydrometallurgical procedure to recover Co, Ni, and Cu from an electrolytic zinc industrial copper filter cake. The copper filter cake is presently unmarketable or of low value because economic and environmentally acceptable processing technology is lacking. Research by the Bureau of Mines has developed a multistage process for recovering or recycling over 93 pct of the Zn, Cd, Cu, Co, and Ni from this material. The stages involved are (1) wet sizing, (2) H_2SO_4 leaching of undersized material, (3) H_2SO_4-MnO_2 leaching of H_2SO_4 leach residue, (4) selective precipitation of As, Cu, and Co-Ni products, and (5) precipitation of manganese for recycling to the leach circuit. The final process residue is only 1.6 wt-pct of the initial cake and consists of lead sulfate.

RI 8583. Magnetic Properties of Alloys Containing Mischmetal, Cobalt, Copper, Iron, and Magnesium, by J. W. Walkiewicz, J. S. Winston, and M. M. Wong. 1981. 22 pp. 8 figs The Bureau of Mines investigated alloys containing mischmetal (MM), cobalt, copper, magnesium, and iron for use in permanent magnets in place of the scarce samarium-cobalt alloys The magnetic properties of MM-Co,

MM-Co-Cu, MM-Co-Cu-Mg, and MM-Co-Cu-Fe-Mg alloys were evaluated. Magnets were fabricated by powder metallurgy consisting of arc-melting the metals, crushing and grinding the resultant alloys, alining and compacting the powder, and sintering the compacts. Magnetic values of $_MH_c$ = 4.7 kOe, $_BH_c$ = 4.07 kOe, B_r = 6.81 kG, and $(BH)_{max}$ = 10.0 MGOe were obtained with a MM-Co alloy containing 36±0.5 wt-pct MM. By substituting copper and magnesium for part of the cobalt, the values for $_MH_c$ and $_BH_c$ were increased to 29.0 kOe and 5.89 kOe, respectively. This intrinsic coercivity value exceeded that of Sm-Co alloy obtained in our laboratory. The addition of iron to MM-Co-Cu-Mg alloys resulted in an increase of B_r to 6.90 kG and $(BH)_{max}$ to 10.3 MGOe. Copper and magnesium contents of these alloys were optimized to obtain maximum values of H_c.

RI 8584. Laboratory Analysis of Pozzolan (Fly Ash) Concrete, by Earl L. Phillips. 1981. 27 pp. 30 figs. The Bureau of Mines conducted laboratory tests on samples of pozzolanic-cement concrete to develop a low-strength backfill. Results show that support costs can be lowered by replacing a portion of the portland cement in mine backfill with pozzolan (fly ash) and lime. Unconfined compression tests on various ratios of fly ash to cement in 84 samples produced compressive-strength curves that can be used to estimate the best backfill mix for any mine.

RI 8585. Monitoring Ground Movements Near Caving Stopes —Methods and Measurements, by Louis A. Panek and Willard J. Tesch. 1981. 108 pp. 63 figs. The Bureau of Mines measured rock-mass movements above the undercutting level in a block-caving mine by means of instrumentation installed in drifts and in long drill holes several hundred feet ahead of the approaching panel caving. The instruments included a borehole inclinometer probe to determine the change of profile along a cased drill hole, break-detection cable monitored by time-domain reflectometry to determine the locations of new cracks, multiple-anchor-position extensometers to measure longitudinal ground movements in boreholes, cross-drift extensometer rosettes to measure the amount and direction of deformation in planes normal to the drift axis, and tiltmeters to determine the change of profile along the drift. Off-the-shelf hardware, components, and instruments were incorporated as much as possible, often in innovative arrangements. To assist the prospective user to devise monitoring schemes for specified measurement objectives and to anticipate the problems that will be encountered, installation and operation of the instruments for this application are described in detail and their comparative advantages are discussed. The sensitivity of measurement was great enough to detect ground movements that preceded cracking, although cracking was found to be pervasive to distances of several hundred feet from the caving boundary.

RI 8586. Monitoring Submicrometer Particles in Sealed Fire Areas, by C. D. Litton, M. Hertzberg, A. L. Furno, and J. M. Kuchta. 1981. 20 pp. 12 figs. Submicrometer particle concentrations and average particle sizes were monitored for four full-scale sealed coal fires in the multiple-entry section of the Bruceton Experimental Mine. The data from these tests indicate that there exists a very good correlation between the submicrometer particle concentrations and the maximum temperatures measured within the coalbed. As the maximum coalbed temperature decreases with time after sealing, the submicrometer particle concentrations show a corresponding reduction. This particle-temperature correlation is in sharp contrast to the gas concentration data obtained, for which essentially no correlation exists with the measured coalbed temperatures. The results of these full-scale tests indicate that the measurement of submicrometer particle concentrations may be a more realistic approach to determining the status of underground sealed fire areas.

RI 8587. Bentonite-Bonded Rammed Olivine and Zircon Molds for Titanium Casting, by R. K. Koch and J. M. Burrus. 1981. 40 pp. 15 figs. The Bureau of Mines produced several series of titanium castings in order to investigate the feasibility of producing commercial-grade titanium castings in bentonite-bonded olivine or zircon sand molds. The use of these molds for titanium casting was investigated as a possible alternative to the industrially used rammed graphite process. Parameters investigated were mold mixtures, mulling, gating, venting, drying, and mold washing. The investigators found that castings with superior ductility and fatigue life, compared with rammed graphite castings, could be made by fume-free processes in molds bonded by western bentonite, using either olivine or zircon sand. Zircon molds were satisfactory for both light- and heavy-sectioned castings. However, olivine molds were suitable only for light-sectioned castings because the mold-metal reaction became excessive during the pouring of heavy-sectioned castings.

RI 8588. Electrochemical Determination of Gibbs Energies of Formation of Cobalt and Nickel Sulfides, by Seth C. Schaefer. 1981. 18 pp. 6 figs. The Bureau of Mines has determined the standard Gibbs energies ($\Delta Gf°$) of $CoS_{1.035}$ (cobalt sulfide) and $Ni_{2.515}S_2$ (nickel sulfide) with high-temperature galvanic cells using stabilized ZrO_2 (zirconia) as the electrolyte.

RI 8589. Recycling of Waste Magnesite-Chrome Refractories From Copper Smelting Furnaces, by A. V. Petty, Jr., and E. Martin. 1981. 18 pp. 7 figs. In accordance with its objective to maximize minerals recovery from secondary domestic resources, the Bureau of Mines conducted research on recycling chrome refractory wastes. Since 20 pct of the U.S. demand for imported chromite is used in the production of refractories, primarily for the steel, copper, and glass industries, samples of used chrome-containing refractories from copper converter and reverberatory furnaces were investigated to determine their potential for recycling. The samples were beneficiated using a combination of wet magnetic separation, flotation, and leaching techniques, and the concentrates were reformed into briquets for refractory evaluation. Small refractory test specimens produced from the beneficiated concentrates gave modulus of rupture values at 1,350° C comparable to those of commercial mag-chrome brick of similar composition; however, grinding the waste refractories to at least minus 65-mesh was required in order to liberate the metallic copper. Most of the copper was easily recovered using conventional beneficiation techniques, but the finely ground chrome concentrate would require briquetting, calcining, and crushing to produce a coarse grain suitable for recycling into secondary mag-chrome refractories. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8590. Aluminum Chloride Hexahydrate Crystallization by HCl Gas Sparging, by J. H. Maysilles, D. E. Traut, and D. L. Sawyer, Jr. 1982. 38 pp. 13 figs. The Bureau of Mines is conducting research on various technologies to recover alumina from domestic resources for feedstock to existing aluminum smelting capacity as a means to reduce dependence on imported bauxite, which represents 93 pct of U.S. aluminum requirements. One of the more promising technologies being investigated is the hydrochloric acid leaching of kaolinitic clay. In the hydrochloric acid leaching technology, alumina is recovered from iron-free aluminum chloride leach liquor and separated from impurity elements by sparging the liquor with HCl gas to crystallize aluminum chloride hexahydrate (ACH). A large-scale crystallizer with a 336-gallon usable volume was constructed and operated to obtain engineering and design data for potential scale up and to demonstrate the ability of the technology to produce specification grade alumina. Test campaigns involving about 1,400 hours of operation were completed. ACH meeting all chemical purity requirements could not be produced by a single crystallization, but was produced by recrystallizing the product from the calcined kaolin clay leach liquor. Product crystals with a size distribution of more than 80 pct plus 100 mesh and 65 pct plus 65 mesh were made at a rate of 10 pounds of ACH/(hr)(ft^3). The zirconium tube heat exchanger used to maintain constant process temperature operated with an overall heat transfer coefficient of 420 to 500 Btu/(hr)(ft^2)(°F).

RI 8591. Protection Factors of the Airstream Helmet, by Andrew B. Cecala, Jon C. Volkwein, Edward D. Thimons, and Charles W. Urban. 1981. 17 pp. 8 figs. The Bureau of Mines conducted laboratory and in-mine tests on the Racal airstream helmet (Model #AH21) to evaluate its protection efficiency. Laboratory tests indicated that as ambient air velocity increased, the protection offered by the helmet decreased. In tests conducted at several coal mine longwall sections with face velocities under 400 fpm, the helmet was 84 pct effective at reducing respirable dust in the miner's breathing zone. However, at a high-velocity section, 1,200 fpm, the efficiency of the helmet was significantly reduced, confirming our laboratory results.

RI 8592. Beneficiation of Low-Grade California Chromite Ores, by H. B. Salisbury, M. L. Wouden, and M. B. Shirts. 1982. 15 pp. 6 figs. The Bureau of Mines conducted research to determine if low-grade California chromite ores could be beneficiated to produce products suitable for commercial use. This research is part of a Bureau goal to provide technology capable of using low-grade domestic ores to meet emergency demands of the Nation for metals and minerals and in particular those minerals, such as chromite, which are considered critical. Two ores from California were ground and treated using gravity concentration and magnetic separation techniques. An ore from Auburn in central California, assaying 2.5 pct Cr_2O_3, was treated by tabling and magnetic separation to yield a nonmagnetic product containing 44.7 pct Cr_2O_3 at a recovery of 36.4 pct. Core drilling samples from the Seiad Creek area of northern California, assaying about 6 pct Cr_2O_3, were upgraded by tabling to yield a concentrate containing nearly 50 pct Cr_2O_3 with a recovery of 50 pct. Both products are suitable for metallurgical and/or chemical use.

RI 8593. Hydrogen Chloride Sparging Crystallization of Aluminum Chloride Hexahydrate, by D. E. Shanks, J. A. Eisele, and D. J. Bauer. 1981. 15 pp. 13 figs. As part of its effort to produce cell-grade alumina from clay, the Bureau of Mines investigated the hydrogen chloride gas-sparging crystallization of aluminum chloride hexahydrate (ACH) from aluminum chloride liquor, to provide information for optimizing the crystallization operation. Four parameters important in controlling the crystallization of the aluminum chloride hexahydrate and the concentration of impurities, particularly phosphorus and magnesium, in ACH crystals are (1) aluminum chloride concentration in the feed solution to crystallization, (2) hydrogen chloride gas flow rate, (3) temperature, and (4) concentration of phosphorus and magnesium also in the feed solution. Parameters 1, 2, and 3 affect crystal formation. The combined effects are very important because the phosphorus and magnesium concentrate in the crystals during the early stages of crystal growth. Aluminum chloride hexahydrate of cell-grade purity was crystallized from saturated aluminum chloride solutions containing less than 0.003 wt-pct P_2O_5 and 0.010 wt-pct MgO. Crystallization temperatures less than 60° C decreased crystal purity.

RI 8594. Electromagnetic Radiation From Rock Failure, by David R. Hanson and Glen A. Rowell. 1982. 21 pp. 30 figs. Experimental work performed by the Bureau of Mines in a laboratory environment has shown that the formation of failure zones within certain rock types is accompanied by the emission of significant amounts of radiofrequency (RF) electromagnetic (EM) energy. This radiation was detected using nonresonant, "electrically short," broadband antennas. Rock types for which emission was observed include granite, quartzite, and taconite; sandstone and marble did not emit measurable radiation. Amplitude spectra of the radiation showed the energy to be concentrated between 10 and 40 kilohertz. These data indicate that emission is directional, but this has not yet been proven. In addition, amplitude of RF emission increases with increasing crack size. Since emission was observed only for brittle quartz-bearing rocks, it appears the formation of piezoelectric fields is a necessary condition for RF radiation. Plausible mechanisms for emission include rapid decay of piezoelectric fields accompanying the sudden stress release at failure and/or the acceleration of an "exoelectron plasma" through the intense local piezoelectric fields. Since emission appears to increase with the scale of failure, and since antennas do not need to be coupled directly to rock surfaces as with conventional geophones, the possibility of developing a portable system to monitor seismically active areas exists.

RI 8595. Evaluation of the Use of Foam for Dust Control on Face Drills and Crushers, by Steven J. Page. 1982. 13 pp. 6 figs. The increasing concern for dust control in metal and nonmetal mining prompted the Bureau of Mines to investigate the dust suppression technique of applying foam to face drilling and crushing operations in a gypsum mine. Previous attempts to achieve effective dust control on face drills using other techniques, such as dry collection and boom-mounted external water sprays, have not been successful. The largest problem encountered when using these techniques has been the lack of sustained effective dust capture at the face. Results for two faces studied show that injection of the foam through the drill steel provided an average

dust reduction of 95 pct. However, the use of foam on the crusher provided no dust reduction at the operator's position (because of good local ventilation) and a 27-pct average dust reduction for two feeders at a location midway between the operator's position and the crusher. The conclusions obtained from this study are that (1) foam can be an extremely effective dust control technique when used on localized dust sources such as dust generated within a blasthole during drilling, and (2) foam is only marginally effective as a dust control technique when used on nonlocalized dust sources such as dust generated during the feeder-and-crusher operation.

RI 8596. An Evaluation of Three Wet Dust Control Techniques for Face Drills, by Steven J. Page. 1982. 13 pp. 7 figs. The increasing concern for dust control in metal and nonmetal mining prompted the Bureau of Mines to investigate the comparative effectiveness of three wet dust control techniques for face drilling. Previous attempts to achieve effective dust control on face drills with dry collectors have not met with success, the largest problem being sustained effective dust capture at the face. Results show that (1) foam-through-the-drill can provide 95-pct average total dust reduction in gypsum; (2) water mist-through-the-drill can provide approximately 91-pct average total dust reduction and 93-pct average respirable dust reduction in salt; (3) external boom-mounted water sprays can provide approximately 50-pct average dust reduction for both total and respirable dust in salt. The investigation showed that (1) foam and water in small quantities are very effective dust control techniques for face drills when applied through the drill steel at the point of dust generation, and (2) boom-mounted water sprays are only minimally effective for dust control on face drills.

RI 8597. Stress Distribution and Pillar Design in Oil Shale Retorts, by Syd S. Peng and Richard E. Thill. 1982. 33 pp. 21 figs. The design of retort interchamber pillars is important in determining surface stability over in situ retort mines and to the health and safety of miners, particularly with respect to possible escape of heat and toxic gases from retort chambers. Stress distribution in retort interchamber pillars, roof, and floor was examined with the aid of linear, finite-element analysis using data from experimentally determined mechanical properties. Properties determined included elastic moduli, strength, and creep constants in laboratory tests on core covering a 100-foot depth interval in the oil shale from the Piceance Basin in Colorado. The most critical stress concentration was found in the rib side of the interchamber pillar at a height above the floor line of 1.25 times the width. Guidelines for pillar design that consider pillar strength, creep, and retorting temperature effects are proposed.

RI 8598. Rock Mechanics Investigation of Two-Bed Trona Mining, Green River, Wyo., by R. O. Kneisley. 1982. 22 pp. 14 figs. Rock mechanics measurements indicate that the present two-bed mine design used at the Big Island trona mine, Green River, Wyo., results in stable workings. Vertical pressure changes in the lower panel pillars and horizontal pressure changes in the lower bed roof and floor indicated negligible upper bed mining influence. Pillar stresses stabilized soon after upper bed mining was completed. Strata movements in the pillar ribs, roof, and floor were also negligible and stabilized soon after completion of upper bed mining. Using tributary area theory, the confined core approach, and studies of model trona pillars it is shown that increased extraction ratio is possible. A program of gradually increased extraction ratio accompanied by simple measurements should result in a mine design that includes both higher recovery and long-term stability.

RI 8599. Guidelines for Selecting Seismic Detectors for High-Resolution Applications, by C. Melvin Lepper. 1981. 37 pp. 24 figs. To provide the U.S. mining and energy industries with information in the selection of seismic detectors for high-resolution applications, the Bureau of Mines evaluated 35 velocity detectors (geophones) and 9 accelerometers. It was found that velocity detectors with natural frequencies from 10 to 100 Hz were effective for seismic studies in the 5- to 600-Hz spectrum and that accelerometers were most effective in the 100- to 1,000-Hz range. Although the accelerometers described in this report performed about equally with the better velocity detectors tested, the accelerometers showed higher output voltage levels at higher frequencies, which is an advantage. It is important that a seismic detector and its intended purpose be matched properly to achieve the intended results in high-resolution applications. There are many factors that could affect proper matching, thus careful selection of the best detector for a particular application must be exercised.

RI 8600. Electric Ignition of Lycopodium Powder in a Modified Hartmann Apparatus, by T. A. Kubala, F. J. Perzak, and E. L. Litchfield. 1981. 9 pp. 3 figs. Electric discharge ignition has been reinvestigated in a modified Hartmann apparatus for lycopodium powder with air. Minimum stored energy to ignite aid dispersions of lycopodium was 25 to 30 mj; ignition occurred with 1 gram of lycopodium dispersed into the 2.7-liter vessel. Ignition energy was measured as a function of the weight of powder used, although some reservations are expressed concerning the uniformity of the lycopodium-air mixtures. In particular, wall layers of lycopodium, remaining after dispersal of 1 gram of lycopodium, were as easily ignitable as the most easily ignited air dispersion. Thus, an unanswered question has arisen concerning the role of surface coatings in the flammability of all marginally ignitable mixtures.

RI 8601. Crushing Techniques for Pneumatic Concentration of Mica, by C. W. Smith, C. E. Jordan, and G. V. Sullivan. 1982. 16 pp. 7 figs. Research was conducted by the Bureau of Mines to determine the effectiveness of various types of crushers for use with the Bureau-developed pneumatic concentration technique for mica. Three types of crushers were investigated in this study, a roll crusher, a jaw crusher, and a hammer mill. All the mica concentrates produced contained over 82 percent mica, but recoveries varied considerably. The roll crusher gave the lowest recovery of 46 percent of the mica followed by the jaw crusher with a recovery of 50 percent of the mica. The hammer mill proved the most effective, producing four concentrates with recoveries of at least 70 percent.

RI 8602. Electrolytic Method for Recovery of Lead From Scrap Batteries, by E. R. Cole, Jr., A. Y. Lee, and D. L. Paulson. 1981. 19 pp. 4 figs. Bench-scale research at the Bureau of Mines has resulted in the successful development of a combination electrorefining-electrowinning method for recycling all the lead in scrap batteries. The method reduces energy consumption and eliminates toxic

emissions, in contrast to present pyrometallurgical smelting, and the lead produced is pure enough for use in maintenance-free batteries. Anodes cast from molten lead scrap were electrorefined in 1- and 2-liter plastic cells using an electrolyte composition of 70 g/l Pb and 90 g/l free H_2SiF_6 (fluosilicic acid). Both reagent-grade and waste H_2SiF_6 were used. Cathode starting sheets were made from refined lead. Aloes, and later bone gelatin, and calcium lignin sulfonate addition agents were employed. The sludge remaining after separation of the lead metal was treated in a two-step leaching operation to solubilize the lead for recovery by electrowinning. Conditions for electrowinning were essentially the same as for electrorefining, except that insoluble PbO_2-Ti (lead dioxide-coated titanium) anodes were used. The best results for electrorefining and electrowinning were obtained with a current density of 170 amp/m^2 and a cell temperature of 25° to 35° C. Cathode purity ranged from about 99.9 to 99.9+ pct Pb. Maximum energy consumption after 3 days, for electrorefining and electrowinning, was 90 and 700 kwhr per metric ton of refined lead, respectively.

RI 8603. Canopy-Air Curtain Dust Reductions on a Gathering-Arm Loader, by Jon C. Volkwein, Steven J. Page, and Edward D. Thimons. 1982. 9 pp. 6 figs. The canopy-air curtain was originally developed by the Bureau of Mines to surround the operator of a continuous mining machine with a zone of clean air. This report describes the application and testing of a canopy-air curtain on a gathering-arm loader, as well as some of the problems associated with providing a zone of clean air to a standing, semimobile operator. The area of air-curtain coverage and effects of air velocity are discussed. In its present form, the canopy-air curtain provides a 50-percent reduction in respirable dust to the operator.

RI 8604. Electrowinning Nickel and Cobalt From Domestic Laterite Processing. Preliminary Laboratory-Scale Results, by R. E. Mussler and R. E. Siemens. 1982. 20 pp. 9 figs. As part of an overall goal to develop technology that can maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines is evaluating a method for selectively extracting nickel and cobalt from low-grade domestic laterites. The method involves electrowinning to recover the metals in pure form; therefore, preliminary laboratory-scale electrowinning tests were conducted in both a nondiaphragm and a diaphragm cell to determine the effect of variables on energy efficiency under controlled conditions. Electrolytes were generally reagent-grade sulfate solutions that were prepared to stimulate electrolyte that could be obtained by stripping nickel- and cobalt-rich solvent extraction reagents. Limited tests were conducted with electrolyte generated from laterite leach solutions. Electrical energy consumption in a nondiaphragm cell was 2.06 kwhr/lb Ni with the cell operated at 50° C, a cell feed of 90 g/l Ni, a pH of 3.5, an extraction of 3.2 g/l, and a cathode current density of 20 amp/ft^2. The energy requirement decreased with increasing concentration and temperature, and increased with increasing extraction and current density. At 50° C, energy consumption in the nondiaphragm cell was 21 pct greater than in the diaphragm cell, but it was only 5 pct greater at 65° C. For this reason and because of overall cost considerations, operation at 65° C with the nondiaphragm cell was preferred. Smooth sheets of cobalt were obtained by electrowinning in a nondiaphragm cell at selected temperatures from 50° to 85° C and with cobalt concentrations from 55 to 87 g/l. The energy consumption (1.48 kwhr/lb) was 22 pct lower with a cobalt concentration of 75 g/l and a cell temperature of 65° C than with a cobalt concentration of 55 g/l and a cell temperature of 50° C.

RI 8605. Solvent Extraction of Nickel and Copper From Laterite-Ammoniacal Leach Liquors, by D. N. Nilsen, R. E. Siemens, and S. C. Rhoads. 1982. 29 pp. 15 figs. The Bureau of Mines is investigating a method to recover Ni, Cu, and Co from low-grade domestic laterites through reduction roasting, leaching, solvent extraction, and electrowinning unit operations. The objective of this research is to develop processing technology that can convert low-grade domestic deposits containing critical metals into national reserves. As a part of this research, a solvent extraction system was investigated for the extraction of nickel and copper, followed by the separation and production of suitable electrolytes. Nickel and copper were coextracted from ammoniacal ammonium sulfate leach liquors (pH~9.5) with LIX 64N extractant in a laboratory-size mixer-settler continuous circuit. Three extraction stages resulted in >99-pct extraction of nickel, substantial copper extraction, and essentially no cobalt extraction from leach liquors. A crowd stage reduced the ammonia loading on the solvent by maximizing nickel loading. Residual ammonia was removed from the loaded solvent with a pH-controlled scrub. Nickel and copper loaded on the solvent were separated by selective stripping. Typical nickel strip circuit operation using electrolyte containing 90 grams per liter (g/l) Ni and 11.9 g/l H_2SO_4 yielded >99.9 pct Ni stripped from the solvent in five stages. The copper loading on the recycled solvent was controlled in a copper strip stage using electrolyte containing 25 g/l Cu and 160 g/l H_2SO_4.

RI 8606. Evaluation of REO Model BT 300 C-D Blasting Machine Tester, by John H. Scott, Karl R. Becker, and J. Edmund Hay. 1982. 15 pp. 2 figs. At the request of the Mine Safety and Health Administration, U.S. Department of Labor, the Bureau of Mines evaluated the model BT 300 C-D blasting machine tester, manufactured and distributed by Research Energy of Ohio, Inc. (REO), to determine whether the tester performed as stated by the manufacturer and responded satisfactorily to electrical faults introduced into the blasting machine circuit. Tester readings were recorded for 13 blasting machines and for 12 circuits constructed to simulate the electrical parameters of actual machines. The tester readings were acceptable for all of the blasting machines, although the switch position assigned to one machine produced an off-scale reading. The tester responded satisfactorily to the simulated circuits and detected serious voltage or capacitance faults when they were introduced. However, it did not respond accurately to certain resistance faults. Temperature tests were also made, and the tester performed equally well at temperatures of 20°, 42°, and 81° F. This tester was judged a useful accessory for field checking blasting machines for defective batteries and capacitors, despite its limitations. It is recommended that the tester manufacturer specify the lowest acceptable reading at which a blasting machine may be used and below which the blasting machine should be returned to the laboratory or manufacturer for maintenance.

RI 8607. The Theory of Flammability Limits. Radiative Losses and Selective Diffusional Demixing, by Martin Hertzberg. 1982. 38 pp. 7 figs. The concept of limit burning velocities is being used to formulate

a quantitative theory of flammability limits. Competing and complicating processes dissipate power from a combustion wave and quench propagation at some characteristically low limit velocity. Two earlier reports dealt with process (a), natural convection (RI 8127); and with process (b) conductive-convective wall losses (RI 8469). This report considers process (c), radiative losses, and process (d), selective diffusional demixing.

RI 8608. Mechanical Properties of Oil Shale and Overlying Strata, Naval Oil Shale Reserve, Anvil Points, Colo., by Dennis R. Dolinar, Frank G. Horino, and Verne E. Hooker. 1982. 43 pp. 24 figs. Physical property tests were conducted on drill core from three exploratory holes on the Naval Oil Shale Reserve near Anvil Points, Colo. Data and regression analysis curves are presented. Data obtained above the Mahogany zone were used to estimate the potential zone of surface effects from underground mining. Single specimen testing was primarily used to obtain Mohr's envelope and subsequent rock properties. The technique is shown to provide satisfactory results for this rock type with a significant reduction of core preparation and testing time.

RI 8609. Beneficiation of High-Magnesium Phosphate From Southern Florida, by T. O. Llewellyn, B. E. Davis, G. V. Sullivan, and J. P. Hansen. 1982. 16 pp. 4 figs. The Bureau of Mines, as part of its goal to develop technology that can conserve domestic mineral resources investigated beneficiation methods for recovering phosphate minerals from two Southern Florida deposits with high magnesium content. Chemical analyses of sized fractions indicated that no coarse pebble concentrate could be produced from either deposit. Conventional fatty acid-fuel oil batch flotation tests on two phosphate samples, analyzing 6.8 and 8.5 pct P_2O_5, yielded concentrates containing 28.97 to 29.80 pct P_2O_5 at recoveries ranging from 72.4 to 76.9 pct of the flotation feed. The MgO content ranged from 1.20 to 1.36 pct. Bubbling SO_2 gas through an aqueous concentrate slurry, further reduced the MgO content of these phosphate concentrates to 0.5 and 0.8 pct, but with a concomitant loss in the phosphate recovery. Settling characteristics of slimes from both phosphate samples showed a slow settling rate, which is a typical characteristic of other slimes in the region. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8610. Effect of Ferric Ion on Corrosion Resistance of Zirconium in HCl-$AlCl_3$ Environment, by William D. Riley and Bernard S. Covino, Jr. 1982. 15 pp. 10 figs. In order to evaluate the corrosion resistance of zirconium in mineral extraction processes, such as clay-hydrochloric acid leaching process for extracting alumina, the Bureau of Mines conducted corrosion studies in HCl-$AlCl_3$-$FeCl_3$ environments. A series of weight loss and electrochemical tests were conducted at 25° and 65° C in aluminum chloride ($AlCl_3$) plus hydrochloric acid (HCl) solutions containing 0 to 1,000 ppm ferric ion. It was determined that zirconium, which normally exists in a passive state in chloride-containing solutions, undergoes pitting attack in solutions containing more than 100 ppm of ferric ion. It is also shown that an oxide film prepared in air at high temperature offers protection in acid solutions containing levels of ferric ion from 300 to 1,000 ppm.

RI 8611. Large-Scale Dewatering of Phosphatic Clay Waste From Central Florida, by B. J. Scheiner, Annie G. Smelley, and D. R. Brooks. 1982. 11 pp. 6 figs. As part of its mission to reduce pollution associated with mineral production, the Bureau of Mines is developing a dewatering technique for phosphatic clay waste that uses a flocculant, polyethylene oxide (PEO). This flocculant forms strong, stable flocs, which can be partially dewatered on a static screen and dewatered further on a rotary screen. Using this technique, a field test unit (FTU) was operated at a nominal 100 gal/min. Consolidated phosphatic clay material containing 20 percent solids was produced when feed slurries of 3 percent solids were treated with 0.69 pound of PEO per ton of feed solids. Pit and column tests indicated that the PEO-treated material continued to dewater; compacted products containing 40 percent solids were obtained after 45 days.

RI 8612. Improvements in Heap Leaching To Recover Silver and Gold From Low-Grade Resources, by G. E. McClelland and J. A. Eisele. 1982. 26 pp. 15 figs. As part of its mission to assure an adequate domestic supply of metals, essential to the Nation's welfare, the U.S. Department of the Interior, Bureau of Mines, investigated a particle agglomeration technique as a means for improving the flow of leaching solution through heaps of clayey or finely crushed, low-grade, gold-silver ores. Bench- and pilot-scale experiments showed that the percolation rate of cyanide leaching solution was markedly enhanced by mixing the ore with a portland cement binder, moistening the mixture, and mechanically agglomerating and aging the feed prior to heap building and leaching. The rate of gold and silver recovery markedly increased because of the increased, uniform percolation of leaching solution through the agglomerated feed. The use of concentrated cyanide solution instead of water during the agglomeration procedure decreased the leaching time required to obtain maximum recovery. Results of bench- and pilot-scale experiments are discussed.

RI 8613. Effect of Direct-Current Firing Levels on Detonator Delay Times, by Karl R. Becker and J. Edmund Hay. 1982. 13 pp. Detonators representing a sampling of various domestic commercial delay detonators were fired at various direct-current (dc) firing levels. Results of firings using well-below-recommended firing levels showed marked increases in delay times above the nominal values. There was also a marked increase in variation, to the extent that out-of-sequence firings would be essentially assured in any typical blasting round at these low firing levels. Within the range of recommended levels the effects of current increases were not considered to be of great importance relative to other overriding effects, such as the significant difference noted in average values of detonators from different lots having the same nominal delay. This effect, when combined with the normal variation noted among members from the same lot, would cause out-of-sequence firings with detonators from a neighboring delay period. Where comparisons with results from another study were possible, it was found that both studies observed quite similar variations in delay times about the average values, and a lower probability of out-of-sequence firings for the shorter delay period groups. The criterion of the previous study for assessing the likelihood of observing out-of-sequence firings, when applied to the Bureau of Mines data, properly identified two neighboring delay period groups where out-of-sequence firings would occur.

RI 8614. Effectiveness of Three Water Spray Methods Used To Control Dust During Bagging, by Jon C. Volkwein, Robert P. Vinson, and Edward D. Thimons. 1982. 9 pp. 3 figs. The industrial sand industry has been exploring new techniques to reduce dust. One company was experimenting with adding water during bagging operations to the surface of the bag, and into the product as it flowed into the bag. The Bureau of Mines, using instantaneous dust sampling instruments, measured the effectiveness of three methods of adding water. Results indicated that various types of water sprays applied in carefully controlled amounts could reduce dust up to 50% at worker locations at the bagging machine and inside a railroad boxcar. This report also discusses constraints such as product handling, customer acceptance, cold weather problems, dust collector performance, and other areas.

RI 8615. Recovery of Metal Values From Lead Smelter Matte by Chlorine-Oxygen Leaching, by D. L. Pool, B. J. Scheiner, and S. D. Hill. 1982. 19 pp. 6 figs. To increase metal recoveries and to minimize pollution by improved extraction technology, the Bureau of Mines investigated a hydrometallurgical technique to recover copper, lead, nickel, and cobalt from lead smelter mattes. The metals were converted from insoluble sulfides to soluble chlorides using a HCl-Cl_2-O_2 leaching system. Parameters studied in a 50-gallon, glass-lined reactor were the ratio of hydrochloric acid to chlorine, chlorine consumption per pound of matte, oxygen reaction pressure, and temperature. The matte material used contained, in percent, 19.7 Cu, 52 Pb, 2.9 Ni, 1.5 Fe, 0.38 Co, 0.19 As, 0.41 Zn, and 0.12 Cd. Extraction of Cu, Pb, Ni, Co, and Cd ranged from 92 to 98 pct, with concomitant extractions of Fe and As of <0.1 pct. The Cu and Pb were recovered as electrowon metals, while the Ni, Co, and Cd were recovered as mixed hydroxides.

RI 8616. Orifice Plate Design Studies for a Multiple-Compartment, Ion-Exchange Column, by G. R. Palmer, I. L. Nichols, R. G. Smith, and D. C. Seidel. 1982. 17 pp. 7 figs. Preliminary studies by the Bureau of Mines were conducted to determine the feasibility of a multiple-compartment, ion-exchange (MCIX) column simulator for examining the effect of multiple-orifice plates in the column. A rectangular, five-orifice, three-compartment, MCIX simulator with a cross-sectional plate area of 0.66 ft^2 was used for the investigation. Orifices with open areas of 1, 3, and 5 percent were used with various operating conditions. The study was separated into three separate sections: (1) solution flow effect, (2) fluidization effect, and (3) resin transfer effect. The solution flow and fluidization studies showed that for solution flow rates of about 3 gpm/ft^2, a 1-percent open area plate functioned best, while at solution flow rates of 9 and 15 gpm/ft^2, the best open areas were 3 and 5 percent, respectively.

RI 8617. Determination of Ferric Ion Diffusion and Activity Coefficients From Chronopotentiometric Data, by B. W. Madsen. 1982. 23 pp. 9 figs. As part of a program to maintain an adequate supply of minerals and metals to meet national economic and strategic needs, the Bureau of Mines conducted research to determine the diffusion coefficients for ferric ions in synthetic copper leach solutions. Determination of ferric ion diffusion coefficients in typical dump leach solutions is necessary for predicting leaching rates of copper from large-scale leaching operations and for optimizing concentrations of ferric iron in solutions to maximize leaching efficiency. Derivative chronopotentiometry, an electroanalytical technique, was used to determine ferric ion diffusion coefficients. The diffusion coefficient decreased dramatically with increasing concentration of iron in solution. An empirical model was used to relate the ferric ion diffusion coefficient to the total amount of sulfate in solution. Measuring the diffusion coefficient dependence on temperature yielded an activation energy of 5.5 kcal/mole of ferric ion. Activity coefficients of ferric ions as a function of concentration were calculated from diffusion coefficient data.

RI 8618. Effects of Feed Preparation on HCl Leaching of Calcined Kaolinitic Clay To Recover Alumina, by R. S. Olsen, W. G. Gruzensky, S. J. Bullard, and J. L. Henry. 1982. 24 pp. 7 figs. The Bureau of Mines is engaged in a continuing research effort toward the recovery of alumina from kaolinitic clay and other nonbauxitic domestic minerals. Hydrochloric acid extraction of calcined clay is among the acid processes under consideration. Although aluminum is easily leached from calcined clay, the presence of fines and slimes in the leached residue has hindered the application of this and other acid leaching processes. A clay feed preparation method was therefore developed that eliminated the slimy nature and the separation problems normally associated with leached clay residues. The preparation process consists of crushing the raw clay to minus 20 mesh, dampening the crushed clay with a fine water mist while tumbling on a rotating disk, and calcining the misted clay at 750° C. The misting process increases residue settling rates threefold to 9 cm/min (18 ft/hr) and filtration rates by two orders of magnitude. Leaching kinetics were determined for misted clay feeds in a batch, stirred-tank reactor. Rapid leaching occurred during the first 85 to 90 pct of the extraction. The linear relationship of extraction to time during this initial phase corresponded to a zero order reaction with a rate constant of around 10 pct/min.

RI 8619. Removal of Organic Contaminants From Aluminum Chloride Solutions, by Jack C. White, Jack L. Henry, and Charles J. Krogh. 1982. 17 pp. 9 figs. The Bureau of Mines, in its efforts to insure the continued viability of the domestic minerals economy, has been engaged for several years in research on the extraction of alumina from domestic, nonbauxitic resources. Hydrochloric acid leaching of kaolin is one of the more promising technologies being studied for recovering alumina for feedstock to existing aluminum smelting capacity; 93 pct of this feedstock is currently imported either as bauxite or alumina. Organics contamination of pregnant leach liquor, originating during solvent extraction for removal of iron from aluminum chloride solution formed during hydrochloric acid leaching, causes rapid deterioration of the semihard rubber lining of process equipment. These organics were removed by a skimming tank-coalescer-activated carbon adsorption system. Organic levels of less than 10 ppm from the coalescer and less than 0.5 ppm from carbon adsorption were achieved. Analytical methods employing CCl_4 extraction and infrared spectrophotometry were developed to determine the organic content of both the liquor and the carbon. Mass transfer zones delineated in the carbon columns provide adsorption data for the design of larger systems.

RI 8620. Geologic Structures in Coal Mine Roof, by Noel N. Moebs and John L. Ellenberger. 1982. 16

pp. 11 figs. Studies by the Bureau of Mines have identified geologic structures in mine roof rock that contribute to many roof falls in Appalachian coal mines. These structures, including paleochannels, scours, pinchouts, slickensides, clay veins, crevasse splays, and joints, can often be identified during, and sometimes before, mine development. Mine projections can be revised to reduce the adverse effects of discontinuities in roof structure; large roof areas of laminated sandstone or incompetent strata generally can be delineated or inferred from exploratory drill hole data, and the need for supplementary support can be anticipated. Accurate descriptions of roof geology also provide some indication of optimum length and type of roof bolts that should be installed.

RI 8621. Thermodynamic Properties of Synthetic Acmite ($NaFe^{3+}Si_2O_6$), by K. O. Bennington and R. R. Brown. 1982. 12 pp. The thermodynamic properties of synthetic acmite, $NaFe^{3+}Si_2O_6$, were determined by the Bureau of Mines. The enthalpy of formation was determined by hydrofluoric acid solution calorimetry. The values of the standard enthalpy of formation at 298.15 K, $\Delta Hf°_{298.15}$, from the elements and from the oxides, $\Delta H°_{298.15}$, are

$$\Delta Hf°_{298.15} = -615.87 \pm 0.71 \text{ kcal/mole},$$

$\Delta H°_{298.15}$ (from oxides) $= -32.08 \pm 0.53$ kcal/mole. Various experimental data were combined with other data from the literature to calculate all the related thermodynamic properties in the range of 298 to 1,263 K. The standard Gibbs energy of formation is $\Delta Gf°_{298.15} = -575.8$ kcal/mole.

RI 8622. Steels From a Variety of Ferrous Scrap Including Materials of Low Quality, by V. R. Spironello, I. D. Shah, and R. H. Nafziger. 1982. 15 pp. 9 figs. One of the primary objectives of the Bureau of Mines solid waste utilization program is the recycling of the magnetic fraction of municipal solid waste called raw refuse scrap. In this investigation, several types of scrap of differing quality, including refuse and turnings, were melted in a 1-ton electric arc furnace in various combinations to produce steel in noncritical (construction) grades. Information on furnace operation and on the behavior of tramp and alloying elements was obtained. The research showed that it is possible to produce acceptable steel from a variety of steel scrap. Although some scrap is routinely used in steelmaking, it was found that up to 50 to 55 pct of the scrap charge can be refuse, provided it is combined with higher quality scrap. The chemistry of the steels was generally acceptable, and all of them were rolled without difficulty. The specification (ASTM 615) for the steels produced was grade 40 or grade 60, containing 0.30 or 0.40 pct C, with minimum yield strengths of 40,000 or 60,000 psi, respectively. Most of the steels met the specification requirements. Information on typical microstructures of some of the steels is included. The composition of some furnace dusts showed high levels of Sn, Pb, and Zn.

RI 8623. Engineering Properties of Combined Coarse and Fine Coal Wastes, by Bill M. Stewart and L. A. Atkins. 1982. 18 pp. 9 figs. The Bureau of Mines conducted laboratory tests to determine the effects on the physical properties of coarse coal waste of adding large amounts of fine coal waste. Maximum laboratory dry density, optimum moisture content, shear strength, and permeability tests were conducted on samples that contained 18 to 60 pct minus No. 4 (U.S. Standard sieve size) coal waste. For the nonslaky materials, maximum laboratory densities were highest and permeabilities lowest when the samples contained between 30 and 40 pct minus No. 4. Shear strength increased rapidly when the proportion of minus No. 4 was increased from 20 to 40 pct, but then increased only slightly or leveled off when the minus No. 4 was increased to 60 pct. Optimum moisture content and permeability were the physical properties most affected by the addition of fines. Optimum moisture content increased as much as 3 pct, and permeabilities decreased up to three orders of magnitude. Slaky coal waste material had physical property reactions to the addition of fines substantially different from those of nonslaky material.

RI 8624. Zirconium Oxide Molds for Small Molybdenum Investment Castings, by E. D. Calvert and H. W. Leavenworth, Jr. 1982. 26 pp. 18 figs. As part of its goal to minimize the requirements for critical and strategic minerals, the Bureau of Mines is conducting research to foster the use of domestically abundant materials such as molybdenum. This report describes the development of an investment shell molding technique that can be used to make castings of molybdenum and its alloys. The mold material is cubic ZrO_2 with a monoclinic ZrO_2 binder. The shell, formed by standard investment molding techniques described in the text, is prepared for molybdenum casting by firing for 6 hours at 1,550° C (2,822° F) or for 4 hours at 1,650° C (3,002° F). The resulting castings have predictable and reproducible dimensions with good detail. As-cast strength is poorer than the strength of wrought materials below 1,600° F. At and above this temperature, tensile strengths of cast and wrought materials are nearly equal. Aqueous corrosion of the castings in most media is insignificant.

RI 8625. Diagnostics of Sealed Coal Mine Fires, by J. M. Kuchta, A. L. Furno, L. E. Dalverny, M. J. Sapko, and C. D. Litton. 1982. 25 pp. 22 figs. The Bureau of Mines investigated four simulated coal gob fires to obtain a more reliable data base for defining the state of a sealed mine fire and to evaluate the performance of various fire detectors. The fires were conducted in a multiple-entry section of the Bruceton Experimental Mine by heating 4,000 to 21,000 pounds of rubblized bituminous coal to ignition and monitoring the temperature, gas emissions, and smoke under ventilated and sealed combustion conditions. Product gas concentrations depended upon the coal bed size, coal temperature, heating rate, and oxygen concentration or ventilating condition but varied little after the fires were sealed. Expressions are given that define the temporal variations of CO and O_2 after sealing when the coal temperature decreased rapidly. The CO/CO_2 ratio is a more sensitive fire indicator than the $CO/\Delta O_2$ ratio, although the latter is universally used for detecting the incipient state of a coal fire. In comparison, the Jones-Trickett ratio

$$\frac{CO_2 + \frac{3}{4}\ CO - \frac{1}{4}\ H_2}{\Delta O_2}$$

is less reliable for this purpose. The best detector for determining the state of a mine fire after it has been sealed was a prototype submicrometer smoke particulate sensor. Limitations of the various detector systems are also discussed.

RI 8626. Effects of Sodium Chloride Leach Solution Additive on Simulated In Situ Leaching of a Chalcopyrite Ore, by T. G. Carnahan and R. E. Lindstrom. 1982. 16 pp. 6 figs. The Bureau of Mines conducted research to simulate in situ leaching of a porphyry

copper sulfide ore. The purpose was to determine the effects on copper leaching of additions of NaCl to a conventional sulfate leach system and to analyze the oxidant requirements and the oxidation products that resulted from leaching of the sulfide minerals in the ore. Baseline sulfate and sulfate plus 2-pct-NaCl-leach-solution experiments employing 167-kg (367-lb) and 152-kg (333-lb) charges, respectively, were conducted. The minus 25.4-cm (10-inch) ore was leached at 90° C under flooded conditions with 2.8 MPa (400 psig) of oxygen bubbling through the system. Sixty-seven pct of the copper was extracted in 1,236 days of leaching in the NaCl experiment, whereas 47 pct of the copper was extracted in 913 days of leaching in the baseline experiment. Diffusion into and out of the ore fragments controlled the rate of leaching, which precluded enhancement of the leach rate by the chloride ions. The calculated oxygen consumption was 3.17 kg/kg of copper extracted in the baseline experiment and 3.46 kg/kg of copper extracted in the experiment to determine the effect of chloride ions.

RI 8627. Amphiboles in Soapstone Ridge, Ga., by Rolland L. Blake. 1982. 17 pp. 17 figs. Petrographic methods of examination were used by the Bureau of Mines on a suite of samples of ultramafic rock from Soapstone Ridge, Ga., located about 8 miles south-southeast of Atlanta. The samples were analyzed to determine (1) their potential for releasing regulatory particles upon crushing and grinding and (2) their concentration of fibrous particles that approach the dimensions of amphibole and serpentine asbestos minerals. Such particles might be generated during grading and excavation for housing and industrial development and could become a health concern. Light optical microscopy, scanning electron microscopy, and X-ray diffraction were the techniques used to examine the samples. Six of the twelve samples contained amphibole as a major mineral; in five, it was a moderate to minor mineral. One sample contained no amphiboles, and serpentine was not observed or identified by X-ray diffraction in any of the samples. In nine of the samples, the amphiboles exhibited a habit that was either prismatic or acicular, but not asbestiform. Two of the samples did contain asbestos, occurring as small veins or fracture fillings, which represented only a minor percentage of the total sample. Similar petrographic screening is recommended for examining any rock deposit or mine location to delineate hazardous and nonhazardous mineral areas.

RI 8628. Investigation of Longwall Gateroad Roof Support Characteristics at Powhatan No. 4 Mine. Instrumentation Plan, by G. J. Chekan and D. R. Babich. 1982. 9 pp. 8 figs. This Bureau of Mines publication describes the plan used to instrument two longwall gateroads at the Powhatan No. 4 Mine of the Quarto Mining Co. Vibrating wire stressmeters, flatjack U-cells, multipoint extensometer stations, and convergence stations were installed in or on the coal pillars, roof bolts, and roof strata of the gateroad entries. The instruments measure pillar stresses, bolt loadings, and strata movements as the gateroad entries are developed and the longwall panel(s) is mined. The report details only the instrumentation plan of the longwall gateroads and not the evaluation of any subsequent data. This is because a complete analysis of the data cannot be made until extraction of the longwall panel(s) is complete.

RI 8629. Analysis of Vapor-Aluminum-Diffused Stainless Steels, by L. L. Oden, M. P. Krug, and R. A. McCune. 1982. 12 pp. 7 figs. The Bureau of Mines analyzed vapor-aluminum-diffused stainless steels prior to conducting corrosion measurements in severely sulfidizing environments. These studies were conducted in response to the national need to better control the environmental and economic costs of corrosion. Specimens of a ferritic alloy and austenitic alloys types 316 and 310 were treated by a proprietary vapor-aluminum diffusion process and a dual vapor-aluminum diffusion process. Weights and dimensions were recorded before and after treatment, and comprehensive metallographic, X-ray, and electron microprobe analyses were conducted for both single- and dual-vapor-aluminum-diffused specimens. Surface aluminum concentrations ranged from 26 to 34 wt-pct for all alloys. Dual treatment increased the quantity of aluminum per unit area by a factor of 2 and increased the depth of penetration by a factor of 3. The aluminum-diffused region of the ferritic alloy was single-phase, αFe solid solution that was ordered on the surface, whereas two distinct diffusion layers were observed on the austenitic alloys. The outer layer comprised αFe solid solution that was ordered on the surface, and the inner layer was a two-phase mixture of αFe solid solution and the intermetallic compound AlNi.

RI 8630. Assessment of Subsidence Data From the Northern Appalachian Basin for Subsidence Prediction, by Sathit Tandanand and Larry R. Powell. 1982. 14 pp. 7 figs. Geological differences among various coalfields restrain the applicability of subsidence prediction using empirical approaches previously developed. The Bureau of Mines assessed data collected from 16 longwall panels in the Northern Appalachian basin. Attention was focused on the effects of rock lithology, excavation width, and panel depth on the subsidence factor. The results show that the subsidence factor can be expressed in terms of the width-to-depth ratio by a simple exponential equation, which has a coefficient tentatively considered as the subsidence index. This index varies with the lithology of a particular site, and can be expressed in terms of percent distribution of weak and strong rocks in the overburden.

RI 8631. Hydrogenation Catalysts From Intermetallic Compounds, by G. B. Atkinson, L. J. Nicks, E. G. Baglin, and D. J. Bauer. 1982. 8 pp. 5 figs. Properties of catalysts prepared from intermetallic compound precursors were investigated by the Bureau of Mines as part of its mission to decrease U.S. dependence on foreign sources for scarce catalytic materials, such as nickel, cobalt, and chromium. Methods were developed whereby catalysts with surface areas of 30 to 40 m^2/g were prepared from intermetallic compounds. Activity of these catalysts for the methanation reaction and methanol synthesis was determined using a fixed-bed, single-pass, flow-through reactor. Catalysts prepared from rare-earth-nickel intermetallics had specific activity for methanation that was five times greater than that of commercial catalysts and were equal to or better than commercial catalysts with regard to sulfur tolerance. Under identical reaction conditions, catalysts prepared from thorium-copper intermetallics produced more than 10 times as much methanol as a commercial low-pressure catalyst and exhibited a high degree of catalytic stability.

RI 8632. Fire Detection Systems in Conveyor Belt Haulageways, by C. D. Litton, M. Hertzberg, and A. L. Furno. 1982. 26 pp. 9 figs. The results of full-scale fire tests are used to determine optimum distributions of fire sensors for the protection of con-

veyor belt haulageways in underground coal mines. Empirical relationships are derived that relate the spacing of fire sensors to the rate of development of the fire hazard. For this application, a critical fire size is defined as that size of fire for which belt ignition and subsequent flame spread down the belt is assured. Detection and alarm, regardless of sensor type or sensing methodology, must be achieved at some point in time before the critical fire size is reached. Based upon this approach, it is found that the horizontal spacing for products-of-combustion sensors is in the range of 300 to 600 meters, while the required thermal sensor spacing is found to be ~4 meters or less. Additional design criteria are discussed for product-of-combustion fire sensing systems.

RI 8633. High-Temperature Corrosion Resistance of Basic Refractories to Coal and Lignite Ash Slags, by J. E. Pahlman, C. F. Anderson, and S. E. Khalafalla. 1982. 11 pp. 2 figs. The Bureau of Mines conducted research to determine the resistance of basic refractories to corrosion by ash slags that would result from the burning of coal and lignite in metallurgical operations. Basic refractories are of economic interest because they are from one-third to one-half as expensive as 90- to 99-pct-alumina refractories. Static tests were performed at 1,300° C and dynamic tests at 1,400° to 1,650° C to investigate the stability of refractory specimens in a slag environment. In alkali-containing lignite ash slags, in order of decreasing resistance, magnesite, magnesite-chrome, and chrome-magnesite refractories all had corrosion resistances equal to or better than 90- to 99-pct-alumina refractories. These basic refractories formed slag penetration layers in dynamic tests, which helped protect them from further attack. Chemically bonded basic refractories in general did not have as good a resistance to slag attack as did burned refractories of the same composition. In very acidic coal ash slag, a chrome-magnesite refractory containing 30 pct MgO plus a slag inhibitor and direct-bonded magnesite-chrome refractories with 60 pct MgO had good resistance to attack. Chrome-magnesite refractories (30 to 40 pct MgO) were moderately to severely attacked, and refractories with greater than 70 pct MgO were severely attacked by this same slag.

RI 8634. Iron Extraction From Simulated Aluminum Nitrate Leach Liquor, by J. A. Eisele, F. R. Smith, and D. J. Bauer. 1982. 9 pp. 5 figs. As part of its goal of maintaining an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines has studied the removal of iron from simulated aluminum nitrate leach liquors by solvent extraction. Iron must be removed from aluminum nitrate liquor produced by leaching calcined kaolinitic clay with HNO_3 to reduce the iron level in alumina to less than 0.02 wt-pct Fe_2O_3 for use in reduction cells. The parameters reported are for (1) extracting iron from a feed containing 1.5 g/l Fe with di(2-ethylhexyl) phosphoric acid (EHPA), (2) stripping loaded organic phase with 20-pct HCl, and (3) water washing of loaded and stripped organic phase. Recommended operating conditions are two extraction stages using 15 vol-pct EHPA in kerosine and three stripping stages using 20-pct HCl. Results are also given for tests using other extractants and stripping agents.

RI 8635. The Determination of the Points of Zero Charge of Fine Mineral Particles by a Titration Technique, by D. A. Stanley, P. M. Brown, and B. J. Scheiner. 1982. 7 pp. 4 figs. The Bureau of Mines has developed a simple titration technique for determining the points of zero charge (PZC) on minerals. The technique consists of titrating a mineral slurry with the potassium salt of polyvinyl sulfuric acid (PVSK) in the presence of an indicatory dye and a positively charged polymer. Values obtained by this simple method are in good agreement with values found in the literature.

RI 8636. Preliminary Studies on the Dewatering of Coal-Clay Waste Slurries Using a Flocculant, by Jalna R. Zatko, B. J. Scheiner, and Annie G. Smelley. 1982. 15 pp. 7 figs. Coal-clay waste slurries were dewatered in laboratory- and small-scale continuous tests by the Bureau of Mines using polyethylene oxide (PEO) as a flocculant. Dewatering from a nominal 7-wt-pct solids to over 50-wt-pct solids was accomplished using 0.5 lb of PEO per ton of feed in small-scale continuous tests. Parameters such as pH, initial solids content, and PEO concentrations were investigated. Water recovered from dewatering was reused as dilutant for PEO solutions.

RI 8637. Laboratory Evaluation of the Du Pont P-2500 Automatic Flow-Controlled Personal Dust Sampling Pump, by Robert J. Timko, Kenneth L. Williams, and George H. Schnakenberg, Jr. 1982. 18 pp. 13 figs. The objective of this Bureau of Mines research work was (1) to determine how well the E. I. du Pont de Nemours & Co. P-2500 personal dust sampling pump controls the flow rate at 2 L/min and (2) to compare respirable dust measurements made using the P-2500 with those made using a nonpulsating sampling flow system, both using the Dorr-Oliver 10-mm nylon cyclone dust size classifier. The calibrator and the operation manual for the P-2500, supplied by the manufacturer, were also evaluated. Flow tests consisted of long-term (6- to 8-hour) flow stability tests at various backpressures, a low-flow indicator examination, flow controller response time tests, and pulsation tests. Dust tests were performed using coal, silica, and Arizona road dust. No tests were performed to examine effects of temperature, barometric pressure, vibration, or mechanical shock. These pumps peformed well within manufacturer specifications in all tests.

RI 8638. Description and Economic Evaluation of Flue Gas Desulfurization by the Modified Citrate Process, by R. H. Lien, D. A. Martin, and W. I. Nissen. 1982. 26 pp. 8 figs. The Bureau of Mines developed a flue gas desulfurization process as part of its goal of minimizing the undesirable environmental impacts associated with energy and mineral-processing plants. The modified citrate process involves absorption of sulfur dioxide (SO_2) in a buffered citric acid solution. The SO_2-loaded solution is regenerated by countercurrent contact with steam in a packed tower. The wet SO_2 product is then dried and can be liquefied or further processed to make sulfuric acid. Test data from process investigation unit studies are presented. Material balances, flowsheets, and cost estimates are given for recovering SO_2 from copper smelter reverberatory gas, led smelter sintering machine tail gas, and powerplant stack gas. Operating cost estimates show the process will add $0.04 per pound of copper, $0.01 per pound of lead, and $0.015 per kwhr to the cost of the respective operations. These costs could be substantially reduced if a source of waste heat was available to provide the process steam requirements.

RI 8639. Assessment of Environmental Impacts Associated With Phosphogypsum in Florida, by Alexander May and John W. Sweeney. 1982. 19 pp. 3 figs.

In its role to provide technology to prevent or limit adverse environmental impacts associated with mining or minerals processing, the Bureau of Mines has conducted research at its Tuscaloosa Research Center to assess the environmental impacts of phosphogypsum produced by the Florida phosphate industry. Over the years, stockpiles containing 335 million tons of phosphogypsum have accumulated and the industry continues to generate an additional 33 million tons a year. Samples from approximately 1,000 feet of drill core, obtained from nine stockpiles, were characterized using chemical, X-ray diffraction, emission spectrographic, radiological, and physical means. The data developed indicated that phosphogypsum is not a corrosive or toxic hazardous waste as defined by Environmental Protection Agency criteria. Radium concentrations averaged 21 picocuries per gram and its content was inversely related to particle sizes. Thirty-nine elements were detected in phosphogypsum; concentrations of these elements did not vary with depth within the stockpiles. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8640. Drilling a Horizontal Coalbed Methane Drainage System From a Directional Surface Borehole, by David C. Oyler and William P. Diamond. 1982. 50 pp. 25 figs. Three long horizontal holes were drilled from a directionally drilled surface hole at the Emerald Mine near Waynesburg, Pa. The purpose was to adapt the technique of directional drilling for use in draining methane from coalbeds. A 504-m (1,652-ft) long, 76-mm (3-in) diameter, circular arc pilot hole was drilled, using a downhole mud motor, to enter the Pittsburgh coalbed at a vertical depth of 350 m (1,000 ft). The hole was reamed to 222 mm (8-3/4 in) and was cased to a measured depth of 486 m (1,595 ft). Three 76-mm (3-in) diameter horizontal drainage holes were then drilled, totaling 2,909 m (9,544 ft) of horizontal hole. Improvements in drilling methods increased the average drilling rate from 20.4 m (67 ft) to 64.9 m (213 ft) per day. The cost of drilling the directional and horizontal holes (using a Government-owned drill rig) was $1,169,530, a figure inflated by inexperience and by delays caused by lost-circulation problems and fishing operations. An estimated total drilling cost of $960,000 (including rental of a drill rig) for an improved system, was determined by a detailed cost analysis. Initial gas and water production from November 1979 through May 1980 was low because of caving of the horizontal holes drilled in shale near the bottom of the casing.

RI 8641. A Microseismic System for Monitoring Slope Stability, by C. Melvin Lepper, Allan P. Poland, and C. Thomas Mullis. 1982. 64 pp. 51 figs. Microseismic energy is generated when stresses accumulated in rock formations are released in the form of fracturing. The acoustic emissions resulting from these rock fractures and movements are detectable as velocity signals in the earth near the energy source. A Bureau of Mines microseismic system that is capable of detecting the acoustic emissions from pit slope movements is described. The digital circuitry incorporated in the system allows a microprocessor program to immediately calculate and present the location coordinates for the seismic energy source in the mine pit wall. This monitoring system is compact, portable, reliable, and relatively inexpensive and rapidly provides accurate information to the mine operators about the stability of a pit slope.

RI 8642. Effects of Temperature on Simulated In Situ Leaching of a Chalcopyrite Ore, by Thomas G. Carnahan. 1982. 16 pp. 6 figs. The Bureau of Mines conducted research to simulate in situ leaching of a chalcopyrite ore. The purpose was to obtain a direct comparison between moderate-temperature and elevated-temperature in situ leaching of copper from minus 10-inch ore and to analyze the sulfuric acid and oxygen requirements of the leaching system. Experiments employing oxygen were conducted at 35° and 90° C on 362- and 367-lb ore charges, respectively, under flooded conditions and at 400 psig. At 90° C, 47 pct of the copper was extracted in 913 days of leaching; at 35° C, 27 pct of the copper was extracted in 915 days. Diffusion into and out of the ore fragments controlled the rate of leaching. Oxygen consumption was 1.46 lb/lb of copper extracted at 35° C and 3.15 lb/lb of copper extracted at 90° C. Sulfuric acid requirements of the ore were 5.49 and 7.48 lb/lb of copper extracted at 35° and 90° C, respectively.

RI 8643. Gravimetric Preparation of Primary Standard Gas Mixtures in the Parts Per Trillion Range, by Ernest W. Loya, Charles A. Seitz, and David E. Emerson. 1982. 4 pp. A method for preparing gravimetric primary standards of helium in the parts per trillion range has been developed by the Bureau of Mines. The standards are used to calibrate a specially modified mass spectrometer used in determining the abundance of helium-3 and helium-4 in geochemical samples and of helium-3 in isotopically purified helium-4. The desired gas standards are prepared in 5-kg metal cylinders filled to 1,800 psia. Relative errors of less than 1 pct have been attained in the parts per trillion range using a successive dilution technique.

RI 8644. Underground Gob Gas Drainage During Longwall Mining, by Steven J. Schatzel, Gerald L. Finfinger, and Joseph Cervik. 1982. 14 pp. 15 figs. Gas drainage through surface boreholes has been the conventional means of methane control for U.S. longwall gobs. However, these vertical boreholes are becoming so costly, and the surface rights so difficult to obtain, that the Bureau of Mines is developing underground gob gas drainage as an alternate means of methane control for U.S. longwalls. Holes are drilled into the roof over the panel and on retreating longwalls, towards the working face from a location inby the face. As the longwall retreats, an increasing portion of the hole intercepts the fracture system over the caved gob. A surface exhauster maintains a vacuum on a pipeline paralleling the panel and draws the methane mixture out of the mine. Auxiliary systems of gob gas drainage during longwall mining will be essential for an increasing number of coal mines. Deep and gassy mines often find ventilation insufficient for adequate dilution of methane in bleeder entries. Although this cross-measure method of degasification has been used successfully in Europe, some of the European techniques cannot be directly applied to U.S. mines. This is the first study of its kind in this country.

RI 8645. Subsidence Over Four Room-and-Pillar Sections in Southwestern Pennsylvania, by Noel N. Moebs. 1982. 23 pp. 15 figs. The Bureau of Mines measured surface subsidence above four small coal mine room-and-pillar sections in southwestern Pennsylvania, to obtain preliminary information on the mag-

nitude and character of selected parameters, such as angle of draw and maximum subsidence, which are essential to the development of subsidence prediction methods. Data varied widely at the four sites; this is attributed to local geologic and mining conditions. Surface deformation at each site was of a magnitude normally associated with severe structural damage.

RI 8646. Separation of Copper-Nickel Mattes From Duluth Gabbro Concentrates by Flotation and Magnetic Methods, by Robert B. Schluter. 1982. 14 pp. 8 figs. The Bureau of Mines investigated separating copper-nickel mattes to recover a copper-rich fraction suitable for processing by conventional copper metallurgical processes and a nickel-rich fraction suitable for processing in a hydrometallurgical nickel circuit. Distribution of cobalt and precious metals between the copper and nickel fractions was also determined. A matte containing 65 pct Cu, 9 pct Ni, 4 pct Fe, and 20 pct S was separated into a copper fraction that comprised 80 pct of the matte weight and contained 70 pct Cu and <1.5 pct Ni, plus a nickel fraction that contained 40 pct Ni and 30 pct Cu. Recoveries of copper and nickel into their respective fractions were 90 pct and 87 pct. These results were obtained in a laboratory flotation cell at a matte grind of 90 pct minus 500 mesh and a pH of 12.4, using 1.7 pounds DPG (diphenylguanidine) per ton of matte as collector and frother. Magnetic separation was used to remove metallic iron-nickel alloy from the copper fractions. Distribution of cobalt was about 70 pct to the nickel fraction and 30 pct to the copper fraction. Silver reported predominately to the copper fraction, while Au, Pt, and Pd were essentially entirely recovered in the nickel fraction.

RI 8647. Thermodynamics of Calcination of Calcite, by H. C. Ko, N. Ahmad, and Y. A. Chang. 1982. 9 pp. Heats of solution of calcium carbonate (calcite) and calcium oxide in hydrochloric acid were determined by solution calorimetry. Combination of these two heats yields a value of 42.643±0.024 kcal/mole for the enthalpy of calcination of calcite at 298.15 K. Literature data on $\Delta H^\circ_{298.15}$ of calcination of calcite were reviewed and compared. Thermodynamic properties for the calcination process were calculated from 298.15 to 1,500 K using Gibbs energy functions. This research was undertaken by the Bureau of Mines as an effort to provide thermodynamic data for the advancement of minerals technology, energy conservation, and environmental preservation.

RI 8648. Results of EPA Extraction Procedure Toxicity Test Applied to Copper Reverberatory Slags, by E. A. Johnson, L. L. Oden, and P. E. Sanker. 1982. 16 pp. 4 figs. As part of its effort to reduce the environmental impact associated with mining and metallurgical operations, the Bureau of Mines used a modified form of the Environmental Protection Agency's Extraction Procedure toxicity test on copper reverberatory slags that contained low, medium, and high levels of the impurity elements As, Pb, Sb, Bi, and Zn. All tests resulted in extracts that did not exceed those limits published in the May 19, 1980, Federal Register; therefore, these solid wastes were designated as nonhazardous for most landfill disposal situations. However, arsenic and lead levels disturbingly close to the allowable limits—and even higher levels of copper and zinc, for which there are no established limits—leached from the high-impurity-element granulated slags. These slags should be handled in such a way so as to minimize the possibility of water contamination. One baghouse dust was tested according to the EPA procedure and found to exceed the extract limits by a factor of 10. This solid waste may be considered hazardous.

RI 8649. Silver Recovery From Cyanide Tailings Using an Acidic NaCl-$FeCl_2$ Leachant, by P. R. Bremner. 1982. 7 pp. In keeping with its mission to maximize mineral and metal recovery from domestic sources, the Bureau of Mines investigated a method to extract silver from tailings not amenable to cyanidation. Results of a laboratory study on the recovery of silver from cyanide tailings containing 1.7 ounces of silver per ton by leaching with an acidic ferrous chloride-sodium chloride solution are presented. The effects of reagent concentration and reaction time on the leaching of silver were investigated. A leaching solution containing 5 wt-pct NaCl, 2.5 wt-pct $FeCl_2$, and 1.2 wt-pct HCl (for acidity) extracted 82 pct of the silver from the tailings during a 24-hour leach. The amount of HCl consumed during the leach was 46 pounds of HCl per ton of feed. Only 23 pct of the silver was extracted by conventional cyanidation. Ninety-nine percent of the silver was recovered from the pregnant solution by cementation onto iron powder.

RI 8650. Corrosion Resistance of Ceramic Materials to Hydrochloric Acid (20 Wt-Pct at 50° C), by James P. Bennett. 1982. 11 pp. 5 figs. To improve construction materials for emerging chemical and metallurgical technologies, the Bureau of Mines is investigating the acid resistance of ceramic materials. In the study described here, eight commercial ceramic materials comprising two red shale, two fire clay, a silica, a silicon carbide, a carbon, and a high-alumina brick were evaluated. Samples were exposed to 20 wt-pct HCl at 50° C for 110 days. The test apparatus designed to evaluate the materials is described. Changes in chemical and mineralogical composition, cold crushing strength, volume, and weight, and leach rates of Al, Ca, Fe, K, Mg, Na, Si, and Ti ions were monitored. In general, the statistically significant physical property changes that occurred were small. In many cases, no changes were detected.

RI 8651. Safe, Effective Hangup Clearance for Underground Mines, by David P. Lindroth and Sterling J. Anderson. 1982. 12 pp. 9 figs. The Bureau of Mines has developed and successfully tested a hangup clearance module for use in clearing hangups in underground mine chutes and ore passes. The Bureau's tests showed that the hangup clearance module can be effectively used to clear mine hangups. Furthermore, it is believed that clearance using this module is quicker, safer, and more efficient than the method currently used. The hangup clearance module uses a ballistic disk explosive charge that can clear hangups located as far as 50 feet (15.2 m) from the position where the charge is detonated. Mine personnel can therefore set up the module and the charge it contains without being exposed to dangerous areas. This report describes the principles of operation of the module, provides data and drawings for its construction, and gives instructions for its setup and use. The report summarizes the development of the module, briefly discusses preliminary and underground tests, and lists the current and potential applications of the hangup clearance module to underground mining.

RI 8652. Case History of a Pilot-Scale Acidic In Situ Uranium Leaching Experiment, by Michael T.

Nigbor, William E. Engelmann, and Daryl R. Tweeton. 1982. 81 pp. 84 figs. The Bureau of Mines assisted the Rocky Mountain Energy Co. in a pilot-scale in situ leaching experiment at Casper, Wyo., to determine if sulfuric acid can be used as a cost-effective alternative lixiviant (leachant) for uranium in situ leaching. This experiment, which lasted more than 2 years, is the first fully documented pilot-scale operation in which the leaching-restoration cycle was completed using sulfuric acid instead of the more common carbonate-bicarbonate leachant. This report describes activities at the experimental site, presents extensive geochemical data from startup to site restoration, compares laboratory and field experiments, and discusses the environmental aspects of acid leaching. The data showed that sulfuric acid is apparently an effective leaching solution. Three to five grams of acid per liter of ground water resulted in a production solution grade of 80 to 100 ppm uranium. Restoration was successful, but required extended flushing. The pH was the last chemical parameter to return to baseline, requiring about 350 days. This was longer than was predicted in laboratory simulations. The data also showed that mobilization of toxic elements such as selenium, arsenic, radium, thorium, and molybdenum stayed within reasonable limits and quickly fell back to preleach concentrations during restoration.

RI 8653. Restoration of Surface Vegetation on Uranium Wastes at Uravan, Colo., by L. J. Froisland, P. L. Placek, and M. B. Shirts. 1982. 13 pp. 7 figs. The Bureau of Mines conducted a 4-year research program at Uravan, Colo., on a 2-1/2-acre reclamation plot on the slope of a uranium tailings pile that had been covered with mine waste rock. The purpose of this study was to determine the effects of plant species, type of irrigation, type of fertilizers, and use of dust control chemicals on plant growth and surface coverage. Best grass coverage, nearly 100 percent with 240 plants per square foot, was developed in a section that was seeded with crested wheatgrass, fertilized with sewage sludge, and sprinkler irrigated. For comparison, a section that had been treated with commercial fertilizers developed 3.1 crested wheatgrass plants per square foot and 24 percent coverage without irrigation, and 8 plants per square foot and 75 percent coverage with irrigation. Results of spraying a dust control chemical were inconclusive. Russian-thistle invaded all test sections and ranged in density from 0.6 to 7.3 plants per square foot.

RI 8654. An Iron-Aluminum-Molybdenum Alloy as a Chromium-Free Stainless Steel Substitute, by J. S. Dunning. 1982. 13 pp. 4 figs. The Bureau of Mines investigated a series of Fe-Al-Mo alloys strengthened by ZrC (zirconium carbide) precipitates as chromium-free substitutes for stainless steels. Melting and fabrication methods were devised, and the effects of minor additions of columbium (niobium) and cerium on the mechanical properties and oxidation resistance were determined. Zirconium carbides could not be controlled reliably to produce fine precipitate dispersions. A more reliable carbide strengthening mechanism is required if the high-temperature strengths of types 304 and 316 stainless steels are to be duplicated. Workability and oxidation resistance of the alloy series were excellent.

RI 8655. Copper Losses and the Distribution of Impurity Elements Between Matte and Silica-Saturated Iron Silicate Slags at 1,250° C, by E. A. Johnson, P. E. Sanker, L. L. Oden, and J. B. See. 1982. 18 pp. 14 figs. The Bureau of Mines determined the effect of slag additives on copper solubility and the distribution of typical impurity elements between copper-iron matte and silica-saturated fayalite (iron silicate) slag at 1,250° C, in CO-CO_2 atmospheres with 10 pct SO_2 Small additions (<10 pct) of CaO, Al_2O_3, and MgO were shown to decrease copper solubility of the slag. Additions of CaO increased the solubility of bismuth and tellurium in the slag at lower matte grades. Al_2O_3 additions decreased the solubility of tellurium in the slag, but increased that of bismuth at lower matte grades. MgO additions increased the solubility of both at lower matte grades. With no additives, matte grade did not affect the solubility of bismuth in slags, whereas increasing matte grade resulted in a slight decrease in the tellurium solubility in slag. Additions of CaO or As_2O_3 alone to the slag increased selenium and arsenic distribution to the matte, but had little or no effect on antimony distribution; whereas small MgO additions decreased antimony distribution to the matte but had no effect on arsenic and selenium distribution. In slags with no additives, selenium distribution to the matte increased with increasing matte grade, while that of antimony decreased and that of arsenic was unchanged.

RI 8656. Electrochemical Studies of Platinum-Group Metals in Molten Alkali Metal Cyanides, by D. R. Flinn and C. L. Manger. 1982. 16 pp. 9 figs. The Bureau of Mines has studied the electrochemical parameters important to the preparation of coatings of the platinum-group metals. Using molten mixtures of sodium and potassium cyanides in an inert atmosphere, techniques have been developed that permit the preparation of baths for platinum, rhodium, and iridium electrodeposition. Cyclic voltametric and slow sweep rate linear polarization techniques have been utilized to determine optimum potential and current values for preparation of plating baths and for the electrodeposition of coatings. Techniques are described for the deposition of platinum and rhodium coatings at near 100 percent anode and cathode current efficiencies, and for iridium at approximately 80-percent efficiency. Palladium deposition from these molten cyanide baths remains unsatisfactory. The chemistry of the palladium-containing cyanide bath is discussed. Examples of scanning electron microscope photomicrographs of typical platinum coatings are presented. Techniques are described for the preparation of platinum coatings on large objects.

RI 8657. Laboratory Testing of Chemical Oxygen Self-Rescuers for Ruggedness and Reliability, by Jerry W. Stengel, Nicholas Kyriazi, and Sarah L. Benz. 1982. 21 pp. 12 figs. The Bureau of Mines subjected two manufacturers' chemical oxygen (KO_2) self-rescue breathing apparatus to a series of laboratory environmental treatments designed to stimulate various conditions in underground coal mines. The environmental treatments consisted of extremes of temperature, shock, and vibration. The tests were designed to be used as predictors of the ability of the self-rescuers to survive those environmental insults with no degradation in their protection to the wearer. Based on the severity of the treatments, simulating conditions more severe than offered by the mining environment, the two apparatus tested should be able to withstand the abuse offered by the mining environment and still function as intended in an emergency. Correlation of these tests with results of long-term field evaluations is needed to provide confidence in the laboratory tests as predictors.

RI 8658. Superheated Drop Vaporization: Halon 1301, by John C. Edwards and Henry E. Perlee. 1982. 19 pp. 6 figs. The Bureau of Mines has developed a time-dependent droplet vaporization model (in the absence of forced convection) that can be applied to the vaporization of liquid Halon 1301 droplets (vapor pressure at 300 K = 14 atm) sprayed from an extinguisher. It was found that rapid surface vaporization quickly lowers the droplets' surface temperature very near to the boiling temperature, and the vaporization becomes diffusion controlled. Although the lifetime of the droplet is proportional to the square of the initial radius of the droplet, the elapsed time prior to complete droplet vaporization is not proportional to the square of the droplet radius, as an equilibrium model would indicate.

RI 8659. Recovery of Cadmium, Zinc, and Lead From Lead Smelter Flue Dusts, by V. R. Miller, T. L. Hebble, and D. L. Paulson. 1982. 12 pp. 6 figs. The Bureau of Mines has developed a technique to separate and recover the three major components, Pb, Zn, and Cd, from lead smelter flue dust. This research was conducted as part of the Bureau's effort to reduce environmental conflicts and occupational hazards associated with mineral-processing operations and to recover valuable constituents in emissions and effluents. The laboratory process utilizes sulfation roasting of the flue dust followed by water leaching to extract over 95 pct of the cadmium and zinc. Ninety-nine percent of the cadmium was recovered from solution by cementing with zinc dust, and zinc was electrowon from the resulting solution after purification. Zinc electrolysis was carried out in a 1-liter cell at 35° C with a cathode-current density of 8 A/dm^2 in a solution containing 65 g/l Zn^{++} and 180 g/l H_2SO_4. Current efficiencies of 80 pct were obtained. The leached residue consisted largely of $PbSO_4$, which was converted to $PbCO_3$ and leached with H_2SiF_6 to produce $PbSiF_6$ electrolyte. Ninety-five percent of the lead contained in the residue was converted to electrolyte. Lead was electrowon from solutions containing 70 g/l Pb^{++} and 90 g/l H_2SiF_6 using a lead cathode, PbO_2-coated titanium anodes at 28° C, and a current density of 1.6. A/dm^2. Current efficiencies approaching 92 pct were obtained. Accessory minerals such as cobalt and nickel were separated into purification residues and liquor.

RI 8660. Determination of Geologic Features Associated With Linears, by Jacqueline H. Jansky and Paul W. Jeran. 1982. 8 pp. 5 figs. The Bureau of Mines conducted a study to determine the relationship between geologic features and linears. Cleats, kettlebottoms, and roof rolls were mapped and superimposed on the linear plots for a coal mine in West Virginia. No clear relationships were evident. This may be due, in part, to the mining practice of leaving head coal, which obscures geologic features that may exist in the roof. Future studies should concentrate on mines where roof is extensively exposed.

RI 8661. Anion Characterization of Florida Phosphate Rock Mining Materials and U.S. Cement Kiln Dust by Ion Chromatography, by Gary W. Kramer and Benjamin W. Haynes. 1982. 8 pp. 2 figs. The Bureau of Mines has developed a rapid analytical method for the determination of anions by ion chromatography (IC) in phosphate rock mining materials and cement kiln dust (CKD). The procedure employs an Na_2CO_3 fusion of the sample, followed by a water extraction that allows direct injection of the sample into an ion chromatograph without separator column poisoning by the transition metal ions. Fluoride (F^-) and phosphate (PO_4^{3-}) were determined in 24 phosphate rock processing and waste material samples by the IC method. The results were compared with a pyrohydrolytic distillation-titration method for F^- and a colorimetric procedure for PO_4^{3-}. Excellent analytical agreement was obtained for F^- and PO_4^{3-} values determined by IC and the comparable wet chemical methods. Fluoride values ranged from 0.3 wt-pct in the filter cake to 3.6 wt-pct in phosphate rock concentrate. Phosphate values ranged from 1.2 wt-pct in the filter cake to 33.8 wt-pct in the rock concentrate. Fluoride, chloride, phosphate, nitrate, and sulfate in several CKD samples were determined by the IC method and standard wet chemical techniques. Excellent agreement was obtained between the two methods for all anions. A total of 113 CKD samples from all areas of the United States was analyzed by the IC method. Fluoride values ranged from < 0.01 to 0.36 wt-pct. Chloride values ranged from < 0.01 to 12.5 wt-pct. Sulfate values ranged from 0.41 to 31.6 wt-pct. Phosphate and nitrate were detected in only about 25 pct of the samples at > 0.02 wt-pct. Maximum phosphate and nitrate values were 1.0 and 1.6 wt-pct, respectively.

RI 8662. Superplasticity in Commercial and Experimental Compositions of Magnesium Alloy Sheet, by M. M. Tilman and L. A. Neumeier. 1982. 29 pp. 17 figs. The Bureau of Mines conducted research to evaluate superplastic behavior in commercial magnesium-base alloys AZ61A, ZK60A, ZW3, AZ31B, ZW1, and an experimental Mg-12 pct Al alloy. Strain-rate sensitivity indices (m-values), maximum elongations, and effects of superplastic elongation on tensile properties were determined on fine-grained sheet. Inert-gas-pressure hemisphere-forming tests were conducted on selected sheet stock of the five alloys. Formability trials on AZ31B alloy sheet were conducted on industrial equipment for comparison with commercial superplastic forming of Zn-Al alloy. Closed-die-forming tests were performed on extruded ZK60A rod. All alloys exhibited well over 100-pct elongation, indicating superplasticity, at temperatures and strain rates near the maximum m-values. Tensile properties were generally reduced following 100-pct superplastic elongation, but not to an extent that would preclude use of the commercial alloys in the superplastically deformed condition. The potential for industrial superplastic forming of AZ31B sheet was indicated by hemisphere forming in the laboratory and substantiated in industrial forming trials.

RI 8663. Effect of the Diurnal Cycle and Fan Shutdowns on Radon Concentration in an Experimental Uranium Mine, by Connie S. Musulin, John C. Franklin, and V. W. Thomas. 1982. 13 pp. 12 figs. Radon concentrations in shallow uranium mines such as the Bureau of Mines experimental research mine are affected by barometric pressure changes. The radon concentrations show a significant correlation with absolute pressure, but over a period of days, a steady rise or fall in barometric pressure will result in noncorrelation of data. Fan shutdowns also affect radon concentrations, and an equation was derived to determine the time required for the radon concentration to return to normal after a fan shutdown, whether the ventilation is blowing or exhausting.

RI 8664. Radon Emanation From Stopes Backfilled With Cemented Uranium Mill Tailings, by J. C. Franklin, R. A. Washington, J. C. Kerkering, H. Montone, and R. Regan. 1982. 8 pp. 3 figs. An experiment was conducted by the U.S. Bureau of Mines and the Canada Centre for Mineral and Energy Technology (CANMET) to measure the emanation rate of radon from cemented unclassified mill tailings in two dewatered stopes of a uranium mine at Elliot Lake, Ontario, Canada. The radon was monitored upstream and downstream and in both stopes to determine the concentration in the stopes and the amount exhausted from both stopes. The emanation rate was determined to be 0.55 $pCi/cm^2\ sec^{-1}$ from the mill tailings, which is approximately 1,000 times higher than the average flux in the mine before backfilling.

RI 8665. Probability of Encountering Coalbed Discontinuities During Vertical and Horizontal Borehole Drilling, by David W. Houseknecht. 1982. 21 pp. 11 figs. Probabilities of encountering coalbed discontinuities during vertical or horizontal drilling in a specific coalbed can be estimated based on analysis of mined-out areas of the coalbed where the size, shape, orientation, and distribution of discontinuities are known. The resultant probability estimates can be applied to cost-risk evaluations of drilling programs proposed for exploratory, developmental, or methane drainage purposes in undeveloped areas of that coalbed. Data compiled from mine maps of the Beckley Coalbed in southern West Virginia were used to estimate the probabilities that discontinuities would be encountered in two illustrative hypothetical drilling programs—one for drilling vertical boreholes and the other for drilling horizontal boreholes. Analysis based on a mined-out area of the Beckley Coalbed indicated that vertical methane drainage boreholes spaced 1,000 feet apart in a square grid pattern would each have a 29-percent probability of encountering a discontinuity in a geologically unexplored area of the coalbed. It was also determined that exploratory vertical drilling could locate most of the discontinuities if a borehole spacing of 2,500 feet were used. For horizontal drainage boreholes in the Beckley Coalbed, the analysis indicated a linear relationship between hole length and the probability of encountering a discontinuity.

RI 8666. Electrokinetic Densification of Solids in a Coal Mine Sediment Pond—A Feasibility Study (In Two Parts). 1. Laboratory and Field Tests, by R. H. Sprute and D. J. Kelsh. 1982. 32 pp. 15 figs. This report describes a feasibility study to consolidate coal waste sludge in a 100-acre pond by applying direct current between floating and buried electrodes. The study was conducted by the Bureau of Mines under a cooperative agreement with Washington Irrigation and Development Co., located near Centralia, Wash. Part 1 covers results of laboratory tests at the Bureau's Spokane Research Center and a small-scale field test at the cooperator's coal preparation plant in western Washington. The process is efficient and cost-effective when power is applied at low current density. A proposed system, fully described in part 2, has electrodes covering 21 acres of pond surface radially arranged around a central power platform. Densification of pond contents would require 2 to 3 years of treatment. Total cost of equipment, labor, and material is approximately $500,000.

RI 8667. Weathering of a Base-Metal Sulfide Leaching Residue, by T. G. Carnahan and M. A. Lucas. 1982. 11 pp. 12 figs. The Bureau of Mines conducted laboratory-scale weathering research on a leach residue containing elemental sulfur and mixed metal sulfides. Experiments were performed to determine pH and impurity element concentrations in the effluents as functions of time and to determine the effects on effluent concentrations of mixing the residue with dolomite tailing material. Four 800-day tests were conducted simultaneously. Soluble metal concentrations, especially zinc and copper, were excessive in the effluents from washed and unwashed samples of the residue. Concentrations of up to 20 g/l of Zn and 12 g/l of Cu were obtained. The pH values of the unwashed and washed residue effluents at the completion of the experiments were 2.8 and 1.9, respectively. Sulfuric acid from oxidation of pyrite caused the pH decrease. Mixing unwashed residue with dolomite tailing to maintain a near-neutral pH minimized the heavy metals content in the effluents. The pH in the dolomite tests increased slowly after the first 360 days and attained values of 7.8 and 8.2, respectively, for tailing containing 1 pct leach residue and for tailing devoid of leach residue. Dissolved zinc and copper did not exceed 0.10 g/l of Zn and 0.001 g/l of Cu.

RI 8668. Recovery of Ultrafine Barite From Mill Wastes, by W. E. Lamont and G. V. Sullivan. 1982. 12 pp. 6 figs. The Bureau of Mines conducted flotation tests on a mixture of barite waste materials from Nevada in which essentially all of the barite values were finer than 20 micrometers. Flotation variables investigated in these tests were the effects of (1) sodium silicate as a pulp dispersant, (2) sodium hydroxide as a pH modifier, (3) increased amounts of sodium cetyl sulfate, (4) conditioning time, and (5) solids content during conditioning. The optimum flotation conditions were achieved by adding 2.5 pounds of sodium silicate and 10 pounds of sodium cetyl sulfate per ton of feed and conditioning the pulp for 20 minutes at a 35-percent solids content. Using these conditions, a concentrate was produced that contained 94.7 percent $BaSO_4$, with an attendant recovery of 90.9 percent of the barite in the feed. In addition to the flotation tests, a selective barite flocculation process was developed to treat extremely fine barite. A barite concentrate containing 96.5 percent $BaSO_4$ with an attendant recovery of 82.1 percent of the barite was produced by selective flocculation. A process patent application has been filed based on this process.

RI 8669. Degasification of the Mary Lee Coalbed, Brookwood, Ala., by John H. Perry, Leonard J. Prosser, Jr., and Joseph Cervik. 1982. 13 pp. 13 figs. The Bureau of Mines has developed several techniques for draining methane from coalbeds in advance of mining. Drilling long horizontal holes from an underground location is one such technique, which was successfully demonstrated in the Pittsburgh and Sunnyside Coalbeds. The same technique has now been applied in the Mary Lee Coalbed at Jim Walter Resources, Inc.'s No. 4 Mine, Brookwood, Ala., where two holes were drilled horizontally—one to a depth of 1,010 feet (308 m) and the other to 540 feet (165 m). The 1,010-foot (308-m) hole proved successful in degasifying a portion of the Mary Lee Coalbed. The hole drained methane for 1 year, during which time the initial gas flow of 200,000 ft^3/d (5,663 m^3/d) declined to 65,000 ft^3/d (1,840 m^3/d). Total gas production was 40×10^6 ft^3 (1.1×10^6 m^3). The gas was of commercial quality, with 98 pct methane and a heat rating of

990 Btu/ft³ (36.89 Mj/m³). The methane emissions from the faces of the mine section advancing into the degasified zone were reduced by 60 pct. The 540-foot (165-m) hole was terminated prematurely when it became impossible to maintain an open hole. Because of caving, very little gas was drained through this hole.

RI 8670. Firing an Iron Ore Pelletizing Kiln With Low-Btu Gas From Lignite, by John C. Nigro. 1982. 22 pp. 7 figs. This Bureau of Mines report summarizes the performance characteristics of a 30-day around-the-clock gasification-pelletizing test conducted in October and November of 1980 with North Dakota Indianhead lignite. Gasification was conducted in a commercial-size, 6.5-ft-diam, single-stage, fixed-bed, atmospheric pressure producer with a rated capacity of about 30 million Btu/hr. Iron oxide pellets made from a commercial hematite concentrate were fired with the low-Btu gas in a 2.8-ft-diam by 35-ft-long pilot plant rotary kiln at a rate of 900 lb of pellets per hour. Gasifier operations at fuel feed rates up to 3 tons of lignite per hour and hematite pellet induration with raw 160-Btu/std ft³ lignite gas are described.

RI 8671. Thermodynamic Data for Arsenic Sulfide Reactions, by A. D. Mah. 1982. 85 pp. Thermodynamic data on compounds of arsenic and sulfur were critically evaluated by the Bureau of Mines. Changes of standard enthalpy and Gibbs energy, and logarithms of the equilibrium constants were tabulated as a function of temperature for reactions involving these compounds.

RI 8672. Sludge Disposal From Acid Mine Drainage Treatment, by T. E. Ackman. 1982. 25 pp. 7 figs. The Bureau of Mines conducted a study of current trends in methods employed by the coal industry to dispose of acid mine drainage (AMD) treatment sludge. Thirty-three AMD treatment plants, operated by 11 Pennsylvania coal companies, were randomly surveyed. These plants provided data for calculating sludge volumes, as well as information on sludge settling, transportation, and disposal. Onsite visits allowed observation of problems associated with the various methods of sludge disposal: (1) disposal into a deep mine, (2) permanent retention in ponds, (3) disposal at an active coal refuse area, and (4) onsite burial. Method 1 is the most frequently used and the most environmentally sound. It is apparent, based on this representative sampling of AMD treatment plants, that the magnitude of sludge production is such that an aggressive and directed effort in reduction of sludge volume is seriously needed. The areas of major concern are (1) the amount of surface land required for sludge storage and disposal, (2) reclamation of these disturbed surface areas, and (3) effective and efficient means of removing, transporting, and disposing of AMD sludge. In this report, an engineering approach to the practical problems associated with the existing disposal methods is presented, together with recommendations for future research.

RI 8673. Recovery of High-Grade Barite From Waste Pond Materials, by W. E. Lamont and G. V. Sullivan. 1982. 13 pp. The Bureau of Mines studied the potential for recovering marketable barite concentrates that meet oil well drilling-mud specifications from barite waste pond materials. The study was conducted as part of the Bureau's research program to conserve domestic mineral resources by advancing mineral recycling technology. The samples, which were obtained from Georgia, Nevada, Missouri, and Illinois, varied widely in character, particle size, and barite content. The samples were treated with sodium silicate and sodium cetyl-stearyl sulfate and then floated. The flotation flowsheet was modified to reject barren coarse and/or slime fractions from some of the samples, and one feed sample had to be scrubbed prior to flotation to remove residual flotation reagents. The cleaned concentrates had $BaSO_4$ contents ranging from 95.0 to 96.9 percent, while recovering 81.2 to 95.9 percent of the barite in the feed. The specific gravity of each concentrate exceeded the specification of 4.2. The removal of the flotation reagents from the flotation concentrate was not investigated. This research was conducted under a memorandum of agreement between the Bureau of Mines, U.S Department of the Interior, and the University of Alabama.

RI 8674. Size and Shape Characterization of Fibrous Zeolites by Electron Microscopy, by Kim B. Shedd, Robert L. Virta, and Ann G. Wylie. 1982. 20 pp. 10 figs. The U.S. Bureau of Mines Particulate Mineralogy Unit examined the habits of six zeolite minerals commonly occurring in domestic zeolite deposits. Mineral habit is of interest because current theory on the potential for sarcoma production in test animals emphasizes the size and shape of mineral particles, without regard to composition or structure. A scanning electron microscopic study revealed that, of these six minerals, only mordenite and erionite crystallized in acicular to fibrous habits. The fibrous varieties of these two minerals were characterized by size and shape on the transmission electron microscope, and their dimensions were compared with those of asbestos and amphibole cleavage fragments. When comminuted, these two minerals possess "fibrosity indices" similar to those of amphibole cleavage fragments. One sample, a rare woolly erionite, has uniform widths, large aspect ratios, and a "fibrosity index" similar to those of asbestos.

RI 8675. Degasification Study From an Air Shaft in the Beckley Coalbed, by Tobias W. Goodman, Joseph Cervik, and George N. Aul. 1982. 19 pp. 19 figs. The Bureau of Mines conducted research to degasify a virgin block of coal in the Beckley Coalbed using long horizontal holes drilled in an array from the bottom of a ventilation air shaft. Eight horizontal holes and an in situ pressure hole were drilled in a radial pattern to depths ranging from 418 to 910 ft (127 to 277 m) and 205 ft (62 m), respectively. The investigation showed the shaft was in a basin saturated with water, which resulted in low gas flows from holes. The in situ pressure at 200 ft (61 m) into the coalbed was 79 psig (544.6 KN/m²). The average gas and water flows for the eight holes were 94,100 ft³/day (2,665 m³/day) and 13 gal/min (49.3 l/min). After 514 days of degasification, 18.7 million ft³ (0.53 million m³) of gas had been drained. Methane face emissions, which were measured as a section advanced toward the shaft, were reduced about 77 pct, emphasizing the value of drainage by this technique. All holes were grouted before the area around the shaft was mined.

RI 8676. Chromium Recovery From Nickel-Cobalt Laterite and Laterite Leach Residue, by D. E. Kirby, D. R. George, and C. B. Daellenbach. 1982. 22 pp. 7 figs. In line with the Bureau of Mines goal of providing technology to maintain a supply of minerals adequate to meet national economic and stra-

tegic needs, a method for recovering chromite from lateritic material was investigated. Laterites are a large resource of Ni, Co, and Cr, critical metals of which the United States has insufficient domestic sources. A roast-leach method was developed by the Bureau to extract nickel and cobalt from domestic laterites. A concurrent effort was made to recover chromium from either unprocessed laterites or the leach residues. This report characterizes laterites and laterite leach residues. It describes a chromite recovery procedure using conventional industrial beneficiation equipment for sizing, low-intensity magnetic separation, and gravity concentration. Concentrates containing 20.0 to 22.4 pct Cr (29.0 to 32.7 pct Cr_2O_3) and with a 1.6:1 to 1.9:1 Cr-Fe ratio were recovered from laterites and residues containing 1.3 to 2.5 pct Cr with recoveries exceeding 50 pct. Because of their low grade and fine size, these concentrates would be suitable for preparing chromium chemicals. The direct beneficiation of laterites for chromite recovery resulted in the minerals containing nickel and cobalt concentrating in slime products. No iron oxide coproducts of acceptable grade were recovered from either laterites or residues.

RI 8677. Sand Bed Dewatering of Alumina Miniplant Tailings, by R. L. Rickel, P. J. Barrett, and D. M. Starrett. 1982. 10 pp. 4 figs. The Bureau of Mines, as part of its minerals environmental technology research, conducted a study of mine waste tailings disposal. Part of the investigation evaluated the sand bed dewatering technique for disposal of alumina miniplant tailings as a means to increase consolidation rates and contain effluents. The technique employs a bed of sand resting on an impervious bottom. The tailings slurry is impounded over the sand layer and is dewatered through bottom drain piping. The study employed a single 10-ft-high, 6-in-diam, clear polyvinyl chloride (PVC) column, and thickener wastes from the acid leaching of calcined kaolin clay. Results showed a consolidation rate of 41 in in 186 days for a total volume reduction of 37 pct. Sand bed dewatering was an efficient technique for solid consolidation and effluent containment when compared with data obtained from other dewatering studies.

RI 8678. Direct Flotation of Potash From Carnallite, by D. G. Foot, Jr., C. E. Jordan, and J. L. Huiatt. 1982. 11 pp. 4 figs. The Bureau of Mines devised a direct flotation method for recovering potash from carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$) ore characterized by a high content of water-insoluble impurities. The method includes (1) a decomposition leach of the carnallite, (2) flocculation-depression of the insoluble slimes, (3) potash rougher, cleaner, and recleaner flotation, and (4) final product leaching. The technique eliminates the necessity for removing the water-insoluble slimes by mechanical or flotation desliming. Laboratory results demonstrated that the direct flotation procedure, when compared with conventional techniques, yielded equivalent or improved flotation results with equal or less reagent consumption. Locked-cycle testing of the direct flotation method recovered 87.8 pct of the potassium in the flotation feed in a final product containing 60.6 pct K_2O. A flowsheet incorporating the carnallite leaching-potash flotation procedure is presented.

RI 8679. Hydrometallurgical Treatment of Arsenic-Containing Lead-Smelter Flue Dust, by P. A. Bloom, J. H. Maysilles, and H. Dolezal. 1982. 12 pp. 3 figs. Arsenic-containing flue dusts are currently being stockpiled by several nonferrous smelters in the United States. These stockpiles are a source of environmental concern since the dusts can be transported by wind and contain water-soluble arsenic. The stockpiles also represent an alternate source of metals. To provide a quality environment, the Bureau of Mines investigated a process to make environmentally acceptable the discard of arsenic obtained from the treatment of arsenical flue dust. The process includes (1) leaching arsenic from a lead smelter copper dross flue dust, (2) fixing arsenic as an insoluble compound, and (3) recovering other metal values. Overall results of acid-leaching tests on lead-smelter flue dusts showed that H_2SO_4 dissolved 80 to 90 percent of the As, Zn, and Cd, and up to 86 percent of the In. Pb, Ag, and Au remain in the residue, which can be recycled to the smelter. Indium was recovered from the strong acid leach solution by solvent extraction; arsenic was fixed in a stable form by precipitation with $Fe_2(SO_4)_3$ and CaO or $CaCO_3$. (*Out of print.*)

RI 8680. Operation of a Mineral Recovery Unit on Brine From the Salton Sea Known Geothermal Resource Area, by L. E. Schultze and D. J. Bauer. 1982. 12 pp. 4 figs. The Bureau of Mines operated a mineral recovery unit to recover metal values from post-flash geothermal brines from the Salton Sea known geothermal resource area as part of its research into the use of plentiful resources. The brine was available for metals recovery after its heat content had been used to generate electricity. The brine source was treated with lime to precipitate the contained iron, manganese, lead, and zinc before injection of the heat-depleted brine into the underground reservoir. Data are presented on the effects of process variables, such as rate and method of lime addition and air oxidation versus air exclusion. Variations in precipitation of metal values, composition of precipitates, effectiveness of slurry thickeners, and methods of treating the precipitates to recover metal values are discussed.

RI 8681. Beneficiation of a Phosphate Ore Produced by Borehole Mining, by B. E. Davis, T. O. Llewellyn, and G. V. Sullivan. 1982. 10 pp. As part of its program to increase the domestic availability of critical minerals, the Bureau of Mines conducted characterization and beneficiation studies on a St. Johns County, Fla., phosphate ore that was mined by borehole mining. Results revealed that the ore from this test mine was mostly sand-size carbonate-fluorapatite and quartz and contained 24.6 percent P_2O_5. Concentration by various flotation techniques produced phosphate concentrates that ranged, in percent, from 30.0 to 31.4 P_2O_5, 0.73 to 0.80 MgO, and 2.8 to 7.2 acid insoluble. Recovery of the phosphate from the ore ranged from 89.4 to 96.3 percent.

RI 8682. Failure Analysis of Diesel Exhaust-Gas Water Scrubbers, by Robert W. Waytulonis, Sean D. Smith, and Lito C. Mejia. 1982. 19 pp. 13 figs. The Federal Bureau of Mines contacted 29 organizations—mine maintenance departments and equipment manufacturers—concerning service experience and construction of diesel exhaust-gas water scrubbers. Scrubbers are used primarily on mobile diesel-powered mining equipment subject to 30 CFR 36. Because the scrubbers cool exhaust gas and act as flame arresters, their failure would compromise safety in underground mines. Scrubber maintenance problems and frequency and modes of failure were identified, and construction materials and techniques were evaluated. Three failed scrub-

bers were randomly selected from two cooperating mines, and their modes of failure were determined. In conjunction with failure analyses, mine water and scrubber water solution samples were chemically analyzed to characterize corrosive properties. Sludge and mineral deposits and different types of corrosion and metal fatigue were identified as problems leading to scrubber failure. The corrosion process is explained; maintenance practices, construction materials, and manufacturing methods that could be used to reduce premature failures and allow longer effective scrubber life are identified; and basic changes in scrubber design are suggested. If type 304 stainless steel is used throughout the scrubber and regular maintenance is performed, long, dependable service can be expected. Other materials such as 304L, 316, or other more exotic steel alloys may be necessary under certain conditions.

RI 8683. Determination of Sulfates in Diesel Exhaust, by Robert W. Freedman and Frederick A. Sharp. 1982. 7 pp. 3 figs. This report describes sampling and analytical procedures used for measurement of sulfates in diesel tailpipes and in the diluted exhaust within dilution tunnels. A variety of methods exist for sulfate analysis for such systems, including ion exchange. Two chemical methods used by the Bureau of Mines are described in detail. These are based upon spectrophotometric measurement of chloranilic acid using barium chloranilate. The procedures are rapid and relatively inexpensive. In general, ion exchange is preferred by many analysts for sulfate analysis. However, it is more complex and expensive than chloranilic acid procedures, which are adequate for exhaust analysis.

RI 8684. Application of a Photodiode Array Optical Spectrometer to the Study of the Incendivity of Light Alloys Impacting on Rusted Steel, by T. J. Driscoll, D. R. Flinn, and W. C. Lederer. 1982. 17 pp. 8 figs. Methane-air mixtures can ignite as a result of sparking or rubbing of materials, particularly by impact involving light alloys and rusted steel where an exothermic thermite reaction can occur. This report reviews the published literature and describes a new method utilized by the Bureau of Mines for studying the processes occurring during collisions of light metals with rusted steels. The method involves measuring the spectra of sparks and explosions in methane-air mixtures using a photodiode array. Initial results obtained using magnesium and aluminum alloy 6061-T651 projectiles striking rusted steel are reported. These results indicate that the continuous parts of the spectra show a larger intensity for incendive sparks compared with nonincendive sparks, with the largest relative change in the higher energy, ultraviolet region. An unexpected shift of the intensity maximum for the continuous parts of the spectra towards the infrared region was observed for the more incendive sparks. Evaluation of rusted steel samples with electron microscopy, energy-dispersive X-ray spectrography, and Auger electron spectroscopy after they had been impacted by aluminum alloys indicated that aluminum was transferred to the steel in the form of islands that became larger as a function of increasing projectile velocity.

RI 8685. Refractory Properties of Brick Produced From Beneficiated Chrome-Containing Furnace Linings, by Arthur V. Petty, Jr. 1982. 16 pp. 8 figs. In Bureau of Mines research on recycling chrome-containing refractory wastes, used refractories from argon-oxygen decarburization and electric steelmaking furnaces were beneficiated. By means of dry magnetic separation on minus 6-mesh crushed wastes, a concentrate was produced. After minor adjustments to the particle size distribution, full-size refractory brick were dry-pressed by a commercial producer and fired to 1,450° and 1,730° C. Standard testing procedures were used to determine the cold-crushing strength, modulus of rupture at 25°, 1,300°, and 1,500° C, hot load, thermal shock resistance, thermal expansion, and slag resistance. Optical and electron microscopy were used to determine grain-bonding mechanisms, and energy-dispersive analysis of X-rays was used to determine elemental distribution. The test results indicate that the beneficiated material could be used to produce a refractory product suitable for moderate-temperature applications. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8686. Molybdenum Removal From Concentrator Waste Water, by R. O. Dannenberg, A. E. Petersen, P. B. Altringer, and P. T. Brooks. 1982. 16 pp. 6 figs. The Bureau of Mines conducted laboratory batch and small-scale continuous tests to remove traces of dissolved molybdenum from water simulating waste discharged from a molybdenum concentrator. Molybdenum concentrations, initially ranging from 2 to 10 ppm, were decreased to 0.5 ppm or less by coprecipitation of the molybdenum with freshly precipitated ferric hydroxide. The precipitate was separated as a froth by dissolved-air flotation for subsequent disposal. Although the treated water met current environmental standards for contained molybdenum, contained particulate iron might have to be removed by filtration for the water to be acceptable. Estimated costs of treating concentrator effluent water were 55 cents, 57 cents, and 64 cents per 1,000 gal at initial molybdenum concentrations of 2, 4, and 10 ppm, respectively.

RI 8687. Introduction of Sulfur Into Copper Converter Slags To Produce Copper Matte, by J. I. Paige and W. E. Anable. 1982. 16 pp. 7 figs. As part of a continuing effort to develop technology that maximizes mineral and metal recovery from domestic resources, the Bureau of Mines investigated a method to totally utilize copper converter slags without recycling them back through the matte smelting furnace. The research was directed toward (1) recovering the contained copper in converting slags by producing a recyclable copper-iron matte, (2) carbothermically reducing the slags to recover the iron, and (3) producing slag wool from the depleted slags. This report deals with the reduction of three industrial converting slags, containing 2.0 to 7.3 wt-pct Cu, in an 800-kVA electric arc furnace to produce a recyclable copper-iron matte. The addition of sufficient iron pyrite to provide 29 to 113 pct of the stoichiometric sulfur (based on producing 40-pct-Cu matte) produced a recyclable matte (36 to 61 pct Cu) at an energy consumption of 520 to 700 kWh per ton of solid material charged. The expected energy saving for treating molten slag is an electric furnace (5- to 9-MVA range) is about 400 kWh per ton of molten slag treated.

RI 8688. Enthalpies of Formation of $ZnO \cdot 2ZnSO_4$ and $CoSO_4 \cdot 6H_2O$, by H. C. Ko and R. R. Brown. 1982. 6 pp. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology, the standard enthalpies of formation for $ZnO \cdot 2ZnSO_4$ and $CoSO_4 \cdot 6H_2O$ were

determined by HCl acid solution calorimetry. The values are -550.31 ± 0.28 and -641.33 ± 0.15 kcal/mol, respectively.

RI 8689. Flotation of Rare Earths From Bastnäsite Ore, by E. Morrice and M. M. Wong. 1982. 13 pp. 17 figs. As part of its efforts to maximize process efficiency and decrease energy requirements in mineral processes, the Federal Bureau of Mines has investigated methods for beneficiating bastnäsite ores from Mountain Pass, Calif. The results of a bench-scale study on the flotation of bastnäsite ore are presented. Flotation at a pulp temperature of 40° to 45° C yielded a cleaner concentrate containing 58.7 pct RE_2O_3 at a rare-earth recovery of 67 pct. These results are comparable to those reported for the commercial beneficiation method in which the pulp is heated to boiling before flotation. An attempt was also made to recover a barite flotation concentrate from the bastnäsite rougher tailing. Concentrates containing only 70 percent barite were obtained.

RI 8690. Recovery of Zinc and Sulfur From Sphalerite Concentrates by Reaction With Sulfuric Acid, by H. H. Dewing, S. E. Lay, and A. A. Cochran. 1982. 16 pp. 7 figs. The Bureau of Mines constructed a process research unit (PRU) to demonstrate new technology for extracting zinc from sphalerite concentrates. Up to 9 kg/hr of sphalerite (ZnS) concentrate was reacted at ambient pressure in the PRU with 80 pct sulfuric acid at 160° to 180° C to produce zinc sulfate and elemental sulfur. The PRU consisted of a three-stage glass reactor system: a 4-liter premix stage in which feed was slurried with 78 to 82 pct H_2SO_4, a 40-liter stirred reactor, and a 150-liter settling stage in which high reaction conversions were effected and excess H_2SO_4 for recycle was separated from insoluble $ZnSO_4$ and sulfur. Evolution of sulfur-containing gases was minimized by subsurface addition of acid feed slurry to the stirred reactor and by exclusion of air from the reactor to prevent the oxidation of elemental sulfur. Conversion of zinc to zinc sulfate averaged over 99 pct at the optimum acid concentration of 80 pct. Total sulfur losses (primarily SO_2) were less than 2 pct of the sulfur in the sphalerite. Elemental sulfur remained in the insoluble portion of the settled reactor product after leaching with simulated spent zinc electrolyte containing sulfuric acid. The sulfur residue contained 75 to 89 pct sulfur. Neutral zinc sulfate, required for zinc electrowinning processes, was separated from the sulfuric acid leach solution by crystallization at $-15°$ C as zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$). The crystallization operation simultaneously effected a partial concentration of the recycled electrolyte solution by removing water.

RI 8691. Software Techniques in Microseismic Data Acquisition, by John P. Coughlin. 1982. 51 pp. 3 figs. Software techniques developed by the Bureau of Mines Denver Research Center for real-time microseismic data analysis are presented. These techniques focus on the simple acquisition of P-wave arrival times and their use in event location. The paper discusses in detail software techniques to separate microseismic events from mining noise such as drilling and from very large events such as rock bursts. Incorporation of these techniques has enhanced the reliability and accuracy of computer-based monitoring of microseismic activity in ongoing research by the Bureau.

RI 8692. Acoustic Emission Source Location—A Mathematical Analysis, by Francis R. Redfern and Robert D. Munson. 1982. 27 pp. 4 figs. Newton's method of solving a nonlinear equation is employed to develop a least-squares acoustic emission source location method in which the spatial residuals of the location equations are minimized. These residuals, related to the distances from the least-squares source location perpendicular to the surfaces described by the location equations, permit location error to be estimated to first order along the spatial axes. The solutions obtained by this method are the best spatial solutions to the location equations in the least-squares sense. Also presented is a procedure by which the geometrical control of a transducer array can be evaluated using the rate of change of source location with fractional velocity change.

RI 8693. Magnet Properties of Alloys Containing Lanthanum, Cobalt, Copper, and Magnesium, by J. W. Walkiewicz and M. M. Wong. 1982. 16 pp. 10 figs. One of the objectives of the Bureau of Mines is to develop substitution technology for scarce materials. In accordance with this goal, alloys containing lanthanum, cobalt, copper, and magnesium were investigated for fabrication of rare-earth-cobalt (RE-Co) permanent magnets. A complete substitution of lanthanum for samarium and a partial substitution of copper for cobalt was accomplished. Magnets of La-Co and La-Co-Cu-Mg alloys were fabricated by powder metallurgy techniques and evaluated. A maximum intrinsic coercivity of 23.2 kOe was obtained with a La-Co-Cu-Mg alloy. In comparison, maximum values of 9.3 kOe and 11.6 kOe were obtained with La-Co and La-Co-Cu alloys, respectively. The substitution of copper and magnesium for part of the cobalt resulted in a large increase of intrinsic coercivity, similar to the results of Bureau research with mischmetal-Co-Cu-Mg alloys. Unlike the mischmetal-Co-Cu-Mg magnets, the La-Co-Cu-Mg magnets showed signs of physical deterioration on exposure to air. The effects of fabrication parameters on the magnetic properties of the La-Co-Cu-Mg alloys were also determined.

RI 8694. Aluminum Extraction From Anorthosite by Leaching With Hydrochloric Acid and Fluoride, by P. R. Bremner, J. A. Eisele, and D. J. Bauer. 1982. 7 pp. 4 figs. The United States is more than 90 pct dependent on imported bauxite as a source for aluminum, but it has vast nonbauxitic aluminum resources, such as kaolinite, anorthosite, alunite, etc. As part of a program to devise processes for treating these resources, the Bureau of Mines investigated a bench-scale leaching process using hydrochloric acid (HCl) and fluoride to extract aluminum from Wyoming anorthosite. HCl and fluoride-to-aluminum (F/Al) mole ratios were studied with respect to aluminum extraction for single-stage, cocurrent, and countercurrent leaching modes. Using 95 pct stoichiometric HCl and a F/Al mole ratio of 0.27, 90 pct of the aluminum was extracted by countercurrent leaching. Single-stage leaching with the same amount of acid and fluoride extracted 48 pct of the aluminum. Three fluoride sources, CaF_2, Na_2SiF_6, and H_2SiF_6, were used and gave similar results on aluminum extractions.

RI 8695. Vanadium Roast-Leach Dissolution From Western Phosphate Tailings, by J. H. Russell, D. G. Collins, and A. R. Rule. 1982. 19 pp. 4 figs. As part of its efforts to maximize resource recovery, the Bureau of Mines conducted studies to recover valuable byproducts from Western phosphate bene-

ficiation tailings. Potential byproducts include phosphorus, vanadium, and uranium. The objective was to determine roasting and leaching conditions for maximum dissolution of vanadium from tailings containing approximately 13 pct P_2O_5 and 0.23 pct V. Sulfuric acid leaching tests were conducted with the tailings either as a dilute suspension, dried, or in a roasted condition with or without NaCl added during roasting. More than 90 pct of the vanadium was dissolved by roasting at 850° C for 120 min with 8-pct NaCl and leaching at 75° C for 120 min with an excess of 2*N* H_2SO_4. By roasting without NaCl and avoiding the difficulties of the chloride impurity, nearly 80-pct vanadium dissolution was achieved with an 800° C roast for 180 min. Quadratic regression equations were derived to relate vanadium dissolution to roasting and leaching conditions.

RI 8696. Chemical Equilibria in Chlorination of Clay, by A. D. Mah. 1982. 43 pp. To assist Bureau of Mines research in extractive metallurgy and to add to the thermodynamic data base useful to others, energy calculations were made for 63 reactions relating to investigations on the production of anhydrous aluminum chloride from chlorination of clay.

RI 8697. Recovery of Iron and Copper From Copper Smelting Furnace Slags by Carbon Injection, by J. I. Paige, D. L. Paulson, and W. L. Hunter. 1982. 19 pp. 7 figs. The Bureau of Mines, U.S. Department of the Interior, conducts research on methods to minimize the requirements for mineral raw materials through conservation, substitution, and increased minerals and metals recovery from primary and secondary domestic resources. To further this goal, prior Bureau research had devised a pyrometallurgical technique (RI 8211) to recover metallic iron and copper from molten copper smelting furnace slags by carbothermic reduction. As a continuation of this Bureau research on the carbon injection technique, reverberatory and electric furnace slags were treated in an 800-kva electric arc furnace by simultaneously top feeding the slag and injecting coke breeze into the bottom of the molten bath. Results of the tests show that 76 to 89 pct of the copper and up to 48 pct of the iron contained in the smelting furnace slag were recovered in a metallic phase, while 56 to 82 pct of the carbon injected into the system was utilized as the reductant. Laboratory evaluation has shown that the metal product, which contains 86.9 to 95.0 wt-pct iron and 1.3 to 4.1 wt-pct copper, will be a satisfactory medium for recovering copper by cementation. The expected energy consumption for the process is 110 kwhr per ton of molten slag treated and 520 kwhr per ton of solid material charged.

RI 8698. Economic Analysis of Surface Mining Mobile Equipment Fire Protection Systems, by William H. Pomroy, Neil Goodwin, and Frank Lynch. 1982. 23 pp. 11 figs. The Bureau of Mines, through a 4-year program of combined in-house and contract research, has developed the necessary hardware and software technology to provide rugged, reliable automatic fire protection for surface mining mobile equipment. One element of this program was a continuing effort to help foster rapid mining industry acceptance of the technology by keeping end user costs reasonable. This report is an analysis of the economic impact of surface mining mobile equipment fires and the cost benefit of utilizing automatic fire protection systems to abate these losses.

RI 8699. An Evaluation of Used Aluminum Smelter Potlining as a Substitute for Fluorspar in Basic Oxygen Steelmaking, by Victor R. Spironello and Ishwarlal D. Shah. 1982. 11 pp. 3 figs. The Bureau of Mines has conducted studies of the slags related to ferrous technology to evaluate experimentally acceptable substitutes for the auxiliary flux, mineral fluorspar, in steelmaking operations. Comparative heats were made in a 1/4-ton, pilot-scale, basic oxygen furnace (BOF) to evaluate a waste material known as "used potlining." Used potlining is recovered from alumina reduction cells after its useful life and contains significant levels of fluorine and sodium in various compounds. This material in both lump and pelletized form provided adequately fluid slags, based on observations made during BOF operation. No adverse effects were found on furnace performance, metal and slag chemistry, the strength of the steel produced, or the environment. Fluorine recovery in the slag was about the same as that obtained when using fluorspar, as were the losses to the scrubber water and solids. No difference was observed in furnace-refractory attack, as determined by the level of magnesia in the slag. The sodium recovered in the slag apparently also contributed to fluidity, since the fluorine input was at about two-thirds that of the fluorspar. Used potlining was determined experimentally to be a satisfactory substitute for fluorspar in basic oxygen steelmaking.

RI 8700. Methodology for Determining Occluded Gas Contents in Domal Rock Salt, by David M. Hyman. 1982. 11 pp. 2 figs. The Bureau of Mines has developed two experimental designs for determining the volumes and relative proportions of the various gas species, particularly methane (CH_4), occluded in rock salt. To date, the rock salt samples analyzed have been relatively small (400- to 1,000-gram) grab samples from Louisiana gulf coast domal salt mines. The results obtained are comparable to results in Polish domal salt mines, in terms of occluded gas volumes per mass of rock salt. The notable difference between the Louisiana and Polish occluded gas mixtures is in the relative proportions of the individual gas species. The two methods used by the Bureau are ball-mill crushing and dissolution. Of the two, the dissolution method appears to be more versatile because it can be performed in situ. The relevance and applicability of data on the occluded gas contents of rock salt are dependent on sample size, sample collection method, geologic context of the sample, and the correlation with gas emissions that occur as a result of mining-induced fractures and pressure differentials.

RI 8701. A Case History of a Major Rock Burst, by Fred Leighton. 1982. 14 pp. 9 figs. The Bureau of Mines monitored a rock-burst-prone pillar in a metallic ore vein, up to and through failure, to measure its reactions to increasing loads, as it was mined. Three parameters were monitored: the stress changes at chosen points within the pillar, the displacement characteristics of the drift above the pillar, and the microseismic activity in and around the pillar. In descending order of effectiveness, the microseismic technique, vibrating wire stress measurements, and displacement measurements reflected the pillar reactions, and all showed good correlation to one another. A major rock burst in the pillar, which destroyed about 100 feet of drift above the pillar, occurred at the end of this study. This burst was preceded by a large anomaly in the microseismic activity in the failure area.

RI 8702. Electromagnetic Surface Fields Due to a Magnetic Dipole Buried in a Three-Layered Earth, by Steven M. Shope. 1982. 22 pp. 7 figs. The Bureau of Mines electromagnetic trapped miner location and communications system requires a thorough understanding of through-the-earth electromagnetic wave propagation. An earth model incorporating a magnetic dipole buried in a three-layered earth has been developed. The dipole source is located in the second subsurface layer. By application of proper limiting values, the three-layered model is reduced to two different two-layered models and eventually to the homogeneous half-space model. The solutions are in the form of infinite integrals. A numerical analysis was carried out and a computer program written to evaluate the surface magnetic fields. Numerical values for the magnetic field at the point above the source are presented in a variety of models.

RI 8703. Design Criteria for Sheathed Permissible Explosive Charge for Open Shooting in Flammable Atmospheres, by Richard J. Mainiero and J. Edmund Hay. 1982. 12 pp. 10 figs. The Bureau of Mines conducted research to evaluate the optimum design for a rock-breaking explosive charge that could be fired unconfined in a gassy or dusty coal mine without the danger of igniting the flammable atmosphere. Charges of various shapes, with and without cavities, were tested in a gallery using 3- by 3- by 1-ft concrete blocks as simulated boulders. For these tests the optimum charge, in terms of cost, weight, and convenience in handling, consisted of a flat 1-½-lb charge of permissible explosive seven-eighths of an inch thick and 7 in in diameter encased in a ½-in thick layer of fine salt (NaCl). This work demonstrated that it should be possible to produce an inexpensive explosive rock-breaker charge that would be safe to use in underground coal mines.

RI 8704. Electrochemical Determination of Thermodynamic Properties of Manganomanganic Oxide and Manganese Sesquioxide, by Seth C. Schaefer. 1982. 17 pp. 7 figs. The Bureau of Mines investigated thermodynamic properties of Mn_3O_4 (manganomanganic oxide) and Mn_2O_3 (manganese sesquioxide). The standard Gibbs energies of formation ($\Delta Gf°$) of Mn_3O_4 and Mn_2O_3 from their lower oxides were determined with high-temperature galvanic cells using stabilized ZrO_2 (zirconia) as the electrolyte.

RI 8705. Calcination of Aluminum Nitrate Nonahydrate in a Fluidized Bed, by Jack C. White, Jack L. Henry, and Davis E. Traut. 1982. 23 pp. 19 figs. As part of an investigation of the production of alumina by the nitric acid leaching of kaolinitic clay, the Bureau of Mines designed, built, and tested a fluidized-bed system for the calcination of aluminum nitrate nonahydrate to alumina, while recovering nitric acid. The calciner consisted of an 8-in-square by 36-in-tall vessel containing 18 in of fluidized solids. Molten aluminum nitrate, sprayed directly into the fluidized solids, formed sandy, granular alumina by growth of successive layers on fluidized particles. Solids were fluidized in a dense bed at temperatures of 250° to 500° C with steam, air, or mixtures thereof. Decomposition of nitrate ranged from 4 to 10 pct during single-pass steam or air fluidization, respectively. Alumina dust losses and low throughput are significant unsolved problem areas.

RI 8706. The Solubility of Methane, Carbon Dioxide, and Oxygen in Brines From 0° to 300° C, by Stephen D. Cramer. 1982. 17 pp. 10 figs. The solubility of methane, carbon dioxide, and oxygen was measured in brines at temperatures from 0° to 300° C as part of Federal Bureau of Mines research on the corrosion of metals in high-temperature geothermal and mineral processing environments. Solubilities were measured by the technique of extracting pure gas, dissolved at pressures where Henry's law was applicable, from known volumes of brine. The results were smoothed with respect to temperature. The solubility, expressed in terms of the Henry's law constant, reaches a maximum at temperatures ranging from 60° to 100° C for methane and oxygen, and from 160° to 170° C for carbon dioxide. The Henry's law constant increases, that is, gases are salted out of the brines, in the presence of dissolved salts. Salting-out coefficients are strongly dependent upon temperature. The temperature dependence of the Henry's law constant for geothermal brines is different from that for sodium chloride brines owing to the more complex chemistry of the geothermal brines. The solubility of oxygen and carbon dioxide in brines exposed to air saturated with water vapor and at a total pressure of 760 mm Hg is reported for temperatures from 0° C to the normal boiling point.

RI 8707. Purification of Cl_2-O_2 Leach Liquors by Zinc Cementation, by G. B. Atkinson, J. E. Murphy, and J. A. Eisele. 1982. 8 pp. 4 figs. To develop technology to help assure an ample domestic supply of zinc, the Bureau of Mines is investigating an aqueous chlorine-oxygen leaching process for treating complex sulfide concentrates. This report discusses the purification of aqueous Cl_2-O_2 leaching solutions by utilizing zinc cementation to remove Cd, Co, Cu, Ni, and Pb. Additional processing of the purified solution is necessary to produce $ZnCl_2$ crystals suitable for molten-salt zinc electrowinning cells. The effects of solution temperature, reaction time, zinc dust concentration, $ZnCl_2$ concentration, and degree of agitation on the removal of impurities were investigated for both simulated and actual leaching solutions. Zinc dust addition to a leaching solution at 30° C decreased the Cd, Cu, Ni, and Pb concentrations to acceptable levels of less than 3 mg/l each. By increasing the solution temperature to 75° C, the cobalt content was decreased to less than 5 mg/l, an acceptable level for producing electrolytic cell-grade $ZnCl_2$. Impurity removal rates from $ZnCl_2$ solutions are $Pb > Cu = Cd > Ni > > Co$. An increase in the solution temperature increases the rate of removal for these metal impurities.

RI 8708. Inhibition and Extinction of Coal Dust and Methane Explosions, by Martin Hertzberg, Kenneth L. Cashdollar, Charles P. Lazzara, and Alex C. Smith. 1982. 29 pp. 16 figs. The Bureau of Mines 8-liter flammability system was used to study the effectiveness of a variety of powdered inhibitors in preventing the propagation of explosions of coal dust or methane in air. Over 35 different chemical additives were evaluated against Pittsburgh seam pulverized coal. The least effective inhibitors were the carbonates, which required mass additions in the range of two to three parts inhibitor to one part of coal dust in order to prevent propagation. The most effective inhibitors were the derivatives of ammonium phosphate, which were effective quenching agents at additions of only one part inhibitor to four parts of coal dust. Alkali halide powders were of intermediate effectiveness. These laboratory-scale results are in good agreement with full-scale mine experiments in all cases where detailed comparisons have been made. Data were also obtained for the effectiveness of several of the

same powdered inhibitors against methane-air explosions. Their relative order of effectiveness and the concentration ranges required for quenching the gas explosion are comparable to those measured for coal dust explosions. Data are also presented for the effectiveness of N_2 and CF_3Br addition. Some preliminary data are also presented for powder addition to methane burner flames. Those data are compared with other burner data and evaluated in terms of their relevance to explosion tests.

RI 8709. Flammability of Mixed Gases, by D. S. Burgess, A. L. Furno, J. M. Kuchta, and K. E. Mura. 1982. 20 pp. 19 figs. About 100 tests of flammability were carried out with H_2, CH_4, and CO in mixtures with air using the Federal Bureau of Mines 12-ft-diameter spherical pressure vessel as an explosion test chamber. The LeChatelier approximation gave slightly conservative estimates of the limits of downward flame propagation (onset of significant pressure rise) using the following measured values for the individual gases, in percent: H_2, 8.5; CH_4, 5.25; CO, 13.0. No justification could be offered for using the LeChatelier law for upward flame propagation limits and indeed reported data suggest that calculated values would not be conservative. The observed upward limit for methane-air mixtures (4.85 pct) was less than the widely accepted lean limit for this fuel; those for lean hydrogen-air mixtures and carbon monoxide-air mixtures did not differ from the lowest accepted values. Diffusional effects on the propagation of single, binary, and ternary fuel mixtures are discussed.

RI 8710. A Novel Bromine Calorimetric Determination of the Formation Enthalpies of Sulfides, by J. M. Stuve. 1982. 5 pp. A novel calorimetric solution technique, recently developed at the Bureau of Mines, was tested using synthetic samples of chalcocite (Cu_2S) and covellite (CuS). The solution of these refractory sulfides was accomplished by oxidation with bromine in a moderately acidic, aqueous solution. The resulting values for the standard enthalpies of formation ($\Delta Hf°$, 298.15) for Cu_2S(c) and CuS(c) were —18.1 ±1.1 kcal/mol and —13.3 ±1.1 kcal/mol, respectively. These values are in good agreement with published formation values derived from other methods of physicochemical measurement.

RI 8711. Performance Evaluation of Electromagnetic Techniques for the Location of Trapped Miners, by John Durkin. 1982. 30 pp. 36 figs. The Bureau of Mines has conducted field studies in coal mines throughout the United States to determine the effectiveness of electromagnetic techniques in locating miners trapped underground following a mine accident. Data from these tests have been used to generate models of expected signal and noise distributions as found above mines throughout the coalfields. These distributions have aided in placing the expected performance of a through-the-earth electromagnetic communications technique into a probabilistic framework. Results show that at a 10-pct false alarm rate, the expected probability of detecting a miner's signal from a depth of 1,000 ft is 54 pct; at 500 ft it is 95 pct. These depths exceed the actual depths of 90 pct and 50 pct, respectively, of U.S. coal mines. Sensitivity studies have shown that at a depth of 1,000 ft, for every 3 db of improvement in signal-to-noise ratio, the probability of detection increases 6 to 8 pct.

RI 8712. Alumina Miniplant Operations—Production of Misted Raw Kaolin Feed, by John L. Schaller, Don B. Hunter, and Dwight L. Sawyer, Jr. 1982. 20 pp. 12 figs. The Bureau of Mines, U.S. Department of the Interior, has investigated the extraction of alumina from domestic kaolin clay by leaching with boiling 26 wt-pct hydrochloric acid. Acid leaching of crushed calcined kaolin feed yields slurries that are slow settling and difficult to filter because of the presence of fine particles generated in crushing, calcining, and leaching. Laboratory research showed that tumbling and moistening crushed raw kaolin on a pelletizing disk caused the fines to agglomerate on the surfaces of the larger particles, while the sharp edges and corners of the larger particles were rounded off. Minus 16-mesh crushed raw kaolin was misted on a 36-in-diam, 8-in-deep pelletizing disk at rates of 175 to 250 lb/hr, and was calcined in either a rotary or a fluidized-bed calciner; negligible degradation occurred. The physical properties of the misted calcined kaolin were evaluated in the leaching system of the clay-hydrochloric acid miniplant. Only minor attrition occurred during leaching, and the slurry was readily filtered on a continuous belt filter.

RI 8713. Atmospheric Pressure Desilication of Leach Liquors From Lime-Sinter Processing of Anorthosite, by Masami Hayashi. 1982. 14 pp. 9 figs. The Bureau of Mines conducted laboratory studies to investigate methods for desilicating sodium aluminate solution derived from leaching a limestone-anorthosite sinter with 10-pct Na_2CO_3 solution. Desilication tests were made at atmospheric pressure to determine the effects of time and additions of lime and desilication residues. A two-stage, countercurrent desilication procedure was developed to reduce the SiO_2 content sufficiently to meet specifications for cell-grade Al_2O_3. Both stages were conducted at boiling temperatures at atmospheric pressure. Reagent lime was charged as desilication seed to the partially desilicated solution in the second stage, and a product (desilication residue) precipitated by the lime addition was charged to the freshly leached solution in the first stage. Average Al_2O_3 loss in the desilication circuit was 5.8 pct, and the product solution contained less than 0.04 g/l SiO_2. Complete precipitation of Al_2O_3 by carbonation resulted in a hydrate containing less than 0.01 pct SiO_2. Calcination of this hydrate would produce Al_2O_3 meeting the 0.015 pct SiO_2 specification for cell-grade material.

RI 8714. Lime-Sinter Processing of Anorthosite for the Recovery of Alumina, by V. E. Edlund. 1982. 21 pp. 5 figs. As part of a research program for recovering alumina from domestic nonbauxitic resources, the Bureau of Mines investigated a lime-sinter, caustic leach technology for anorthosite. This report discusses the unit operations—feed preparation, sintering, and leaching. Acceptable pellets for the bench-scale sintering studies were prepared from mixtures of minus 200-mesh anorthosite and limestone using water alone as the pelletizing agent. Heating pellets at 1,270° to 1,360° C for periods of 0.5 to 2 hr, followed by a 15-min soaking period at 700° C and cooling to room temperature, produced a sinter that dusted to more than 90 pct minus 65 mesh. The weight ratio of limestone to anorthosite was critical in producing sinter exhibiting good dusting and leaching characteristics. A ratio of 2.0 was optimum for the bulk samples of anorthosite and limestone used in this research. Leach solutions from lower ratio sinters were unstable; gelation became progressively more severe with higher ratio sinters. Leaching the dusted sinter with 10-pct Na_2CO_3 at 60° C extracted 85 to 90 pct of the alumina in a product solution containing about 50 g/l Al_2O_3. Leach resi-

due in contact with pregnant solution tended to set up as a rigid gel as a result of cementation, compaction, and gelation. The presence of a calcium-sodium zeolite [$(Ca, Na_2)_6 \cdot (Al_2SiO_4)_{12} \cdot 27\text{–}30H_2O$] in the ungelled residues seemed to be the main difference between gelled and ungelled residues.

RI 8715. Statistical Approach to the Analysis of Bias and Precision in Reusable Gas-Detecting Devices, by R. Emmett Hughlett and George H. Schnakenberg, Jr. 1982. 27 pp. 13 figs. The Bureau of Mines has developed a statistical approach to the laboratory evaluation of response bias and precision in gas detectors. The techniques described employ a computerized analysis and a new method of data presentation called composite graphing. The underlying theory, its practical application to the data, and the experimental equipment and procedure are described.

RI 8716. Recovery of Scheelite and Byproduct Sphalerite From Western U.S. Tactite Ores, by J. M. Gomes, A. E. Raddatz, and M. M. Wong. 1982. 9 pp. 2 figs. Bench-scale flotation tests were conducted on two western tactite ores to study the recovery of tungsten and zinc minerals. The investigation, which is part of the Bureau of Mines ongoing program to develop methods for beneficiating minerals and metals from domestic low-grade ores, demonstrated the feasibility of producing scheelite, sphalerite, and their bulk concentrates. Sphalerite concentrates containing 51 to 53 pct Zn and less than 0.11 pct WO_3 were selectively recovered prior to scheelite flotation. Zinc recovery ranged from 85 to 91 pct. Scheelite concentrates containing 17 to 25 pct WO_3 were then recovered from the ore; tungsten recoveries ranged from 88 to 94 pct. Bulk flotation concentrates containing 84 to 91 pct of the WO_3 and 87 to 95 pct of the zinc also were prepared. More than 98 pct of the WO_3 in a bulk concentrate containing 9 pct WO_3 was extracted by autoclave leaching with a soda solution. The zinc remained in the leached residue.

RI 8717. Recovery of Platinum-Group Metals From Stillwater Complex, Mont., Flotation Concentrates by Matte Smelting and Leaching, by E. G. Baglin, J. M. Gomes, and M. M. Wong. 1982. 15 pp. 6 figs. As part of an effort to decrease U.S. dependence on imports of critical and strategic metals, the Bureau of Mines investigated three leaching methods for extracting the base metals and recovering platinum-group metals (PGM) from matte prepared from Stillwater Complex flotation concentrates. Because of a limited supply of natural material, synthetic matte of composition similar to matte prepared from natural concentrates was used to devise the extraction sequences. The validity of the sequences was verified with matte prepared from Stillwater concentrates. In two-stage matte leaching, first-stage H_2SO_4 leaching extracted 99 pct of the nickel and iron from the matte but negligible amounts of copper and PGM. Second-stage oxidative leaching with $Fe_2(SO_4)_3$ or $FeCl_3$ solubilized more than 98 pct of the copper and no precious metals. Sequential leaching, in which acid and oxidizing lixiviants were added sequentially to the matte without an intervening filtration step, extracted 99 pct of the Fe, Ni, and Cu. A roasting-leaching technique, in which the residue from first-stage leaching was roasted between 360° and 500° C before a second leaching with H_2SO_4, solubilized 98 pct of the copper. The three leaching methods yielded high-grade PGM residues containing more than 98 pct of the PGM in the matte.

RI 8718. Method for Producing Zirconyl Sulfate Solution From Zircon Sand, by D. J. MacDonald, R. A. Guidotti, and H. G. Henry. 1982. 13 pp. 4 figs. The Bureau of Mines has carried out investigations on a method for producing zirconyl sulfate solution from zircon sand, comprising (1) reacting zircon sand with molten NaOH, (2) leaching the resultant fusion frit with water to remove sodium silicate and to convert sodium zirconate to hydrous zirconium oxide, and (3) leaching the hydrous zirconium oxide from unreacted sand with hot, dilute H_2SO_4 to produce crude zirconyl sulfate solution. The following conditions were found to be suitable: reacting 0.6 kg of NaOH per kilogram of zircon sand for 10 min at 600° C; leaching the frit with 3 to 4 liters of water per kilogram of solids; leaching the residue with 5.1 liters of water and 1.25 liters of 98-pct H_2SO_4 per kilogram of original solids for 10 min at 90° C; and filtering or decanting to recover unreacted zircon sand. A preliminary cost estimate is included.

RI 8719. Stability Relationships Between Petalite ($LiAlSi_4O_{10}$) and Spodumene ($LiAlSi_2O_6$), by Kenneth O. Bennington. 1982. 15 pp. This investigation is part of the Bureau of Mines research effort directed at advancing mineral technology and minimizing energy requirements for extractive metallurgy. The emplacement of the primary minerals petalite ($LiAlSi_4O_{10}$) and spodumene ($LiAlSi_2O_6$) in the lithium pegmatites is examined on the basis of their Gibbs energies of formation determined from lithium metasilicate and oxides, using a series of proposed reactions. The reaction between spodumene, quartz, and petalite ($LiAlSi_2O_6 + 2SiO_2 \rightleftarrows LiAlSi_4O_{10}$) apparently does not take place in nature but may be proved experimentally.

RI 8720. Recovery of Tungsten From a Hydrothermally Altered Deposit, by A. E. Raddatz, J. M. Gomes, J. J. Sjoberg, and M. M. Wong. 1982. 14 pp. 8 figs. The Bureau of Mines is investigating methods for recovering tungsten from domestic resources. A calcine-quench-leach (CQL) technique was developed for the extraction of tungsten from the Golconda, Nev., hot springs ores. The deposit contains disseminated tungsten that cannot be beneficiated by conventional techniques and must be treated by hydrometallurgical methods. The CQL procedure consists of calcining the ore at 900° C for 3 hours, quenching in a solution containing 1.5 parts of Na_2CO_3 and 1.5 parts of NaOH per part of WO_3 in the ore and at a solution-to-ore ratio of 3 to 1, leaching at 200° C and at 250 psig for 3 hours, and filtering and washing the residue. A series of closed-circuit batch tests showed that 92 pct of the tungsten was extracted from a sample containing 2.32 wt-pct WO_3. The pregnant solution contained 11 g/l WO_3.

RI 8721. Removal of Leachable Metals and Recovery of Alumina From Utility Coal Ash, by Robert C. Gabler, Jr., and Robert L. Stoll. 1983. 20 pp. 3 figs. The extraction of metals from coal ash was investigated by the Bureau of Mines in an effort to produce a more environmentally acceptable waste and offset waste disposal costs with recovered metal values. The research was conducted in two steps: determination of the parameters that affect extraction of metals from coal ash and development of extraction-recovery procedures. Data obtained indicate that the major parameter affecting the extraction of metals from coal ash is the calcium content of the ash. Other parameters such as furnace type and operating temperature had much smaller effects on metal extraction. Two procedures were studied

for metal extraction: an acid leach procedure for high-calcium ashes and a lime sinter-acid leach procedure for low-calcium ashes. An alumina product was recovered that, with sufficient washing, meets Hall cell specifications. The leach residues pass the EPA EP Toxicity Test and are thus nonhazardous wastes available for a variety of uses.

RI 8722. Laboratory Testing of a Radial-Axial Loading Splitting Tool, by Sterling J. Anderson and David E. Swanson. 1982. 26 pp. 21 figs. To define the technical competence and capabilities of a nonexplosive excavation concept, the Bureau of Mines conducted reduced-scale laboratory tests of a mechanical excavation tool called a rock splitter. Hydraulically actuated splitters, capable of generating both radial and axial loads on a predrilled hole, were designed and fabricated. Through paired variable testing and drifting simulation, reduced-scale splitter performance was evaluated in concrete. Testing proved that the rock splitter is capable of excavating within the highly confined drift setting and that it offers a distinct advantage over splitters that can generate radial loads only.

RI 8723. Investigation of Methane Emissions From an Advancing Face in the Belle Isle Domal Salt Mine, Louisiana, by A. T. Iannacchione, G. L. Finfinger, T. M. Kohler, and D. M. Hyman. 1982. 24 pp. 32 figs. The Bureau of Mines measured methane emission rates from an advancing salt face ranging from 15 to 56 ft^3/ton (0.5 to 1.8 m^3/t). Small room size, use of a continuous miner, and a well-defined ventilation system made possible air velocity and methane concentration measurements. These measurements, representing data from 18 production days, were conducted in an area of abnormally low-grade salt. Methane emissions occurred primarily during the advance of the salt face by continuous miner.

RI 8724. In-Plant Recycling of Stainless and Other Specialty Steelmaking Wastes, by L. W. Higley, Jr., R. L. Crosby, and L. A. Neumeier. 1982. 16 pp. 5 figs. It is estimated that well over 20 million lb of chromium and 8 million lb of nickel, plus other metal values, are diverted annually to furnace dusts, mill scale, and contaminated swarfs in the domestic stainless and other specialty steelmaking industry. Little inroad has been made toward the in-plant recycling of these wastes to reclaim the metal values. The Bureau of Mines has devised a process for recovering about 90 pct of the chromium and molybdenum and well over 90 pct of the nickel and iron from stainless steelmaking furnace dusts, swarf, and mill scale. Other metals such as manganese are also recovered. Initial laboratory results were confirmed and expanded to include a wide variation of stainless steelmaking waste mixtures. Later experiments have included specialty steelmaking wastes other than from stainless steelmaking. Significantly, the ease of technology transfer has been demonstrated by a number of industrial-sized (19-ton) commercial electric furnace heats, in which the pelletized wastes represented some 10 to 20 pct of the furnace charge, replacing part of the normal scrap charge. Results of these successful large-scale trials are presented. Some information is also presented on incorporation into the pellets of chromium-bearing particulate wastes originating from other than steelmaking production. Cost evaluation indicates the process is economically attractive.

RI 8725. Laboratory Studies on the Treatment of Ferric Chloride Stripping Liquor From a Clay-Hydrochloric Acid Leaching Process, by Robert M. Doerr. 1982. 7 pp. In a process being investigated by the Bureau of Mines for recovering alumina from domestic nonbauxitic resources, calcined kaolinitic clay is leached with hydrochloric acid. Iron impurity in the clay is coleached and is removed in a solvent extraction step prior to crystallization of aluminum chloride hexahydrate, which is subsequently thermally decomposed to alumina. The $FeCl_3$-HCl stripping liquor from the solvent extraction step is unsuitable for discharging to the environment; furthermore, economics requires recovery of the contained chloride values. In the present research, it was shown that the stripping liquor can be reacted with calcined clay to yield $AlCl_3$ in solution, plus precipitated iron oxides, residual silica, and unreacted excess clay as mixed solids. For the recovery of the $AlCl_3$ solution, the slurry could be separated or returned to the clay-HCl process stream at the solids washing step that follows primary HCl leaching of the clay. For the range 20° to 99° C, the time (t) (10^3 sec) required to react the waste liquor with excess clay, for essentially complete iron precipitation, depends on the absolute temperature (T) chosen, according to the expression

$$t = e^{[9{,}000/T = 23.5]}.$$

Alumina was tried as a reagent alternative to clay but was not very effective, even under pressure and at high temperatures.

RI 8726. Fire and Explosion Properties of Oil Shale, by J. K. Richmond, M. J. Sapko, and L. F. Miller. 1982. 39 pp. 43 figs. This is a progress report summarizing more than 5 years of a long-range Bureau of Mines research program. The purpose of this program has been to investigate the fire and explosion properties of Green River oil shale in the Bureau's Experimental Mine, in laboratories, and in the field. The lean limits of explosibility of oil shale dust, by small- and large-scale tests, are reported as a function of grade, ignition source, and particle size. A limited number of laboratory tests on the autoignition of oil shale dust layers and the spontaneous combustion tendencies of oil shale are described. Moderate-scale rubble fire tests were conducted to determine flame spread rates as a function of ventilation flow. With the aid of a system to continuously monitor methane emissions in a deep oil shale mine, the characteristics of the methane flow are reported as a function of ventilation and blasting procedures, and are compared with gas yields from core samples. Tentative predictions as to the emission of the methane to be expected in deep oil shale mines, far from the outcrop, are offered. Brief reference is made to a parallel investigation into the fire and explosion hazards of oil shale mining and processing by a Bureau contractor; detailed results of the latter investigation are to be found in the contractor's reports.

RI 8727. Reactivity of ANFO With Pyrite Containing Weathering Products—Evaluation of Additional Inhibitors, by Yael Miron, Thomas C. Ruhe, and J. Edmund Hay. 1982. 14 pp. 8 figs. Ammonium nitrate-fuel oil (ANFO) blasting agents may undergo an exothermic reaction when they contact warm ore bodies that contain pyrite and its weathering products. The reaction is very fast at temperatures above 80° C. Urea, when present in sufficient amounts, inhibits this reaction at temperatures below 180° C. But urea-ammonium nitrate mixtures are very hygroscopic and, in certain climates, may be difficult to handle in the field. Reaction-inhibiting characteristics of three compounds were reported by the Bureau of Mines in 1979. Recently, the Bureau

investigated the reaction-inhibiting qualities of five additional compounds. Mixtures of ANFO, pyrite, weathering product, and prospective inhibitors were slowly heated, under conditions simulating a hot borehole, to determine prospective inhibitor capability at temperatures up to ~175° C. Small-scale thermal tests of the same mixtures were used for verification and clarification of results. Two organic compounds, phthalimide and xanthine, similar in structure to urea, failed to inhibit the reaction. Zinc oxide and calcium carbonate were found inferior to urea, though zinc oxide raised the onset of reaction from 80° C to about 140° C. Only magnesium oxide was found to be similar to urea in its inhibitory ability at temperatures below 175° C. Based on results from analysis of quenched residues, the use of more than 5 wt-pct magnesium oxide is recommended.

RI 8728. Application of Carbonate-Silica Flotation Techniques to Western Phosphate Materials, by A. R. Rule, D. E. Larson, and C. B. Daellenbach. 1982. 13 pp. 4 figs. In cooperation with a Western phosphate producer, the Bureau of Mines conducted research to apply its carbonate-silica flotation technology to ore feed from a commercial washing-sizing beneficiation plant. The flotation process includes depression of phosphate minerals with fluosilicic acid and anionic flotation of carbonate minerals, followed immediately by cationic flotation of silica. In laboratory and pilot plant tests the washing-sizing beneficiation plant feed ore was screened at 150 mesh and classified in hydrocyclones at 20 μm. The process was used to remove carbonate and silica impurities from the 150-mesh by 20-μm fraction of the feed ore. The plus 150-mesh fraction met concentrate grade requirements, and the minus 20-μm fraction was considered slime tailings. In laboratory tests conducted by the Bureau, flotation concentrates were produced containing about 0.75 pct MgO and up to 30 pct P_2O_5 with flotation recoveries of 70 to 80 pct P_2O_5. In a 1,000-lb/hr, onsite pilot plant at Simplot's Conda mill, concentrates were produced that were higher in grade and contained fewer impurities than concentrate produced in the existing commercial operation. The overall results show a potential 12- to 15-pct increase in total phosphate recovery if the flotation process is incorporated into the existing washing-sizing plant.

RI 8729. Building Seals by Pneumatic Stowing in Mine Closure Operations, by Slavoljub D. Maksimovic and John C. Draper. 1982. 23 pp. 22 figs. The Bureau of Mines, through a cooperative agreement with Duquesne Light Co. of Pennsylvania, field tested a method of using pneumatic stowing of crushed limestone to construct seals in long-abandoned mine openings that were part of an active mine closed shortly before sealing. A total of 13 openings at 11 sites were backfilled. In pneumatic stowing, material is conveyed through a pipeline and into the mine opening under low air pressure. The stowing equipment consists of a power supply, a blower, a feeder to inject material into the pipeline, and nozzle for directing the placement. Material is ejected from the nozzle at high velocity, creating a high-compaction fill upon impact. The fill material used was well-graded limestone aggregate up to 1½ inches in diameter, with sufficient fines. This fill was modified at five locations by the addition of portland cement, expansive cement, and/or bentonite. The pneumatic stowing method is safer and faster than conventional methods, is cost competitive, and eliminates or reduces the exposure of workers to possible hazards since the nozzle can be kept outside the mine opening. The equipment is mobile, but some modifications in the technique would improve performance. The technique was used at remote locations where other methods could not be used without disturbing the environment.

RI 8730. Sealing Openings in Abandoned Mines by Pneumatic Stowing, by Slavoljub D. Maksimovic and Jennings R. Lipscomb. 1982. 26 pp. 18 figs. The Bureau of Mines, through a memorandum of agreement with the State of Ohio, tested a method of constructing seals in abandoned mine openings in Ohio by means of pneumatic stowing of crushed limestone and gravel with sand. A total of five openings and one shaft were backfilled. Pneumatic stowing uses compressed air to convey material through a pipeline and into the mine opening. The stowing equipment consists of a power supply, a blower, a feeder to inject the material into the pipeline through an airlock, and a nozzle for directing the placement. Material is ejected from the nozzle at high velocity, creating a high-compaction fill upon impact. Well-graded aggregate up to 2 inches in diameter and having sufficient fines is used as fill. The stowing method is safer and faster than conventional methods, is cost competitive, prevents trespass into abandoned mine openings, and eliminates or reduces the exposure of workers to possible hazards since the discharge nozzle can be kept at the mouth of the opening. The equipment is mobile, and, with some modification, the technique could be widely used for sealing abandoned and active mine openings, even in remote locations and during severe weather conditions.

RI 8731. Recovery of Phosphate From Florida Phosphate Operations Slimes, by C. E. Jordan, C. W. Smith, G. V. Sullivan, and B. E. Davis. 1982. 13 pp. 5 figs. The Bureau of Mines conducted tests on seven samples of Florida phosphate operations slimes to develop a method to recover phosphate presently being discarded because of its small grain size. A system of hydrocyclones and hydroseparators was used to recover up to 96 pct of the plus 400-mesh material from the slimes. This plus 400-mesh material was subjected to fatty acid flotation, and concentrates containing up to 33.4 pct P_2O_5 were produced. As much as 88 pct of the phosphate (P_2O_5) was recovered from the plus 400-mesh material, and up to 29.6 pct was recovered from the total slimes. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the U.S. Department of the Interior, Bureau of Mines, and the University of Alabama.

RI 8732. Influence of Selected Additives and $CaO:SiO_2$ Ratio on High-Temperature Strength of MgO Refractories, by Nancy S. Raymon. 1982. 8 pp. The Bureau of Mines investigated the effect of controlled additions of selected metal oxides, as well as the adjustment of the calcia-to-silica ratio on the high-temperature strength of refractory-grade periclase. Increases in the hot flexural strength of some periclase materials in the range of threefold to fourfold were obtained with additions of ZrO_2 and by adjustments of the $CaO:SiO_2$ ratio to the 2.5 to 3.0 level. Results show that for each periclase refractory raw material, there exists a combination of level of ZrO_2 addition and an adjustment to the $CaO:SiO_2$ ratio that optimizes the hot flexural strength of each of these materials. Data also indicate that the improved hot strengths can be attributed to the high-temperature secondary phases formed between the different levels of periclase impurities and the additives, resulting in improved intergranular high-temperature bond

strength. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8733. Recovery of Sulfur and Accessory Metals From a Leaching Process Residue, by K. P. V. Lei, T. G. Carnahan, and J. A. Eisele. 1982. 14 pp. 5 figs. The Bureau of Mines, as part of its research effort to minimize the generation of hydrometallurgical waste, investigated a sodium sulfide leaching-electrolysis procedure for treating hydrometallurgical residues for elemental sulfur and base-metals recovery. Research was conducted on a leaching residue from a lead concentrate. The following procedure was developed. 1. The elemental sulfur was dissolved as polysulfide with a Na_2S solution. 2. The resultant metal sulfide bearing residue was oxidatively acid leached in a cationic membrane electrolysis cell; the metals were solubilized at the anode, and a base was generated at the cathode. 3. The elemental sulfur was recovered from the polysulfide solution by neutralizing with the acid in the anolyte. Byproducts of the neutralization were H_2S and a sodium salt solution. 4. Sodium sulfide was regenerated by reacting the H_2S byproduct with the base in the catholyte. 5. Lead as $PbCl_2$ was recovered from the anode residue by brine leaching, and the other metals were recovered from the sodium salt solution as metal sulfides. 6. The barren filtrate from the metal sulfide precipitation constituted the recycled electrolyte. Ninety-eight percent of the elemental sulfur, 98 pct of the lead, and up to 80 pct of other accessory metals were recovered from a residue obtained from the $FeCl_3$-NaCl leaching of a lead concentrate.

RI 8734. Stripping SO_2-Loaded Citrate Solutions With Pressurized Steam, by R. H. Lien. 1982. 8 pp. 5 figs. The Bureau of Mines has conducted research on a flue gas desulfurization (FGD) process as part of its goal of minimizing the undesirable environmental impacts associated with sulfur dioxide (SO_2) bearing waste gases. This FGD process, referred to as the modified citrate process, involves absorption of SO_2 in a buffered citric acid solution. The absorbed SO_2 is subsequently stripped from the solution using steam, which regenerates the solution and produces a wet SO_2 product. This product can be further processed to make sulfuric acid or liquid SO_2. Economic evaluations showed the process to be expensive when the stripper was operated at or near ambient pressures because of the large amounts of steam required for solution regeneration. Research was directed at reducing steam consumption in the stripper. The effect of stripper pressure on steam consumption was investigated. A process research unit (PRU) was operated with the stripper pressurized in the range of 5 to 150 psig. Test results showed that steam consumption decreased with increased stripper pressure. For example, when operating the PRU stripper at 150 psig, 4.1 grams of steam per gram of SO_2 was required to remove 90 pct of the SO_2 from a 1.0-vol-pct-SO_2 gas. This compares to 7.1 grams of steam per gram of SO_2 required for 90-pct SO_2 recovery at 5 psig.

RI 8735. Sulfur Hexafluoride as a Mine Ventilation Research Tool—Recent Field Applications, by Robert J. Timko and Edward D. Thimons. 1982. 15 pp. 12 figs. Sulfur hexafluoride (SF_6) is an odorless, colorless, nontoxic gas that has found acceptance as a tracer gas in research on ventilation patterns, measurement of air leak rates, respirable dust reductions due to bagging hood modifications, and the study of airflows relating to gob boreholes. Following a short review of the SF_6 sampling technique, this report describes recent Bureau of Mines projects in which SF_6 was used successfully as a tracer gas, enabling researchers to acquire representative data quickly and inexpensively.

RI 8736. Alumina Miniplant Operations—Calcination of Kaolin in a Direct-Fired Rotary Kiln, by Theodore L. Turner, Dwight L. Sawyer, Jr., Don B. Hunter, and Earle B. Amey III. 1982. 24 pp. 7 figs. This Bureau of Mines report describes calcination of kaolinitic clay in a direct-fired 2½- by 24-ft rotary kiln at 750° and 775° C. Methods for preparing kaolin feed materials and characterization of calcined products are discussed. Approximately 99 pct of the alumina in a typical eastern Georgia kaolin was soluble in HCl after calcination at either 750° or 775° C.

RI 8737. Physical Beneficiation of Titanium Plant Solid Wastes: Recovery of Titanium Minerals and Coke, by J. I. Paige, R. E. Mussler, and G. W. Elger. 1982. 23 pp. 9 figs. The Bureau of Mines studied methods for recovering unreacted titanium minerals and petroleum coke from titanium chlorination plant wastes prior to neutralization treatment with lime. The objective was to recover valuable raw materials and to reduce the amount of waste materials that must be treated for disposal. Samples of solid wastes were physically beneficiated by gravity concentration (tabling) to recover titanium minerals containing 69.0 to 92.4 wt-pct TiO_2 and by selective carbon flotation to recover petroleum coke containing 94.0 to 96.8 wt-pct C. Laboratory data indicate that the recovered titanium mineral would decrease the amount of solid waste to be disposed of from 32.8 to 53.9 wt-pct. The recovery of coke would further decrease the amount by an additional 32.9 wt-pct. Preliminary tests conducted on recovering vanadium, chromium, and columbium from liquors obtained by leaching chlorination residues also have shown that (1) 97 pct of the vanadium was extracted from leach liquors in a two-stage solvent extraction procedure and (2) 58 pct of the columbium and 40 pct of the chromium were separated from the leach liquors by an ion exchange technique using a strong acid resin.

RI 8738. Effects of a Fan Shutdown on Radon Concentration in a Positive Pressure Ventilated Mine, by Connie S. Musulin, John C. Franklin, and F. Andrew Roberts. 1982. 10 pp. 5 figs. The Bureau of Mines conducted an experiment at Exxon Mineral Co.'s Buffalo Shaft Operation to determine the time required for radon concentrations to return to a base average after fan shutdowns. Shutdown times ranging from 5 min to 16 hr were evaluated. An equation was derived to calculate a ratio that determines the time required for the radon concentration to return to the average level that existed in the mine prior to shutdown. For fan shutdowns of 15 min or more, underground personnel should be evacuated to areas with natural downcast ventilation. For shutdowns of less than 1 hr, personnel should not return to the working area until the elapsed time is four times the shutdown, or until the working area is resampled and found safe. If the mine is not in production during weekends, the downcast fans can be turned off from midnight Friday until 4 p.m. Sunday, and the radon daughter concentration should be below 1 working level throughout the mine by the start of the shift Monday. This fan shutdown would conserve energy and save the mining company an estimated $21,000 each year.

RI 8739. Application of the Cooper-Eaton Equation to the Compaction Behavior of Phosphatic Clay Waste and Attapulgite, by L. W. Brandt, D. A. Stanley, and B. J. Scheiner. 1982. 9 pp. 6 figs. As part of its objective to expand the body of mineral information as a basis for new technology, the Bureau of Mines conducted research on the fundamental behavior exhibited by phosphate clay waste in settling ponds. A semiempirical equation used to describe the compaction of ceramic powders in a single-acting die was applied to aqueous phosphatic clay waste and attapulgite slurries. This equation,

$$\overset{*}{V} = a_1 e^{-K_1/P} + a_2 e^{-K_2/P},$$

was found to describe the compaction of an attapulgite gel and a phosphate slime gel by a moving screen. $\overset{*}{V}$ is the ratio of the compaction achieved at a given pressure, P, to the compaction achieved at a pressure sufficient to remove all space between particles. The constant a_1 represents the fraction of compaction achieved at low pressure by rearrangement of flocs to higher packing density, and a_2 represents the fraction of compaction achieved at higher pressure resulting from removal of voids within flocs. K_1 and K_2 are constants determined from the experimental data. Both the low-pressure and high-pressure compaction mechanisms were observed in the compaction of the clays. These two compaction mechanisms offer an explanation for the observation that impounded slimes initially dewater rapidly and then dewater at a much slower rate.

RI 8740. Precision of Personal Sampling of Respirable Dust in Coal Mines, by John A. Breslin, Steven J. Page, and Robert A. Jankowski. 1983. 12 pp. 2 figs. The Bureau of Mines measured respirable dust in coal mines by means of multiple dust samplers worn by persons moving about the mines. The measurements were made primarily to evaluate the effectiveness of certain dust-control techniques; however, for this report, the data have been analyzed to determine the precision of the personal dust-sampling measurements. A total of 68 sets of measurements were available from multiple personal samplers. The measured dust masses were less than 1.0 mg because the sampling times were short. The coefficient of variation calculated from these data was 18.5 pct, compared with coefficients of variation ranging from about 10 to 30 pct, which were calculated from the most precise and extensive data available for fixed-point dust measurements made in coal mines. From this comparison, it is concluded that dust samplers worn by personnel are as precise as fixed-point samplers in measuring respirable coal dust; the wearing of the samplers by someone moving about a mine does not contribute significantly to the variation in measurements made with these instruments.

RI 8741. Debrining of Potash-Clay Waste Slurries, by Annie G. Smelley, Bernard J. Scheiner, Margaret M. Ragin, and Jalna R. Zatko. 1983. 11 pp. 7 figs. As part of its program to develop technology that will encourage maximum utilization of the Nation's mineral resources, the Bureau of Mines conducted research on debrining potash-clay waste slurries by means of flocculation with a high-molecular-weight polymer and subsequent solid-liquid separation on a rotating trommel screen. In laboratory batch tests, potash-clay waste slurries were consolidated from initial clay contents of 8 pct to final contents of 30 pct with a polymer dosage of 1.2 lb/ton of dry clay waste. Small-scale continuous tests yielded debrined products containing 20 pct solids using a polymer dosage of 1 lb/ton of dry clay solids. This work is based upon work done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8742. Effects of Impurities in Electrolytes on Electrowinning of Lead From Lead Chloride, by D. C. Fleck, R. G. Sandberg, and M. M. Wong. 1983. 8 pp. 1 fig. The Bureau of Mines, in a cooperative research program with four lead companies, has investigated ferric chloride leaching of galena to prepare lead chloride for molten-salt electrowinning to produce lead metal. The hydrometallurgical-electrolytic process is an alternative to the sintering-smelting-refining process currently used to produce lead metal and avoids the environmental problems associated with a conventional smelter. During investigations on the electrowinning aspects of the work, it was noted that certain cations, moisture, and sulfate in the electrolyte affect lead metal purity, cell voltage, current efficiency, and viscosity of the electrolyte. Results of bench-scale tests are reported on the effects of $CaCl_2$, $CuCl_2$, $FeCl_2$, $MgCl_2$, NaCl, $ZnCl_2$, $PbSO_4$, and moisture on electrolysis. As impurities increased in the electrolyte, current efficiency decreased. $CaCl_2$, $CuCl_2$, and $FeCl_2$, decreased current efficiency by 12 to 47 pct. $ZnCl_2$ gave a small voltage increase, while $CaCl_2$ addition equivalent to 4.9 pct Ca caused a 50-pct increase in voltage. The lead metal was contaminated in direct proportion to the $CuCl_2$ buildup in the electrolyte. Anode corrosion was observed with $MgCl_2$ and $MgCl_2 \cdot 6H_2O$. Viscosity increased appreciably with the buildup of NaCl, $CaCl_2$, and sulfate. Electrolyte foaming occurred with $ZnCl_2$, $MgCl_2 \cdot 6H_2O$, $MgCl_2$, $FeCl_2 \cdot 2H_2O$, and $FeCl_2$. Moisture inhibited the coalescence of the lead metal.

RI 8743. Coal Cutting Mechanics and Noise Generation, by Roy C. Bartholomae and R. S. Becker. 1983. 28 pp. 15 figs. This Bureau of Mines report presents the results of a laboratory investigation of coal cutting mechanics and noise. These experiments were performed using a linear cutting apparatus that operates over a broad cutting speed range. The influence of several coal cutting parameters on the noise, force, productivity, and specific energy associated with linear cuts was ascertained. Some basic theoretical aspects of coal cutting mechanics and noise generation are discussed, and the results of the laboratory experiments are used to formulate analytical models of the coal cutting forces and noise. The analytical model for coal cutting noise is then generalized to account for the more important effects of rotary cutting. Based on the generalized model, an estimate of the sound pressure level at an operator's position is made for a typical continuous mining machine. It is concluded that by employing linear rather than rotary cuts, using deeper depths of cut, slower cutting speeds, and more efficient cutting tools, it is possible to reduce the level of coal cutting noise, as well as provide benefits to other important areas of health and safety in underground mining.

RI 8744. Leaching Rates for the HCl Extraction of Aluminum From Calcined Kaolinitic Clay, by R. S. Olsen, S. J. Bullard, W. G. Gruzensky, R. V. Mrazek, and J. L. Henry. 1983. 11 pp. 4 figs. The Bureau of Mines is engaged in research to recover aluminum from kaolinitic clay and other nonbauxitic domestic resources. As part of this work, calcined Georgia kaolin was prepared by a process that prevents slime formation and makes the leached residues fast settling and easy to filter. The leaching reaction for calcined kaolinitic clay in a 5 pct stoichiometric ex-

cess of boiling 23- to 26-pct HCl was found to be zero order. Rate constants based on the weight-fraction of aluminum in the clay were found to be between 0.095 and 0.15 min^{-1} depending on feed preparation and leaching parameters. The mathematical relationships between aluminum extraction and time for both batch and continuous, stirred-tank operations were derived and verified experimentally.

RI 8745. Relative Enthalpies of Ni_3S_2, by M. J. Ferrante and N. A. Gokcen. 1982. 8 pp. 1 fig. The Bureau of Mines determined the enthalpies of Ni_3S_2 relative to 298.15 K to provide new thermodynamic data for advancement of mineral science and technology. Enthalpies were measured with a copper-block calorimeter from 298.15 to 1,197 K. A solid-solid transition was found at 834±1 K, with an isothermal heat absorption of 13.32 kcal/mol. The temperature of this solid-solid transition was accurately measured by differential scanning calorimetry. Because Ni_3S_2 does not melt congruently, the heat of fusion of 4.70 kcal/mol was obtained by extrapolation of enthalpy measurements from the solid and liquid phases to approximately 1,064 K. Tabulated values are given for the relative standard enthalpy, heat capacity, entropy, and Gibbs energy function between 298.15 and 1,800 K. Enthalpies are also given in equation form and combined with data from the literature to derive values of standard enthalpies of formation and Gibbs energies of formation. Similar calculations were made for the reaction of crystalline and liquid nickel with gaseous diatomic sulfur for Ni_3S_2(c, 1).

RI 8746. Low-Rank Coals and Waste Materials for Reduction Roasting and Metallization of Iron Oxides, by Roy E. Peterson and Warren M. Mahan. 1983. 17 pp. 9 figs. The Bureau of Mines conducted bench-scale research to evaluate materials that showed potential as low-cost reductants for use in the ironmaking industry. These materials were lignite, subbituminous coal, coal char, tree trimmings, refuse-derived paperboard, used crankcase oil, and peat. To compare their effectiveness, the materials were tested in the reduction roasting of nonmagnetic taconite and, except for oil and peat, in the reduction of iron oxide pellets to metallized pellets. Reduction was conducted in a 18-cm-diameter rotary drum, which was externally heated in an electric furnace. Over 92 pct of the iron was magnetically recovered from a nonmagnetic taconite after roasting with any of the reductants, but greater quantities of reductant were required to achieve this when the waste materials were used. The fossil fuels were also more effective for metallizing pellets, although metallization above 90 pct were also obtained with tree trimmings and refuse paperboard. However, refuse paperboard had to be frequently recharged to the furnace because it depleted rapidly.

RI 8747. Development of a Soft-Soldering System for Aluminum, by W. L. Falke, A. Y. Lee, and L. A. Neumeier. 1983. 15 pp. 9 figs. The Bureau of Mines has developed a system that permits the "soft" soldering of aluminum and aluminum alloys with standard tin-lead solders. The method employs application of a thin nickel-copper-alloy coating to the substrate, which enables the tin-lead solders to wet readily and spread over the areas to be joined. With conventional technology, aluminum and aluminum alloys are extremely difficult to solder because tenacious surface oxide films prevent wetting. With the Bureau-developed method, the aluminum substrate is mechanically or chemically cleaned to facilitate bonding to a minute layer of zinc that is subsequently applied with an electroless zincate solution. The nickel-copper-alloy (30 to 70 pct Ni) coating is then applied electrolytically over the zinc, using immersion cell or brush-coating techniques. Development of acetate electrolytes has permitted deposition of the proper alloy coatings. The coated areas can then be readily joined with conventional tin-lead solders and fluxes. The joints so formed are ductile, strong, and relatively corrosion resistant, and exhibit strengths equivalent to those formed on copper and brass when the same solders and fluxes are used. The method has also been employed to soft-solder magnesium alloys.

RI 8748. Determination of Bit Forces Encountered in Hard Rock Cutting for Application to Continuous Miner Design, by Sam G. Demou, Richard C. Olson, and Carl F. Wingquist. 1983. 24 pp. 23 figs. Drag bit cutting tests were conducted chiefly to determine bit forces encountered in rock types representing a range of compressive strength and hardness and thus enable the design engineer to estimate a continuous miner's performance in a range of rock types. Testing was carried out on the Bureau of Mines uniquely designed, instrumented rock cutting device (RCD). This device can make 3-ft-long cuts at various depths and speeds to approximate full-scale drag bit cutting by continuous miners. Point attack and cutter bits were tested on four rock types ranging in compressive strength from 7,200 psi (trona) to 29,600 psi (Valders white rock). Cutting tests were made at depths up to 1 in and speeds up to 70 in/sec. Data included normal and cutting forces, groove depth, groove width, and weight of rock broken. The effect of varying the cutting speed was determined, and specific energies were calculated for the various conditions. The bit wear was also observed. For the rocks tested, compressive strength and hardness are good indicators of forces, specific energy, and wear encountered. Results, especially bit wear observations, show the possibility of extending continuous miners, already being used in trona, to Indiana limestone (10,000 psi). Rapid bit deterioration precludes use in Tennessee marble (16,800 psi) and Valders white rock (29,600 psi).

RI 8749. Selective Nickel Electrowinning From Dilute Electrolytes, by G. R. Smith, W. R. Thompson, and P. E. Richardson. 1983. 20 pp. 15 figs. Critical and strategic metals are often present in small quantities in low-grade domestic ores. When these ores are leached, the resulting solution usually contains the metals in very dilute quantities. Selective electrowinning from dilute electrolytes was investigated by the Bureau of Mines. A metal deposit containing 84 pct nickel was electrowon from the leach solution of a complex domestic ore bulk flotation concentrate originally containing approximately 2 wt-pct nickel. Key to achieving accelerated deposition rates, in the case of dilute solutions, is the rapid movement of the electrolyte through the electrowinning cell. Pure, synthetic nickel electrolytes were used to establish deposition parameters, and to optimize electrolyte velocity or mass transfer rates. Hydrodynamic and electrodeposition parameters for both the synthetic and leach electrolytes are presented and the experimental research described. Selective electrowinning appears to offer a viable alternative to physical separation methods to obtain separate metal "concentrates" from low-grade ores.

RI 8750. Characterization of Steelmaking Dusts From Electric Arc Furnaces, by Stephen L. Law, Wayne F. Lowry, Janet G. Snyder, and Gary W. Kramer. 1983. 26 pp. 2 figs. The Bureau of Mines charac-

terized 32 bulk samples of electric arc furnace steelmaking dust for chemical, physical, and extraction procedure (EP) toxicity properties to provide a basis for resource recovery decisions. Surface areas, densities, weight loss on drying, and semiquantitative data on 48 elements were obtained. Quantitative values for Ag, Al, Ba, Br, C (total and free), Ca, Cd, Cl, Co, Cr, Cu, F, Fe, K, Mg, Mo, Na, Ni, NO_3, P, S (total and sulfate), Si, Sn, Ti, V, and Zn were obtained for each sample. Arsenic and selenium were determined in selected samples. The valence states of Cr, Fe, and Zn were obtained for all samples. The EP toxicity test for hazardous waste classification resulted in 29 of the 32 dusts exceeding the criteria for listing as a hazardous waste. Leached Cd, Cr, and Pb were the problem in each case, with selenium also high in several of the leachates. Density separation studies show a trend for zinc and lead to be more concentrated in less dense fractions and chromium in the more dense, though the extremely fine particle size (generally < 0.2 μm) will probably preclude physical separation as a viable resource recovery option.

RI 8751. Enthalpy of Formation of 2CdO • $CdSO_4$, by H. C. Ko and R. R. Brown. 1983. 4 pp. The Bureau of Mines maintains an active program in thermochemistry to provide thermodynamic data for the advancement of mineral science and technology. As part of this effort, the standard enthalpy of formation at 298.15 K, ΔHf°, for 2CdO • $CdSO_4$ was determined by HCl acid solution calorimetry to be -345.69 ±0.61 kcal/mol.

RI 8752. Low-Iron Cu-Ni-Co Matte From Duluth Complex Sulfide Concentrate by Direct Smelting, by I. D. Shah, P. L. Ruzzi, and R. B. Schluter. 1983. 10 pp. 8 figs. The copper-nickel ore of the Duluth Gabbro Complex in northeastern Minnesota is a large potential domestic resource of cobalt and platinum-group metals. However, because of the low grade of the primary metal values (0.5 pct Cu, 0.15 pct Ni), the private sector has assigned a relatively low priority to the development of technology for processing this ore, anticipating that mining probably would not begin until the mid-1990's. Furthermore, preliminary processing flowsheets considered by the mining companies centered on the primary metal values. As part of an effort to help provide the basis for technology to recover critical and strategic minerals from domestic resources, the Bureau of Mines is investigating methods to recover all of the mineral values, in the Duluth Gabbro material, with particular attention to the byproduct critical minerals. A key step in this process is the removal of a relatively large amount of iron present in the bulk sulfide flotation concentrate to permit subsequent extraction of mineral values. This report describes a direct smelting method that removes most of the iron and produces a copper-nickel-cobalt matte, an intermediate product from which the metal values subsequently are separated. Copper, nickel, and cobalt grade and recovery data are presented for the direct smelting method. Test results showed that under certain conditions some of the mineral values reported to the slag, requiring slag cleaning to recover them.

RI 8753. Laboratory Investigations on the Behavior of Accessory Elements in Lead Blast Furnace Smelting, by Elizabeth A. Johnson, L. L. Oden, and John N. Koch. 1983. 17 pp. 8 figs. The effect of slag composition on lead losses to slags and on the behavior of associated accessory elements in lead blast furnace smelting has been studied by the Bureau of Mines. Equilibrations of 30 g of lead and synthetic slag doped with Cu, In, Tl, and Sb at 1,200° C in CO-CO_2 atmospheres revealed the importance of the FeO:SiO_2 ratio and the basicity ratio, $(CaO + MgO)$:SiO_2, of the slag. Lead losses to slags increased with an increasing FeO:SiO_2 ratio and decreased with an increasing basicity ratio. Copper and indium distribution coefficients,

$$L_x = \frac{\text{wt-pct X in bullion}}{\text{wt-pct X in slag}},$$

increased from 15 at the lower basicity ratios to near 60 at higher basicity ratios. L_{Tl} values increased from 20 to 150 as slag basicity increased. L_{Cu}, L_{In}, and L_{Tl} were relatively independent of the FeO:SiO_2 ratio, but increased with greater amounts of accessory elements in the system. Antimony distribution alone was shown to be strongly affected by FeO:SiO_2 ratio, although data were scattered. L_{Sb} values ranged from 20 to 800 and decreased sharply with increasing FeO:SiO_2 ratios. The basicity ratio and the level of accessory element load did not have any noticeable effect on L_{Sb}.

RI 8754. Compatibility of Nickel Electrolyte Containing Sodium Sulfate With a Solvent Extraction System, by Ruth A. Holmes, D. N. Nilsen, and R. E. Siemens. 1983. 12 pp. 6 figs. A Bureau of Mines method for recovering nickel, cobalt, and copper from low-grade domestic laterites is described, which includes the unit operations of solvent extraction and electrowinning. Previous Bureau work indicated that addition of Na_2SO_4 (sodium sulfate) to the nickel electrolyte improved current efficiency in nickel electrowinning. The present study determines the compatibility of Na_2SO_4 with nickel stripping in the solvent extraction operation of the Bureau method. The effect of adding 100 g/l Na_2SO_4 on nickel stripping, phase disengagement, and pH was determined in comparative laboratory-scale tests. In continuous-circuit testing, Na_2SO_4 reduced stripping efficiency to the extent that five, insead of four, strip stages were required for complete stripping of nickel from the loaded solvent. In tests made in a phase-disengagement cell that had a variable settler area, the addition of Na_2SO_4 did not significantly affect phase separation characteristics. The pH of the nickel electrolyte in the temperature range of 20° to 65° C was also unaffected by the addition of Na_2SO_4. An economic evaluation showed that the energy saved by adding Na_2SO_4 to the electrotyte would more than offset the cost of adding another stripping stage.

RI 8755. Preliminary Evaluation of Bit Impact Ignitions of Methane Using a Drum-Type Cutting Head, by David A. Larson, V. William Dellorfano, Carl F. Wingquist, and Wallace W. Roepke. 1983. 23 pp. 21 figs. Preliminary laboratory experiments have been conducted by the Bureau of Mines to define the influence of bit geometry on methane ignitions as a step toward establishing safer mining-machine operating parameters. The experimental system was designed to simulate the operation of a continuous mining machine, using a drum-type cutterhead of normal diameter with a narrow cross section, permitting full-diameter drum cutting tests to be run on material representative of sandstone lenses (or inclusions) in coal seams. Two conical bit types were tested at shallow depths of cut with three drum speeds. Bits that rotated in the mounting block during testing did not produce ignitions. The ignition frequency for used bits was three to four times greater than for new bits at the same kerf depth.

RI 8756. Selective Recovery of Arsenic From Aqueous Solutions With Hydrated Titanium Dioxide, by B. W. Madsen and D. A. Martin. 1983. 8 pp. 10 figs. Bureau of Mines research to recover arsenic from mining industry waste material and process streams is reported. Batch and column approaches were investigated for adsorbing arsenic from acid leach solutions and ion-exchange eluate solutions with hydrated titanium dioxide granules. A method for producing hydrated titanium dioxide granules was devised to provide material suitable for use in a packed adsorption tower. Selective adsorption of arsenic from acidic leach solutions was achieved. The loading capacity of arsenic on the granules was 14 wt-pct when synthetic solutions were used, but lower when actual leach solutions were used. Other elements in the leach solution were Zn, Cd, and In. The granules were used in an attempt to lower the arsenic content in a solution containing 0.95 g/l W and 0.027 g/l As from a process devised by the Bureau of Mines to treat Searles Lake brine. The arsenic content was lowered to less than 0.001 g/l, but unacceptable amounts of tungsten also were adsorbed by the granules. Adsorbed tungsten was partially stripped with pH 11.5 NaOH, and both tungsten and arsenic were completely stripped with 5*M* NaOH solution. Repeated loading and stripping of the granules had no effect on the loading capacity for arsenic.

RI 8757. Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals, by H. E. Hilliard, B. W. Dunning, Jr., and H. V. Makar. 1983. 15 pp. 5 figs. The Bureau of Mines investigated processed hydrometallurgical procedures for removing base metals from mechanically processed fractions of obsolete military electronic scrap. Feed material was a minus ¼-in nonmagnetic metallic concentrate produced by high-tension separation. Aluminum was extracted from the feed material in the first-stage ambient temperature, 20-wt-pct sodium hydroxide leach, which was followed by incineration to remove organic matter. A portion of the soluble nickel was extracted in the second-stage oxidizing dilute sulfuric acid leach. Copper and the remainder of the soluble nickel were extracted in the third-stage oxidizing concentrated sulfuric acid leach; copper was recovered from the spent leachate by cementation with an iron-base magnetic fraction. The third-stage leach residue and leachate contained essentially all of the precious metal values.

RI 8758. Corrosion-Resistant Sulfur Concretes, by William C. McBee, Thomas A. Sullivan, and Bing W. Jong. 1983. 28 pp. 23 figs. Sulfur concretes have been developed by the Bureau of Mines as construction materials with physical and mechanical properties that suit them for use in acid and salt corrosive environments where conventional concretes fail. Mixture design methods were established for preparing sulfur concretes using different types of aggregates and recently developed mixed-modified sulfur cements. Bench-scale testing of the sulfur concretes has shown their potential value. Corrosion resistance, strength, and durability of sulfur concrete are superior to those of conventional materials. Field in situ evaluation tests of the sulfur concretes as replacement for conventional concrete materials are in progress in corrosive areas of 24 commercial chemical, fertilizer, and metallurgical plants.

RI 8759. Alumina Miniplant Operations—Overall Mass Balance for Clay-HCl Acid Leaching, by Dwight L. Sawyer, Jr., Theodore L. Turner, and Don B. Hunter. 1983. 29 pp. 10 figs. To provide technology that can help decrease the dependence of the U.S. aluminum industry on imported bauxite, the main ore of aluminum, the Bureau of Mines is investigating the extraction of aluminum from abundant domestic reserves of kaolinitic clay. Miniplant studies of the continuous leaching of calcined kaolin with boiling 25-pct HCl acid resulted in a 93- to 99-pct extraction of the acid-soluble alumina in the calcined kaolin feed. Data are presented for an acid leaching study carried out in three or four continuously stirred tank reactors (CSTR) in series, feed rates of 100 to 250 lb/hr of calcined kaolin, and total nominal residence times of 0.7 to 2.3 hr. A material balance for a 176-lb/hr calcined kaolin feed rate in a circuit consisting of three reactors, four classifiers, and five thickeners is given. Data provide detailed compositional and physical information for calcined kaolin, process liquors, and acid-leached residue solids.

RI 8760. Recovery of Chromium From Surface-Finishing Wastes, by H. O. McDonald and L. C. George. 1983. 8 pp. 1 fig. The Bureau of Mines has demonstrated a hydrometallurgical method to separate chromium from other metals in a variety of surface-finishing wastes by precipitation with benzoate ion. The resulting chromium salt may then be converted to the hydroxide, and the benzoate may be recycled. Chromium recoveries of 92 to 100 pct are obtained.

RI 8761. Effect of Asymmetric Wear of Point Attack Bits on Coal-Cutting Parameters and Primary Dust Generation, by Wallace W. Roepke and Bruce D. Hanson. 1983. 16 pp. 8 figs. The Bureau of Mines conducted a series of experiments using Illinois No. 6 coal to determine the effect of asymmetric wear on airborne respirable dust (ARD), specific energy, cutting force, and normal force. Plumb-bob-type bits —one new bit and four ground with different sized flats—were used. Constant-depth linear cuts at 0.32, 0.64, 1.27, and 2.54-cm cut depths were made. Both cutting force and normal force increased as the flat area increased. Specific energy demonstrated a statistically significant increase with flat area at the 0.32- and 1.27-cm cut depth only. Specific ARD showed a statistically significant decrease with increasing flat area only at the 0.64-cm cut depth. Increasing cut depth increased cutting force but decreased specific energy and specific ARD. Normal force increased with increasing cut depth for the new bit but exhibited a maximum at 0.64 cm for the bits with flats.

RI 8762. Calamity Hollow Mine Fire Project (In Five Parts). 1. Development and Construction of the Burnout Control Ventilation System, by Meherwan C. Irani, Robert F. Chaiken, Louis E. Dalverny, Gregory M. Molinda, and Karen E. Soroka. 1983. 29 pp. 29 figs. The Bureau of Mines is developing a new technological approach to handling the problems of fires in abandoned coal mines and waste banks. This new technology involves the accelerated combustion of "waste" coals in place (i.e., in situ) under controlled exhaust ventilation conditions, which allows for total management of the combustion products, including utilization of the heat produced. This new concept could significantly lower the costs of reducing the environmental and public safety hazards associated with waste coal fires, and could lead to the conversion of a coal waste to a coal resource. The controlled burnout technolgy has progressed from the laboratory stage to a full-scale field evaluation stage at the site of an abandoned-

coal-mine fire. This first report describes the site selection, evaluation, and preparation, and the design and construction of the full-scale controlled burnout installation. Subsequent reports will deal with the results of the operational field trial.

RI 8763. Pilot Mill Flotation of Anorthositic Platinum-Palladium Ore From the Stillwater Complex, by E. Morrice. 1983. 8 pp. 2 figs. The Bureau of Mines investigated methods for beneficiating platinum-group metal ores from the Stillwater Complex, Montana, as part of its program to increase the supply of critical and strategic minerals and metals from domestic resources. This report presents results of a 5-day continuous campaign employing a pilot flotation mill to recover sulfide concentrate containing platinum-palladium values from anorthositic ore. A mercaptobenzothiazole-sulfuric acid reagent suite was used. The pilot flotation mill was operated at an average feed rate of 106 lb/hr of ore. A rougher concentrate containing 8.5 pct of the feed was prepared: it assayed 1.1 oz/ton Pt and 3.5 oz/ton Pd. Recovery of platinum and palladium were 91 and 87 pct, respectively.

RI 8764. Velocity and Orientation Effects on the 10-mm Dorr-Oliver Cyclone, by Andrew B. Cecala, Jon C. Volkwein, Robert J. Timko, and Kenneth L. Williams. 1983. 11 pp. 9 figs. The Bureau of Mines conducted a brief laboratory study on the 10-mm-diam Dorr-Oliver nylon cyclone to investigate (1) whether high wind speed (> 300 ft/min), or sampler inlet orientation with respect to wind direction, can introduce errors when sampling respirable dust, and (2) whether any such errors can be reduced by using an inlet shield. Being preliminary in nature, the study was not structured to produce definitive results, but rather to discern likely trends and to indicate whether or not a more in-depth study of the problem is warranted. Photometric mass sensing measurements suggested that as the wind velocity increased, the cyclone sampling directly into the high-velocity airstream tended to oversample, relative to the cyclone sampling in a low-velocity airstream. Orientation of the sampler introduced measurable differences in sampling efficiency at higher wind velocities. A shield placed around the cyclone diminished the effects of wind velocity and sampler orientation on sampler performance. Results of this work offer sufficient evidence to substantiate the need for a more in-depth study.

RI 8765. General Time-Dependent Solutions for Radon Diffusion From Samples Containing Radium, by P. J. Dallimore and R. F. Holub. 1983. 49 pp. 10 figs. The Bureau of Mines has calculated general time-dependent solutions for radon diffusion from cylindrical and slab rock samples containing uniform radium distribution. Results have been obtained for several sets of boundary conditions. The method is suitable for determining the effective diffusion coefficient and the effective porosity for radon.

RI 8766. Extracting Vanadium and Uranium From Low-Grade and Mill-Grade Ores From the Colorado Plateau, by I. L. Nichols, G. R. Palmer, and J. L. Huiatt. 1983. 16 pp. 9 figs. The Bureau of Mines is investigating vanadium recovery from various domestic resources. A low-grade carnotite ore sample containing 0.34 pct V_2O_5 and 0.04 pct U_3O_8 was leached, and the results were compared with those of similar leach tests using a mill-grade sample containing 1.26 pct V_2O_5 and 0.19 pct U_3O_8. Experiments on the two ore samples included agitation leaching, pugging, salt-roast leaching, and autoclave leaching. None of the leaching methods investigated showed any significant advantage over another except autoclaving, which reduced the leach time but at the expense of greater acid consumption. Typical of the experimental results attained are the data gathered from the agitation leaching tests. Agitation leaching of the mill-grade ore with 100 lb/ton H_2SO_4 resulted in extractions of 94 pct U_3O_8 and 33 pct V_2O_5. To increase the vanadium extraction from 33 to 91 pct required concentrations of 300 lb/ton H_2SO_4 and 10 lb/ton $NaClO_3$. Complementary agitation leach tests on the low-grade ore required 200 lb/ton H_2SO_4 to extract 94 pct U_3O_8, and 300 lb/ton H_2SO_4 and 10 lb/ton $NaClO_3$ to extract 90 pct V_2O_5.

RI 8767. Long-Term Effectiveness of Deep Mine Sealing at Moraine State Park, Butler County, Pa., by Slavoljub D. Maksimovic and Bernard R. Maynard. 1983. 35 pp. 17 figs. The Bureau of Mines conducted water sampling with flow measurements at Moraine State Park to determine the long-term effectiveness of the deep mine sealing completed between 1969 and 1971. Data collection in 1979 and 1980 consisted of taking two samples per weir location from a group of mine entries. These data were compared with baseline data from before and 1 year after seal completion, utilizing standard statistical procedure. The total mean water discharge and total mean iron load increased, whereas the mean acid load decreased. The minimum water discharge, minimum acid, and total minimum iron load increased, and the maximum water discharge, maximum acid, and total maximum iron load decreased as a result of sealing. The acid load variance was reduced approximately 55 pct. The water discharge and water quality were more consistent than before sealing. In general, the water quality was better within a mine pool than at the discharge points; the development of a pool did not insure improvement at the discharge points. Overall, mine sealing improved the water quality in the park's Lake Arthur.

RI 8768. Mathematical Modeling of Accessory Element Distribution in Metallurgical Processes—Computerization of a Lead Smelter Plant, by M. A. Lucas, C. M. Flynn, Jr., and T. G. Carnahan. 1983. 46 pp. 3 figs. The Bureau of Mines has developed a computerized mathematical model to predict the distribution of accessory elements throughout a metallurgical process. The model can be used to determine process conditions that effect better accessory element control consistent with continued high primary metal recovery. The model presented is specific for determining the bismuth distribution in lead smelting but can be adapted to most extractive metallurgical processes. Thermodynamic, kinetic, and process parameters form the base for the model. Its logic and structure are described in detail.

RI 8769. Recovering Mercury From a Flotation Concentrate by Continuous Leaching-Electrolysis, by G. B. Atkinson, J. E. Murphy, and J. A. Eisele. 1983. 9 pp. 4 figs. The Bureau of Mines, in cooperation with McDermitt Mine, investigated a method for recovering mercury metal from mercury sulfide flotation concentrate by a hydrometallurgical technique. This preliminary report shows the feasibility of leaching mercury with a cupric chloride solution and electrowinning mercury from the solution. Proposed chemical reactions are shown in equations 1 through 3:

$$2CuCl_2 + HgS \rightarrow 2CuCl + HgCl_2 + S^\circ; \quad (1)$$

$$HgCl_2 \xrightarrow{\text{electrolysis}} Hg + Cl_2; \quad (2)$$

$$2CuCl + Cl_2 \rightarrow 2CuCl_2 \quad (3)$$

A bench-scale leaching-electrowinning apparatus capable of treating 2.36 kg of sulfide concentrate in 11 days was operated continuously. An acid chloride solution containing, in grams per liter, 70 Ca, 60 Cu, 30 Fe, and 80 Hg was used as both leachant and electrolyte; 99.5 pct of the mercury was solubilized from the sulfide concentrate. Electrolysis of the leaching solution recovered mercury metal at an average current efficiency of 32 pct and an average energy consumption of 1.2 kwhr/lb Hg. Results from a preliminary economic evaluation indicated that a plant producing 31,500 flasks of mercury per year would have a capital cost of $3.7 million and an operating cost of $62 per flask of mercury.

RI 8770. Integrated Operation of Ferric Chloride Leaching, Molten-Salt Electrolysis Process for Production of Lead, by M. M. Wong, R. G. Sandberg, C. H. Elges, and D. C. Fleck. 1983. 21 pp. 16 figs. The Bureau of Mines, under a cooperative research program with four lead companies, has investigated a nonsmelting process for the production of lead metal. The process, which would eliminate sulfur dioxide generation and minimize particulate lead emissions, involves ferric chloride leaching of galena concentrate to produce lead chloride, followed by molten-salt electrolysis of the lead chloride to yield lead metal and chlorine. This chlorine is used to regenerate ferric chloride in the leaching solution. The process was tested in an experimental unit with a capacity of 500 lb of lead metal per day. The tests were performed in three 10-day and six 5-day campaigns, during a period spanning 28 mo. The study was carried out using a southeastern Missouri lead concentrate. Typical lead recovery was about 98 pct. Process problems related to impurity build-up and control were studied. When copper and silver impurities were removed from the leaching solution, a lead metal purity of 99.999 pct was obtained. Lead-in-air levels and lead-in-blood levels of operating personnel were monitored. The process has potential for producing lead with minimum pollution, but is not ready for commercial utilization. Operation of a prototype commercial electrolytic cell and a full-scale pilot-plant investigation by industry are needed to evaluate the commercial viability of the process.

RI 8771. A Water Elutriator System for Recovering Nonmagnetic Metals From Automobile Shredder Rejects, by D. K. Steele and J. W. Sterner. 1983. 22 pp. 10 figs. An 18-in-diam column water elutriator was designed, tested, and operated by the Bureau of Mines for recovering nonferrous mixed metals from automobile shredder rejects. The water elutriator separated metals from nonmetals contained in shredded nonmagnetic rejects. The unit was constructed and integrated into a local automobile shredding operation. Nonmagnetic rejects from the automobile shredder were fed onto the surface of a column of rising water. Dense materials fell through the rising water and were collected as a sink product at the bottom of the column; medium-density materials were removed as an intermediate product in a water flow through a discharge port located between the overflow and sink; and light materials were immediately carried out in the overflowing water at the top of the column as a float product. Nearly 99 pct of the mixed metals were recovered from the nonmagnetic rejects as a 70-pct-metal concentrate. Other operating conditions yielded a 93.7-pct-pure-metal product resulting in a 93.1-pct metal recovery. Float rejects are combustibles, light plastics, foam rubber, and minimal amounts of coated and uncoated copper wire. The middling discharge contained mainly medium-density rubber, plastics, glass, rock, coated and uncoated wire, and frequently some thin-sheet stainless steel and wrought aluminum. Maximum metal recovery in the operating program was achieved using a water velocity of 52 fpm (650 gpm). Maximum purity was obtained with a velocity of 88 fpm (1,100 gpm). Water was recycled through a 12,000-gal baffled clarifying tank. Entrainment water losses with the float and middling rejects averaged 50 gpt of reject feed. Records maintained by the shredder operator show a 34-pct increase in nonmagnetic metals recovery during a 1-yr operation of the water elutriator as compared to recoveries from a previously used air classification system. This report is based upon work done under an agreement between the Bureau of Mines and Learner-Pepper Co., Salt Lake City, UT.

RI 8772. Factors Affecting the Preparation of Misted Clay Feed and Solids-Liquid Separation After HCl Leaching, by R. S. Olsen, W. G. Gruzensky, S. J. Bullard, and Jack L. Henry. 1983. 25 pp. 17 figs. Although aluminum is easily leached from calcined clay with boiling mineral acids, the presence of fines and slimes in the leached residue has hindered the application of acid leaching processes. A feed preparation method was, therefore, devised that provided a dense, smooth-surfaced, fine-grained clay. The important factors affecting feed quality were determined to be(1) crushing the raw clay to the size desired for the leaching process, (2) moistening the crushed clay with a fine mist of water while tumbling on a rotating disk, (3) drying the misted clay, and (4) calcining the dried clay at 750° C in a fluidized bed. Clay treated by this method was leached with HCl, and its residue was washed by water displacement in 4-ft-deep beds. Bed permeabilities on the order of 47 darcys or 4.6×10^{-7} cm^2 were obtained with the leached residues.

RI 8773. Mechanical Properties of Some Portland Cement Concretes Made With Coal and Coal Waste as Aggregates, by Bing W. Jong and William C. McBee. 1983. 12 pp. 6 figs. A bench-scale evaluation of coal and coal waste materials as aggregate materials for use in longwall mine supports was undertaken as part of the Bureau of Mines Health and Safety program on ground control. Performance data were obtained on portland cement concretes (PCC) prepared with coal and coal wastes as aggregate materials. The effects of high-early-strength accelerators on strength and creep and of superplasticizers on strength properties of PCC formulated with coal and coal waste were investigated. Concrete formulated with a high-early-strength accelerator and coal and coal waste has 20 and 40 pct greater compressive strength, respectively, than the control samples without admixture. A concrete formulated with coal waste and the high-early-strength accelerator, using four bags of cement per cubic yard and a water-cement ratio of 1.0, had the lowest creep value of all the coal- and coal-waste-formulated PCC's tested.

RI 8774. A Digital Instrumentation Package for an Improved Torsion Pendulum, by R. W. Nash and A. E. Schwaneke. 1983. 9 pp. 6 figs. This report describes the design and operation of a digital instrumentation package for the Bureau of Mines improved torsion pendulum, a scientific instrument that measures the vibration damping of metallic materials. The new design eliminates manual analog-to-digital conversion, reduces the data acquisition time, and increases the precision of the measurements. The digital output can be coupled directly

to a microprocessor or computer to produce the final data in real time.

RI 8775. An Evaluation of Aluminum Smelter Potlining as a Substitute for Fluorspar in Cupola Iron-melting and in Basic Oxygen Steelmaking, by Victor R. Spironello. 1983. 18 pp. 3 figs. The Bureau of Mines has studied slags associated with ferrous melting, to evaluate substitutes for the auxiliary flux mineral, fluorspar. A waste material recovered from alumina reduction cells, "used potlining," was tested in an 18-in-ID basic-lined cupola and in a ¼-ton, pilot-scale, basic oxygen furnace (BOF). One potlining fraction, No. 1 cut, is a carbonaceous (graphitic) material and represents the bulk of the entire cell lining. The other fraction, No. 2 cut, is a refractory backup. These materials contain significant quantities of fluorine, and other elements in various compounds. The potlining fractions were blended in ratios believed representative of available materials. Both lump and pelletized forms provided extremely fluid slag. No adverse effects were found on furnace performance, chemistry or strength of the metals produced, or the environment. Fluorine recovery in the slag and fluorine losses to the scrubber water and solids were about the same as when fluorspar was used. There was apparently no lining loss from the cupola, but there was lining attack in the BOF. Since the fluidizing ability of potlining is due in part to sodium and other elements such as aluminum and silicon, less fluorine is needed in the slags when potlining is used.

RI 8776. Evaluation of Radium and Toxic Element Leaching Characteristics of Florida Phosphogypsum Stockpiles, by Alexander May and John W. Sweeney. 1983. 18 pp. 2 figs. The Bureau of Mines conducted studies to determine if phosphogypsum, a waste material from the processing of phosphate rock, contains hazardous toxic materials as defined by the Environmental Protection Agency (EPA) and whether leaching of these toxic materials and radium may occur. Samples of the phosphogypsum stockpiled material were evaluated using the EPA extraction procedure, atomic absorption, neutron activation, X-ray diffraction, and chemical and physical means. Radiological tests performed used both the germanium-lithium and emanation methods. The data show that the phosphogypsum stockpiles are not hazardous toxic waste as defined by EPA criteria. Trace elements and radium are not leached from the phosphogypsum stockpiles. Absorption of trace elements and radium by phosphogypsum is the major reason for their not being leached. The standard error of measurement of radium concentrations was 4.7 pCi/g. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8777. Correlation of LANDSAT and Air Photo Linears With Roof Control Problems and Geologic Features, by Jacqueline H. Jansky and Ronald F. Valane. 1983. 22 pp. 23 figs. The Mine Safety and Health Administration (MSHA), U.S. Department of Labor, did a linear analysis for a new underground coal mine in Grant County, WV, through the interpretation of LANDSAT imagery and high-altitude, color-infrared aerial photography, to identify areas of potentially unstable roof in advance of mining. The Bureau of Mines included this mine in its ongoing study of the correlation between geologic features and linears. Three years after the analysis, after mining had progressed through the plotted linears, a cooperative Bureau-MSHA study evaluated the effectiveness of the linear plot in predicting areas of unstable roof and defined the geology associated with the linears. Adverse roof conditions at this mine include roof falls, potted-out roof, water inflow, and local areas requiring supplemental support. At the time of this study, 34 pct of the mine workings were within 200 ft of a plotted linear. Fifty percent of the adverse roof area in the mine occurred within this same area. The primary geologic anomaly associated with the linears is an increased frequency of jointing. The majority of the plotted linears coincide with the prominent joint orientations. Additional features observed in the linear zones include roof rolls and a standstone channel that cuts into the coal seam.

RI 8778. The Enthalpy of Formation of Synthetic Cancrinite [$Na_{7.68}(Al_6Si_6O_{24})(NO_3)_{1.68}(H_2O)_{4.1}$], by K. O. Bennington and R. R. Brown. 1983. 7 pp. Cancrinite is one constituent of "red muds," a high-volume waste product of alumina production by the Bayer process. The Bureau of Mines determined the thermochemical properties of cancrinite as part of a program to provide such data for minerals of industrial importance. Cancrinite [$Na_{7.68}(Al_6Si_6O_{24})(NO_3)_{1.68}(H_2O)_{4.1}$] was synthesized by reacting aluminum silicate gel with a solution of NaOH and $NaNO_3$, and the composition was determined by chemical analysis, differential scanning calorimetry, and thermogravimetric analysis. The heat of solution was determined by hydrofluoric acid solution calorimetry. The standard enthalpy of formation at 298.15 K, $\Delta Hf°_{298}$, is

$$\Delta Hf°_{298} = -3{,}487.97 \pm 2.6 \text{ kcal/mol},$$

and the standard enthalpy of formation from the oxides and $NaNO_3$, $\Delta H°_{298}$, is

$$\Delta H°_{298} = -215.20 \pm 1.8 \text{ kcal/mol}.$$

RI 8779. Thermodynamic Properties of Pollucite (A Cesium-Aluminum-Silicate), by K. O. Bennington, R. P. Beyer, and G. K. Johnson. 1983. 18 pp. The thermodynamic properties of pollucite [$(Cs_{0.650}Na_{0.185}Rb_{0.028})(AlSi_2)(O_{5.863}OH_{0.137}) \cdot 0.19H_2O$] were determined by the Bureau of Mines in collaboration with the Argonne National Laboratory. The standard enthalpy of formation determined by hydrofluoric acid calorimetry is

$$\Delta Hf°_{298} = -3{,}098.52 \pm 3.63 \text{ kJ mol}^{-1}.$$

The standard enthalpy of formation from the oxides is

$$\Delta H°_{298} \text{ (from oxides)} = -209.50 \pm 2.38 \text{ kJ mol}^{-1}$$

Low-temperature heat capacities were determined by adiabatic calorimetry from 5.0 to 306.1 K. The derived standard entropy is

$$S°_{298} = 207.24 \pm 0.43 \text{ J mol}^{-1}\text{K}^{-1}.$$

Enthalpy increments above 300 K were measured by copper-block drop calorimetry from 349 to 674 K. Various experimental data were combined with other data from the literature to calculate the Gibbs energies of formation and equilibrium constants of formation over the temperature range of measurements. Standard enthalpies of formation and Gibbs energies of formation are given as functions of temperature. The Gibbs energy of formation is

$$\Delta Gf°_{298} = -2{,}919.9 \text{ kJ mol}^{-1}.$$

RI 8780. Reducing Longwall Tailgate Workers' Dust Exposure Utilizing Water-Powered Scrubbers, by John A. Organiscak, Jon C. Volkwein, and Robert A. Jan-

kowski. 1983. 11 pp. 8 figs. Laboratory and underground studies were conducted by the Bureau of Mines to evaluate the effectiveness of a water-powered scrubber and a brattice partition to create a clean split of air for longwall workers at the tailgate. In simulated laboratory tests, the system was very effective in creating a clean split of air. Observed system efficiencies were 74 and 84 pct with induced airflows of approximately 2,000 and 2,500 cfm, respectively. Underground evaluations indicated that the system was capable of reducing respirable dust at the tailgate. The first underground evaluation resulted in protection efficiencies of 30.7 and 42.5 pct at scrubber water pressures of 150 and 450 psig, respectively. A 33.7-pct protection efficiency was observed in the second underground evaluation with a modified partition and the scrubber operating at 250-psig water pressure. To be most effective, the system should have the scrubber operating at a flow rate of 10 gpm at 500 psig to deliver a maximum quantity of cleaned air behind a well-sealed partition.

RI 8781. Above-the-Earth Field Contours for a Dipole Buried in a Homogeneous Half-Space, by Steven M. Shope. 1983. 14 pp. 4 figs. An essential element of the Bureau of Mines electromagnetic location and communication system for trapped miners is a quantitative knowledge of the surface and above-surface electromagnetic fields created by an underground transmitter. The field solutions given in this report use approximations in which the displacement currents are negligible for low frequencies. The earth is represented by a homogeneous half-space model in which a dipole source is immersed. The vertical magnetic field equipotential contours at and above the surface are graphically mapped. The volumes of the regions bounded by these contours are directly related to the geometrical zones of signal detectability. Knowledge of the detectability zones will enable the proper search strategies to be developed for airborne detection of trapped miners.

RI 8782. Physical Property Data on Coarse Anthracite Waste, by Bill M. Stewart and L. A. Atkins. 1983. 24 pp. 17 figs. Since 1974, a large amount of data has been developed concerning the physical properties and stability characteristics of waste generated by the mining and preparation of bituminous coal. However, very little information has been developed on the properties and characteristics of anthracite waste. During this Bureau of Mines research project, coarse anthracite breaker refuse from five sites in eastern Pennsylvania was sampled, and the physical properties, which indicate stability characteristics, were determined in the laboratory. Coarse anthracite breaker refuse is quite similar to coarse bituminous refuse in chemical and mineralogical composition. However, the physical properties of the anthracite waste materials tested are different from those of coarse bituminous refuse. For the coarse anthracite breaker refuse tested, the average maximum laboratory density is 113.2 lb/ft^3, the average angle of internal friction (direct shear) and average cohesion are 30.2° and 2.6 psi, respectively, and the average permeability (four sites) is 1.24×10^{-2} cm/sec. Stability analyses were conducted on six theoretical anthracite waste embankments. These analyses show the effects on minimum safety factors of geometry, phreatic surface level, and physical properties.

RI 8783. Copper-Manganese-Base Silverless Brazing Systems, by V. R. Miller and W. L. Falke. 1983. 16 pp. 10 figs. The Bureau of Mines conducted research on substitute brazing filler alloys with properties similar to those of silver filler alloys in an effort to conserve silver and reduce hazards from cadmium emissions. Experimental work was conducted first on the commercial silver brazing alloys BAg-1, BAg-1a, BAg-2, and BAg-3 to establish criteria for evaluating the substitute alloys. Properties investigated included the wettability of copper, brass, and steel substrates, and the strength of joints made with the filler alloys. A series of experimental alloys containing 50 to 60 pct Cu, 20 to 28 pct Mn, and 17 to 30 pct Zn was prepared and evaluated, together with Cu-Mn-Zn alloys with 5 pct Pb or 2 pct Ni. Wetting properties and joint strengths were not as good as those for silver filler alloys, and the high application temperatures reduced the copper and brass base metal strengths. However, experimental alloys containing 70 pct Cu, 15 to 20 pct Mn, and 10 to 16 pct Sn had wetting and strength properties approaching those of the silver filler alloys. The application temperatures for these alloys were higher than those for silver fillers, but not as high as those for the Cu-Mn-Zn alloys. With the Cu-Mn-Sn alloy fillers, copper alloy joint members are less deteriorated by recrystallization than when applying Cu-Mn-Zn alloys. The Cu-Mn-Sn system has potential for further development as a substitute brazing alloy system, particularly if the melting temperature can be reduced by the addition of other elements without decreasing the ductility and wetting.

RI 8784. Toward Development of a Hard-Rock Mining Machine—Drag Cutter Experiments in Hard, Abrasive Rocks, by Roger J. Morrell and Richard J. Wilson. 1983. 19 pp. 13 figs. The Bureau of Mines conducted drag cutting experiments in hard, abrasive rock in an effort to extend the capabilities of an experimental kerf-core mining machine. The basic kerf-core mining machine cannot be used in hard, abrasive rocks because of the high wear experienced by the kerf cutters. These experiments were conducted in an effort to develop a method of preweakening the rock ahead of the kerf cutters in order to reduce the high cutting loads and hence the higher wear rates experienced by the cutters. The two "preweakening" techniques studied were indenting with mechanical wedges and single and double slotting with diamond saws. The best cutter force reduction achieved with mechanical indenting was 70 pct, whereas double slotting achieved force reductions of up to 99 pct. Conceptual designs of preweakening systems that could be retrofitted onto the basic kerfing cutterhead were developed for both the indenting and the slotting techniques. A high-energy impactor with wedge bit was used for the indenting method, and high-pressure water jets were used for the slotting method. A preliminary technical and economic analysis was performed for both of these full-scale systems to illustrate the methodology and to point out the important technical and economic factors that must be considered.

RI 8785. Kettlebottoms: Their Relation to Mine Roof and Support, by Frank E. Chase and Gary P. Sames. 1983. 12 pp. 14 figs. Kettlebottoms are columnar masses of rock—the preserved casts of ancient tree stumps—embedded in coal mine roof strata (of which they are a part). Because unsupported kettlebottoms can detach from a mine roof without warning, they are a hazard to miners. The primary objectives of this investiga-

tion were (1) to better define and describe kettlebottoms and (2) to evaluate kettlebottom support techniques in terms of safety and effectiveness. A telephone survey of mine operators, interviews with Mine Safety and Health Administration (MSHA) personnel, and underground mine visits were conducted in Pennsylvania, West Virginia, and Kentucky. Information gathered during this investigation indicates that the size and frequency of kettlebottoms in mine roof are dependent upon past geologic events and biological processes active during the deposition of roof sediments. To ensure the safety of mine personnel, all undermined kettlebottoms should be supported. The roof should be bolted next to kettlebottoms less than 3 ft in diameter, close enough to allow a portion of a wood or steel header to be extended beneath each kettlebottom for support. Two bolts and a wood plank or steel strap should be employed to support kettlebottoms over 3 ft in diameter.

RI 8786. Industrial Evaluation of Sulfur Concrete in Corrosive Environments, by W. C. McBee, T. A. Sullivan, and B. W. Jong. 1983. 15 pp. 13 figs. Over the past several years the Bureau of Mines has developed a sulfur concrete (SC) technology in which chemically modified sulfur is mixed with suitable mineral aggregates to produce construction materials that are resistant to corrosion by acids and salts. Modified SC materials have been tested in actual operating conditions in 50 corrosive process environments at 40 commercial plants. SC components ranging from small test coupons to 4-ton acid sump tanks were fabricated and installed at plant locations where chemical corrosion was destroying conventional concrete materials. Through cooperative agreements with several companies, floors, retaining walls, and foundations were cast in place using SC materials, then monitored for resistance to corrosion and retention of strength properties. After 4 years of testing there was essentially no evidence of material degradation or loss of strength. Conventional concrete materials, however, were attacked and in some cases completely destroyed under the same conditions. Minor degradation, similar to that encountered with portland cement concrete (PCC), occurred when sulfur concrete was exposed to strong alkali, hot chromic acid, and copper slimes solutions. Although long-term aging characteristics of SC materials are still being determined, already these materials are finding widespread use in metallurgical, chemical, and fertilizer processing plants.

RI 8787. Effect of Potassium Ethylxanthate Degradation on Flotation of Chalcopyrite and Molybdenite, by W. W. Simpson, I. L. Nichols, and J. L. Huiatt. 1983. 8 pp. 4 figs. The Bureau of Mines conducted research to determine the effects of potassium trithiocarbonate (KTTC), a degradation product of potassium ethylxanthate (KEX), on flotation of chalcopyrite and molybdenite. Small amounts of KTTC were identified in fresh and aged solutions of KEX using thin-layer chromatography. Hallimond tube flotation tests on pure minerals showed that KTTC acts as a weak collector for chalcopyrite. Both KEX and KTTC tend to depress molybdenite, but the depression effect is easily overcome by addition of a small quantity of fuel oil. The results of the Hallimond tube tests were confirmed in batch flotation tests using a porphyry copper ore.

RI 8788. Distribution and Analyses of Gold and Silver in Mechanically Processed Mixed Electronic Scrap, by B. W. Dunning, Jr., F. Ambrose, and H. V. Makar. 1983. 17 pp. 6 figs. The Bureau of Mines investigated the concentration and distribution of precious metals in the various fractions produced from mechanical processing of obsolete military electronic scrap. Whole avionic units, printed circuit cards, and electrical connectors were processed and analyzed. Materials recovered included baghouse lights, wire bundles, magnetics, and metal concentrates from eddy-current and high-tension separation. Higher value fractions were processed by a commercial toll refiner for recovery of gold and silver. Lower value fractions were analyzed by the Bureau. Three fractions, the lights, wire bundles, and metallics from high-tension separation, contained most of the precious metals. Depending on the type of scrap feed, these fractions represented 34 to 60 pct of the original sample weight. Collectively, they represented 68 to 97 pct and 75 to 98 pct of the contained gold and silver, respectively. (*Out of print.*)

RI 8789. Synthetic Fluorspar Flux in the Basic Cupola: Evaluation of Operation and Fluorine Volatility, by H. W. Kilau, V. R. Spironello, I. D. Shah, and W. M. Mahan. 1983. 20 pp. 8 figs. The Bureau of Mines evaluated synthetic fluorspar as a substitute for natural fluorspar flux in basic cupola ironmaking. The synthetic fluorspars tested were prepared from waste fluosilicic acid generated during the processing of fluorapatite ore. The cupola trials showed the synthetic products to be the equivalent of natural fluorspar from an operational standpoint. However, wet scrubber sampling showed that substantial losses of volatilized fluorine occurred from the cupola during operation. The losses during synthetic fluorspar trials considerably exceeded those from natural fluorspar trials. Laboratory viscosity testing, using a high-temperature rotational viscometer, confirmed this finding and indicated that fluorspar volatility in slags is related to slag basicity. Synthetic fluorspar is accordingly recommended more for highly basic cupola operation (>1.3 basicity) than for neutral or acid operation, because of the increased potential for pollution and baghouse filter deterioration.

RI 8790. Beneficiation of a Western Mesabi Nonmagnetic Taconite After Reduction Roasting With Lignite, by Roy E. Peterson and John E. Moy. 1983. 19 pp. 9 figs. The Bureau of Mines has been developing and evaluating methods for beneficiating the large deposits of nonmagnetic (oxidized) taconite located on the western Mesabi Range. In this segment of the research, a sample representing about 0.5 billion tons of nonmagnetic taconite from near Grand Rapids, Minn., was beneficiated using a reduction roasting, magnetic separation, flotation process. The sample contained 32.1 pct iron and 49.1 pct silica. Tests were conducted both on a bench scale and with a 1,000-lb/h pilot plant. In the bench-scale research a concentrate containing 69.0 pct iron and 4.5 pct silica was produced with an iron recovery of 82.1 pct. In the pilot plant, reduction roasting was conducted in a 35-ft kiln using lignite as the reductant and major source of fuel. Dust from the kiln exhaust was pelletized and recycled to the kiln. The roasted taconite was beneficiated by magnetic separation and flotation to produce a product containing 67.9 pct iron, 5.5 pct silica, and 69.7 pct of the iron in the kiln feed. The cyclone separation in the grinding circuit was sharpened by demagnetizing the cyclone feed in a 400-Hz, 1,000-Oe magnetic field.

RI 8791. Novel Coal-Cutting Bits and Their Wear Resistances, by Lung Cheng, Israel Liebman, Aldo L. Furno, and Richard W. Watson. 1983. 15 pp. 13 figs. Based on earlier tests that showed steel to be much more likely to cause frictional ignition than tungsten carbide, the Bureau of Mines redesigned coal-cutting bits to reduce the hazard of face ignitions. Two bit designs—a mushroom-shaped bit with a conical shank and a dovetail bit with a rectangular shank—are described, as well as bit wear tests conducted in the laboratory and in an operating coal mine. In laboratory tests, for ⅛-, ¼-, and ½-in-deep cuts and cutting speeds of 280, 500, and 660 ft/min, the mushroom bit had significantly longer tip wear life than the conventional bit; the dovetail bit was also superior to the conventional bit. Results of in-mine tests on the mushroom bit agree well with laboratory results. In-mine tests of the dovetail bit are underway.

RI 8792. Corrosion of Selected Metals and a High-Temperature Thermoplastic in Hypersaline Geothermal Brine, by R. K. Conrad, J. P. Carter, and S. D. Cramer. 1983. 20 pp. 7 figs. The Bureau of Mines conducted corrosion research to determine suitable construction materials for geothermal resource recovery plants. Weight loss, pitting and crevice corrosion, U-bend stress corrosion, and electrochemical polarization measurements were made on selected metals in brine and steam process environments produced from high-enthalpy hypersaline brine from geothermal well Magmamax No. 1 at the Salton Sea Known Geothermal Resources Area, Imperial Valley, Calif. Cadmium (and by extension cadmium coatings) and a 6061-T6 aluminum alloy were unsatisfactory because of high general corrosion rates and, in the case of aluminum, severe pitting. Molybdenum and niobium (columbium) were resistant to general corrosion, pitting, and crevice corrosion. Copper alloys corroded at rates that may preclude their use in wellhead brine. The presence of iron accelerated the corrosion of the copper alloys. Titanium alloys were resistant to general corrosion and stress corrosion cracking in all of the environments. They exhibited crevice corrosion in some of the brine and steam environments and Ti6Al4V pitted in the brine environments. They exhibited passive behavior over a broad range of potentials. Exposure tests were conducted on a high-temperature polyphenylene sulfide thermoplastic (Ryton) in the same environments. A 40-pct-graphite-fiber-reinforced Ryton composite deteriorated readily in wellhead brine and failed in all of the brine and steam process environments; Ryton coatings on 316L stainless steel were adherent and performed well.

RI 8793. The Generation, Collection, and Analysis of Welding Fumes, by J. F. McIlwain and L. A. Neumeier. 1983. 14 pp. 6 figs. The Bureau of Mines investigated fumes generated by selected welding materials used in mines in order to help determine their relative hazard potential. The initial phases of the study have been completed. A welding-fume generation and collection apparatus was designed, assembled, and calibrated. Five brands of coated, AWS-type E308-16 stainless steel electrodes were tested. Total fume generation rates of 0.39 to 0.51 g/min were measured. Quantitative chemical analyses were conducted for all of the principal fume constituents. Two analytical schemes were used to determine levels of the Cr^{6+} and Cr^{3+} species contained in the welding fumes; comparable results were obtained. The Cr^{6+} was found to be the most hazardous constituent, leading to a maximum allowable total fume exposure of 1 mg/m^3. Fume generation rates and fume constituent analyses will be derived for other groups of welding electrodes using similar procedures.

RI 8794. A Ball-on-Block Impact-Spalling Wear Test and Results on Several Iron Alloys, by R. Blickensderfer and B. L. Forkner. 1983. 18 pp. 10 figs. An impact wear testing machine was devised by the Bureau of Mines that simulates the repeated impact conditions encountered in large milling and grinding operations where breakage and spalling are problems. The apparatus provides data on materials that may help in the design of alloys with improved resistance to deformation, spalling, and breakage. The test blocks are 2 in thick by 6 in by 8 in. Impacts are produced by dropping 3-in-diam balls weighing 4 lb from a height of 10 ft. Tests were run until breakage occurred or to a total of 100,000 impacts. Four types of failures of the test block were observed: (1) cold flow of the bulk material by plastic deformation, (2) flaking of the surface in the impact region, (3) spalling of the block to form a crater in the region of impact, and (4) breakage of the test block into two or more major pieces. The effects of composition, heat treatment, microstructure, and hardness on type of failure are discussed.

RI 8795. Problems Facing Coal Mining and Gas Production in the Hartshorne Coalbeds of the Western Arkoma Basin, OK, by A. T. Iannacchione, C. A. Kertis, D. W. Houseknecht, and J. H. Perry. 1983. 25 pp. 27 figs. Major problems facing the development of coal and gas resources of the Hartshorne Coalbeds include the complex distribution of minable and unminable coal, high methane content and bed pressure, faulting, variations in degree of dip, presence of natural gas fields in associated sandstones, and legal problems, caused by local geologic characteristics, in identifying gas origin. This Bureau of Mines study provides pertinent geologic information for long-range planning of subsurface coal and gas production from the Hartshorne Coalbeds. Pittsburg, Coal, Hughes, and Atoka Counties, OK, have approximately 1 billion metric tons (1.1 billion short tons) of Hartshorne coal in place. The methane resource of Hartshorne Coalbeds is estimated at 9.2 billion m^3 (325 billion ft^3) and varies with overburden and rank. These estimates were compiled from gas well density logs, coal-core data, outcrop measurements, abandoned mine maps, and the literature. The Hartshorne Coalbeds represent a valuable coal and gas resource which at present is contributing nothing to coal and gas production. This report discusses potential problems and serves as a reference for future exploration and development work. Recognition of these potential geologically related problems prior to development of this basin will reduce hazards and allow for an economic recovery of these resources. GPO Stock No. 024-004-02118-7. $4.75.

RI 8796. Caustic Extraction of Alumina and Soda From Dawsonite-Bearing Oil Shale, by Gene Asai, J. E. Mauser, R. L. Lincoln, and Jack L. Henry. 1983. 20 pp. 8 figs. The Bureau of Mines investigated the caustic extraction of alumina and soda from retorted dawsonite-bearing oil shale, as part of a program to devise technology for treating alternative domestic sources of alumina for the production

of aluminum metal. Colorado oil shale yielding 13 pct oil (35 gal/ton) and containing 12 wt-pct dawsonite (representing about 4 pct extractable alumina) was retorted to obtain oil-free (spent) shale. Spent shale was leached with dilute NaOH to determine the effect of particle size, retorting temperature, leaching variables, and storage conditions on extraction of alumina and soda and dissolution of impurities. Maximum alumina and soda extractions were obtained by promptly leaching minus 28-mesh spent shale. obtained by retorting raw shale at about 500° C, with 0.5*N* NaOH. Under these conditions, dissolution of impurities such as Ca, Fe, Ti, and P was low. Leaching tests were made on spent shale stored for periods of up to 30 days at 0° to 42° C and at 0 to 100 pct relative humidity. These tests indicated that significant reductions in alumina extraction would occur if spent shale were stored in ambient Colorado air under naturally fluctuating temperature and humidity.

RI 8797. Examination of Effluents Generated From Processing Domestic Laterites, by Laurel A. Powers and R. E. Siemens. 1983. 13 pp. 5 figs. The Bureau of Mines process for recovering Ni and Co from low-grade domestic laterites uses a reduction roast followed by an ammonia, ammonium sulfate leach. This investigation examined the waste streams of the process for their potential environmental impact and focused on the laterite residue produced. The U.S. Environmental Protection Agency's extraction procedure (EP) toxicity tests and column leaching showed that leachable metal concentrations would be low enough so that the residue would not be considered a hazardous waste under present definitions. Under nonacid leaching conditions, about the same amount of metal was extracted from laterites as from their residues, and the leachates were similar to water samples from an undisturbed laterite deposit. Washing tests on the laterite residue showed that ammonia and ammonium sulfate concentrations were reduced according to equilibrium stage calculations, resulting in residues that would be acceptable for revegetation. With water washing only, the residue would not be considered a hazardous waste even though significant amounts of Ni and Co were absorbed from entrained leach solution onto the residue. Washing first with fresh leach solution and then with water prevented this absorption and thus improved the overall metal recovery.

RI 8798. Thermal and Electrical Ignitability of Dust Clouds, by Ronald S. Conti, Kenneth L. Cashdollar, Martin Hertzberg, and Israel Liebman. 1983. 40 pp. 45 figs. The Bureau of Mines conducted a comprehensive laboratory study of the thermal ignitability of various carbonaceous dust clouds with particular emphasis on various ranks of coal dust. The tests were conducted using a new 1.2-L furnace. Autoignition temperatures of dust clouds were obtained as a function of coal volatility and particle size. Dust particles and gas samples were collected by a rapid-sampling system in order to study the reactions involved in preignition and postignition processes. The autoignition temperatures measured in the new 1.2-L furnace were significantly lower and therefore more conservative than those measured previously in the Godbert-Greenwald furnace. The combined effects of thermal and electrical ignition of dust clouds were also studied in the 1.2-L furnace using electrical discharges of varying energies at ambient and elevated temperatures. The minimum spark energy necessary to ignite a dust cloud decreased significantly as the temperature of the dust cloud increased.

RI 8799. Problems in the Control of Anthracite Mine Fires: A Case Study of the Centralia Mine Fire (August 1980), by Robert F. Chaiken, Robert J. Brennan, Bernice S. Heisey, Ann G. Kim, Wilbert T. Malenka, and John T. Schimmel. 1983. 93 pp. 54 figs. The Bureau of Mines has conducted a study of mine fires in the anthracite region of Pennsylvania to determine the most effective approaches to fire control in this area. The problems involved in controlling an anthracite fire include the geological and mining conditions in this area, the propagation characteristics of anthracite, the fire control methods available, the hazards associated with these fires, and the marginal effectiveness of past fire control projects. From this general background, fire control options were discussed as they apply in 1980 to the Centralia mine fire. Probable effectiveness, feasibility, and costs were assessed. The options evaluated include four excavation plans, flooding, hydraulic flushing, water curtain isolation, mining to construct an underground barrier, burnout control, and relocation of the community. The most advantageous from a technical viewpoint is an excavation method combining complete excavation of the fire zone within the borough with trenching to confine the remaining fire. It appears that for many anthracite fires, as for the Centralia mine fire, there are no available control measures that have a moderate cost, are proven effective, and produce minimal disruption on the surface.

RI 8800. Coal-Cutting Forces and Primary Dust Generation Using Radial Gage Cutters, by Wallace W. Roepke and Jon I. Voltz. 1983. 24 pp. 10 figs. The Bureau of Mines determined coal-cutting forces and primary dust generation of four styles of radial gage bits as used on end rings of continuous mining machines. Direct comparisons for reference were made with two widely used conical plumb-bob types having 60° and 90° (nominal) included tip angles. The cutting forces for all of the gage bits were similar to those of the 60°-tip plumb-bob bit. All bits except the RAD-3 gage bit generated similar amounts of primary total dust at shallow cutting, but during deeper cutting, the amounts varied and the gage bits produced as much as 2½ times the dust produced by the 60° bit. This seems atypical since past experience has always shown differences in dust generation at shallow cutting. The specific energy was more like that found previously with other bits, since the values were spread at shallow cutting but became nearly similar at deeper cuts. The 90° bit and the RAD-3 gage bit are not recommended for use except in extremely difficult cutting conditions where dust and forces are of secondary importance. The choice among the remaining four bits can be made on the basis of dust, energy, forces, or cost, as circumstances dictate.

RI 8801. Testing Modified Coal-Cutting Bit Designs for Reduced Energy, Dust, and Incendivity, by Wallace W. Roepke and Bruce D. Hanson. 1983. 31 pp. 15 figs. Four bit designs, two conical and two radial, were tested in coal against a 60° conical reference bit to obtain data on orthogonal cutting forces and primary respirable dust generation. One conical and one radial design were modified by the Bureau of Mines for these tests. Results were mixed: One radial bit used substantially lower overall cutting forces and specific energy than the other bits and

was the only cutter lower on energy and most forces than the standard 60° bit. However, it generated more specific and total dust than any other bit. The four bits were also tested for incendivity, with a 90° plumb-bob bit as the reference. The frictional ignition tests were designated to simulate both trimming top rock and cutting such rock during advance on-sump. Results of these tests were also mixed. The radial bits were substantially less incendive than the reference bit and caused no ignitions in either top trimming or sump modes. Only the modified mushroom-tipped conical bit caused ignitions. Bits similar to this modified design should not be used on drum-type miners in gassy mine areas; instead, the other types of bits tested should be used to reduce ignition potential to a minimum.

RI 8802. Drag Bit Cutting Characteristics Using Sintered Diamond Inserts, by Wallace W. Roepke, Bruce D. Hanson, and Carl E. Longfellow. 1983. 30 pp. 17 figs. The Bureau of Mines tested new designs of drag bit cutters with sintered diamond inserts instead of standard tungsten carbide tips. The bits were tested for orthogonal cutting forces, primary dust generation, and incendivity, with a standard plumb-bob type conical cutter (60° included tip angle) as the reference. Preliminary wear and impact-failure testing were also done. The results were mixed. Two new designs had forces similar to those of the reference bit, but one new design had about twice the normal force. This same design had almost twice the specific energy during shallow cutting but generated an equal or slightly lower amount of primary dust than did the reference bit. Incendivity was eliminated for two radial designs. One conical design had ignition only after more than 15 impacts, but the other conical design was incendive. Impact failure occurred, but not so quickly as anticipated. Over 7,500 impacts on a sandstone face, with a total cutting distance of more than 1,981.2 m, only scuffed the leading edge of the sintered diamond cutting face but put hairline cracks in the substrate mounting pad. Additional design and testing are needed to develop an optimum cutter, but prospects look good for this material.

RI 8803. Dewatering of Talc Slurry, by Gwendolyn D. Hood, Annie G. Smelley, and Bernard J. Scheiner. 1983. 10 pp. 6 figs. The Bureau of Mines investigated techniques for dewatering slurries from talc-processing operations to improve water reclamation and produce dewatered solids suitable for disposal. Various flocculating reagents were evaluated, and a nonionic polyacrylamide was found to be most effective in a specialized flocculation dewatering technique. The flocculation dewatering method was applied in laboratory batch tests and in continuous tests using a static screen, a belt-roller device, and a clarifier-thickener laboratory unit. In continuous tests using the unit, wastes of 3.5 pct solids were dewatered to 56.9 pct solids using 0.03 lb of flocculant per ton of dry solids treated. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the U.S. Department of the Interior and the University of Alabama.

RI 8804. Concrete Crib Design and Field Testing, by T. W. Smelser and L. N. Henton. 1983. 41 pp. 21 figs. This Bureau of Mines report presents a review of underground testing, test results, and design guidelines of steel-fiber-reinforced concrete (SFC) mine support (cribbing) developed at the Spokane Research Center. The objective of the work was to verify, in field applications, the performance, economics, and acceptance by the mining industry of the SFC supports and establish design guidelines for their use underground. Results indicate superior performance, favorable economics, and enthusiastic acceptance by the mining industry.

RI 8805. Alumina Miniplant Operations—Separation of Aluminum Chloride Liquor From Leach Residue Solids by Classification and Thickening, by Roy T. Sorensen, Dwight L. Sawyer, Jr., and Theodore L. Turner. 1983. 23 pp. 19 figs. The Bureau of Mines has investigated the recovery of cell-grade alumina by HCl leaching of calcined kaolin in the alumina miniplant at its Boulder City (NV) Engineering Laboratory. Classification and thickening were used for separating aluminum chloride leach liquor from the siliceous residue generated in the acid leaching step of the clay-HCl process. Coarse solids were classified from fines at 115 mesh and countercurrently washed in three additional spiral classifiers. Fines were treated in a conventional five-thickener, countercurrent decantation circuit. When this method was applied to the solids-liquid separation of slurry from HCl leaching of minus 10-mesh calcined kaolin, 75 pct of the residue reported as classifier sands and 25 pct as thickener underflow. Predicted individual classifier and thickener area requirements were 6 and 25 ft^2/tpd, respectively. Total thickener circuit flocculant requirement was 2.4 lb/ton solids. Aluminum chloride pregnant liquor was produced that analyzed 8.4 pct Al_2O_3, and contained more than 97 pct of the alumina in the liquid phase of the slurry. Bench-scale settling tests were used to correlate fines content of leach residue to thickener area and flocculant requirements.

RI 8806. Recovery of Alumina From Anorthosite by an HCl-F-Gas Sparging Crystallization Process, by J. A. Eisele and D. J. Bauer. 1983. 11 pp. 4 figs. The Bureau of Mines is investigating the recovery of alumina from domestic nonbauxitic resources including anorthosite. The United States has large reserves of anorthosite, but its aluminum content is less than 50 pct soluble in acid, unless a source of fluoride is added to the acid. A flowsheet that includes leaching with HCl and fluoride followed by crystallization of $AlCl_3 \cdot 6H_2O$ from the pregnant liquor by HCl gas injection was designed. Approximately 90 pct of the aluminum values were recovered from the anorthosite when a ratio of 0.14 mole of fluorine per mole of aluminum was used. Sodium chloride is cocrystallized with the $AlCl_3 \cdot 6H_2O$ but is removed by water washing of the Al_2O_3 product. A material balance is given based on results of laboratory studies of the unit operations.

RI 8807. Corrosion Resistance of Ceramic Materials to Hydrochloric Acid, by James P. Bennett. 1983. 14 pp. 4 figs. To identify construction materials for emerging technology in chemical and metallurgical processes, the Bureau of Mines investigated the acid resistance of ceramic materials. Eight commercial ceramic materials comprising two red shale, two fire clay, a silica, a five-clay-bonded silicon carbide, a carbon, and a high-alumina brick were evaluated. Samples were exposed for 110 days to 20 wt pct HCl at 50°, 70°, and 90° C and to 30 wt pct HCl at 70°C. Statistically significant changes in cold crushing strength, volume, and weight were generally small or not detected. The leach rates of Al, Ca, Fe, K, Mg, Na, Si, and Ti ions were moni-

tored. The carbon brick sample had the best acid-resistant properties with a maximum total leached ion weight loss of 0.004 wt pct. The silicon carbide, the silica, and one of the fire clay bricks also had excellent acid-resistant properties. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8808. Use of Foam for Dust Control in Minerals Processing, by Jon C. Volkwein, Andrew B. Cecala, and Edward D. Thimons. 1983. 11 pp. 7 figs. The Bureau of Mines conducted a series of tests to evaluate the effectiveness of mixing a compressed-air-generated foam with dried whole-grain silica sand to suppress dust in minerals processing plants. Dust at downstream transfer points was monitored with personal gravimetric samplers and with Real-Time Aerosol Monitors that were connected to strip chart recorders. Results showed dust reductions of 80 to 90 pct on three separate occasions at two different plants. The mechanism by which foam suppresses dust is discussed, as are the constraints on the use of foam, which may include incompatibility of the foam with the mineral product, difficulty in controlling the foam generator, and cost.

RI 8809. Electrochemical Determination of Thermodynamic Properties of Manganese Sulfate and Cadmium Oxysulfate, by Seth C. Schaefer. 1983. 20 pp. 7 figs. The Bureau of Mines investigated thermodynamic properties of $MnSO_4$ and $2CdO{\cdot}CdSO_4$ to obtain basic thermodynamic data applicable to the treatment of mineral concentrates during roasting and sintering processes. Standard Gibbs energies of formation were determined with high-temperature galvanic cells using stabilized ZrO_2 as the electrolyte.

RI 8810. Magnetic Properties of Synthetic Mischmetal Alloyed With Cobalt, Copper, Iron, and Magnesium, by J. W. Walkiewicz, M. M. Wong, and E. Morrice. 1983. 14 pp. 17 figs. The Bureau of Mines investigated alloys containing lanthanum (La), praseodymium (Pr), neodymium (Nd), cobalt (Co), copper (Cu), iron (Fe), and magnesium (Mg) as possible components of a permanent magnet material utilizing a cerium-free synthetic mischmetal (M) as a substitute for scarce samarium (Sm) metal. Magnets containing M-Co-Cu-Mg and M-Co-Cu-Fe-Mg were fabricated by powder metallurgy techniques and evaluated. A synthetic mischmetal (M20) containing 20 pct La, 60 Pr, and 20 Nd yielded the best overall magnetic properties. The M20-Co-Cu-Mg alloys had energy products as high as 13.2 MGOe, remanences as high as 7.89 kG, normal coercivities as high as 6.26 kOe, and intrinsic coercivities as high as 13.4 kOe. The best value of intrinsic coercivity, 22.9 kOe, was obtained with an M-Co-Cu-Mg magnet in which the synthetic mischmetal contained 30 pct La, 50 Pr, and 20 Nd. These values compare favorably with those of the Sm-Co magnets fabricated and measured at the Bureau's Reno Research Center, which had energy product of 15.1 MGOe, remanence of 7.8 kG, normal coercivity of 7.5 kOe, and intrinsic coercivity of 27.4 kOe. Iron substitution for part of the cobalt resulted in a decrease of magnetic properties, although several percent iron can be added before a drastic loss of magnetic properties occurs.

RI 8811. Experimental Drift Linings in a Block-Caving Operation—A Field Demonstration, by W. C. McLaughlin, L. A. Thomas, and J. L. Harasha. 1983. 32 pp. 32 figs. Under a cooperative agreement, the Bureau of Mines, Magma Copper Co., and ASARCO, Inc., tested backfilled ground support systems at two elevations in Magma's San Manuel, AZ, mine. The tests were mainly for guidance in designing the loading crosscuts of the new ASARCO Sacaton underground mine. Two-piece, wide-flange steel sets for 8- by 8-ft (2.44- by 2.44-m) and 11- by 11-ft (3.36- by 3.36-m) openings were designed. Set spacing was 3 ft (0.91 m) and 5 ft (1.52 m), respectively. After erection, the sets were lagged with various test materials. The void between the lining and the ground was backfilled with sand and pea gravel. Instruments measuring strain (used to determine changes in stress) were placed beneath the sets and in the backfill. Results indicate the backfilled sets in the smaller drift (2315 grizzly level, panels 6 and 7) of 8- by 8-ft (2.44- by 2.44-m) cross section are a viable permanent support system, lower in cost than the standard formed concrete. Results are inconclusive in 2615 grizzly level, panels 5 and 6, where wide-flange steel sets were used with 5-ft (1.52-m) long concrete gob lagging of T-design.

RI 8812. Determining Vapor Density and Gaseous Diffusion Coefficients of Sb_2S_3 Using a Modified Transpiration Apparatus, by B. W. Madsen, A. Adams, and P. A. Romans. 1983. 14 pp. 10 figs. A modified transpiration apparatus was devised by the Bureau of Mines to permit rapid and accurate measure of the vapor transport and vapor diffusion coefficients of antimony sulfide (Sb_2S_3) and other compounds at temperatures to 1,045 K. The apparatus was equipped with dual condensers and valves to switch the flow of vapor in a fraction of a second from one condenser to the other, thus allowing short-interval sampling under equilibrium conditions. Reliability of the technique was established by measuring the vapor pressure of $ZnCl_2$ as a function of temperature and comparing the results with published data. As part of an investigation of the vapor concentrations and species of accessory element sulfides associated with copper and zinc smelting, the apparatus was used to measure the rate of vapor transport and diffusion coefficients of vapor over liquid Sb_2S_3 as a function of temperature between 870 and 1,045 K. The calculated vapor density was combined with published direct measurements of vapor pressure to calculate the average molecular weight of the gaseous species. Average molecular weight of the vapor in equilibrium with Sb_2S_3 ranged from 286 to 112 g/mol over the temperature range studied.

RI 8813. Mineralogy and Liberation Characteristics of Western Mesabi Range Oxidized Taconites, by Rolland L. Blake. 1983. 26 pp. 15 figs. The Bureau of Mines investigated the mineralogy, tonnage, and beneficiating characteristics of oxidized (nonmagnetic) taconite iron resources of the Western Mesabi Range as part of its program to insure adequate future domestic mineral supplies. Magnetic taconite currently provides about 95 pct of Mesabi production, but the large tonnages of oxidized taconite between the magnetic deposits will be needed to help meet future domestic demand for iron ore. Three bulk samples that represent large tonnages from the Western Mesabi Range were selected to determine their mineral composition and liberation by light optical microscopy and to test

their beneficiating response. This report describes the mineralogy and liberation characteristics of the three samples of the Biwabik Iron Formation for 26.5 mi (42.7 km) from Keewatin to Grand Rapids, MN. (Details of response to beneficiation were reported previously.) The samples represent mostly material from the Lower Cherty Member of the Biwabik Iron Formation, although one sample included some Upper Cherty Member. Minerals of all three samples were quartz (chert), hematite, goethite, and minor to trace amounts of magnetite, iron carbonate, and iron silicates. It was concluded that the oxidized taconites of the Western Mesabi Range represent a subeconomic indicated resource that can be selectively mined and beneficiated as a future large source of iron feed for steelmaking.

RI 8814. Factors Affecting the Dissolution of Gypsum-Bonded Roof Bolts, by S. J. Gerdemann and J. S. Hansen. 1983. 12 pp. 19 figs. In support of its objective to improve mine safety, the Bureau of Mines has searched for better materials and systems to anchor roof bolts. This report describes a study on the effects of mine waters upon accelerated gypsum, one of the materials under consideration. The accelerated gypsum dissolved at an appreciable rate relative to an assumed 10-yr life span of a roof bolt. Surface orientation, initial ion concentration of a dissolving solution, and flow rate of the solution had substantial effects on the dissolution rate. Factors such as water-cement ratio, accelerator content, wax capsule additions to the gypsum in cartridge-installed bolts, surface area, temperature, and curing duration had little effect. In an actual roof-bolt environment, dissolution will occur in static solutions to the solubility limit of gypsum (~2 g/L) and cease, resulting in minimal damage; but in flows of unsaturated solution as slow as 1 L per month, a loss of up to 10 pct will occur in 2 yr. Since miners cannot readily measure the flow or ion concentration of static-appearing water at every roof-bolt site, all such water must be assumed to be pure and flowing. It is recommended that gypsum-bonded roof bolts be confined to dry roofs only.

RI 8815. Laboratory Tests for Selecting Wetting Agents for Coal Dust Control, by H. William Zeller. 1983. 21 pp. 12 figs. The Bureau of Mines is conducting research to determine whether the use of chemical surfactants improves respirable coal dust control and is evaluating laboratory test criteria for selecting effective surfactants. This publication presents the results from wetting effectiveness tests with emphasis on the capillary rise test. The test variables investigated included coal particle size, type of surfactant, surfactant concentration, test duration, and mineral content of the water. In addition to the rise test, measurements of contact angle, zeta potential, and sink time for various coal and surfactant combinations were conducted. No significant correlations among the four wetting tests were observed, a surprising result which implies that each test type measures specific aspects of the wetting phenomenon and also that each test type should only be used to select surfactants for specific applications. For example, the rise test shows solution penetration into porous materials, and the sink test discriminates among surfactants for dispersing finely ground materials into suspension. Another important conclusion is that combinations of agents retain their individual wetting properties, allowing mixtures to be formulated to perform well in both rise and sink tests.

RI 8816. Application of Inorganic Ion Exchangers to Metallurgy, by D. E. Shanks, E. G. Noble, A. M. Pierzchala, and D. J. Bauer. 1983. 19 pp. 1 fig. The Bureau of Mines surveyed a variety of inorganic ion-exchange materials to determine their suitability for removing valuable accessory elements and troublesome contaminants from metallurgical process and waste streams. Most of the materials, which included molecular sieves, heteropolyacid salts, and hydrous metal oxides, did not give adequate separations, did not have the necessary stability in strong acids or bases, or were not in a physical form suitable for ion-exchange use. Many of the suitable inorganic materials, especially the hydrous oxides, were capable of cation exchange with high capacity only in basic conditions, which caused hydrolysis of most of the cations tested. Multivalent anions, such as arsenate and phosphate, were easily removed from acidic solutions by hydrous oxides. Hydrous zirconia was the best material for this purpose. Multivalent anions were not easily desorbed because of compound formation; therefore, conventional ion-exchange techniques could not be employed. As an alternative approach, hydrous ferric hydroxide was used as a filter material to remove arsenate and phosphate from acid solutions. One gram of arsenic was removed from solution for each 20 g of ferric hydroxide. Ferric hydroxide is preferable to hydrous zirconia for use as a filter material because of low cost.

RI 8817. An Analysis of 6X19 Classification Wire Hoist Rope, by R. R. Lowery and G. L. Anderson. 1983. 33 pp. 11 figs. An analysis of three 1¼-in-diam manufactured wire ropes of 6x19 classification was done to identify and describe reference conditions of new rope. Reference condition is of value when examining tested or retired ropes. Measurements of strand and rope pitch and of wire and rope diameter confirmed adherence of all ropes to those construction specifications. Mechanical properties of strength and ductility were determined by accepted methods for the ropes and wires from the ropes. Individual wires from one rope failed to meet minimum wire ductility values. Wire chemical composition varied in average carbon levels, from 0.70 to 0.78 wt pct, and in manganese content, from 0.45 to 0.80 wt pct. One manufacturer's product contained 1 to 3 wt pct Ni and Cr. Heavily wrought pearlitic steel microstructures were porous and contained inclusions. Cold work variations were evidenced by wrought grain width. Recorded anomalies reflected the condition of the manufactured products. The report provides data that compare the three wire ropes studied, but cannot verify the effects that these conditions or anomalies have on rope service life.

RI 8818. Surface Evaluation of the 4M Miniminer System, by August J. Kwitowski. 1983. 71 pp. 63 figs. This report presents the results of a joint Bureau of Mines-U.S. Department of Energy project that evaluated a newly developed low-coal mining system: the 4M miniminer system. The evaluation took place from April through October 1981 and determined potential health, safety, and productivity factors for the mining system using the surface test facilities at Bruceton, PA. The planning, testing, results of testing, and a summary evaluation of the 4M miniminer system are included in the report. The miniminer system was found to be a very good concept with future potential for safe, healthful, and economic production in thin-seam mining. The mining system was also judged to have considerable potential for use in some coal seams that are

presently considered unminable by other existing mining equipment. The preproduction, prototype version of the miniminer system that was tested suffered from several safety and production problems. These problems are also described, along with suggested remedies.

RI 8819. Flocculation of Sulfide Mineral Fines by Insoluble Cross-Linked Starch Xanthate, by S. C. Termes, R. L. Wilfong, and P. E. Richardson. 1983. 23 pp. 26 figs. The Bureau of Mines conducted research on the flocculation of various minerals with insoluble cross-linked starch xanthate (ISX) to determine its potential as a beneficiation technique for low-grade, highly disseminated ores and for selective desliming. Covellite, chalcocite, pyrite, pyrrhotite, chalcopyrite, bornite, sphalerite, galena, and molybdenite fines flocculate with ISX. Floc formation, floc size, and settling rate are dependent on pH, with the pH dependence differing for each mineral. Quartz is not flocculated by ISX. Experiments to obtain selective flocculation of sulfides from quartz were attempted. Good selectivity was only obtained for the bornite-quartz system. Postflocculation separations resulted in flocculated bornite in grades as high as 92 pct. Evidence is presented that the flocculation of many of the sulfide minerals with ISX may involve covalent bonding of the xanthate group to lattice metal site(s).

RI 8820. Cutting Parameters Affecting the Ignition Potential of Conical Bits, by Bruce D. Hanson. 1983. 14 pp. 4 figs. The Bureau of Mines conducted a series of ignition tests with two types of conical bits (plumb bob and pencil) used on continuous mining machines, to determine their ignition potential at various bit speeds, cut depths, and wear conditions. The tests were conducted using single bits mounted on a 34-in-diam drum in a Bureau ignition test facility. The bits impacted blocks of Berea sandstone in a 6.5 pct methane atmosphere at various bit speeds and cut depths. In a new condition, the plumb-bob bits were considerably more incendive than the pencil bits, causing ignitions in 32 of 35 tests at 60 rpm, compared with ignitions in 2 of 22 tests for the pencil bits. The results from new bit testing also show that reduction of bit tip velocity to 180 fpm does not eliminate ignition potential. When subjected to progressive wear, bits of both types were more incendive when they were locked in place, unable to rotate, than when they were free to rotate.

RI 8821. Shaft Furnace Reduction–Oxidation Roasting of Pelletized Alunite Dust, by J. M. Riley, V. E. Edlund, and W. I. Nissen. 1983. 21 pp. 8 figs. The Bureau of Mines investigated a promising new technology for recovering Al_2O_3 from alunite to support the Bureau's alumina miniplant project. Results are presented for a study of the technical feasibility of treating alunite crushing and grinding reject fines for recovery of Al_2O_3. Alunite pellets having sufficient strength and resistance to degradation were produced by combining fines and coarse alunite with a KOH binder. The best pellets were prepared, in a laboratory pelletizer, by adding 1 pct KOH as a 5-pct solution to a mixture of 40 pct alunite dust (98 pct minus 65 mesh) and 60 pct coarse alunite (minus 20 plus 65 mesh). Calcines suitable for K_2SO_4 and Al_2O_3 recovery were produced by reducing dehydrated alunite pellets with sulfur in a laboratory shaft furnace for 4 h at 600° C, followed by air oxidation of the reduced calcine for 1 h at 600° C. This report presents design calculations, schematic diagrams, and discussions of the essential features of a proposed process research unit—a continuous, 6-lb/h alunite shaft furnace—for studying the process.

RI 8822. Vanadium–Uranium Extraction From Wyoming Vanadiferous Silicates, by M. Hayashi, I. L. Nichols, and J. L. Huiatt. 1983. 9 pp. 2 figs. The Bureau of Mines conducted laboratory studies on low-grade vanadiferous silicates from the Pumpkin Buttes and Nine Mile Lake deposits of Wyoming to examine techniques for extracting vanadium and uranium. Recovery from low-grade sources such as these could contribute to future vanadium production and reduce reliance on vanadium imports. The Pumpkin Buttes samples contained 0.03 to 0.04 pct V_2O_5 and 0.06 to 0.12 pct U_3O_8; the Nine Mile Lake samples contained 0.02 to 1.0 pct V_2O_5 and 0.06 to 0.19 pct U_3O_8. Leaching the Pumpkin Buttes samples for 18 h at 80° C with addition of 200 lb/ton H_2SO_4 resulted in recovery of 80 pct of the vanadium contained in the samples. The Nine Mile Lake samples were readily leached, yielding 78 to 94 pct of the vanadium after 3 h at 80° C with addition of 100 lb/ton H_2SO_4. A solvent extraction procedure was used to selectively recover uranium from Pumpkin Buttes and Nine Mile Lake leach solutions and to recover vanadium from the raffinates. In batch shakeout tests, Alamine 336 recovered over 95 pct of the uranium from leach solution adjusted to pH 1. Di-2-ethylhexyl phosphoric acid and Cyanex 272 recovered vanadium from the uranium raffinate after reduction and adjustment to pH 2; vanadium extractions of up to 96 pct and 92 pct, respectively, were achieved.

RI 8823. Resistance of Selected Refractories to Mineral Waste Melts, by Timothy A. Clancy. 1983. 13 pp. 11 figs. In support of research on forming ceramics from mining and processing wastes, the Bureau of Mines tested various commercial refractories to evaluate their resistance to melts of these wastes. Sixteen refractories of various types were exposed in slag erosion tests to two siliceous waste melts with SiO_2/CaO ratios of 4.0 and 2.2. The extent and nature of slag attack were then determined for each refractory. The nature of slag attack was investigated through scanning electron micrographs and microprobe elemental distributions. The refractories that performed best in resisting attack by the melts were high-alumina types, and of the refractories tested, the most resistant was a 90-pct-Al_2O_3, 10-pct-Cr_2O_3 refractory. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8824. Dewatering of Coal–Clay Waste Slurries From Preparation Plants, by P. M. Brown and B. J. Scheiner. 1983. 8 pp. 3 figs. The Bureau of Mines is investigating a dewatering technique for coal-clay waste that uses a flocculant, polyethylene oxide (PEO). This flocculant forms strong stable flocs that can be dewatered on a static screen. A field test unit (FTU) using this technique was operated at approximately 400 gal/min, using a waste stream from the flotation circuit of a coal preparation plant. Consolidated coal-clay material containing 55 to 60 pct solids was produced when the flotation circuit slurries of 2.7 to 8 pct solids were treated with 0.1 to 0.3 lb PEO per ton of solids. The FTU was also operated at 64.5 and 87.5 gal/min using a portion of the underflow slurry

from the preparation plant's thickener. Consolidated coal-clay material containing 55 to 60 pct solids was produced when the thickener underflow slurries of 19 to 24 pct solids were treated with 0.08 to 0.2 lb PEO per ton of solids. PEO-treated materials continued to dewater when placed in a pit. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8825. Slurry Transport Properties of Graded Coal Waste, by R. W. McKibbin, R. R. Backer, and R. A. Busch. 1983. 26 pp. 16 figs. The Bureau of Mines conducted laboratory tests to determine the slurry transport and deposition properties of coal waste. A 188.5-ft pipe test loop was constructed with instruments to measure density, flow, and power and discharge, suction, and differential pressures. A 20-ton sample of Western coal waste was crushed and screened to 100 pct minus ½ in. Eight loop tests using this graded waste were run at slurry densities ranging from 1.15 (25 wt-pct solids) to 1.46 (60 wt-pct solids). The resultant friction-pressure gradients ranged from 0.06 to 0.24 ft of water per foot of 4-in standard steel pipe. Particle-size degradation was significant. In a typical loop test lasting 25 min, the minus 200-mesh fraction increased from 19 pct to 34 pct. Deposition tests showed that without the use of a flocculant, the slurries would not dewater when left to stand for 1 week. With flocculant, additional water was released; however, the settled slurries remained thixotropic. Further testing is necessary to determine their suitability for use as backfill material in active mines.

RI 8826. Neodecanoic Acid as a Co^{3+} Solvent Extractant, by L. R. Penner, Davis E. Traut, and Jack L. Henry. 1983. 10 pp. 3 figs. The Bureau of Mines conducted solvent extraction batch tests to evaluate the usefulness of neodecanoic acid (NDA) for extracting Co^{3+} from ammoniacal leach liquors high in ammonium sulfate. This work is an outgrowth of previous Bureau research in which technology was devised for the recovery of cobalt, nickel, and byproduct copper from domestic laterites. The previously devised technology uses an oxidative ammoniacal sulfate leach to treat the laterite, and nickel and copper are then recovered from the leach solution by solvent extraction and electrowinning. This report deals with the subsequent solvent extraction of cobalt from the nickel-copper raffinate solution. The results showed that about 70 pct of the contained Co^{3+} can be extracted batchwise at pH 8 using NDA (a 10-carbon-chain highly branched carboxylic acid). However, NDA had a solubility of approximately 0.6 to 0.8 g/L in aqueous raffinate following extraction, and this high solubility makes it impractical for use with alkaline solutions that are low in cobalt. In addition, the extracted cobalt species (predominantly cobaltic hexammine), is not amenable to the electrolytic recovery of cobalt metal because of its extreme stability. This fundamental problem, common to all extractants of the cobaltic ammines, is discussed, and an alternative for recovering cobalt metal from loaded solvent by a hydrogen-reduction method is also discussed.

RI 8827. Percolation Leaching of a Chalcopyrite-Bearing Ore at Ambient and Elevated Temperatures With Bacteria, by B. W. Madsen and R. D. Groves. 1983. 14 pp. 11 figs. The Bureau of Mines conducted a large-scale (6.4 t), long-term (2,165 days) test to gain a better understanding of the leaching characteristics of chalcopyritic ores. An ore sample containing 0.77 pct Cu was leached in a fiberglass column by downward percolation of acidified ferric sulfate solutions. Three sets of leaching conditions were investigated: (1) ambient temperature leaching, (2) elevated temperature (50° to 60° C) leaching, and (3) elevated temperature leaching after inoculation with thermophilic bacteria. Leaching at ambient temperature resulted in a copper extraction rate of 0.44 pct per 100 days. Increasing the temperature to 50° to 60° C resulted in decreased activity of natural mesophilic bacteria, and the leaching rate decreased to 0.22 pct per 100 days. The pH was lowered from 2.0 to 1.6, and nutrient solutions that contained thermophilic bacteria were added. This procedure resulted in an increase in the ferric-to-ferrous iron ratio and an increase in the copper leaching rate. However, the increased leaching rate was not sustained, and 120 days after inoculation, the bacterial activity declined, the ferrous iron content increased, and the copper leaching rate decreased.

RI 8828. Vertical Magnetic Noise in the Voice Frequency Band Within and Above Coal Mines, by John Durkin. 1983. 27 pp. 14 figs. Information on vertical magnetic noise in the voice frequency band, both within and above coal mines, is needed for the evaluation of through-the-earth baseband electromagnetic communications at mines where horizontal loop antennas are used. This report discusses the theory of the source of electromagnetic noise, the propagation of this noise to an observation point above a mine, and its interaction with the local earth conductivity structure, which gives rise to vertical magnetic noise. The relationship of surface noise to underground noise is also discussed. Bureau of Mines investigators made surface and underground vertical magnetic noise measurements at a number of coal mines located throughout the United States. These data were modeled through regression analysis to characterize expected noise levels. The results are presented, including results in one-third octaves for use in evaluating the expected performance of through-the-earth communication systems by articulation-index studies.

RI 8829. Structure and Porosity of Electrodeposited Platinum: Evaluation of Four Plating Methods, by M. J. Lynch, R. P. Walters, and D. R. Flinn. 1983. 18 pp. 7 figs. The Bureau of Mines evaluated the feasibility of substituting platinum-coated metals for bulk platinum shapes as a means for conserving platinum. Platinum coatings were prepared using four different methods of electrodeposition, then tested and evaluated. In order for platinum coatings to be useful in process environments, they must be thick, adherent, stress-free, and pore-free. The Bureau evaluated direct-current, current reversal, cathode shielding, and pulsed-current plating techniques for producing a pore-free platinum electrodeposit from a molten cyanide bath. Aqueous corrosion tests of Fe-10Cr substrates coated with approximately 25 μm of platinum showed that pulse plating yielded the most corrosion-resistant and, hence, the most pore-free coatings. The morphology of coating cross sections was in all cases columnar. The average grain size of pulse-plated deposits was independent of thickness, while all other plating techniques produced grains that increased in size as the coatings became thicker. It is believed that the constant grain size in the pulse-plated deposits resulted from better mass transport during the electrodeposition.

RI 8830. Alumina Miniplant Operations—Evaporative Crystallization of Aluminum Nitrate Nonahydrate From Aluminum Nitrate Solutions, by T. L. Turner and Daniel T. Rogers. 1983. 29 pp. 8 figs. As part of a program to investigate technology for the extraction of alumina from abundant domestic ores, the Bureau of Mines studied HNO_3 leaching of calcined Georgia kaolinitic clay. In this investigation, iron impurities were removed from the aluminum nitrate pregnant leach liquor by solvent extraction, and the purified liquor was evaporated to prepare a suitably concentrated crystallizer feed liquor. Aluminum nitrate nonahydrate was crystallized from the liquor to separate the aluminum from undesirable trace elements and excess water. Continuous crystallization at 40° C in a pilot plant vacuum evaporative unit was performed for 5 days to observe the effects of impurity buildup under minimum bleed-stream conditions. Liquor feed rate was 26 lb/h and $Al(NO_3)_3 \cdot 9H_2O$ (ANN) crystal production rate was 17 lb/h. Fe_2O_3 and Cr_2O_3 were not effectively separated from the crystals, and P_2O_5, MgO, and K_2O impurities must be removed by recrystallization. Other impurities did not excessively contaminate the crystals. Washing the crystals with water or aqueous HNO_3 gave an equivalent increase in crystal purity levels by displacing mother liquor. Theoretical equations, applicable to any continuous evaporative crystallization of ANN, were developed to produce material balances for engineering applications.

RI 8831. Alumina Miniplant Operations—Separation of Aluminum Chloride Liquor From Leach Residue by Horizontal Belt Filtration, by Roy T. Sorensen and Dwight L. Sawyer, Jr. 1984. 44 pp. 29 figs. The Bureau of Mines has investigated the recovery of alumina by hydrochloric acid leaching of calcined kaolinitic clay. Bench-scale studies indicated that horizontal belt filtration was a practical method for separating the siliceous residue from aluminum chloride liquor generated in the leaching step. Miniplant-scale continuous testing was performed to evaluate the filter circuits and to compare filtration response of different calcined kaolin feed materials and of different agitator-baffle designs in the leaching reactors. Soluble alumina recovery with a single filter ranged from 94 pct with minus 10-mesh feed to more than 96 pct with minus 35-mesh or misted feed. Process advantages were confirmed for the calcined misted kaolin feed material prepared by a Bureau-developed misting process. With two filters in series, an overall filtration rate of 100 lb solids/$hr \cdot ft^2$ of filter area was attained with a soluble alumina recovery of more than 99 pct. More than 99.5 pct alumina recovery was obtained with a thickener and a two-filter circuit for either the minus 35-mesh or the misted feed. Modifications in leaching reactor design made to decrease particle-to-particle attrition were successful and significantly increased filtration rates and decreased flocculant requirements.

RI 8832. Lime-Gypsum Processing of McDermitt Clay for Lithium Recovery, by V. E. Edlund. 1983. 15 pp. 5 figs. As part of its efforts to devise new and improved methods for recovering lithium from unconventional resources, the Bureau of Mines investigated a lime-gypsum-roast, water-leach technique for processing lithium-enriched (0.01–0.68 pct Li) clays. This report presents the results of a study of the technical feasibility of extracting lithium from raw material representative of clay beds associated with the McDermitt Caldera complex in Nevada and Oregon. Pellets suitable for bench-scale roasting studies were prepared from mixtures of minus 200-mesh clay, limestone, and gypsum, with water used as the pelletizing agent. Roasting pelletized charges at 900° to 1,000° C temperatures for 1- to 4-h periods produced calcines that leached readily, yielding water-soluble lithium sulfate (Li_2SO_4). A 5-3-3 (weight ratio) mix of clay, limestone, and gypsum produced calcines with the best leaching characteristics. More than 91 pct of the contained lithium was extracted from pelletized mix batches roasted in covered refractory boats. Lithium recovery decreased to about 87 pct when the mix was roasted under dynamic conditions in a gas-fired rotary furnace. A reaction mechanism was postulated which indicated that dilution and loss of SO_3 and oxygen in the combustion exhaust adversely affected the leachability of the dynamically roasted calcine.

RI 8833. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum, by G. B. Atkinson. 1983. 11 pp. 10 figs. The Bureau of Mines investigated a method for increasing the leaching rate of bulk superalloy scrap to facilitate recycling and recovery of critical metals such as Ni, Co, and Cr. Three superalloys were investigated, the cast-nickel-base superalloy IN-738, the wrought-nickel-base superalloy Rene-41, and the cast-cobalt-base superalloy Mar-M-509. Superalloys melted with 20, 30, 40, and 50 pct Al metal to form intermetallic compounds were easily crushed to a convenient particle size and reacted rapidly with acid solutions which dissolved the metals. For example, leaching ½-in pieces of unalloyed IN-738 with excess 6*N* HCl at 95° C for 2 h dissolved about 0.5 pct, while leaching 10 g of minus 20-mesh 30 pct Al-70 pct IN-738 with excess 6*N* HCl at 95° C for 2 h dissolved 96.2 pct.

RI 8834. Leaching Aluminum From Calcined Kaolinitic Clay With Nitric Acid, by Richard S. Olsen, William G. Gruzensky, Sophie J. Bullard, R. P. Beyer, and Jack L. Henry. 1983. 14 pp. 3 figs. Prior work by the Bureau of Mines demonstrated a feed preparation method that eliminates the formation of slime during leaching of calcined kaolinitic clay and makes leached residues fast settling and easy to filter. Nitric acid leaching rates determined for calcined kaolinitic clay prepared by this method were found to correspond to a zero-order reaction model for both batch and continuous, stirred-tank leaching. A rate constant of 0.0136 min^{-1} was determined. Separation of solid residues from the reacted slurry was examined, and filtration rates were determined. Permeabilities of the flocculated, leached residues were around 51 darcys, or 5.0×10^{-7} cm^2 for laminar flow through 4-ft-deep beds. (*Out of print.*)

RI 8835. Characterization of Lateritic Nickel Ores by Electron-Optical and X-Ray Techniques, by D. Chandra, C. O. Ruud, and R. E. Siemens. 1983. 12 pp. 4 figs. The mineralogical constitution of a lateritic ore dictates the type of metallurgical process that can be used to extract valuable metals such as nickel and cobalt. To provide needed mineralogical information on the interrelationships of the metals contained in domestic laterites, the Bureau of Mines awarded a grant to Denver Research Institute to study the transition-type, low-grade laterites found in northern California and southern Oregon. For comparison, limonitic-type laterites from New Caledonia and the Philippines were also studied. X-ray diffraction, electron microscopy, electron beam analysis, and conventional petrography were used to determine the mineralogical associations of nickel and cobalt in the laterites. Results showed that for

both laterite types studied most of the nickel and minor amounts of cobalt are associated with the mineral geothite (FeO(OH)). Most of the cobalt and minor amounts of nickel are associated with a mixed manganese oxide (wad) mineral.

RI 8836. Removal of Cyanide and Metals From Mineral Processing Waste Waters, by Joseph E. Schiller. 1983. 8 pp. The Bureau of Mines is investigating methods to treat waste water that contains cyanide. This report describes a new method that removes heavy metals and all forms of cyanide. In the first step, hydrogen peroxide and sodium thiosulfate are added at pH 7 to 9 in a 1:2 molar ratio to convert free and weakly complexed cyanide to nontoxic thiocyanate. Then steryldimethylbenzylammonium chloride is added to precipitate ferrocyanide, and finally, ferric sulfate is added as a sweep floc and sequestrant for heavy metals. After the suspended solids settle, the water is polished by filtering. The water initially contained 1 to 5 mg/L Fe, 1 to 5 mg/L Cu, and 10 to 30 mg/L total cyanide; the level of each of these constituents was reduced to less than 0.02 mg/L.

RI 8837. Stratification in Water Quality in Inundated Anthracite Mines, Eastern Pennsylvania, by K. J. Ladwig, P. M. Erickson, R. L. P. Kleinmann, and E. T. Posluszny. 1984. 35 pp. 19 figs. The Bureau of Mines conducted a field investigation of the water quality in inundated underground coal mines in the Northern Anthracite Field, eastern Pennsylvania. Water samples were collected at multiple depths from nine abandoned mine shafts in the Wyoming Basin, ranging from 68 to 650 m (223 to 2,132 ft) in depth and intersecting as many as seven mined seams in a single shaft. The shafts were also monitored for fluid resistivity, fluid temperature, Eh, and pH using downhole instrumentation. The monitoring program showed that the formerly highly acidic mine water is now slightly alkaline. Sulfate concentrations decreased as much as 74 pct in the flooded workings and 54 pct at a mine water discharge from values reported in 1964 and 1968, respectively. These data are consistent with the inhibition of pyrite oxidation and gradual flushing of oxidation products in flooded mine environments. The monitoring program also revealed significant vertical stratification in water quality in five of the nine shafts, each characterized by two easily recognizable zones. The transitions between zones were sharp, marked by rapid changes in Eh, pH, and ionic composition, the upper zones being less contaminated than the lower zones. The development of stratification appears to be a function of shallow localized flow conditions, arising primarily from the relative positions of mine openings and structural features of the coalbeds.

RI 8838. Water Infusion—An Effective and Economical Longwall Dust Control, by Joseph Cervik, Albert Sainato, and Eugene Baker. 1983. 14 pp. 9 figs. In Europe, water infusion is used widely to reduce generation of respirable dust during mining. Its use in the United States is limited to a few plow operations in the Pocahontas No. 3 Coalbed. This Bureau of Mines report describes the technology for infusing water into a longwall panel and reports the results of a recent demonstration in the Lower Sunnyside Coalbed that achieved dust reductions averaging 58 pct. Because water infusion increases moisture content of the coalbed, face air velocities in excess of 500 ft/min (2.5 m/s) are possible, further diluting dust levels before dust entrainment occurs. An economic analysis shows a 23-pct reduction in operating costs when coal production is increased by changing from unidirectional mining to bidirectional mining with water infusion.

RI 8839. Laboratory Testing of Compressed-Oxygen Self-Rescuers for Ruggedness and Reliability, by Nicholas Kyriazi, John Kovac, Wayne Duerr, and John Shubilla. 1983. 17 pp. 13 figs. The Bureau of Mines subjected three commercial compressed-oxygen self-contained self-rescuers to a series of laboratory treatments designed to simulate various environmental conditions in underground coal mines. The environmental treatments consisted of extremes of temperature and of shock and vibration. The tests were designed to predict the ability of the self-rescuers to withstand those environmental stresses without causing a decrease in wearer protection. A critical concern was internal damage to an apparatus that would cause it to malfunction or seriously degrade its performance without any obvious external signs. The Bureau has previously tested chemical oxygen self-contained self-rescuers in a similar research program. Although the three compressed-oxygen units are not as sturdy as the chemical oxygen self-rescuers tested previously, they performed reliability after treatments on treadmill tests with human subjects and on machine tests using a breathing and metabolic simulator. Serious damage was caused by both the heat treatment of 71° C (venting of the O_2 bottle in most cases), and in the shock treatment (breaking open of the case and dislodging of the components). When physical damage is obvious, a complete refurbishing of the damaged self-rescuer is recommended.

RI 8840. Solid-Liquid Separations in Processing Domestic Laterites, by Gary L. Hundley and R. E. Siemens. 1984. 30 pp. 13 figs. The Bureau of Mines has devised and domenstrated a process for recovering Ni and Co from low-grade domestic laterites. The process consists of four major steps: (1) reduction roast, (2) ammoniacal leach, (3) solvent extraction, and (4) electrowinning. Several solid-liquid separation steps are required that affect the economics of the overall process. In this study, two techniques for solid-liquid separation, centrifugation and thickening, were investigated. This report presents the results of (1) laboratory and pilot plant studies to determine parameters for sizing centrifuges and thickeners and (2) an economic study of the two techniques, based on the requirements of a commercial-size (5,000-tpd) laterite processing plant. Sizing and other equipment-related recommendations, based on data from the Bureau's studies, were obtained from commercial manufacturers. The costs of thickening and centrifugation, including all the unit operations affected, were determined by the Bureau's process evaluation group. The total operating costs for separation using the two techniques (including depreciation on the capital cost of equipment) were found to be quite close: $17.26 per ton of laterite for centrifugation and $18.15 per ton of laterite for thickening. For centrifugal separation, the greatest cost was found to be the initial capital cost for the separation equipment; using thickeners, the greatest cost was for reagent recovery.

RI 8841. Control of Longwall Gob Gas With Cross-Measure Boreholes (Upper Kittanning Coalbed), by A. A. Campoli, J. Cervik, and S. J. Schatzel. 1983. 17 pp. 20 figs. The cross-measure borehole technique is being studied by the Bureau of Mines as an alterna-

tive to the use of surface gob boreholes as a means of controlling methane in gobs during longwall mining. Small-diameter holes are drilled from underground locations into strata overlying the mined coalbed. When the roof strata are fractured by the mining operation, a partial vacuum applied to the boreholes draws the methane out of the fractured strata and prevents it from entering the mine ventilation system. Tests in the Upper Kittanning Coalbed showed that 50 pct of the methane produced by the longwall mining operation was captured by the cross-measure boreholes. Borehole inclination and penetration into the gob are two important borehole parameters that affect the performance of the cross-measure borehole system.

RI 8842. Economic Evaluation of Directional Drilling for Methane Drainage From Coalbeds, by E. C. Baker, D. C. Oyler, John H. Perry, and G. L. Finfinger. 1984. 11 pp. 2 figs. The Bureau of Mines estimated the economic feasibility of investing in a directional hole methane drainage project in the Pittsburgh Coalbed for 5 yr in advance of mining. This report estimates the capital investment and operating cost of recovering 325 MMft³ of methane gas per year and the selling price of approximately 317 MMft³ of gas per year. The labor, equipment, and supply requirements were determined from those of a previous directional hole drilled at the Emerald Mine, near Waynesburg, PA. The cost of equipment, materials, services, and labor are in third quarter 1982 dollars. They were obtained from vendors, contractors, and the U.S. Department of Labor. Findings indicate a total capital investment of $1,381,160. Annual operating cost amounted to $167,690. At a wellhead price of $2.05 per thousand cubic feet, the sale of approximately 317 MMft³ of gas per year results in a rate of return on investment of approximately 25 pct.

RI 8843. Use of a Sodium Silicate Gel Grout for Plugging Horizontal Methane-Drainage Holes, by David C. Oyler. 1984. 20 pp. 19 figs. Methane-drainage holes must be completely filled by grout before mining to prevent the emission of large quantities of gas during mine-through, which would constitute an explosion hazard. In November 1980, seven horizontal holes at the multipurpose borehole, a small-diameter shaft drilled as a Bureau of Mines coalbed methane-drainage installation on the property of the Federal No. 2 Mine, Monongalia County, WV, were plugged using a sodium silicate gel grout. This report describes the grout mix and the use of the grout at the multipurpose borehole, and discusses the results observed upon mine-through of the holes in early 1981. Cost data for the sodium silicate grout are also presented.

RI 8844. A Short-Range Locator System for Detecting Trapped Miners, by William E. Webb, R. H. Church, Walter E. Pittman, Jr., and James R. Boyle, Jr. 1984. 22 pp. 21 figs. As part of the Bureau of Mines health and safety research program, a short-range locator system, capable of locating miners who have become trapped following a mine accident, has been devised. The system consists of a lightweight, low-power radio transmitter incorporated into a miner's cap lamp battery and a directional receiver carried by rescuers. Prototype transmitters have been constructed, and the propagation of their signals has been investigated. The detectability of the signal in underground coal mines has also been investigated. This research indicates that a short-range location system would serve as an economical and practical means of locating miners from within the mine following an accident. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8845. High-Temperature Properties of Alumina Refractory Brick Impregnated With Oxide and Salt Solutions, by Arthur V. Petty, Jr. 1984. 18 pp. 9 figs. The Bureau of Mines has investigated the effect of refractory oxide additions, introduced in soluble form, on the refractory properties of 42-, 58-, and 70-pct-Al_2O_3 brick. Brick having porosities ranging from 12 to 16 pct were impregnated with solutions containing chrome, chrome-iron, zirconium, calcium, magnesium, cobalt, nickel, tin, and manganese ions. Additions of some of these ions provided dramatic improvements to such properties as hot modulus of rupture, hot load, and particularly slag resistance. These improvements can be related to reduction of porosity, amorphous grain boundary phases, formation of more refractory bond phases, and reduction of the wettability of Al_2O_3-containing refractories by metallurgical slags. Fifty-eight-percent-Al_2O_3 brick, impregnated with chrome, showed hot modulus of rupture, hot load, and slag resistance two to five times better than those of untreated 70-pct-Al_2O_3 brick. This could result in reducing the Nation's dependence on imported refractory-grade bauxite generally required for high-Al_2O_3 brick, as domestic alumina resources could be used to produce the improved refractories. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8846. Evaluation of Methods for Recovering Potash From Carnallite Ore, by D. G. Foot, Jr., and J. L. Huiatt. 1984. 19 pp. 10 figs. The Bureau of Mines investigated two methods for recovering potash from carnallite ore in continuous 100-lb/h flotation units. In the insoluble-slimes flotation procedure, insoluble slimes were removed by flotation prior to potash flotation. In the direct flotation method, insoluble slimes were depressed and the potash floated directly without prior removal of the insoluble slimes. Seventy-three percent of the potash in the ore was recovered in a leached final KCl product containing 59.1 pct K_2O using the insoluble-slimes flotation method. The direct flotation method recovered 74.5 pct of the potash in a final product containing 60.2 pct K_2O. The rate of return on the investment was calculated at 13 pct for the insoluble-slimes flotation method and 15 pct for the direct flotation method, based on a Bureau economic evaluation.

RI 8847. Control of Acid Drainage From Coal Refuse Using Anionic Surfactants, by Robert L. P. Kleinmann and Patricia M. Erickson. 1983. 16 pp. 8 figs. To control the formation of acid drainage at its source, the Bureau of Mines has investigated the role of iron-oxidizing bacteria in the oxidation of pyrite. In laboratory tests, it was determined that *Thiobacillus ferrooxidans* could be controlled in coal refuse using anionic surfactants, with an associated decrease in acid production of about 75 pct. Based on these results, large-scale tests were conducted at an 8-acre active coal refuse area in northern West Virginia and an 11-acre inactive refuse pile in southern West Virginia. Acid production was decreased 60 to 95 pct for 4 to 5 months

after application of 55 gal/acre of 30-pct sodium lauryl sulfate solution. To date, effluent surfactant concentrations have been extremely low. Either a hydroseeder or a road-watering truck can be used to apply the surfactant. Since the surfactant solution must reach the pyritic material to be effective, sites that have been reclaimed are generally not amenable to these procedures. A simple laboratory test is described that provides an estimate of adsorption potential; this can be used to calculate a safe application rate.

RI 8848. Magnesia Refractories Produced From Chemically Modified Periclase Grains and $Mg(OH)_2$ Slurries, by James P. Bennett and Timothy A. Clancy. 1984. 14 pp. 4 figs. Based on previous Bureau of Mines research indicating that improved high-temperature properties could be achieved for periclase refractories through chemical additions, the Bureau investigated the properties of full-size bricks produced from chemically modified periclase refractory grains and the suitability of making such chemical additions to $Mg(OH)_2$ slurries prior to production of the periclase grains. In full-size brick testing, strength values, both hot and cold, for the optimized bricks were superior to those for a commercial 98-wt-pct-MgO refractory. The best results were obtained for a natural magnesite with an adjusted $CaO:SiO_2$ (C:S) ratio of 3.0 and a 1.0-wt-pct addition of ZrO_2 and for a seawater periclase with an adjusted C:S ratio of 2.5 and a 0.5-wt-pct addition of MnO_2. For samples produced from chemically modified $Mg(OH)_2$ slurries, additions of both MnO_2 and ZrO_2 and an increase in C:S ratios produced significant increases in hot flexural strength, similar to those resulting from chemical additions made to periclase grains. The most effective modifications were additions of MnO_2 to brine-derived periclases having a C:S ratio adjusted to 3.0. These results on chemically modified magnesia refractories indicate that such material could potentially substitute for magnesia-chrome refractories containing imported chromite. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8849. Purification of Zirconyl Sulfate by Solvent Extraction, by D. J. MacDonald, H. G. Henry, and D. J. Bauer. 1984. 29 pp. 19 figs. The Bureau of Mines has conducted bench-scale investigations leading to the design of an integrated process for producing reactor-grade zirconium oxide (ZrO_2) from zircon sand, which avoids the air pollution, water pollution, fire hazard, and odor problems associated with the hexone-thiocyanate process. The integrated process consists of three steps: production of crude zirconyl sulfate solution, solvent extraction, and production of ZrO_2 from strip liquor. This report describes the solvent extraction step. Multistage, countercurrent liquid-liquid extraction with a tertiary amine in kerosine was used to separate zirconium from a dilute H_2CO_4 solution containing hafnium and other impurities. Process steps described include extraction from an aqueous feed solution to form a hafnium-contaminated, zirconium-bearing organic-phase solution, scrubbing to separate zirconium from coextracted hafnium, stripping to transfer hafnium-free zirconium into an aqueous strip liquor, chloride-loading to produce a chloride-bearing organic solution, scrubbing with the chloride-loaded organic solution to remove traces of uranium impurity from the zirconium-bearing strip liquor, and regeneration to prepare the organic solution for reuse. These steps were performed simultaneously in steady-state, bench-scale experiments. Zirconium recovery of up to 93 pct was achieved. Results of an economic evaluation are included.

RI 8850. Investigation of Methods for Producing Reactor-Grade Zirconium Oxide From a Zirconium-Bearing Chloride-Sulfate Strip Liquor Solution, by D. J. MacDonald, C. E. Defilippi, and H. G. Henry. 1984. 9 pp. 5 figs. The Bureau of Mines investigated two alternative methods for treating a zirconium-bearing chloride-sulfate strip liquor to obtain reactor-grade ZrO_2. One method involves neutralization with NH_3 and the other hydrothermal precipitation. The strip liquor was derived from zircon sand by a Bureau of Mines method for separating zirconium and hafnium via solvent extraction with a tertiary amine. Neutralization with NH_3 to precipitate hydrous zirconium oxide required 0.9 to 1.1 g NH_3 per gram of zirconium. The NH_3 can be recovered for recycle. ZrO_2 that met reactor-grade specifications was produced by precipitation with NH_3. Hydrothermal precipitation of ZrO_2 from strip liquor required that the solution be maintained at 260° C and 680 psi for 10 min and in a noncorrodible pressure vessel. In bench-scale experiments both methods gave zirconium recoveries greater than 99 pct.

RI 8851. Corrosion Resistance of Selected Ceramic Materials to Nitric Acid, by James P. Bennett. 1984. 12 pp. 3 figs. The Bureau of Mines is investigating the acid resistance of ceramic materials to identify construction materials for emerging technology in chemical and metallurgical processes. Eight commercial ceramic materials, including two red shale, two fireclay, a silica, a silicon carbide, a carbon, and a high-alumina brick, were evaluated. Samples were exposed to 40 wt pct HO_3 at 70° and 90° C and 60 wt pct HNO_3 at 50°, 70°, and 90° C for time periods of 110 days. Statistically significant changes in cold crushing strength were generally small or not detected, except for a strength drop in the high-alumina brick, which decreased in strength when exposed to the chosen acid concentrations at 90° C. Volume and weight changes were also measured. The leach rates of Al, Ca, Fe, K, Mg, Na, Si, and Ti were monitored. Increasing temperature or a decrease in the acid concentration resulted in an increased ion leach rate. Of the conditions tested, the most severe corrosion occurred at 90° C for a 40-wt-pct HNO_3 solution. The silica brick had the best overall acid-resistant properties, followed by a red shale and a fireclay brick. The carbon and silicon carbide bricks are not recommended for service. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8852. Evaluation of Mine Seals Constructed in 1967 at Elkins, Randolph County, WV, by Lester M. Adams and Jennings R. Lipscomb. 1984. 30 pp. 9 figs. In 1980, the Bureau of Mines surveyed a group of mine seals in Randolph County, WV, to evaluate their effectiveness for reducing toxic pollutants in mine water discharges. The survey focused on 11 block wet mine seals, but mine seals of several other types were also examined. The seals were installed in 1966 and 1967 in abandoned drift portals by the Federal Water Quality Administration, a predecessor of the Environmental Protection Agency (EPA), in cooperation with the Bureau of Mines and other Federal and State agencies, in a project

known as Elkins Mine Drainage Pollution Control Demonstration Project. The seals were designed to prevent air from entering the mine portals while allowing mine water to flow out. It was believed that by preventing air from entering inactive or abandoned mines, the formation of toxic pollutants and acid mine drainage could be reduced. Evaluation of the seals was based on water flow measurements, water analyses, and visual observations. The Bureau's 1980 data were compared with past data collected by the EPA. Several leaks and failures were observed in the clay seals, as evidenced by apparent blowouts and the absence of vegetation where the mine water surfaced. Analyses of the 1980 data indicated some improvement in the quality of water discharged from many of the wet air seals.

RI 8853. An Analyzer for Determining Helium-4 in the Parts-Per-Billion Range, by Philip W. Holland. 1984. 9 pp. 3 figs. The Bureau of Mines has developed a trace helium analyzer for determining helium-4 in the parts-per-billion range. The instrument is used for analyzing pure gases, laboratory-prepared standards, and atmospheric samples. Accuracy at the 95-pct confidence level in the 50- to 20,000-ppb range is within ±2 ppb or ±0.4 pct, whichever is greater. The minimum detectable helium-4 concentration is calculated to be 5 ppb. The analyzer consists of a modified helium leak-detector mass spectrometer, a laboratory-built sample inlet system, and a liquid-nitrogen-cooled charcoal trap. A programmable integrator and event-control module make automatic operation possible. The portability of the analyzer allows it to be used in the field.

RI 8854. Use of Bureau of Mines Turbomill To Produce High-Purity Ultrafine Nonoxide Ceramic Powders, by Dale E. Wittmer. 1984. 12 pp. 7 figs. Nonoxide ceramic materials could substitute for high-temperature alloy steels containing imported critical and strategic materials such as cobalt, chromium, and nickel if their high-temperature properties can be improved. An important result of this substitution would be a reduction of the Nation's need for imports of critical and strategic materials. In this Bureau of Mines investigation, the primary objective was to produce high-purity ultrafine (particles <5 μm equivalent spherical diameter (ESD)) alpha-silicon carbide (α-SiC) powders with improved high-temperature properties using the Bureau's patented turbomilling process. A secondary objective was to determine the feasibility of using polymer mill construction materials as a means of eliminating metal contamination from the turbomill. Ultrafine α-SiC powders with Brunauer-Emmett-Teller surface areas from 30 to 35 m^2/g ($\sim$0.06 μm particle ESD) were produced in an all-polymer turbomill. These high-purity powders (with 1-pct B and 1-pct C additions) hot-pressed to greater than 99 pct of their optimal density and exhibited properties commensurate with those of commercially available α-SiC. The most promising of the construction materials tested for the major wear surfaces of the turbomill was ultra-high-molecular-weight polyethylene, a polymer thermoplastic. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8855. Hand Dismantling and Shredding of Japanese Automobiles To Determine Material Contents and Metal Recoveries, by J. W. Sterner, D. K. Steele, and M. B. Shirts. 1984. 25 pp. 10 figs. The Bureau of Mines conducted studies on four makes of Japanese automobiles, three 1981 and one 1982 model years, received from three manufacturers to determine if their materials composition would present problems to the current technology used to process junk automobiles for metal recovery. One of each make of automobile was hand-dismantled to determine the materials composition. In addition, two nearly identical automobiles of each make were shredded at a commercial operation where all metal products and rejects were collected for analysis to determine metal and nonmetal distribution. The average weight of the four automobiles to be dismantled, less batteries, tools, and fluids, was 1,938.3 lb. The weight was distributed as 1,472.9 lb ferrous and 115.6 lb nonferrous metals, 275.2 lb combustibles, 72.3 lb noncombustibles, and 2.3 lb electrical components. The dismantled automobiles, less gas tanks, fluids, tools, wheels, tires, and batteries, which were all removed from the automobiles that were shredded, contained an average of 1,389.1 lb ferrous and 101.6 lb nonferrous metals, 305.7 lb nonmetals, and 2.3 lb electrical components. In comparison, materials collected from the shredded automobiles averaged 1,304 lb ferrous metals, 80 lb nonferrous metals, and 341 lb landfill materials. There were no materials used in the manufacture of the late model Japanese automobiles that should present handling or processing problems to the steelmaking or secondary metal recyclers.

RI 8856. A Sulfidation- and Oxidation-Resistant Ferritic Stainless Steel Containing Aluminum, by J. S. Dunning. 1984. 15 pp. 12 figs. Recent developments in energy conversion, mining and minerals processing, pollution control, and chemical equipment have placed increased demands on heat-resistant alloys. Higher corrosion rates from oxidation, hot corrosion, and sulfidation have increased consumption of materials that contain critical and strategic minerals and in many cases have limited productivity. The Bureau of Mines is conducting research on substitute materials having greater resistance to high-temperature corrosive atmospheres above 600° C compared to austenitic stainless steels such as AISI 304, 316, and 310, with the goal of conserving critical metals such as Cr and Ni. The substitute materials are based on Fe-Cr-Ni-Al compositions. Aluminum additions to Fe-Cr-Ni alloys significantly improve high-temperature corrosion resistance, particularly sulfidation resistance. In the alloy, devised by Bureau researchers, aluminum additions are held in the form of a second-phase precipitate, β-NiAl. Minor additions of Ti, Mn, and Si improve workability. Sulfidation resistance of a 12Cr-5Ni-4Al alloy with minor additions of Ti, Mn, and Si alloy is four to five times greater than that of AISI 304 (18Cr-8Ni) and 316 (18Cr-12Ni) stainless steel and three times greater than that of AISI 310 (25Cr-20Ni) stainless steel. Oxidation resistance is superior to that of types 304 and 316 and equivalent to that of type 310 stainless steel. Mechanical properties approach those of type 310 stainless steel.

RI 8857. Electrolytic Method for Recovery of Lead From Scrap Batteries, Scale-Up Study Using 20-Liter Multielectrode Cell, by A. Y. Lee, E. R. Cole, Jr., and D. L. Paulson. 1984. 20 pp. 11 figs. Prior work at the Bureau of Mines resulted in the successful development of a bench-scale, combination electrorefining-electrowinning method for recycling the lead from scrap batteries using waste fluosilicic acid (H_2SiF_6) as electrolyte. This paper describes larger scale experiments. Anodes cast from scrap battery lead were electrorefined in a 20-L multielectrode cell for

3 to 7 days. The anodes, containing 2 to 2.5 pct antimony, were ideal for obtaining firm and adherent slime blankets. Cathode deposits, assaying 99.99 pct Pb, were obtained, with current efficiencies near 99 pct. Sludge leaching was done in 100-L tanks followed by filtering in 61 cm square vacuum pan filters. Lead of greater than 99.99-pct purity was recovered from the filtrate by electrowinning in a 20-L multielectrode cell using insoluble PbO_2-Ti (lead dioxide-coated titanium) anodes and pure lead cathodes. The fluosilicic acid electrolyte depleted in lead was repeatedly recycled to leach more sludge, and there was no problem with impurity buildup. The amount of PbO_2 formed on the anodes during electrowinning was less than 1 pct of the total lead deposited on the cathodes, as long as the phosphorus concentration in the electrolyte was greater than 1.3 g/L. Emissions of lead in air were less than 10 $\mu g/m^3$, well below the proposed OSHA limit of 50 $\mu g/m^3$.

RI 8858. Rapid Identification of Stainless Steel and Superalloy Scrap, by R. D. Brown, Jr., William D. Riley, and C. A. Zieba. 1984. 23 pp. 8 figs. This Bureau of Mines report describes a new methodology for identifying and sorting scrap metals using two modern portable instruments: a thermoelectric sorter and a hand-held emission spectroscope. The method, tested on a 27-sample stainless steel and superalloy array, makes it possible to group and/or identify a typical mixture of high-value metal scrap in two or three steps, whereas as many as seven or eight steps are needed to perform the same separations using chemical spot tests. A portable fluorescent X-ray analyzer identified 19 of the 27 alloys in the same array by name or type; these alloys are included in the microprocessor memory. The remaining alloys were identified by using the analyzer in its elemental analysis mode and comparing the results with alloy specification chemistry. (*Out of print.*)

RI 8859. Safer Procedures for Removing Dragline Wire Rope Terminations, by G. K. Derby. 1984. 27 pp. 22 figs. The Bureau of Mines investigated methods for removing dragline bucket wire rope terminations with the objective of finding efficient methods that are safer than the method most commonly used at U.S. surface mines, which is to use the explosive impact of a projectile fired from a cannon to remove the rope termination. Removal of a wire rope termination for repair or replacement requires separation of the wedge and socket that lock together to secure the rope end. The Bureau investigated currently used methods and improved upon and tested two safer alternate methods for removing wire rope terminations. A cannon test program was conducted, using 40- and 50-gr primer (detonating) cord, to establish the possible force produced with a 4-in-bore cannon and a 55-lb projectile. Wedge and socket units supplied from cooperating mines were separated under controlled conditions to establish data on separation force requirements. The two alternate methods investigated were use of the force generated by (1) a pendulum ram and by (2) a portable hydraulic pusher. Both methods are capable of providing sufficient force to effect wedge and socket separations on draglines with up to 78-yd^3 buckets under normal conditions.

RI 8860. Low-Chromium Heat-Resisting Ferritic Alloys Strengthened by the Chi Phase, by M. L. Glenn and J. S. Dunning. 1984. 18 pp. 17 figs. The Bureau of Mines is conducting research on substitutes for chromium-containing alloys in order to conserve imported critical and strategic materials. Part of this research concentrates on finding low-chromium substitutes for heat-resisting stainless steels for the temperature range 600° to 800° C. Ferritic alloys are emphasized that have oxidation resistance provided by chromium contents as low as 10 pct and stress rupture strength provided by the precipitation of the chi(χ)-phase intermetallic compound, ($Fe_{36}Cr_{12}$ (Mo, Ti_{10}). Initially, research was concentrated on selecting an alloy composition having a minimum chromium content with strengthening provided by the χ-phase. An Fe-(10–12 pct)Cr-6 pct Mo-(1.5–2.0 pct)Ti alloy was selected. After the alloy selection, the tensile, stress rupture, and oxidation properties were determined. Stress rupture properties were found to be similar to those of 304 stainless steel. However, the alloys possessed brittleness during both stress rupture and tensile testing, possibly as a result of too high a content of molybdenum and titanium. Higher than expected oxidation rates were found that may be caused by the high molybdenum content.

RI 8861. Assessment of Methane Hazards in an Anomalous Zone of a Gulf Coast Salt Dome, by A. T. Iannacchione, R. H. Grau III, A. Sainato, T. M. Kohler, and S. J. Schatzel. 1984. 26 pp. 28 figs. This Bureau of Mines research study found gas emission rates from an advancing face, and flows and pressure of gas from an exploration drill hole were dependent upon the geology of salt encountered in a domal salt mine. Normal production-grade "pure" salt adjacent to an anomalous zone was found to have a methane emission rate of less than 5 ft^3/ton (0.1 m^3/t) of mined salt from a room advanced by a continuous miner. Extremely low gas flows [less the 4 ft^3/h (0.1 m^3/h)] and lack of pressure buildup were also observed from this normal salt in a 154-ft (47-m) exploration drill hole. These data indicate that methane emissions should not be a problem when mining in this type of salt. In the adjacent anomalous zone, methane emission rates ranged from 15 to 70 ft^3/ton (0.4 to 1.8 m^3/t) of mined salt from an advancing face. Gas flows of approximately 42 ft^3/h (1.2 m^3/h), and pressures in excess of 900 psig (6,200 kPa) were observed in an exploration drill hole when the anomalous zone was encountered. This information suggests a greater methane emission hazard from the anomalous zone than from the associated normal salt. If this trend of increasing emissions problems associated with anomalous zones of salt is common with similar anomalous zones encountered or observed in other domal salt mines, then special control strategies should be employed to minimize this potential mining hazard.

RI 8862. Calamity Hollow Mine Fire Project (In Five Parts) 3. Instrumentation for Combustion Monitoring, Process Control, and Data Recording, by Louis E. Dalverny, Robert F. Chaiken, and Karen E. Soroka. 1984. 23 pp. 12 figs. The Bureau of Mines has demonstrated a new technological approach that utilizes controlled in situ combustion to bring fires in abandoned coal mines and waste banks under control. This report describes the instrumentation employed to continuously monitor combustion process control and combustion diagnostics during a full-scale field trial at the site of an abandoned coal mine fire. Conventional thermocouple thermometry proved sufficient, although occasionally, borehole probes were damaged above the sheathed section by hot strata. Strain gauge transducers performed as well as capacitance-type transducers for static pressure and flow measurements. Calibration of the strain gauge devices was simpler and less labor intensive. The major in-

strumentation problems encountered during the 4 months of continuous controlled combustion were with the gas-sampling and gas-conditioning assemblies. These suffered from corrosion and particulate damage engendered by combustion product condensates. Performance was improved by changing to porous metal filters and permeation tube dryers. The gas analyzers, employing nondispersive-infrared, paramagnetic, chemiluminescent, and pulse-fluorescence-detection methods, operated properly when supplied with correctly conditioned samples. The report includes recommendations for enhancing sample conditioning, flow monitoring, and data acquisition.

RI 8863. Calamity Hollow Mine Fire Project (In Five Parts). 4. Quenching the Fire Zone, by Robert F. Chaiken, Edward F. Divers, Ann G. Kim, and Karen E. Soroka. 1984. 18 pp. 8 figs. The Bureau of Mines demonstrated a novel water-injection fume-exhaustion (WIFE) procedure for quenching underground coal fires and fire-heated rock as part of its Calamity Hollow Mine Fire Project. The Bureau's existing Burnout Control ventilation system was operated at a vacuum level just sufficient to exhaust the underground fire zone, and water was introduced into the mine through existing boreholes at a rate of 3 to 4 gal/min per borehole. The resulting steam and heated gases were exhausted from the mine, and this led to a rapid and relatively uniform cooling of the entire fire zone and surrounding rock strata. An advantage of the WIFE procedure is that the progress of the cooling process can be monitored. Measured exhaust temperatures decreased from 592° to 162° C (1,100° to 324° F) during the 30-day quenching period. Energy balance computations suggested that 50 pct or more of the burning coal mass was extinguished during this period. Analyses indicated that cooling to 100° C (212° F) with possible complete and permanent extinguishment of the approximately 1-acre underground fire zone might have been achieved if the WIFE procedure had been extended for an additional 20 days. Recommendations are given as to how the WIFE procedure may be improved.

RI 8864. Electrical Properties and Attenuation Distance of Upper Pennsylvanian Coal Measure Rock From Southwestern Pennsylvania, by David P. Lindroth, Carl F. Wingquist, and Andrew L. Dehler. 1984. 27 pp. 9 figs. The Bureau of Mines is engaged in research on ground probing radars for detection of geologic hazards in advance of mining. Penetration distances and interpretation models depend on the dielectric properties and wave propagation characteristics for coal measure stratified media. Relative dielectric constants and dissipation factors were measured under ambient conditions for Pittsburgh Seam coal measure rock over the frequency range of 20 to 100 MHz by the susceptance-variation method. The rock types measured were representative sedimentary rock located above the Pittsburgh Coal Seam. Extreme values for the computed attenuation distance ranged from 1.7 m at 100 MHz for siltstone to 230 m at 20 MHz for a particular limestone.

RI 8865. The Theory of Flammability Limits. Flow Gradient Effects and Flame Stretch, by Martin Hertzberg. 1984. 36 pp. 15 figs. In this Bureau of Mines study, an equation is derived for the limit burning velocity for divergent, spherical propagation from an ignition kernel of radius, r: $(S_u)_e = \frac{2\alpha}{r}\frac{\rho_u}{\rho_b}$. For flame propagation into a preexisting, stretching velocity gradient of magnitude dv/dx, the limit velocity is $(S_u)_e = (\alpha\ dv/dx)^{1/2}$. These formulations are shown to be equivalent to the fluid dynamic concepts of Damkohler, Karlovitz, and Markstein. Existing data for the blowoff limits of flames are shown to give excellent agreement with those concepts provided that proper account is taken of two dilution effects: composition dilution caused by entrainment and velocity gradient dilution caused by flow expansion. Approximate flow-field solutions are also derived for the unburned gas motion above an upward propagating, spherical flame kernel in buoyancy-induced flows. It is shown that the upward hemisphere propagates toward a stagnation plane in a counterflow configuration involving the balance between the combustion force, which accelerates the cold gas upward, and the buoyancy force that accelerates the cold gas downward. The position of the stagnation plane above the upward propagating hemisphere is related to the ratio of the buoyant velocity, v_b, to the burning velocity, S_u. Extinction of the upward propagating wave occurs by flame stretch in that counterflow configuration when $\eta = v_b/S_u$ begins to exceed the expansion ratio, ρ_u/ρ_b, and the wave is blown off by its own buoyancy-induced flow field.

RI 8866. A Basic Chloride Method for Extracting Aluminum From Clay, by P. R. Bremner, L. J. Nicks, and D. J. Bauer. 1984. 8 pp. 3 figs. As part of a program to devise alternative technologies for producing alumina from domestic resources, the Bureau of Mines investigated the leaching of calcined kaolinitic clay to form basic aluminum chloride solutions. Bench-scale experiments were conducted for single-stage batch leaching with $AlCl_3$ solution and three-stage countercurrent leaching with substoichiometric HCl. Variable conditions of clay calcination and leaching were studied to determine their effects on aluminum extraction and pregnant liquor composition. With clay calcined at the best temperature of 850° C, extraction of more than 93 pct of the aluminum was achieved. The basic chloride pregnant liquors were crystallized and yielded the compound $5AlCl_3 \cdot 8Al(OH)_3 \cdot 37.5H_2O$, which can be thermally decomposed to alumina with 61.6 pct of the energy required for decomposition of $AlCl_3 \cdot 6H_2O$. In comparison with the leaching operation in an HCl-clay process, the basic chloride system offers substantial advantages in energy consumption and equipment size requirements. (*Out of print.*)

RI 8867. Dispersion-Selective Flocculation-Desliming Characteristics of Oxidized Taconites, by R. E. Green and A. F. Colombo. 1984. 19 pp. 8 figs. The Bureau of Mines undertook a bench-scale study of three different types of oxidized taconites from the Lake Superior district to improve the dispersion-selective flocculation-desliming process for beneficiating these materials. The response-surface contours of the effects of dissolved ionic species in the water and of three dispersion systems on the selective flocculation process were studied. Results of metallurgical data and chemical analyses of the aqueous phase showed that the water quality affects the performance of the selective flocculation process.

RI 8868. In-Line Aeration and Treatment of Acid Mine Drainage, by T. E. Ackman and R. L. P. Kleinmann. 1984. 9 pp. 5 figs. The Bureau of Mines has invented a simple, low-maintenance system to mix and aerate mine water in a pipeline. It consists of a jet pump, which entrains air by Venturi action, and a static mixer, which induces turbulent flow. The system has no moving parts and is designed to use the pressure generated by an existing mine water discharge pump. The in-line aeration system has been field-tested at a minesite in Greene County,

PA, where high ferrous iron (Fe^{2+}) concentrations were causing discharge problems. Discharge concentrations of Fe^{2+} were reduced from 10 to 20 mg/L to 0.2 to 0.9 mg/L by installation of the aeration system. At high influent Fe^{2+} concentrations (47 to 240 mg/L), the system also proved effective, despite low pH conditions (4.6 to 5.6). Neutralization and aeration were combined into a single step by injecting sodium hydroxide (NaOH) into the port of the jet pump. This resulted in oxidation of the Fe^{2+} within a few seconds, indicating that combining neutralization and aeration optimizes reaction rates.

RI 8869. Apparent Earth Conductivity Over Coal Mines as Estimated From Through-the-Earth Electromagnetic Transmission Tests, by John Durkin. 1984. 18 pp. 5 figs. Electromagnetic narrow-band signals were transmitted through the earth at 27 coal mines located throughout the United States. From those Bureau of Mines tests, apparent earth conductivity values were derived based upon a homogeneous half-space model of the earth. The derived conductivity values were found to be inversely proportional to the transmitted frequency and mine depth. A linear regression model relating the logarithm of the conductivity to the mine depth was formulated, and the results indicate that the mine depth can be an adequate predictor of the apparent earth conductivity above coal mines. Apparent earth conductivity was found to decrease with mine depths.

RI 8870. Lignite Recovery of Cobalt^{3+} From an Ammoniacal Ammonium Sulfate Solution, by G. J. Slavens, Davis E. Traut, L. R. Penner, and Jack L. Henry. 1984. 12 pp. 8 figs. The Bureau of Mines has devised technology to recover cobalt, nickel, and byproduct copper from domestic lateritic material using an oxidative, ammoniacal ammonium sulfate leach. Nickel, cobalt, and copper were recovered by solvent extraction and electrowinning. To reduce the cost and complexity of cobalt recovery, an alternate method using lignite to extract Co^{3+} was investigated as reported herein. In the first 25 BV (bed volumes) of solution contacted with lignite, 97 wt pct of the Co^{3+} was extracted in a downflow column of pH 9.3. After 85 BV, the lignite was loaded to 1.5 wt pct Co^{3+} and further extraction was minimal. The lignite extracted cobaltic ammine complexes rather than cobalt ions and was nonselective as to other metal cations and ammonium ions. Deleterious cations and 80 wt pct of the nonammine ammonium ions were removed prior to acid elution of the lignite. The removal of the ammines prior to elution to produce an ammonium-ion-free Co^{3+} eluate was only partially successful. Thus Co^{3+} removal from ammoniacal solutions by lignite is technically difficult and economically unfeasible. It was also determined that reduction of Co^{3+} to Co^{2+} occurred during the extraction-elution process.

RI 8871. Properties of Filter Cloths for Seepage Control in Coal Mine Waste Embankments, by Robert C. Gabler, Jr. 1984. 23 pp. 8 figs. Three filter cloth fabrics commonly used in drains for coal waste embankments were tested by the Bureau of Mines for clogging behavior and deterioration under simulated field conditions. The objective was to provide guidelines for the mining industry for the proper selection and use of filter cloths to assure safer embankments at mine waste disposal sites. The filter cloths were tested with three coal waste samples in standpipes used to simulate coal mine waste disposal environments. Two of the cloths showed a tendency to become clogged with fines from the wastes. One waste caused clogging by precipitating an iron-silicon compound on the test cloths. No apparent cloth deterioration resulted from exposures to the simulated coal waste environments. (The exposures ranged from 2 to 12 months.) In other tests, exposures to waters in the pH range of 2 to 12 and to reagents used in coal-preparation plants resulted in insignificant or no deterioration, as measured by tensile strength. However, long exposures to sunlight (ranging from 4.6 to 6 months) caused major deterioration in two of the cloths (86- and 98-pct losses in tensile strength) and slight deterioration in the third cloth (9-pct loss in strength).

RI 8872. In-Mine Remote-Actuated Stench Fire-Warning System, by Edward D. Thimons and Mervin D. Marshall. 1984. 6 pp. 5 figs. A remote-actuated stench gas fire-warning system has been designed and tested by the Bureau of Mines. This system makes use of the hardwire network for the mine's phone pager system, thus greatly reducing the system cost. By locating stench gas canisters with remote-actuation release capabilities near working sections, the fire-warning time can be greatly reduced. In a test of the system in a Missouri lead mine, the time required to warn miners of a fire at two working faces was reduced from about 20 min with the conventional system to less than 4 min with the remote-actuated system.

RI 8873. Thermodynamic Properties of Hedenbergite, a Complex Silicate of Ca, Fe, Mn, and Mg, by K. O. Bennington, R. P. Beyer, and R. R. Brown. 1984. 19 pp. 3 figs. This investigation of the thermodynamic properties of hedenbergite is one of a series being performed at the Bureau of Mines on slag-type pyroxenes, which include the pair acmite [$(NaFe^{3+})(Si_2O_6)$] and the nearly identical mineral aegirine. These pyroxene minerals readily assimilate manganese; consequently, this study contributes toward both the future investigation of some manganese minerals and the understanding of slag action in steelmaking.

RI 8874. Minor-Element Interactions in Copper Matte Smelting, by Elizabeth A. Johnson, L. L. Oden, P. E. Sanker, and R. L. Fulton. 1984. 9 pp. 5 figs. Minor-element behavior and interaction in the copper matte-iron silicate slag system have been studied by the Bureau of Mines. In the present work, the possibility of interactions among the minor elements As, Sb, Bi, Se, and Te was investigated. Equilibrations of matte, slag, and one of each of the five minor elements were performed at 1,250° C under typical matte smelting atmospheres of CO, CO_2, and SO_2 for mattes containing 40, 50, and 60 pct Cu. Results are compared with those of a previous Bureau of Mines study in which all five minor elements were present simultaneously.

RI 8875. Estimating Horizontal Drain Design by the Finite-Element and Finite-Difference Methods, by D. R. Tesarik and C. D. Healy. 1984. 26 pp. 67 figs. To ensure the stability of a tailings pond embankment, the height of the phreatic surface must be kept at or below a safe level. In this investigation, the Bureau of Mines analyzed various horizontal drain designs for tailings embankments to determine their effects on location of the phreatic surface. This report describes the investigation, and it includes 21 dimensionless graphs that can be used to estimate the drain spacing and length dimensions necessary to ensure the stability of embankments of various configurations. Analyses were based on the use of

two computer codes, a three-dimensional finite-element code and a two-dimensional finite-difference code. The computer-generated results were compared with results obtained from a laboratory embankment model, other laboratory test results, and piezometric data from two actual tailings embankments. Nearly the same phreatic surface locations were predicted using either of the computer codes. For one of the actual embankments studied, the predicted phreatic surface location was slightly higher than the measured location; for the other, the predicted location closely followed the actual surface trend. Phreatic surfaces of the laboratory model were slightly higher than the code-generated locations, and the differences grew larger as drain length increased or drain spacing decreased.

RI 8876. Performance Comparison of Oxygen Self-Rescuers, by Nicholas Kyriazi and John P. Shubilla. 1984. 28 pp. 34 figs. A performance study of oxygen self-rescuers from the United States and other countries was undertaken as an assessment of present worldwide technology. The apparatus were tested on a breathing and metabolic simulator in the Life Support laboratories of the Bureau of Mines. Parameters monitored during the testing were inhaled levels of CO_2 and O_2, inhaled gas temperature, and breathing resistance. The metabolic demand placed on the apparatus represented the average demand of the 50th percentile miner performing a 60-min man-test 4, as described in 30 CFR 11H. Results presented include apparatus service life and subjective comments as well as averages and peaks of monitored parameters.

RI 8877. Alumina Miniplant Operations—Influence of Reactor Design on the Attrition of Calcined Kaolin During HCl Leaching, by Don B. Hunter, Dwight L. Sawyer, Jr., and Theodore L. Turner. 1984. 21 pp. 16 figs. The Bureau of Mines investigated the extraction of alumina from calcined kaolin by leaching with boiling HCl in a train of three 50-gal continuous, stirred reactors. Slurry discharged from the reactors contained an excessive amount of fines, which impeded solid-liquid separation. Autogenous grinding of coarse solids that accumulated in the reactors was the source of the fines. This report describes modifications to the reactors and to the operations that led to decreased fines generation and improved solid-liquid separation. Modifications to the reactors included custom-made impellers, the addition of a baffle system, a subsurface slurry discharge system, and slower rotation of the impellers. Concurrent testing of a continuous horizontal belt filter showed that the form filtration rates were increased from 350 to almost 1,000 $lb/h \cdot ft^{-2}$ when the modified reactors were used.

RI 8878. Preventing Chromium Leaching From Waste Slag Exposed to Simulated Acid Precipitation: A Laboratory Study, by Howard W. Kilau and Ishwarlal D. Shah. 1984. 21 pp. 11 figs. The Bureau of Mines tested chromium-bearing waste slags from industrial stainless steel and other chrome alloy operations to determine their chromium leachability characteristics under acid precipitation conditions and to devise measures to prevent any pollution originating from this source. Two critical slag composition factors were found to control the chromium leachability: (1) $CaO:SiO_2$ ratio and (2) magnesium content. Above a 2.0 $CaO:SiO_2$ ratio, chromium exists in slag as $CaO \cdot Cr_2O_3$, which can be vulnerable to leaching by acid precipitation especially if oxidized to $CaCrO_4$ when exposed to the environment over an extended period. Maximum chromium leachability from industrial slags occurred when the composition of the slag had about a 2.0 $CaO:SiO_2$ ratio. Between a 1.0 and 2.0 $CaO:SiO_2$ ratio, in the presence of sufficient magnesium, $MgO \cdot Cr_2O_3$ was formed, which is very resistant to oxidation and to dissolution by simulated acid precipitation. Addition of magnesium silicates to molten slag to fix the chromium in the $MgO \cdot Cr_2O_3$ form was successful in preventing chromium leaching in simulated acid rain solutions. Experiments showed olivine and waste taconite tailings were suitable for this purpose. Olivine addition to a waste slag having a composition vulnerable to leaching ($CaO:SiO_2 > 2$) reduced the chromium leachability more than 80 pct.

RI 8879. Influence of Overlying Strata on Methane Emissions in a Northern West Virginia Coal Mine, by J. P. Ulery and G. M. Molinda. 1984. 14 pp. 7 fig. Since 1970, abnormally high methane emissions have been observed in eastern sections of the Federal No. 2 Mine operating in the Pittsburgh Coalbed in northern West Virginia. The nature and volume of these emissions indicate a source other than the coalbed. An investigation was undertaken to delineate probable methane sources. Gas well information and stratigraphic correlation of corehole data indicate that a sandstone directly above the main coalbed is an additional source of methane emissions. The sandstone body appears to be an ancient stream channel, infilled with fine-grained sand and organic matter. Coalification of the organic matter produced methane as a byproduct. Additional methane presumably migrated into the sandstone unit from the subjacent coalbeds. The methane became trapped in the porous clastic unit by the surrounding impermeable strata. Mine development near this unit creates a significant pressure gradient, triggering abnormal methane emissions into the mine along naturally occurring fractures. Predevelopment methane drainage of the sandstone could be accomplished by completing vertical boreholes along its trend.

RI 8880. Simulation of Methane Flows in Noncoal Mines, by Andrew B. Cecala and Edward D. Thimons. 1984. 9 pp. 9 figs. The Bureau of Mines has successfully tested a method to simulate methane (CH_4) flows from face areas through the returns of noncoal mines. This technique involves releasing a small quantity of tracer gas at a working area and sampling for that gas downstream in the return airways. By measuring the dilution of the tracer gas, the dilution of any volume of CH_4 released at the face can be calculated. This information is useful in selecting locations for CH_4 monitors and in deciding the necessity for permissible equipment in the returns.

RI 8881. Domestic Saprolites as Potential Substitutes for Refractory-Grade Bauxite, by Jack C. White. 1984. 10 pp. 2 figs. The Bureau of Mines evaluated the potential for production of substitute refractory-grade bauxite (RGB) from saprolites and gibbsitic sands of the Southeastern United States. A statistical analysis of data from a reconnaissance sampling program indicates that the discovery potential for saprolites high in gibbsite in the Alabama Piedmont physiographic province is not encouraging. Furthermore, the minus 12-μm mineral concentrates produced from these saprolites and from gibbsitic sands of the Coastal Plain province were impure, contained insufficient alumina, and had poor refractory properties. A saprolite sample from the Valley and

Ridge physiographic province was beneficiated by attrition scrubbing-hydrocycloning-wet high intensity magnetic separation to provide a concentrate containing about 70 pct Al_2O_3 with a pyrometric cone equivalent (PCE) of 35 to 36. Such material may be useful as a substitute for domestic 70-pct-alumina bauxite based on the PCE values. More complete ceramic testing will be necessary to confirm this tentative conclusion. Recovery of only about 10 pct of the original saprolite weight as a high-gibbsite concentrate indicates that the proposed production method would be expensive compared with production costs in Guyana or China, the principal suppliers to the United States. The tonnage of saprolite suitable for production of a high-alumina substitute is still unknown.

RI 8882. Corrosion Rate of Grinding Media in Mill Water, by W. K. Tolley, I. L. Nichols, and J. L. Huiatt. 1984. 13 pp. 9 figs. This report presents data collected during research by the Bureau of Mines on corrosion of grinding media. Corrosion rates of eight alloys commonly used in grinding media were tested in synthetic mill water using an ultrasonic grinding device especially designed for this work. Electrochemical measurements showed variations in corrosion rates for these alloys between 9.8 mpy for medium-carbon steels and 0.14 mpy for high-chromium white irons. Bureau data are discussed along with data from the literature to indicate that corrosion causes less than 10 pct of the wear of grinding media in commercial grinding mills. A comparison of corrosion rates for various types of grinding media shows that alloying elements and electrochemically active inclusions in steel affect the corrosion behavior of the media.

RI 8883. Recovering Lithium Chloride From a Geothermal Brine, by L. E. Schultze and D. J. Bauer. 1984. 13 pp. 8 figs. The Bureau of Mines has devised techniques to recover lithium from geothermal brines as the chloride. More than 99 pct of the lithium was precipitated from a brine containing 170 mg/L Li by adding a solution of $AlCl_3$ and increasing the pH to 7.5 with lime slurry. The Li-Al precipitate was dissolved in HCl and sparged with gaseous HCl to recover the $AlCl_3$; this resulted in a solution containing LiCl and $CaCl_2$. The solution was evaporated at 100° C to obtain a mixture of the chlorides from which 97 pct of the lithium was recovered and 90 pct of the calcium was rejected by leaching with tetrahydrofuran. The LiCl recovered by evaporation of the tetrahydrofuran was purified by dissolution in water and treatment with oxalic acid. The final LiCl solution contained 89 pct of the lithium originally present in the brine and had a purity of 99.9 pct. (*Out of print.*)

RI 8884. Diesels in Underground Mining. A Review and an Evaluation of an Air Quality Monitoring Methodology, by J. Harrison Daniel, Jr. 1984. 36 pp. 21 figs. The underground use of diesel-powered equipment in hard-rock mines is well established, and the use of diesel equipment in underground coal mines is greatly increasing. Studies have shown safety advantages of the equipment based on tons of ore produced. However, as the number of diesel units and their power ratings increase, concern over the health effects of the exhaust emissions becomes more significant. This Bureau of Mines report reviews the underground use of diesel equipment, and presents a comprehensive explanation and evaluation of an advanced air quality monitoring methodology that provides an assessment of the underground atmosphere. The methodology involves the following two phases: (1) establishing pollutant characteristic curves for specific diesel equipment that illustrate the relationship between the concentration of the exhaust pollutants and the concentration of CO_2 measured at the same location and over the same period of time, and (2) using an air quality index to establish a single CO_2 concentration at which the other diesel pollutants are considered below harmful levels. Establishing the characteristic curves requires specialized instrumentation and trained personnel. However, the CO_2 monitoring to assess air quality after the curves have been determined can be performed by mine personnel. Evaluation of the methodology was carried out on the 7,100-ft level of Homestake gold mine, Lead, SD. Data gathered during this investigation are sufficient to demonstrate the methodology, but not extensive enough for statistical validation.

RI 8885. Pilot Mill Flotation of Serpentinized Platinum-Palladium Ore From the Stillwater Complex, by E. Morrice, J. W. Walkiewicz, and G. Casale. 1984. 11 pp. 2 figs. The Bureau of Mines investigated methods for beneficiating platinum-palladium ores from the Stillwater Complex, MT. Results of bench-scale and pilot-scale studies employing froth flotation to recover sulfide concentrates containing platinum-palladium values from a serpentinized ore are presented. Best results in the pilot mill were obtained with a sodium isobutyl xanthate-normal dodecyl mercaptan collector combination at a natural pH of 8.2. A rougher concentrate containing 1.7 oz/ton Pt and 4.7 oz/ton Pd was prepared. Recoveries of platinum and palladium were 96 pct and 86 pct, respectively. Batch cleaner flotation of rougher concentrates yielded concentrates containing 3.7 oz/ton Pt and 9.8 oz/ton Pd.

RI 8886. New Bag Nozzle To Reduce Dust From Fluidized Air Bag Machines, by Andrew B. Cecala, Jon C. Volkwein, and Edward D. Thimons. 1984. 5 pp. 4 figs. A new prototype bag nozzle system has been designed under a Bureau of Mines contract to reduce dust generated during the bagging operation on fluidized air baggers. A field analysis of the new system has shown that the bag operator's dust exposure was reduced 83 pct. The amount of blowback was reduced 89 pct, which corresponds to a significant product savings. The new prototype system has been operating for a substantial period of time with no major problems.

RI 8887. Electrolytic Stripping of Tin in an Acid Fluoborate Electrolyte, by J. G. Groetsch, Jr., R. C. Gabler, Jr., and D. A. Wilson. 1984. 9 pp. 3 figs. Municipal solid waste (MSW) contains about 8 pct ferrous metallics, which are typically recovered by magnetic separators at municipal resource recovery facilities. At present, only about 182,500 ton/yr of MSW magnetics are being processed for remelting out of the ~11 MMton/yr discarded. The Sn in MSW magnetics makes this material difficult to recycle to the steel industry. An electrolytic method using stannous fluoborate-fluoboric acid for removing Sn was evaluated. Optimum concentrations of Sn in the electrolyte and the effects of impurities such as Al, Cu, Fe, and Pb on Sn recovery from the electrolyte were evaluated. Operating parameters were 60 to 65 g/L fluoboric acid and 20 to 30 g/L Sn using stainless steel electrodes at a current density of 60 A/ft². Tests were run with postconsumer scrap and MSW magnetics. Good results were ob-

tained with MSW magnetics, after pretreatment by reshredding, magnetic separation, and air classification. The final Sn content of the MSW magnetics scrap was reduced from 0.18 to 0.017 wt pct. Heat and solvent treatments of MSW magnetics to remove coatings did not significantly improve Sn removal beyond that obtained with material that had only been mechanically pretreated.

RI 8889. Methane Content of Gulf Coast Domal Rock Salt, by Steven J. Schatzel and David M. Hyman. 1984. 18 pp. 10 figs. Large-scale methane releases in domal salt mines have resulted in ignitions and mine fatalities as recently as 1979. Several past studies have implied that hazardous methane occurrences in U.S. salt domes are distributed neither uniformly nor randomly, but are geologically controlled and potentially predictable. A first step by the Bureau of Mines in addressing the problem of methane in domal salt mines required development of a new test to determine volumes of gases in solid salt samples. This report considers the results achieved when 80 domal salt samples were tested for gas content by dissolution in a controlled atmosphere chamber. Criteria were organized to delineate salt types based on geological occurrence. Outburst samples range from 0.014 to 7.4 cm^3 CH_4/100 g NaCl, anomalous salt samples from 0.0027 to 2.6 cm^3 CH_4/100 g NaCl, and normal salts from less than 0.0003 to 0.31 cm^3 CH_4/100 g NaCl. The presence of higher hydrocarbons was most common in samples containing larger quantities of methane. The presence of higher hydrocarbons appears to be useful in detecting methane hazards where some methane may be lost before gas content testing. An exploratory rotary and/or core drilling program, dissolution testing for gas content, and up-to-date geologic mine mapping could allow a mine operator to assess methane hazards in domal salt.

RI 8890. Evaluation of the Safety of One-Hour Compressed Oxygen Self-Rescuers—Results of Destructive Testing, by R. W. Watson, A. L. Furno, W. J. Doyak, and R. L. Brewer. 1984. 70 pp. 45 figs. At the request of the Mine Safety and Health Administration (MSHA) the Bureau of Mines evaluated the potential hazards of three compressed oxygen self-contained self-rescuers (SCSR's) designed for use in underground coal mines. The evaluation followed the lines used in a similar investigation of chemical self-rescuers and involved laboratory experiments as well as field trials designed to simulate a mining environment. They included bullet impact, bonfire, feeder-breaker impact and feed-through, and mining machine runover tests. The work showed that the units were not inherently unsafe but that under certain conditions of extreme abuse they can present a potential ignition or explosion hazard. This, coupled with a survey of reported damage on SCSR's currently deployed in underground mines, which indicated a relatively high frequency of incidents leading to the destruction of the units, led to new recommendations on the deployment of SCSR's. The recommendations formulated by MSHA state that the units should be either properly worn by the miner, stored in heavy containers, or otherwise protected from situations in which they might be accidentally ruptured or destroyed, such as runover by mobile mining equipment.

RI 8891. Evaluation of a Gas-Assisted Cupola, by Victor R. Spironello. 1984. 16 pp. 8 figs. The Bureau of Mines is studying cupola ironmelting technology with the objectives of conserving high-quality raw materials through substitution and increasing productivity. In the preliminary research reported here, a pilot-size cupola was modified by inserting a gas-fired melting and/or preheating chamber into the stack above the level of the coke bed, for study as a prototype for a coal-fired melting chamber. The modified cupola, in which natural gas was used to partially replace foundry coke, was evaluated in several trial runs. Data were obtained on furnace performance, metal and slag chemistry, and scrubber waters as particulates. Results of the modified operation were compared to those of conventional cupola operation. Although this research was preliminary—since the ultimate goal is to use pulverized coal instead of gas—it yielded ample evidence that the melting rate of a cupola can be significantly increased with less than a proportionate increase in energy input. Other evidence suggests that melting of low-density scrap can be enhanced and that scrap containing undesirable and/or oxidizable elements can be appreciably upgraded. This work is continuing and will include the use of pulverized coal of low rank to assist in melting.

RI 8892. Airblast and Ground Vibration Generation and Propagation From Contour Mine Blasting, by Virgil J. Stachura, David E. Siskind, and John W. Kopp. 1984. 31 pp. 45 figs. The Bureau of Mines studied airblast and ground vibrations produced by surface coal mine blasting in Appalachia to determine the topographic or other region-specific effects on generation and propagation. Arrays of seismographs were used to measure blast effects in both rolling-terrain and steep-slope contour coal mining areas. Comparisons were then made with previous blasting data from studies of midwest coal mines located in flat areas. Airblasts were found to have both higher average levels and higher spectral frequencies, consistent with expectations of less efficient blast confinement on the slopes. Topographic channeling of airblast was also observed, leading to more efficient propagation along the hollows or valleys. These two effects produced observed airblast levels higher by 1.9 to 4.4 dB than predicted from previous studies. Ground vibration levels, by contrast, were lower than found in flat-area coal mines. This is consistent with lesser degrees of confinement and the resulting greater blast relief. No specific topographic effect on ground vibration amplitudes was observed.

RI 8893. Ultrasonic Convergence Measurements, by James R. McVey. 1984. 11 pp. 12 figs. Tests during pillar robbing, longwall operations, and other mining activities indicate that roof-floor convergence rates can be used as an indicator of imminent roof failure. A large number of electrical-mechanical devices have been built to measure convergence as well as convergence rates, but most obstruct mine traffic and are costly and time consuming to install. The Bureau of Mines has designed and is evaluating three types of small ultrasonic units to make these measurements. The new instruments provide non-obstructing measurements up to 35 ft away. The ultrasonic transducers can be attached to a roof bolt, placed in an unsupported area (by means of a toss basket), or handheld. Total distance to the target and rate of closure are displayed digitally to 0.001 ft and 0.01 ft/min, respectively. (*Out of print.*)

RI 8894. Corrosion Resistance of Nitrided Low-Alloy Steels, by John V. Scalera. 1984. 20 pp. 8 figs. Because of U.S. dependency on imported critical

metals, the Bureau of Mines has conducted research to evaluate the possible substitution of nitrided low-alloy steels for higher chromium-containing alloys. The corrosion data for nitrided steels are limited primarily to the Soviet literature. The objective of this study was to determine the corrosion properties of six commercially nitrided low-alloy steels in a 5-wt % NaCl solution at pH 4. Weight-loss tests indicated that, in deaerated test solutions, most of the nitrided steels were less corrosion resistant than nontreated steels. However, electrochemical tests indicated that under more oxidizing conditions, nitrided materials are converted to a passive state with a significantly reduced corrosion rate. Electrochemical tests performed in an aerated environment confirmed the passivity of the samples in an oxidizing environment.

RI 8895. Rheology of Ion-Exchanged Montmorillonite Clays, by D. A. Stanley, S. W. Webb, and B. J. Scheiner. 1984. 17 pp. 10 figs. The Bureau of Mines is investigating a method to dewater fine-particle clay waste. In order to more fully understand the effect of ion exchange on clay dewatering, an investigation of the rheological properties of ion-exchanged montmorillonite was undertaken. Viscosity measurements were made on ion-exchanged montmorillonite slurries of the following cations: Na^+, Li^+, NH_4^+, CA^{2+}, Mg^{2+}, and La^{3+}. The univalent ion-exchanged clays were found to have significantly higher viscosities than the multivalent exchanged clays. The measured viscosities were separated into Newtonian and non-Newtonian components using the Ree-Eyring equation. The magnitude of the Newtonian and non-Newtonian viscosity components was found to be dependent upon the floc volume, a parameter controlled by the degree of particle interaction, and the thickness of the individual montmorillonite platelets (tactoids). Both the tactoid thickness and the degree of particle interaction are determined by the hydrated-radius-to-charge ratio of the exchange ion. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8896. Effects of Repeated Blasting on a Wood-Frame House, by Mark S. Stagg, David E. Siskind, Michael G. Stevens, and Charles H. Dowding. 1984. 82 pp. 62 figs. The Bureau of Mines arranged to have a wood-frame test house built in the path of an advancing surface coal mine so it could investigate the effects of repeated blasting on a residential house. Structural fatigue and damage were assessed over a 2-yr period. The house was subjected to vibrations from 587 production blasts with particle velocities that ranged from 0.10 to 6.94 in/s. Later, the entire house was shaken mechanically to produce fatigue cracking. Failure strain characteristics of construction materials were evaluated as a basis for comparing strains induced by blasting and shaker loading to those induced by weather and household activities. Cosmetic or hairline cracks 0.01 to 0.10 mm wide occurred during construction of the house and also during periods when no blasts were detonated. The formation of cosmetic cracks increased from 0.3 to 1.0 crack per week when ground motions exceeded 1.0 in/s. Human activity and changes in temperature and humidity caused strains in walls that were equivalent to those produced by ground motions up to 1.2 in/s. When the entire structure was mechanically shaken, the first crack appeared after 56,000 cycles, the equivalent of 28 yr of shaking by blast-generated ground motions of 0.5 in/s twice a day.

RI 8897. Ti-6Al-4V Alloy Castings Prepared in Zircon Sand Molds and the Effect of Hot Isostatic Pressing, by Jack I. Paige, Philip G. Clites, and Jack L. Henry. 1984. 16 pp. 10 figs. The Bureau of Mines conducted studies to provide data on the room temperature mechanical properties of Ti-6Al-4V alloy cast in waterglass-bonded zircon sand and to determine the effect of hot isostatic pressing (HIP) on these properties. Data on the cast and annealed Ti-6Al-4V alloy were compared with published data for forged and investment-cast Ti-6Al-4V alloy. The average Charpy V-notch impact strength compared favorably with the typical values of 17 ft•lbf for wrought material and 19.2 ft•lbf for investment-cast material. The room temperature mechanical properties of cast and annealed material compared favorably with published values for investment-cast Ti-6Al-4V alloy and exceeded the specifications for (1) titanium and titanium alloy castings, grade C-5 according to ASTM B367–69, and (2) titanium alloy bars and forgings as specified in AMS4928H, except for the AMS4928H minimum requirement for reduction in area (25 pct). The minimum requirements are tensile strength, 130 ksi; yield strength, 120 ksi (0.2 pct); and elongation, 6 pct. None of the specimens tested met the AMS4928H minimum requirement for reduction in area. The HIP process healed the internal casting porosity in the test specimens, but the fatigue strength was not significantly improved. The fatigue properties of both the cast and cast plus hot isostatically pressed castings were significantly lower than those of wrought products.

RI 8898. The Effect of Water Vapor and Water Droplets on the RAM-1 (Preliminary Results), by R. P. Vinson, K. L. Williams, G. H. Schnakenberg, Jr., and N. Jayaraman. 1984. 11 pp. 8 figs. The Bureau of Mines examined the effects of high humidity and water droplets on the GCA Corp. real-time aerosol monitor (RAM-1), which uses a 10-mm cyclone preseparator. Tests were conducted both in a laboratory and in a full-scale model mine entry. The laboratory tests were conducted in a test chamber saturated with moisture and water droplets. Under these extreme conditions, the RAM-1 responded by indicating dust concentrations of 1½ to 2 mg/m³, although the air was dust free. Within the first 2 h of each test, water accumulated in the cyclone and affected the cyclone particle separation characteristics, resulting in readings of 3 to 4 mg/m³. In addition, condensation formed inside the RAM-1 case and affected the liquid crystal display. However, the full-scale mine entry tests revealed that the RAM-1 can function acceptably in an atmosphere of water vapor and water droplets similar to the most severe conditions found in an underground mine.

RI 8899. Scale Inhibitors and Slow-Release Polymers for Mine Water Treatment Systems, by T. E. Ackman, G. R. Watzlaf, T. J. Fox, and R. L. P. Kleinmann. 1984. 14 pp. 14 figs. Scale inhibitors and slow-release polymers were tested by the Bureau of Mines at mine drainage treatment facilities. The scale inhibitors were investigated to determine their effectiveness in controlling gypsum ($CaSO_4$) scale; the polymers were investigated to determine their effectiveness for increasing settling rates of suspended iron hydroxide. Two types of scale inhibitors were tested at a site having a severe $CaSO_4$ scaling

problem. Both proved to be effective in controlling scale formation; in addition, one caused the dissolution of $CaSO_4$ deposits. Slow-release polymers were tested at three mine drainage treatment facilities. These gelatinous polymeric flocculants were found to be convenient and easy to use, but only effective when pH could be controlled.

RI 8900. Partial Replacement of Chromium in Austenitic Stainless Steels by Molybdenum, Copper, and Vanadium, by S. C. Rhoads, S. J. Bullard, and M. L. Glenn. 1984. 13 pp. The Bureau of Mines is investigating low-chromium alloy substitutes for type 304 stainless steel (type 304 SS). The purpose of the research is to reduce the chromium content in austenitic stainless steels used for corrosion-resistant applications. Nine Fe-9Cr-12Ni alloys containing additions of 0 to 5 pct Mo, 0 to 2 pct V, and 0 to 2 pct Cu were selected for evaluation. All of the experimental alloys containing 5 pct Mo and an alloy containing 2Mo-2V-2Cu possessed structure and tensile strengths similar to those of type 304 SS. Alloys containing 5Mo-2V and 5Mo-2V-2Cu had acceptable welding properties as measured by the Varestraint test. Alloys containing at least 2 pct Mo had corrosion resistance comparable to that of type 304 SS in solutions of nitric acid, phosphoric acid, acetic acid, and citric acid. In chlorides, all the experimental alloys were susceptible to localized corrosion and stress corrosion cracking similar to that of type 304 SS. The corrosion properties were established by weight-loss tests, electrochemical polarization tests, and stress-corrosion cracking tests. An Fe-9Cr-12Ni-5Mo-2V alloy and an Fe-9Cr-12Ni-5Mo-2V-2Cu alloy had a combination of welding properties, tensile properties, and corrosion resistance that were most comparable to those of 304 SS.

RI 8901. A Surface Resistivity Method for Measuring Hydrologic Characteristics of Jointed Formations, by Patricia J. Leonard-Mayer. 1984. 45 pp. 44 figs. A Bureau of Mines surface resistivity method has been used to determine the joint strike and coefficient of anistropy of jointed, near-surface formations at five study areas. The field studies demonstrate the use of rotated, or azimuthal, Wenner-Lee arrays for determining the strike of predominant joint sets. The results of the field studies include the following: in a formation having a predominant, vertical joint set, the maximum value of the apparent resistivity (ρ_a) occurs in the same direction (azimuth) as the joint strike; the polar coordinate graph of ρ_a for such a formation is approximately elliptical; the coefficient of anisotropy (λ) can be calculated from the field data, and values of λ for jointed formations are in the same range of values reported for layered formations; values of λ are higher at mined sites than at unmined sites. The azimuthal resistivity method and horizontal profiling were used at a site in Pennsylvania to delineate a zone of intensely jointed and fractured bedrock that provided a flow path from a surface stream to a mine. Analysis of the data has been based on a simple model of a jointed formation having a single joint set; the success achieved to date indicates the need for a more complex model and additional field data.

RI 8902. Effect of Clay Stabilizers on Permeability of Clayey Ore, by Kenneth E. Hjelmstad. 1984. 13 pp. 7 figs. In situ leach mining operations often encounter difficulty maintaining adequate leach solution flow into the ore formation. Swelling and dispersion of clay particles in the formation are often responsible for this permeability loss. Permeability and leaching tests were done in the laboratory on clayey ores to evaluate a clay-stabilizing polymer's effectiveness in preventing these problems. Test results indicate that treating the ores with the stabilizer could maintain permeabilities two to five times greater than the long-term permeabilities present in untreated ores. Both alkaline (pH 8.5) and acidic (pH 2.0) leaches were used in the permeability-leaching tests. Since in situ leaching throughput rate is directly related to permeability, these results also indicate a potentially beneficial effect on operating parameters such as capacity and injection pressure. To determine the reasons for the success of the clay stabilizers, an investigation was conducted to determine the effect of the stabilizer on clay swelling and dispersion. Clay-swelling tests indicated that the clay stabilizer reduced clay swelling. Zeta potential measurements made on fine clay particles treated with the stabilizer were compared to measurements made on untreated particles and indicated that the stabilizer was electropositive and, therefore, could reduce the degree of negative charge on the particles and their tendency to disperse or migrate.

RI 8903. Continuous Beneficiation of Dolomitic Phosphate Ores, by B. E. Davis, T. O. Llewellyn, and C. W. Smith. 1984. 14 pp. 3 figs. Over 80 pct of domestic phosphate rock, which is the starting material for phosphorus-containing fertilizers, comes from central Florida deposits. As higher grade deposits are depleted, lower grade phosphate ores containing MgO in the form of dolomite are encountered. Treating high-MgO ores with present beneficiation technology will not yield a concentrate meeting specifications for acidulation. The Bureau of Mines conducted research on three high-MgO phosphate samples from south Florida. The samples contained, in percent, 5.4 to 10.2 P_2O_5, 1.9 to 7.6 MgO, and 35.3 to 60.1 acid insolubles. A technique of sizing, grinding, desliming, scrubbing, and redesliming was used to produce a feed suitable for continuous flotation studies. A conventional fatty acid-fuel oil rougher flotation followed by two to three cleaner stages resulted in concentrates containing, in percent, 30.7 to 31.5 P_2O_5, 0.6 to 1.3 MgO, and 2.5 to 4.8 acid insolubles. The P_2O_5 recovery from the flotation feed ranged from 55.1 to 89.7 pct. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8904. Corrosion of Friction Rock Stabilizers in Selected Uranium and Copper Mine Waters, by M. M. Tilman, A. F. Jolly III, and L. A. Neumeier. 1984. 23 pp. 7 figs. The Bureau of Mines evaluated corrosion resistance of Split Set friction rock stabilizer mine roof bolts to aid in better prediction of useful service life. Electrochemical corrosion testing was conducted utilizing an automated corrosion measurement system. Natural and/or synthetic mine waters from four uranium and two copper mines were the test media for the two types of high-strength, low-alloy (HSLA) steels from which Split Set stabilizers are manufactured, and for galvanized steel. Tests were conducted with waters of minimum and maximum dissolved oxygen content at in-mine water temperatures. Retrieved Split Set stabilizers were also evaluated for property changes. Galvanized steel was found to be far superior to the unprotected

steel in general corrosion resistance; limited tests indicate little tendency to pitting, contrary to behavior for the uncoated steel. Copper-bearing HSLA steel was slightly more corrosion resistant than non-copper-bearing HSLA steel. Statistical analyses resulted in development of equations relating dissolved oxygen, chloride, sulfate, and magnesium contents of mine waters to corrosion rates of the two HSLA steels (nongalvanized). An equation was developed that relates corrosion rates of galvanized steel to mine water temperature and dissolved oxygen content. Variable conditions in mine environments make corrosion damage difficult to predict and emphasize the need for corrosion prevention and control.

RI 8905. Sulfapave: Densifiable Sulfur Concrete Materials for Corrosive Environments, by W. C. McBee, T. A. Sullivan, and B W. Jong. 1984. 14 pp. 10 figs. Technology for the preparation of densifiable sulfur concrete (sulfapave) materials has been devised by the Bureau of Mines. The materials are intended as new construction materials for use in corrosive areas where conventional materials fail. A series of modified sulfur cements were developed, which can be used in combination with dense-graded aggregates to prepare sulfapave materials with excellent corrosion-resistant properties. The materials can be mixed, laid, and compacted into place with conventional hot-mix asphalt paving equipment. Mixture designs utilizing 5- to 30-pct-modified sulfur cements and dense-graded aggregates gave material properties ranging from rigid to flexible. Laboratory corrosion tests in sulfuric acid showed no material loss or deterioration of physical properties over a 1-year test period in concentrations ranging from 0 to 60 pct at ambient temperatures. Preliminary results on field testing the materials for durability to weathering, corrosion, and traffic have been excellent, with no evidence of failure in the materials.

RI 8906. Electrochemical Determination of Thermodynamic Properties of Bismuth Sesquioxide and Stannic Oxide, by Seth C. Schaefer. 1984. 15 pp. 5 figs. The Bureau of Mines investigated the thermodynamic properties of Bi_2O_3 (bismuth sesquioxide) and SnO_2 (stannic oxide). Equilibrium oxygen pressures of the Bi-Bi_2O_3-O_2 systems were measured by a high-temperature electromotive force (emf) method using a solid electrolyte tube of stabilized ZrO_2 (zirconia). The emf measurements yielded standard Gibbs energies of formation of Bi_2O_3 and SnO_2 from the elements. The enthalpy and temperatures for the α to δ phase transformation of Bi_2O_3 were determined. These data for Bi_2O_3 and SnO_2 were compared with previously reported measurements, and discrepancies were discussed. Standard enthalpies of formation of Bi_2O_3 and SnO_2 were derived by combining results from this investigation with auxiliary data from the literature.

RI 8907. Calcium Sulfide Precipitation of Mercury During Cyanide Leaching of Gold Ores, by R. G. Sandberg, W. W. Simpson, and W. L. Staker. 1984. 13 pp. 10 figs. Many gold-bearing ores throughout the Western United States contain small quantities of mercury. The presence of mercury not only decreases the gold-loading capacity of the activated carbon, but complicates the fire refining of cathodes and creates a potential health hazard. The Bureau of Mines investigated methods to limit mercury extraction during gold ore leaching and to remove mercury from cyanide leach solutions. Mercury dissolution was reduced from 40 to 10 pct by decreasing NaCN concentration from 20 lb to 0.34 lb per ton of solution at a pH of < 11. When 0.1 lb CaS per ton of ore was added to a leach slurry, mercury extraction was reduced from 27 to 0.4 pct. Less than 0.5 pct of the mercury was solubilized when < 0.1 lb CaS per ton of ore, along with lime and NaCN, was added to a simulated grinding circuit.

RI 8908. A Strong Acid-Weak Acid Method for Producing Aluminum Chloride Hexahydrate From Kaolinitic Clay, by D. J. Bauer, D. E. Shanks, and J. A. Eisele. 1984. 7 pp. 3 figs. The Bureau of Mines has conducted extensive studies on the recovery of alumina from kaolinitic clay by a HCl leaching-HCl sparging process. The current study reports a modification of the process, which involves a double-leaching system. The first leach of the calcined clay is made at as high a HCl acid strength as possible so that the dissolution of aluminum chloride hexahydrate ($AlCl_3 \cdot 6H_2O$) is suppressed. Most of the impurities, but very little aluminum, are soluble in the strong acid. After liquid-solid separation and washing, the solids are leached with recycled weak HCl, which dissolves the $AlCl_3 \cdot 6H_2O$. The pregnant liquor is separated from the gangue, and $AlCl_3 \cdot 6H_2O$ is crystallized from solution by injecting HCl gas. A proposed flowsheet is presented, and the effect of bleedstream size on $AlCl_3 \cdot 6H_2O$ purity is discussed.

RI 8909. Field Measurement of Rock Displacement and Support Pressure at 5,955-Ft Level During Sinking of Deep Circular Shaft in Northern Idaho, by M. J. Beus and M. P. Board. 1984. 11 pp. 8 figs. The Bureau of Mines, under a cooperative agreement with Hecla Mining Co., is conducting a rock mechanics study of the 6,200-ft-deep circular, concrete-lined Silver Shaft in northern Idaho. The objective of the project was to instrument and evaluate lining behavior and rock deformation when a deep shaft is constructed in a high in situ stress field and anisotropic rock mass. Rock mass displacements were monitored with multiple-position borehole extensometers. Liner stress and strain were measured with concrete pressure cells and embedment strain gauges. Field data from the 5,955-ft test level show that rock displacement is controlled by rock mass anisotropy. Liner stress and strain levels reflect the high in situ stress field as well as nearby station and raise construction. Maximum stresses measured in the lining, as a result of shaft excavation, are about one-third of its compressive strength. Subsequent loading pocket excavation resulted in significantly increased stress and strain levels in the liner. Continued monitoring and preliminary analysis of the data indicate that concrete-lined, circular shafts are stable for the high, unequal horizontal stress fields and rock anisotropy encountered in deep-level mining. Adjacent development work can be expected to significantly alter the initial stress and displacement conditions.

RI 8910. Centrifugally Cast Glass-Ceramic Pipe From Mining and Processing Wastes, by Arthur V. Petty, Jr. 1984. 29 pp. 12 figs. The Bureau of Mines has researched the utilization of mining and processing wastes as raw materials for the production of glass-ceramic pipe. Characterization of various wastes as to occurrence and chemical composition is reported. A computer program was developed and used to identify waste materials and mixes that would result in glass melts from which glass-ceramics could be produced after cooling and subsequent heat treat-

ments. The production of abrasion-resistant pipe from inexpensive and readily available domestic resources could offer an economical substitute for high-alloy steels containing the critical and strategic materials cobalt and chromium. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8911. Potash Recovery From Process and Waste Brines by Solar Evaporation and Flotation, by D. G. Foot, Jr., J. L. Huiatt, and L. J. Froisland, with an economic evaluation by Deborah A. Kramer. 1984. 27 pp. 25 figs. The Bureau of Mines investigated energy-efficient methods for recovering potash values from process and waste brines. Laboratory pan evaporation of four chloride brines produced crude salts containing predominantly sylvite, halite, and carnallite. Six sulfate-chloride brines produced crude salts containing primarily schoenite, kainite, leonite, sylvite, carnallite, and halite. Potash grades ranged from 7.2 to 22.2 pct K_2O, and recoveries from 84 to 99 pct. Sylvite flotation from chloride evaporites, with amine collector, recovered 90 to 97 pct of the potash in a concentrate containing 54.3 to 60.3 pct K_2O. Fatty acid flotation of the high-sulfate evaporite recovered 78 pct of the sulfate minerals in a 27.8-pct-K_2O concentrate. Flotation of the chloride minerals with amine collector recovered 80 pct of the potash in a 59.7-pct-K_2O concentrate. Solar evaporation of 10,000 gal of brine recovered 99 pct of the potash in a crude evaporite containing 24.5 pct schoenite and 20 pct sylvite. Continuous flotation in a 100-lb/h process research unit recovered over 95 pct of the potash in schoenite and sylvite concentrates containing 28.0 and 62.3 pct K_2O, respectively. An economic evaluation suggested a rate of return of 8 pct for a new facility and 9 pct if the process is adapted to fit an existing plant.

RI 8912. Thermodynamic Properties of Aegirine, by K. O. Bennington, R. R. Brown, and R. P. Beyer. 1984. 16 pp. 1 fig. The thermodynamic properties of aegirine, of composition $[(Na_{0.869}Fe^{3+}_{0.7362}Fe^{2+}_{0.16}Mn_{0.03}Ca_{0.1121})(Al_{0.141}Si_{1.9738})(O_6)]$, were experimentally determined at the Bureau of Mines as part of its efforts to advance minerals technology. The standard enthalpy of formation was determined by hydrofluoric acid solution calorimetry. Low-temperature heat capacities were determined by adiabatic calorimetry from 19.1 to 304.6 K. The derived standard entropy was determined. The heat capacity was measured over the range 348 to 1,198 K by differential scanning calorimetry. These experimentally determined data were combined with data from the literature to calculate the Gibbs energies of formation and equilibrium constants of formation over the temperature range of the measurements. Standard enthalpies of formation are given as functions of temperature.

RI 8913. Refractories for Dry Ash Coal Gasifiers, by L. Y. Sadler III, H. Heystek, Nancy S. Raymon, and Timothy A. Clancy. 1984. 48 pp. 25 figs. This report summarizes the findings of a 9-yr research program, sponsored by the U.S. Department of Energy and conducted by the Bureau of Mines, to evaluate refractory liner materials for coal gasifier reactors. Commercially available refractories were exposed to coal gasifier reactor environments, reproduced in the laboratory with a high-temperature, high-pressure test facility, followed by extensive postexposure evaluation. Thirty-six castable or gunnable refractories and cements and 24 refractory brick were evaluated. The behavior of castable refractories reinforced with stainless steel fibers was also examined. Gas environments that were evaluated included steam, H_2, CO_2, CO, and typical high- and low-Btu gas mixtures. Exposure pressures ranged from 100 to 1,000 psig, temperatures from 500° to 1,100° C, for periods from 50 h to 2,000 h. In some exposures, sodium and/or potassium hydroxide were introduced in order to simulate a high-alkali environment. It was found that intermediate- and low-alumina refractories produced from domestically available raw materials, rather than high-alumina refractories produced from imported raw materials, gave the best service as liner materials and that alkali attack was probably not a serious problem with most refractories. Based on the results of this program, good choices of refractory liner materials for gasifier reactors can be made. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8914. Effect of Drilling Fluids on Permeability of Uranium Sandstone, by Jon K. Ahlness, Donald I. Johnson, and Daryl R. Tweeton. 1984. 16 pp. 4 figs. The Bureau of Mines conducted laboratory and field experiments to determine the amount of permeability reduction in uranium sandstone after its exposure to different drilling fluids. Seven polymer and two bentonite fluids were laboratory-tested in their clean condition, and six polymer fluids were tested with simulated drill cuttings added. Sandstone cores cut from samples collected at an open pit uranium mine were the test medium. The clean fluid that resulted in the least permeability reduction was an hydroxyethyl cellulose polymer fluid. The greatest permeability reduction of the clean polymers came from a shale-inhibiting synthetic polymer. Six polymer fluids were tested with simulated drill cuttings added to represent field use. The least permeability reduction was obtained from a multipolymer blend fluid. A field experiment was performed to compare how two polymer fluids affect formation permeability when used for drilling in situ uranium leaching wells. For this test, the polymer fluid with the best laboratory results (multipolymer blend) was compared with a commonly used polymer fluid (guar gum) that gave poorer laboratory results. When fluid injection rates for the four wells drilled with the guar gum were compared with those for the four drilled with the multipolymer blend, no statistically significant difference was found.

RI 8915. In-Mine Installation of Passive Water Barriers, by Lung Cheng, Richard Pro, Dennis R. Malcolm, and Aldo L. Furno. 1984. 9 pp. 6 figs. The Bureau of Mines has installed passive water explosion barriers in two operating mines to determine their usefulness in U.S. coal mines. The primary objective of this field trial was to determine the effect of the explosion barriers on mining operations. Data were also obtained on the ability of the barriers to withstand the mine environment and on the effect of the barriers on belt operation, ventilation, worker travel, and rock dusting. Fifty barriers were installed at three separate beltway locations, and periodic inspections were made. A year after installation, no defects of the barriers or support hardware were detected, nor was any com-

plaint as to the presence of the barriers made by the mine personnel. To date, 2½ years after installation, the barriers have had no detrimental effect on rock dusting, belt operation, or ventilation. Costs of material, fabrication, and installation are reported herein.

RI 8916. Delayed Blasting Tests To Improve Highwall Stability—A Progress Report, by Virgil J. Stachura and Larry R. Fletcher. 1984. 24 pp. 19 figs. The Bureau of Mines conducted a series of delayed blasting experiments at a West Virginia contour coal mine that resulted in smoother highwalls. The highwalls were smoother owing to reduced overbreak and inherently safer owing to reduced likelihood of rockfall. Reduced overbreak was accomplished by an increase in the highwall hole delays, which changed the effective delay pattern geometry and the direction of burden movement. The blast delays in the highwall holes were 50 to 100 ms longer than the mine's nominal design pattern (flat V, 17- by 42-ms surface delays, 200-ms in-the-hole delay). The burden movement was effectively changed from a 45° angle to 90° with respect to the highwall. The results of the blast delay changes were evaluated using terrestrial photogrammetry to generate vertical profiles at regular intervals. This evaluation showed that delay changes produced generally smoother vertical profiles.

RI 8917. High-Temperature Relative Enthalpies of CuBr, by M. J. Ferrante and R. R. Brown. 1984. 10 pp. 1 fig. Relative enthalpies of CuBr from 298.15 to 1,301 K were measured at the Bureau of Mines to provide thermodynamic data needed for the advancement of mineral technology. The temperatures of transition were measured by differential scanning calorimetry and the standard enthalpies of transition (ΔH°_{tr}) by drop calorimetry. The combined results gave reversible transitions at 657 K with ΔH°_{tr} = 1.10 kcal/mol, at 741 K with ΔH°_{tr} = 0.51 kcal/mol, and at 759 K with an enthalpy of fusion (ΔH°_m) of 1.22 kcal/mol. An anomalous increase in heat capacity preceded the first crystal transition at 657 K. Tabulated values are listed for the standard relative enthalpy, heat capacity, entropy, and Gibbs energy function from 298.15 to 1,500 K. Standard relative enthalpies are also given in equation form and combined with thermodynamic data from the literature to derive values of standard enthalpies of formation and Gibbs energies of formation.

RI 8918. Reduced-Chromium Stainless Steel Substitutes Containing Silicon and Aluminum, by M. L. Glenn and D. E. Larson. 1984. 13 pp. 7 figs. The Bureau of Mines is conducting research on Fe-based alloys using Si and Al additions to reduce the Cr required for heat-resisting applications. Part of this research is being done to evaluate alloys containing (8-10)-Cr-(10-14)Ni-(0-8.5)Si-(0-4)Al to determine which of these alloys have austenitic structures, as well as fabrication properties and oxidation resistance sufficient to substitute for type 304 stainless steel. Based on initial results, an Fe-10Cr-11Ni-5Si alloy and an Fe-8Cr-13Ni-5Si alloy were selected for evaluation of oxidation, stress rupture, and tensile properties. Both alloys have oxidation resistance at 700° and 800° C that is better than that of type 304 stainless steel. The stress rupture strengths are less than that of type 304 stainless steel but significantly better than that of commercial heat-resisting steels with similar Cr contents. Yield strengths of the alloys were equivalent to that of type 304. Both alloys had high tensile strengths comparable to those of stainless steels that transform to martensite during straining (e.g., type 301). These alloys have weld-hot-cracking resistance comparable to that of type 304 stainless steel. This initial study shows that Si has potential as a substitute for Cr in stainless steels for heat-resisting applications.

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Aluminum, by Luke H. Baumgardner and Frank X. McCawley. 20 pp. 3 figs. (*Out of print.*)
Chromium, by John F. Papp. 21 pp. 2 figs.
Cobalt, by William S. Kirk. 16 pp. 2 figs.
Columbium, by Larry D. Cunningham. 14 pp. 1 fig.
Copper, by W. C. Butterman. 18 pp. 6 figs. (*Out of print.*)
Fluorspar, by Lawrence Pelham. 14 pp. 1 fig.
Gold, by J. M. Lucas. 17 pp. 2 figs. (*Out of print.*)
Iron Ore, by F. L. Klinger. 14 pp. 3 figs.
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Lead, by William D. Woodbury and John A. Rathjen. 18 pp. 3 figs.
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Nickel, by Scott F. Sibley. 18 pp. 2 figs. (*Out of print.*)
Phosphate Rock, by W. F. Stowasser. 18 pp. 6 figs.
Platinum-Group Metals, by J. Roger Loebenstein. 20 pp. 7 figs.
Potash, by James P. Searls. 10 pp. 2 figs.
Silver, by Robert G. Reese, Jr. 11 pp. 2 figs. (*Out of print.*)
Tantalum, by Larry D. Cunningham. 14 pp. 2 figs.
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NOTE: Out-of-print publications may be available from the National Technical Information Service. See the section "Reports Available From the National Technical Information Service" for price and order information.

IC 8811. Methodology for Evaluating Integral Gaussian Profiles, by Arthur B. Campbell III. 1980. 18 pp. 2 figs. This Bureau of Mines report describes a method that utilizes a computer program to evaluate integral Gaussian profiles of atomic concentration versus depth in a solid. The specific use illustrated involves profiling ion-implanted metals using proton-induced X-ray emission (PIXE) analysis and ion sputtering (IS) for sectioning.

IC 8812. Bureau of Mines Health and Safety Research. A Status Report Covering Nov. 1, 1978–May 31, 1979, by Staff, Bureau of Mines. 1980. 41 pp. This status report contains 39 individual reports on health and safety research projects now being conducted or recently completed by the Bureau of Mines. The reports on health research cover industrial hygiene, respirable dust, ventilation, noise control, and radiation hazards. The safety research reports cover industrial hazards, ground control, fire and explosion prevention, and methane control. Each report includes background information, a discussion of research progress, and an assessment of each project's current status.

IC 8813. Iron Oxide Pigments (in Two Parts) 2. Natural Iron Oxide Pigments—Location, Production, and Geological Description, by Janice L. W. Jolly and Cynthia T. Collins. 1980. 79 pp. 15 figs. This Bureau of Mines publication reviews the location, principal producers, and geologic occurrence of natural iron oxide pigment deposits. The most famous deposits are found in Cyprus, Iran, Spain, France, Italy, and the Federal Republic of Germany; significant deposits are also exploited in India, the Republic of South Africa, and the United States. Some other countries where iron oxide pigment deposits are, or have been, exploited include Argentina, Australia, Brazil, Burma, Canada, Chile, Egypt, Israel, Jordan, Kenya, Mexico, Morocco, Pakistan, Paraguay, Sweden, the United Kingdom, and Venezuela. Most iron oxide pigment deposits were derived by decomposition of rocks and minerals, resulting in the secondary redistribution and concentration of liberated iron into favorable sites of accumulation. Gossans, laterites, bog iron ores, karst sediments, river channel sediments, and contact metamorphic limestones are favorable sites for iron oxide pigment deposits. Large-scale sedimentary iron deposits such as the minette, Clinton, and black band ores, and Precambrian iron formations are also important pigment sources. Iron oxide pigments are both mined as a primary product and produced as a byproduct of mining other ores, such as iron ore, barite, or sulfides. Maps, tables of production and trade, and lists of producers are included where possible. (*Out of print.*)

IC 8814. Valuation of Potash Occurrences Within the Nuclear Waste Isolation Pilot Plant Site in Southeastern New Mexico, by Robert C. Weisner, Jim F. Lemons, Jr., and Luis V. Coppa. 1980. 94 pp. 32 figs. Current production costs and market conditions in the potash industry of the Carlsbad area were studied to determine the potential values of the potash mineral resource that would be lost or foregone if the Waste Isolation Pilot Plant (WIPP) facility is constructed on the proposed site in that area. The purpose of the WIPP project is to investigate the possibility of developing a nuclear waste disposal plant in the salt formations at the site. Mining and processing under the most favorable recovery systems were considered. Value determinations were based upon estimated operating and capital costs of current mine-mill operations in the Carlsbad area. This study was made for the Energy Research and Development Administration (ERDA) by members of the Federal Bureau of Mines Minerals Availability System staff. (*Out of print.*)

IC 8815. MILS: The Mineral Industry Location System of the Federal Bureau of Mines, by Andrew W. Berg and Fred V. Carillo. 1980. 24 pp. 16 figs. The Bureau of Mines Mineral Industry Location System (MILS) is part of the computerized Minerals Availability System (MAS), a comprehensive data base of known mineral deposits. MILS, the location subsystem of MAS, has become widely used by the minerals industry and organizations with land-use planning and land management responsibilities. Information on more than 135,000 mineral locations and processing plants in the United States is contained in the data base. This information includes the name, location, mineral commodity, type of operation, bibliography, and cross-references for each property or prospect. Computer-drawn map overlays at various scales showing clustered MILS locations and computer printouts keyed to those overlays are available for inspection and reproduction at the Bureau's Field Operations Centers at Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash. (*Out of print.*)

IC 8816. Minerals Health and Safety Contract Research, Development, and Demonstration in Fiscal Year 1980, by Staff, Division of Minerals Health and Safety Technology. 1980. 50 pp. This publication summarizes, for potential contractors and other interested parties, the research, development, and demonstration contract projects programed by the Bureau of Mines for fiscal year 1980 (October 1, 1979-September 30, 1980) under its Minerals Health and Safety Research program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the system technology required to create a healthier and safer working environment

for the Nation's mining and minerals processing workers. (*Out of print.*)

IC 8817. Minerals Health and Safety In-House Research, Development, and Demonstration in Fiscal Year 1980, by Staff, Division of Minerals Health and Safety Technology. 1980. 34 pp. This publication summarizes, for all interested parties, the research, development, and demonstration in-house projects programed by the Bureau of Mines for fiscal year 1980 (October 1, 1979-September 30, 1980) under its Minerals Health and Safety Research program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the system technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers (*Out of print.*)

IC 8818. The Physical Chemistry of Mineral-Reagent Interactions of Sulfide Flotation. Proceedings of Symposium Held at College Park, Md., April 6–7, 1978, compiled by Paul E. Richardson, Garrett R. Hyde, and Morris S. Ojalvo. 1980. 171 pp. This symposium was sponsored by the Bureau of Mines, U.S. Department of the Interior, in order to critically examine the state-of-the-art of sulfide flotation chemistry and to define current and emerging problems that should be emphasized in future fundamental research. The topics covered through invited papers include both reviews and recent research results in the areas of thermodynamics of reagent-mineral interactions; collector adsorption processes; the effects of solid-state point defects on flotation; activation and deactivation phenomena; the electrochemical role of oxygen in sulfide flotation; environmental problems in flotation; and selective flocculation of fines. Papers giving perspectives on flotation research in relationship to our national mineral requirements and the relationships between industrial flotation research and academics are also presented. An edited summary of the symposium follows the papers.

IC 8819. Analytical Chemistry of the Citrate Process for Flue Gas Desulfurization, by W. N. Marchant, S. L. May, W. W. Simpson, J. K. Winter, and H. R. Beard. 1980. 20 pp. 10 figs. The citrate process for flue gas desulfurization (FGD) is a product of continuing research by the U.S. Bureau of Mines to meet the goal of minimizing the objectionable effects of minerals industry operations upon the environment. The reduction of SO_2 in solution by H_2S to produce elemental sulfur by the citrate process is extremely complex and results in solutions that contain at least nine different sulfur species. Process solution analysis is essential to a clear understanding of process chemistry and its safe, efficient operation. The various chemical species, the approximate ranges of their concentrations in citrate process solutions, and the analytical methods evolved to determine them are hydrogen sulfide ($\sim 0M$ to $0.06M$) by specific ion electrode, polysulfides (unknown) by ultraviolet (UV) spectrophotometry, elemental sulfur ($\sim 0M$ to $\sim 0.001M$ dissolved, $\sim 0M$ to $\sim 0.1M$ suspended) by UV spectrophotometry, thiosulfate ($\sim 0M$ *to* $\sim 0.25M$) by iodometry or high performance liquid chromatograph (HPLC), polythionates ($\sim 0M$ *to* $\sim 0.01M$) by thin layer chromatography (TLC), dithionite (searched for but not detected in process solutions) by polarography or TLC, bisulfite ($\sim 0M$ to $0.2M$) by iodometry, sulfate ($\sim 0M$ to $1M$) by a Bureau-developed gravimetric procedure, citric acid ($\sim 0M$ to $0.5M$) by titration or visible colorimetry, glycolic acid ($\sim 0M$ to $1M$) by HPLC, sodium ($\sim 1.5M$) by flame photometry, and chloride by argentometric titration.

IC 8820. Supply Analysis Model (SAM): A Minerals Availability System Methodology, by Robert L. Davidoff. 1980. 45 pp. 10 figs. Growing domestic and global demands for mineral resources have established an imperative need for developing comprehensive, versatile mineral supply analysis evaluation tools. The Minerals Availability System (MAS) of the Bureau of Mines is meeting this need with its computerized Supply Analysis Model (SAM). This paper describes the SAM system and the quantitative methods used by the MAS for mineral supply analyses. The MAS evaluating process consists of deposit identification, tonnage and grade determinations, engineering and cost evaluations, financial analyses, and supply curve generation. MAS has developed this computerized system primarily to facilitate the maintenance of data information for the constructing of commodity supply curves. The SAM system presently has the analytical capabilities of simultaneously (1) evaluating many mineral deposits, (2) updating mineral supply information to reflect inflationary changes in costs and prices, and (3) conducting sensitivity analysis to determine impacts on mineral supply under various conditions. Many potential users in both government and industry will find the SAM system a valuable tool for policy analysis, forecasting, and planning. The SAM system has been constructed so that any types of information that are similar to the data elements in the MAS data base may be used to perform supply studies. The storage space needed for the SAM system's programs, files, and output data is approximately 14 million characters. (*Out of print.*)

IC 8821. Availability of Critical Scrap Metals Containing Chromium in the United States. Superalloys and Cast Heat- and Corrosion-Resistant Alloys, by LeRoy R. Curwick, Walter A. Petersen, and Harry V. Makar. 1980. 51 pp. 11 figs. This Bureau of Mines report presents the results of a study conducted to assess the domestic availability of chromium from superalloy and cast heat- and corrosion-resistant alloy scrap material. Six alloy classes included in this survey were investment cast, hardfacing, and wrought nickel- and cobalt-base alloys, wrought nickel-iron-base alloys, and heat- and corrosion-resistant alloy castings. Data were collected for 1976 on metallic scrap generation, use patterns, and production practices for these alloy producing and using industries. A model was developed that allowed an assessment of the materials flow circuits within the industries that produce these alloys. The types, amounts, sources, secondary products, and ultimate destinations of chromium-containing metallic scrap for the six alloy classes were determined. Regarding the overall recycling efficiency of these alloy producing and using industries, of the 580.9 million pounds of scrap generated from these six alloy classes in 1976, about 72 percent (416.8 million pounds) was remelted by the same alloy-producing industries, about 18 percent (104.9 million pounds) was downgraded into stainless and low-alloy steels, about 3 percent (19.7 million pounds) was exported, and about 7 percent (39.5 mllion pounds) was lost through landfill or other disposal or service wastage. The lost material is primarily contaminated oxides for which recovery is currently uneconomic. How-

ever, the 124.6 million pounds of scrap material downgraded or exported in 1976 contained potentially recoverable critical strategic elements. The amount of scrap material lost to the six alloy-producing industries in this manner contained 22.1 million pounds of chromium, 53.4 million pounds of nickel, 5.9 million pounds of cobalt, 35.9 million pounds of iron, and 7.3 million pounds of other alloying elements. (*Out of print.*)

IC 8822. Availability of Critical Scrap Metals Containing Chromium in the United States. Wrought Stainless Steels and Heat-Resisting Alloys, by Charles L. Kusik, Harry V. Makar, and Michel R. Mounier. 1980. 51 pp. 6 figs. As part of an effort to establish the extent of the domestic chromium supply that could be exploited in case of adverse changes in international chromium production and trading patterns, a two-part study was conducted for the Bureau of Mines, to assess the domestic availability of critical metals in scrap containing significant amounts of chromium. This report describes the part of the study that deals with wrought stainless steels and heat-resisting alloys. Data were collected on types of scrap, sources, quantities, and ultimate disposition, leading to the conclusion that in 1977 about 62,000 tons of contained chromium was unrecycled. Unrecovered obsolete stainless steel scrap accounts for most of these uncollected chromium values. Error margins in the amount of uncollected scrap are estimated to be 10 to 20 percent. (*Out of print.*)

IC 8823. Surface Coal Mining Reclamation Equipment and Techniques. Proceedings: Bureau of Mines Technology Transfer Seminars, Evansville, Ind., June 3, 1980, and Denver, Colo., June 5, 1980, compiled by Staff — U.S. Bureau of Mines. 1980. 80 pp. 36 figs. These proceedings consist of papers presented at two Bureau of Mines Technology Transfer Seminars in early 1980 for the purpose of disseminating recent advances in mining technology related to surface coal mining reclamation.

IC 8824. Mineral Depletion Allowances and U.S. Import Dependence, by Phillip N. Yasnowsky and Annette P. Graham. 1980. 13 pp. This Bureau of Mines report examines the percentage depletion allowance rate structure in relation to several criteria that are indicative of U.S. mineral import dependence. These criteria are the minerals considered as strategic and critical for stockpiling purposes, the ratio of reserves to forecast cumulative demand (1976-2000) for selected minerals, and the U.S. net import reliance as a percentage of apparent consumption (1978), also for selected minerals. In general, it was found that there does exist a direct, although not perfect, relationship between the percentage depletion allowance rates and the degree of import dependence as indicated by these three criteria. The higher percentage rates tend to be associated with those minerals for which the United States is, or will likely be, heavily dependent on foreign sources. In addition, a basic discussion of the mineral depletion allowance is provided, including numerical examples illustrating the computation of the allowance under several assumptions. Also, the percentage depletion allowance rates for individual minerals are tabulated. (*Out of print.*)

IC 8825. Bureau of Mines Statistical Projection Methodology of U.S. Mineral Consumption by End Use: Aluminum as an Example by William Y. Mo and Barry W. Klein. 1980. 109 pp. 89 figs. This Information Circular provides a detailed background documentation of how the Bureau of Mines projects U.S. mineral demand to the year 2000. These statistical projections serve as a quantitative basis for contingency forecasting of the low, high, and probable U.S. demand for nonfuel minerals by end-use categories and are published in the Bureau of Mines Mineral Commodity Profiles and Mineral Facts and Problems series. Aluminum is used as an example in this study. (*Out of print.*)

IC 8826. Materials Recycling. An Overview of the Sixth Mineral Waste Utilization Symposium, compiled by S. A. Bortz and K. B. Higbie. 1980. 157 pp. 28 figs. This Bureau of Mines report reviews the information presented at the Sixth Mineral Waste Utilization Symposium cosponsored by the Bureau of Mines, U.S. Department of the Interior, and the ITT Research Institute. Environmental scientists and engineers from nine countries participated in the symposium, which was held May 2-3, 1978, at the Chicago campus of ITT Research Institute. The 56 papers presented on the reclamation and recycling of mining and mineral wastes, municipal solid waste, industrial wastes, and scrap metal are summarized herein.

IC 8827. Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1980, by Staff, Division of Minerals Environmental Technology. 1980. 41 pp. This publication summarizes the in-house and contract research and development projects programed for fiscal year 1980 by the Bureau of Mines under its Minerals Environmental Research activity. The document provides a mechanism for interested parties, including potential contractors, to gain insight into ongoing and projected work of the Bureau's environmental research efforts. Research to identify and correct environmental problems associated with mining and metallurgical operations has long been an integral part of the Bureau's mission. Through the years, efforts of various Bureau programs have yielded valuable information on the origin and control of many of these problems. With the reorganization of the Bureau of Mines in 1979, the Minerals Environmental Technology program was structured to consolidate these efforts into a single program that will systematically investigate all aspects of mining- and processing-related environmental pollution and damage—from initial discovery of the mineral resource to ultimate return of the land to productive use. In fiscal year 1980, the Bureau received an appropriation of about $21 million to conduct research and development work on these problems.

IC 8828. Surface Mine Truck Safety. Proceedings: Bureau of Mines Technology Transfer Seminars, Minneapolis, Minn., June 25, 1980, Birmingham, Ala., July 9, 1980, and Tucson, Ariz., July 24, 1980, compiled by Staff —Bureau of Mines. 1980. 61 pp. 41 figs. These proceedings consist of an introduction and four descriptive papers. The first paper is an update on fire protection for large haulage vehicles, the second paper is concerned with improved visibility systems for large haulage vehicles, the third paper is on improved ladders for large haulage vehicles, and the fourth paper is concerned with large haulage vehicle operator training systems.

IC 8829. Review of Horizontal Drilling Technology for Methane Drainage From U.S. Coalbeds, by Gerald

L. Finfinger and Joseph Cervik. 1980. 20 pp. 13 figs. This Bureau of Mines publication reviews underground methane drainage programs being conducted in various coalbeds. Equipment used in drainage programs such as drills, underground pipelines, and methane monitoring systems is described.

IC 8830. A Statistical Analysis of Coal Mine Fire Incidents in the United States From 1950 to 1977, by L. Bruce McDonald and William H. Pomroy. 1980. 42 pp. 3 figs. This Federal Bureau of Mines publication is a statistical analysis of all surface and underground coal mine fires reported in the United States from 1950 to 1977. Accounts of selected nonreportable fires and opinion data gathered via interviews with mine safety directors were separately analyzed. Both reported and nonreportable fires were analyzed by time trends, State, ignition source, burning substance, location in mine, equipment, detection, duration, injuries, fatalities, and successful extinguishing agents. It was found that the majority of all mine fires were electrical in origin. The equipment most frequently involved in underground fires was conveyor belts, and in surface fires, it was crushers and/or breakers. Underground fires occurred most often near the working face. Water and hand-portable extinguishers were the most common method of extinguishment.

IC 8831. Helium Resources of the United States, 1979, by B. J. Moore. 1980. 27 pp. 7 figs. The Bureau of Mines has estimated helium resources of the United States at 727 billion cubic feet as of January 1, 1979. These resources are divided into four categories in decreasing degrees of assurance of their existence: (1) Helium in storage and in measured natural gas reserves, 185 billion cubic feet; (2) helium in indicated natural gas resources, 150 billion cubic feet; (3) helium in hypothetical natural gas resources, 186 billion cubic feet; and (4) helium in speculative natural gas resources that makes up the remaining 206 billion cubic feet. The identified helium reserves, which are made up of that in measured and indicated natural gas categories, are further divided into depleting, nondepleting, and stored classifications. The depleting resources are those that are associated with natural gasfields that are, or will be, produced for the natural gas they contain. All of the helium in undiscovered natural gas resources are included in this classification. These depleting resources comprise 600 billion cubic feet of the total resource base. The nondepleting helium resources are estimated to total 88 billion cubic feet. There is 39 billion cubic feet of helium in storage in Cliffside gasfield near Amarillo, Tex. (*Out of print.*)

IC 8832. Automatic Fire Protection Systems for Surface Mining Equipment, by William H. Pomroy and Kenneth L. Bickel. 1980. 38 pp. 32 figs. Fire on surface mining equipment is a serious hazard to life and property. The Bureau of Mines, through a program of contract and in-house research, has developed and in-mine demonstrated reasonably priced, reliable automatic fire protection systems to deal with this problem. This report reviews the development and subsequent testing of systems for haulage trucks, front-end loaders, coal augers, dozers, drills, and shovels. A variety of fire sensors, extinguishing agents, and control systems are discussed in the context of mine equipment designs and operating environments.

IC 8833. Analyses of Natural Gases, 1979, by B. J. Moore. 1980. 100 pp. 1 fig. This publication contains analyses and related source data for 269 natural gas samples from wells and pipelines in 18 States. All of the samples were obtained and analyzed during calendar year 1979 as a part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted in the United States by the Bureau of Mines since 1917. In late 1965, the survey was expanded to include foreign gasfields. The analyses published herein were made by mass spectrometer and a special helium analysis apparatus, which are described in Bureau of Mines Bulletins 486 and 576. (*Out of print.*)

IC 8834. The Impact of U.S. Railroad Abandonment on Domestic Mineral Industries, by Ronald F. Balazik. 1980. 18 pp. 1 fig. This Bureau of Mines study is intended to identify and evaluate potential effects of impending large-scale U.S. rail line closings (abandonment) on domestic nonfuel mineral industries. This is the first nationwide study of rail abandonment impacts focused on nonfuel minerals. The analysis presented is based principally on a survey of 200 rail freight records and on statistical tests that correlated 2,000 points in the Bureau's Mineral Industry Location System (MILS) with 700 prospective abandonments throughout the United States. The conclusions derived from the analysis can be useful in evaluating proposed national rail abandonment policy and legislation regarding nonfuel mineral shipping. Among these conclusions are the following: (1) Certain mineral materials (especially fertilizers) are likely to account for a large percentage of the rail traffic affected by abandonment in the next few years, but the total tonnage involved will be small; (2) abandonment will adversely affect some mineral shippers, particularly local short haulers; and (3) abandonment could significantly reduce the opportunity to develop new resources or reopen defunct mining facilities. Despite these problems, however, the data examined in this study do not indicate that current abandonment trends will cause widespread disruption of domestic nonfuel mineral shipping. (*Out of print.*)

IC 8835. Guide to Substation Grounding and Bonding for Mine Power Systems, by Wils L. Cooley and Roger L. King. 1980. 27 pp. 16 figs. Although electric utility companies have been active in grounding and bonding within substations, the mining engineer or mine electrical engineer is not involved to the extent that he can be fully up-to-date on the most effective practices for substation construction. The coal mine power system is grounded in a fundamentally different way from most other industrial power systems and is subject to considerable Federal and State regulations. At this time, there is little information that is directly applicable to the mine situation, especially if the substation must be built in an area of limited size or in low-conductivity earth. The objective of this guide is to provide specific engineering information to the mining industry. Using as little theory as possible, it was written to be general enough to cover most substations, but specific enough to provide direct help with each substation. It will attempt to recommend practice that is in agreement with present Federal rules and regulations.

IC 8836. The U.S. Copper Mining Industry. A Perspective on Financial Health, by T. T. Tomimatsu. 1980. 20 pp. 3 figs. This Bureau of Mines paper

investigates, explores, and analyzes the corporate structure dynamics and financial ratios to evaluate the economic health of the U.S. copper producers. It highlights the corporate policy options and measures of corporate profitability and suggests that a competitive domestic copper industry will exist in the future. The study highlights the activities of 14 selected major copper-producing companies, including their subsidiaries or affiliates, that were responsible for more than 95 percent of the total U.S. production in each of the years since 1969. The selected firms are not all primarily in the business of producing copper. Several of the large producers are classified by the financial institutions as integrated oil and gas enterprises. (*Out of print.*)

IC 8837. Noise Control of Diesel-Powered Underground Mining Machines, 1979, compiled by J. H. Daniel, J. A. Burks, R. C. Bartholomae, R. Madden, and E. E. Ungar. 1981. 29 pp. 23 figs. This Bureau of Mines report presents results of a survey of underground mining equipment and of two demonstration programs showing the feasibility of quieting a load-haul-dump (LHD) machine and a personnel vehicle. Typical noise levels are presented for the major machine types used in underground mines, along with estimates of the noise overexposure of miners who operate or work near these machines. General principles of noise control are explained, and the application of these principles is illustrated in the description of modifications made to the LHD machine and the personnel vehicle. The noise control package installed on the personnel vehicle lowered its noise level by 14 dbA after 4 months of operation, and inspection of the LHD machine after 2½ years of operation with the modifications showed its noise level 7 dbA lower than that of the unmodified machine. Noise dosimeter measurements indicated that both machines were in compliance with Federal noise regulations for a typical shift.

IC 8838. Polychlorinated Biphenyls: Regulations and Substitutes. A Compliance Manual for the U.S. Mining Industry, by R. A. Westin, R. P. Burruss, B. Woodcock, and R. L. King. 1981. 66 pp. 23 figs. Polychlorinated biphenyls (PCB's) have been widely utilized as fire-resistant dielectric coolants in electrical equipment used in mining applications, including transformers, capacitors, electric motors, and electromagnets. In addition, PCB's have been used in hydraulic fluids and heat-transfer fluids and are present in many oil-filled transformers. The U.S. Environmental Protection Agency (EPA) recently banned the manufacture of PCB's and equipment using PCB's, and imposed strict requirements on the continued use and disposal of existing PCB equipment. This manual discusses the EPA requirements, suggests ways to decrease the risks resulting from continued use of PCB equipment, and surveys the non-PCB equipment that is available as replacements for the PCB electrical equipment presently used in mines.

IC 8839. Minerals Health and Safety Contract Research, Development, and Demonstration in Fiscal Year 1981, by Staff, Division of Minerals Health and Safety Technology. 1981. 36 pp. This publication summarizes, for potential contractors and other interested parties, the research, development, and demonstration contract projects programed by the Bureau of Mines for fiscal year 1981 (October 1, 1980-September 30, 1981) under its Minerals Health and Safety Technology program. Contingencies may require that a significant portion of the program be deferred into fiscal year 1983. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the systems technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers.

IC 8840. Minerals Health and Safety In-House Research, Development, and Demonstration in Fiscal Year 1981, by Staff, Division of Minerals Health and Safety Technology. 1981. 32 pp. This publication summarizes, for all interested parties, the research, development, and demonstration in-house projects programed by the Bureau of Mines for fiscal year 1981 (October 1, 1980-September 30, 1981) under its Minerals Health and Safety Technology program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the system technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers.

IC 8841. The Noise Exposure of Operators of Mobile Machines in U.S. Surface Coal Mines, 1979, by J. H. Daniel, J. A. Burks, R. C. Bartholomae, R. Madden, and E. E. Ungar. 1981. 24 pp. 10 figs. This report, summarizing the results of two studies sponsored by the Bureau of Mines, presents information on the types of mobile machines used in surface coal mines in the United States, and the amount of noise to which miners are exposed. Data consist of a calculated value of the probability of noise overexposure caused by specific equipment. These data are extrapolated to estimate the number of overexposed operators. Bulldozers were identified as the major contributors to noise overexposure, and the report presents results of a Bureau-funded program on the feasibility of providing retrofit noise control on bulldozers.

IC 8842. Preventing Large-Battery Explosions, by D. Cummins and S. F. Pangerl. 1981. 11 pp. 2 figs. This Information Circular presents a brief history of the lead-acid battery and describes ways to prevent serious injury from battery explosions when servicing and charging lead-acid batteries, particularly in the surface mining industry. The Mining Safety and Health Administration (MSHA), U.S. Consumer Product Safety Commission, battery manufacturers, and the mining industry have all contributed information as well as recommendations for injury-free handling for this report.

IC 8843. High-Temperature Corrosion Resistance of Ceramic Materials, by T. A. Clancy. 1981. 31 pp. Since many new mineral processing systems under development can impose severe corrosive conditions on construction materials, the Bureau of Mines reviewed and assessed the literature on corrosion resistance of ceramic materials. Corrosive conditions were categorized as (1) acids and aqueous solutions, (2) glass and slag/metal melts, and (3) gases. Information on the corrosion resistance of ceramic materials, generally, is disseminated by many sources, each of which is interested in specific corrosive environments. Based on this survey, it was noted that (1) the development of standardized tests is needed to study solution-type corrosion of ceramics, (2) slag/melt corrosion data are the most comprehensive of the available data, and (3) better

definition of corrosion mechanisms in gaseous environments is needed. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama. (*Out of print.*)

IC 8844. Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1981, by Staff, Division of Minerals Environmental Technology. 1981. 48 pp. This publication summarizes the in-house and contract research and development projects programmed for fiscal year 1981 by the Bureau of Mines under its Mineral Environmental Technology activity. The document provides a mechanism for interested parties, including potential contractors, to gain insight into ongoing and projected work of the Bureau's environmental research efforts. Research to identify and correct environmental problems associated with mining and metallurgical operations has long been an integral part of the Bureau's mission. The environmental research and demonstration activities of the Bureau were consolidated in 1979 with the formation of the Minerals Environmental Technology program, which is directed toward the elimination or reduction of environmental problems associated with the extraction and processing of minerals. Among the efforts underway are development of data and technology for assessing the potential environmental impact of minerals development, for monitoring minerals extraction operations, and for establishing viable reclamation requirements on abandoned mine lands; development and demonstration of technology for control of environmental disturbances during minerals extraction operations; development and demonstration of land reclamation and mine closure techniques to restore or enhance the productive use of mined lands; development of engineering techniques that incorporate state-of-the-art mining environmental technology in the design and planning of minerals extraction operations; development and demonstration of new mining systems that greatly reduce or eliminate the adverse environmental impacts of minerals extraction; and providing the technologic base for Federal, State, and local establishment of environmental standards for mining operations. Included in the mineral-processing-related work are projects to clean mineral-processing waters; demonstrate a Bureau process for scrubbing SO from powerplant stack gas; recover dissolved minerals from process streams; stabilize discarded dusts, slags, and tailings; remove hazardous contaminates from byproduct wastes; reduce generation of waste solids; and improve metallurgical process engineering to eliminate pollution. Approximately $21 million was appropriated for this work in fiscal year 1981.

IC 8845. State Regulations Pertaining to the Use of Internal Combustion Engines Underground, by Robert W. Waytulonis. 1981. 76 pp. The mining regulations of all 50 States were reviewed by the Bureau of Mines, and those parts pertaining to the use of internal combustion (IC) engines (particularly diesel engines) in underground mines or confined spaces were extracted. Also extracted were subjects associated with the use of IC engines; for example, storage and handling of flammable liquids, maintenance, and ventilation requirements. As the laws now stand, 29 States have specific regulations that affect the operation of diesel engines in underground coal and/or metal and nonmetal mines. The other States have no regulations because either they have no mining activities or they defer to Federal regulations. Six States have regulations expressly prohibiting the use of diesels in underground coal mines. Specific contacts (addresses and phone numbers) precede each State's regulations to facilitate inquiries about regulation revisions and interpretation. (*Out of print.*)

IC 8846. Pumped-Slurry Backfilling of Abandoned Coal Mine Workings for Subsidence Control at Rock Springs, Wyo., by G. J. Colaizzi, R. H. Whaite, and D. L. Donner. 1981. 100 pp. 61 figs. The Bureau of Mines, at the request of local authorities in Rock Springs, Wyo., investigated and conducted through contracts a multistage program of exploratory drilling and pumped-slurry backfilling of 15 areas of potential subsidence in abandoned mine workings underneath that community. Initially, the Bureau in 1969 had recommended a program of gravity blind flushing of some of the inaccessible mine voids, and in 1970 a new technique, the pumped-slurry injection process, was tested for the first time in a site adjacent to the city area of severe surface subsidence. Success of this initial testing program, and of a large-scale project in Scranton, Pa., led to further large-scale projects, funded by Congress, that resulted in the successful backfilling not only of all 15 target areas of potential subsidence in Rock Springs, but also of several areas in other States. Total cost of the projects in Rock Springs, including the original pumped-slurry test, was $3,243,993. A total of about 923,000 tons of sand was injected hydraulically into mine voids, rendering 178 acres of residential and central-downtown areas of Rock Springs less susceptible to subsidence damage. The pumped-slurry method was proved to be much superior to the gravity blind flushing method in terms of the amount of solids that could be injected underground through a single borehole. However, there are special conditions that make this technique more or less applicable in different areas or underground configurations, as noted in the report's conclusions. (*Out of print.*)

IC 8847. Control of Methane by Ventilation of Shafts During Raise Drilling, by Slavoljub D. Maksimovic. 1981. 11 pp. 8 figs. At some coal mines, methane gas is released during raise drilling. At the request of the Mine Safety and Health Administration (MSHA), U.S. Department of Labor, the Bureau of Mines conducted ventilation surveys at different raise drill sites to assess various methods of reducing methane concentration. The resulting data indicate that raise drill shaft cavities are ventilated by air compressors, vacuum pumps, auxiliary blower fans, and free intake air from the surface. The compressors, pumps, and fans operate simultaneously or separately. At the bottom of the shaft cavities, ventilation is controlled by regulators and airlocks. Methane is monitored, measured, and periodically sampled on the surface, at the bottom and at different levels in the shaft cavities. Maximum concentration of 3.5 percent was measured in one shaft in West Virginia. Air velocity down the raise drill shafts is always very low. Maximum recorded air down the drill stem was 3,000 cfm, which can be increased by adding air compressors. The best way to ventilate shaft cavities is through

the simultaneous use of air compressors and vacuum pumps. If the methane concentration cannot be reduced with additional compressors, then the inside diameter of the drill rod should be increased, or larger pilot hole drill bits should be used.

IC 8848. Cobalt Availability—Domestic. A Minerals Availability System Appraisal, by G. R. Peterson, D. I. Bleiwas, and P. R. Thomas. 1981. 31 pp. 5 figs. The Bureau of Mines evaluated the potential supply of cobalt from known domestic resources, both as a primary product from some deposits and as a byproduct from others, and found that U.S. production could play an important role in meeting U.S. cobalt needs by the mid-1980's. This production would be of a relatively short duration, however, with production declining significantly before the year 2000. As part of the study, a tonnage-price relationship was developed indicating the quantity of cobalt that could be produced from known cobalt-bearing deposits at various primary commodity prices and at a 15-percent rate of return on the required capital investment. All capital and operating costs are calculated in August 1980 dollars, and commodity prices are based on August 1980 prices. Known U.S. cobalt-bearing deposits which represent the current U.S. cobalt reserve base contain about 310,800 metric tons of cobalt in slightly over 1 billion metric tons of demonstrated mineralized material. Approximately 37 percent of the cobalt contained in the reserve base is considered recoverable using existing technology. Of this quantity, about 87,000 metric tons of cobalt is economically recoverable assuming a cobalt price of $25 per pound, a copper price of $1 per pound, and a lead price of $0.40 per pound. Assuming that the cobalt price decreases to $15 per pound, keeping copper and lead prices constant, the quantity that is considered economically recoverable declines to about 45,700 metric tons. Domestic cobalt consumption in 1979 was 7,900 metric tons (17.4 million pounds). Currently, no primary cobalt is produced from domestic resources, and none has been produced since 1971. (*Out of print.*)

IC 8849. Room and Pillar Retreat Mining. A Manual for the Coal Industry, by Peter W. Kauffman, Steven A. Hawkins, and Robert R. Thompson. 1981. 228 pp. 107 figs. This Bureau of Mines publication is designed primarily to provide mine engineers and production-level mine managers with the following: (1) Information to assist them in making the decision to retreat mine and in selecting the best retreat mining technique for specific mining conditions. (2) Information on mine planning that will enable them to design mine layouts for safe and efficient retreat mining. (3) Information that will enable them to develop a section foreman's handbook. The manual has been organized to gradually increase in level of detail as the reader progresses from beginning to end. Individuals interested in an overview of retreat mining can confine themselves to the first few chapters. Those interested in mine planning should read the middle chapters as well. Those interested in the development of a foreman's handbook should read the entire manual. (*Out of print.*)

IC 8850. Economic Significance of the Florida Phosphate Industry. An Input-Output (I-O) Analysis, by Anthony M. Opyrchal and Kung-Lee Wang. 1981. 62 pp. 17 figs. This Bureau of Mines study assesses the economic significance of the Florida phosphate industry to selected counties in Florida, the State of Florida, and the Nation; it also includes a brief survey of the industry's international impact. Based on forecasts of Florida phosphate production in 1981, and using constant 1977 dollars, estimates are given for 1981 for regional and national output, the value of this output, income, and employment created by the phosphate industry in Florida. Federal, State, and county tax revenues generated by the State's phosphate industry are also estimated for 1981. The concentrated impact of the phosphate industry on certain areas of Florida and on the State's regional industries is examined using economic base analysis complimented by an industrial complex approach. The industry's impact at the State and national levels is examined through input-output analysis. In addition, an attempt to forecast for 1990 the effects of constraints on phosphate rock mining as a result of economic conditions and other factors is included as an appendix to the report. Also discussed is the phosphate industry's importance to the U.S. balance of trade; U.S. agricultural production, including forward linkages; the U.S. sulfur industry; and the phosphate industry's importance to the production of fluorine and uranium byproducts from fertilizer manufacturing. (*Out of print.*)

IC 8851. Selection of Lixiviants for In Situ Uranium Leaching, by Daryl R. Tweeton and Kent A. Peterson. 1981. 35 pp. This Bureau of Mines publication provides information to assist in selecting a lixiviant (leach solution) for in situ uranium leaching. The cost, advantages, and disadvantages of lixiviants currently used and proposed are presented. Laboratory and field tests are described, and applications of geochemical models are discussed. Environmental, economic, and technical factors should all be considered. Satisfying environmental regulations on restoring groundwater quality is becoming an overriding factor, favoring sodium bicarbonate or dissolved carbon dioxide over ammonium carbonate. The cheapest lixiviant is dissolved carbon dioxide, but it is not effective in all deposits. Technical factors include clay swelling by sodium, acid consumption by calcite, and the low solubility of oxygen in shallow deposits. Laboratory leaching tests can provide useful data. However, they can be misleading if, for example, the ore is allowed to oxidize before testing or if distilled water instead of formation water is used for making solutions for permeability tests. Geochemical models presently are more useful for indicating trends in solubility than in reliably predicting concentrations. (*Out of print.*)

IC 8852. In Situ Mining Research. Proceedings: Bureau of Mines Technology Transfer Seminar, Denver, Colo., August 5, 1981, compiled by Staff—Bureau of Mines. 1981. 107 pp. 37 figs. These proceedings consist of an overview of the in situ mining research currently being carried out by the Bureau of Mines. The following papers emphasize two general aspects of the in situ mining method: the environment and productivity. Both areas are extremely important, particularly because in situ leach mining is a relatively new mining method from a commercial point of view. Topics covered include the restoration of ground water, the selection of lixiviants, in situ mining of commodities other than uranium, in situ mining costs, the application of resistance measurements to in situ mining, an acid leach mining case history, and the use of branched boreholes for in situ mining. A bibliography of Bureau of Mines publications on in situ mining is appended. (*Out of print.*)

IC 8853. Proceedings of the Workshop on Techniques for Measurement of Thermodynamic Properties, Albany, Oreg., August 21–23, 1979, compiled by N. A. Gokcen, R. V. Mrazek, and L. B. Pankratz. 1981. 438 pp. 101 figs. To improve communication among Government, industry, and academic researchers in the field of thermodynamics, the Federal Bureau of Mines sponsored a Workshop on Techniques for Measurement of Thermodynamic Properties in August 1979. Participants at the workshop presented 33 papers on the subjects of temperature measurement and control, general calorimetric techniques, low-temperature calorimetry, high-temperature calorimetry, galvanic cells, ionic solutions, and heterogeneous phase equilibria. A special invited lecture was presented by E. F. Westrum, Jr., on the resolution of lattice heat capacity. This Information Circular comprises the proceedings of the workshop and includes the texts of papers presented and discussion by attendees.

IC 8854. Minerals and the Tokyo Round of the MTN, by Daniel E. Sullivan. 1981. 18 pp. This Bureau of Mines publication examines the potential impact on minerals of the tariff and nontariff agreements that resulted from the Tokyo Round of the Multilateral Trade Negotiations, which were conducted under the auspices of the General Agreement on Tariffs and Trade. These agreements will affect minerals by reducing tariff levels and by changing rules by which they are traded internationally. (*Out of print.*)

IC 8855. Uranium Mine Ventilation Costs, by Robert C. Bates. 1981. 18 pp. 4 figs. This Bureau of Mines report converts published data on the cost of ventilating uranium mines to a common price base and analyzes these data to determine the cost per ton of uranium ore at various levels of radiation exposure control. There appears to be an exponential increase of cost as the radiation level is lowered. The 1967 base costs are extrapolated to present dollars, and some cost comparisons are given for other radiation control measures. (*Out of print.*)

IC 8856. Analyses of Natural Gases, 1980, by B. J. Moore. 1981. 236 pp. 1 fig. This publication contains analyses and related source data for 675 natural gas samples from wells and pipelines in 24 States and 5 foreign countries. The samples obtained and analyzed during calendar year 1980 are included in tables 1–4. Those samples included in tables 5–7 were collected during the years 1960 through 1979. However, permission to publish the analyses of those samples was not given until the past year when the operators were again contacted to seek release of the information. All of these samples were collected as a part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted in the United States by the Bureau of Mines since 1917. In late 1965, the survey was expanded to include foreign gasfields. The analyses published herein were made by mass spectrometer and a special helium analysis apparatus, which are described in Bureau of Mines Bulletins 486 and 576. (*Out of print.*)

IC 8857. Mine Waste Disposal Technology. Proceedings: Bureau of Mines Technology Transfer Workshop, Denver, Colo., July 16, 1981, compiled by Staff—Minerals Research. 1981. 70 pp. 53 figs. This Bureau of Mines publication consists of an overview of the mine waste management research currently being conducted by the Bureau. The following papers, given at a Technology Transfer Workshop, emphasize the increasing importance of research related to the safety and environmental considerations of mine waste disposal in recent years. Current work related to legislation passed in the last 10 years and their subsequent standards includes the development of adequate monitoring systems, development of stability and seepage prediction and control techniques, control of runoff water, and control of leaching solutions. Selected topics are included here that cover coal mine waste disposal, embankment slope stability monitoring, flow failures of mine tailings impoundments, and controlled burnout of abandoned coal mine fires. The projects described provide a current documentation of problems being addressed.

IC 8858. Mine Safety Education and Training Seminar. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., Dec. 9, 1980, Springfield, Ill., Dec. 12, 1980, and Reno, Nev., Dec. 16, 1980, compiled by Staff—Pittsburgh Research Center. 1981. 76 pp. 16 figs. Research personnel from the Bureau of Mines, a representative of the Mine Safety and Health Administration, and research contractors for the Bureau of Mines met with other Government and industry representatives at three seminar locations in December 1980 to discuss the findings and products of Bureau research on mine safety training. The research program is aimed at providing assistance to the mining community in its efforts to reduce industrial-type, human-error accidents through research establishing performance based methods and media for employee training. Research emphasis is directed toward development of baseline materials and instructional models; development of methods for structuring and evaluating health and safety, supervisory, and occupational training; and the continued investigation and application of current learning and simulation technology that could significantly enhance the effectiveness of training opportunities.

IC 8859. An Introduction to the Mine Inspection Data Analysis System (MIDAS), by W. F. Watts, Jr., R. L. Johnson, D. J. Donaven, and D. R. Parker. 1981. 41 pp. 11 figs. This report describes the Mine Inspection Data Analysis System (MIDAS) developed by the Bureau of Mines to analyze the records of industrial hygiene samples collected by the Mine Safety and Health Administration (MSHA) in metal and nonmetal mines. MIDAS is the first system capable of sorting, editing, analyzing, and reporting these data. It is also the first system designed to be used by a number of Government agencies. At present the system contains 225,000 personal and area samples for 61 contaminants in 45 industries. The records date from 1974 to early 1980, and MSHA plans to provide yearly updates to the system. This report presents preliminary analyses of dust exposures and discusses the potential uses and limitations of these data. Analysis of the dust data for 1978 and 1979 showed that bagging had the highest percentage of dust overexposure. More than 40 pct of the 1,536 respirable quartz dust, total nuisance dust, and total silica dust samples exceeded the MSHA exposure limit. Other dusty occupations are ranked according to their percentage of overexposure.

IC 8860. Operation of the International Tin Agreement, by Thomas J. Witzig. 1981. 24 pp. 5

figs. This Bureau of Mines report is a background study of the International Tin Agreement. Attempts at stabilizing the tin market prior to the agreement are detailed, as well as the conditions and negotiations that set up the agreement. Details of the five consecutive 5-year agreements beginning in 1956 are presented, with emphasis on membership and the agreements' primary tools: the buffer stock and export controls. Attention is focused throughout on the United States activities during the period, especially with regard to its strategic stockpile, and its involvement with the agreement culminating in its membership, for the first time, in the fifth agreement beginning in 1976. Considerations leading to the U.S. decision to join are detailed, and U.S. activities in the negotiations for the sixth agreement are presented. The status and outlook for the agreement are discussed, and evaluations of the effectiveness of the agreement and its components are reviewed. (*Out of print.*)

IC 8861. Alumina Availability—Domestic. A Minerals Availability System Appraisal, by Gary R. Peterson, Robert L. Davidoff, Donald I. Bleiwas, and Richard J. Fantel. 1981. 23 pp. 8 figs. In order to determine the potential availability of alumina to feed U.S. aluminum smelters, the Bureau of Mines evaluated 39 domestic mines and deposits of bauxite, alunite, and high-alumina clays and found that substantial increases in alumina prices would be necessary before nonbauxite deposits could become competitive with bauxite. As part of the study, a price-tonnage relationship was developed indicating the quantity of alumina that could be produced from known deposits at various alumina prices and at a 15-pct discounted cash flow rate of return on the required capital investment. All capital and operating costs were calculated in August 1980 dollars. The domestic bauxite reserve base comprises three operating bauxite mines in Arkansas containing about 15.6 million metric tons of recoverable alumina (Al_2O_3). Ferruginous bauxites, clays, and alunites fall into the subeconomic category of identified aluminum resources, which, at the demonstrated level, contain over 4,000 million metric tons of alumina that are estimated to be recoverable. Analyses indicate that, at the demonstrated resource level, a total of about 15.6 million metric tons of alumina, all from three active Arkansas bauxite mines, is recoverable at a 1980 price of $0.12 per pound ($264 per metric ton) of alumina. A price of approximately $0.26 per pound ($573 per metric ton) of alumina would be required for production of the total U.S. resource. Thus, unless new technological breakthroughs occur that could make alternate sources of alumina competitive with bauxite, U.S. dependence upon imported bauxite will continue to increase. (*Out of print.*)

IC 8862. Land Utilization and Reclamation in the Mining Industry, 1930–80, by Wilton Johnson and James Paone. 1982. 22 pp. 13 figs. This Bureau of Mines study indicates that land utilized by the mining industry for mineral extraction and processing from 1930 through 1980 amounted to 5.7 million acres, or 0.25 percent of the land mass in the United States. Land reclaimed by the industry during the same period was 2.7 million acres, or 47 percent of the land utilized. Land use by the mining industry includes surface land used for excavation or mining, for waste from underground mining, and for wastes from milling or processing operations. Data on land use for disposal of overburden waste from surface coal mines and on areas affected by subsidence associated with underground mining are included for the period 1930–71 only. The 10 leading States in total land used for mining over the 51-year period were, in decreasing order, Pennsylvania, Kentucky, Ohio, Illinois, West Virginia, Florida, Indiana, California, Alabama, and Missouri. Seven mineral commodities accounting for 92 percent of land use are, in decreasing order, bituminous coal, sand and gravel, stone, phosphate rock, clay, copper, and iron ore, all predominately surface mined. Bituminous coal production was responsible for nearly half of the total area utilized. Reclamation of mined lands and waste disposal sites over the reporting period was largely on lands utilized in mining bituminous coal; 75 percent of the land used for bituminous coal production was reclaimed. (*Out of print.*)

IC 8863. Proceedings of Seminar on the Role of Overburden Analysis in Surface Mining, Wheeling, W. Va., May 6–7, 1980. Sponsored by the American Council for Reclamation Research and the Bureau of Mines, compiled by D. G. Simpson and W. T. Plass. 1982. 51 pp. 6 figs. This Bureau of Mines publication contains the texts of the four papers presented at the May 6–7, 1980, seminar on the role of overburden analysis in surface mining. Coverage includes the geologic distribution of pyrite and calcareous material and its relationship to overburden sampling, overburden sampling and analysis, use of soil-overburden data in mine planning and development, and minesoil classification.

IC 8864. The Relation of Geology to Mine Roof Conditions in the Pocahontas No. 3 Coalbed, by Noel N. Moebs and John C. Ferm. 1982. 8 pp. 2 figs. Bureau of Mines studies of mine roof fall problems in the Pocahontas No. 3 Coalbed of southern West Virginia and southwestern Virginia have established that type and sequence of rock are significant factors in roof competence. The poorest conditions occur where the immediate roof consists of slump structures and slickensided rock. The best conditions occur where the roof consists of a sequence that coarsens upward from shale to massive sandy shale. A small manual of color photographs of rock types was devised to aid in identifying drill cores. Proper identifications should enhance the prediction of areas of potential roof problems in advance of mining.

IC 8865. Underground Metal and Nonmetal Mine Fire Protection. Proceedings: Bureau of Mines Technology Transfer Seminars, Denver, Colo., Nov. 3, 1981, and St. Louis, Mo., Nov. 6, 1981, by Staff, Bureau of Mines. 1981. 150 pp. 93 figs. These proceedings consist of an overview of the underground metal and nonmetal mine fire protection research currently being conducted by the Bureau of Mines. The following papers address the areas of prompt, reliable fire detection, fire planning and warning, fire suppression, and personnel protection. Selected topics are included here that cover fire protection systems for shafts, underground fueling areas, and mobile underground mining equipment; spontaneous combustion, improved stench, and product-of-combustion fire warning systems; computer-aided ventilation modeling; fire doors; and an investigation of fire hazards in mine timbers. The projects described provide a current documentation of problems being addressed.

IC 8866. Ergonomics-Human Factors in Mining. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., December 3, 1981, St. Louis, Mo., December 10, 1981, and Denver, Colo., December 15, 1981, compiled

by Staff, Pittsburgh Research Center. 1981. 167 pp. 17 figs. These proceedings consist of papers presented at three Bureau of Mines Technology Transfer Seminars on ergonomics in the mining industry. These seminars were held in December 1981, and covered topics relating to ergonomics and mining in the areas of the man-machine interface, and design of the work environment. This area of research is directed toward reducing accidents traditionally associated with human error.

IC 8867. Borehole Shear Tester: Equipment and Technique, by Khamis Y. Haramy. 1981. 19 pp. 21 figs. This Bureau of Mines paper describes the use of the borehole shear tester (BST) in mines. Assembly and procedure sections explain how the equipment is assembled and used properly. Schematics of the BST, limitations, test hole specifications, data recording, and calculations are all explained briefly, and an example of the data collecting and calculations is given to assist understanding.

IC 8868. Reduction of Airborne Contaminants From Welding Exhaust at Surface Mines, by G. K. Derby. 1982. 11 pp. 4 figs. The Bureau of Mines studied the problems caused by airborne contaminants from welding exhaust in surface mining operations and investigated equipment designed to reduce existing hazards. Four commercially available welding-fume exhaust units were tested to determine their effectiveness. Results indicated that the four units had the capability of controlling airborne particulate concentrations and bringing them to within allowable exposure limits.

IC 8869. Critical and Strategic Minerals in Alaska: Cobalt, the Platinum-Group Metals, and Chromite, by James C. Barker, Jan C. Still, Thomas C. Mowatt, and John J. Mulligan. 1981. 8 pp. 3 figs. A uniquely mineralized area extends from northwestern Canada through Alaska into eastern Siberia. Some of the metals found there are relatively rare in the conterminous United States. Among these are cobalt, the platinum-group metals, and chromite. Geologic evidence suggests that cobalt and the platinum-group metals may be present in deposits that could constitute nationally important reserves. Chromite in potentially minable deposits is known, but it may be relatively less abundant. Limited reserves of these metals have been delineated, but most of the favorable terranes and reported occurrences throughout the vast expanse of Alaska remain unexplored. As part of the mineral studies mandated under the Alaska National Interest Lands Conservation Act, the Bureau of Mines' Alaska Field Operations Center and the Bureau's research centers at Albany, Oreg., and Reno, Nev., are cooperating in a long-range program to investigate occurrences and delineate reserves of cobalt, the platinum-group metals, and chromite in Alaska. Studies of other critical and strategic minerals will be phased in during succeeding years, as ongoing projects are completed. This first in a series of annual reports summarizes available information about deposits and past production of cobalt, the platinum-group metals, and chromite, and describes current and planned Bureau investigations of these minerals. (*Out of print.*)

IC 8870. Analyses of Natural Gases, 1917–80, by B. J. Moore. 1982. 1055 pp. 1 fig. This publication contains 12,554 analyses of gas samples from oil and gas wells and natural gas pipelines in 39 States and 24 foreign countries. These gas samples were collected in the period 1917–80 as part of the Bureau of Mines survey for helium occurrences. The gas analyses contained herein were made by several methods over the period covered. Analytical work on samples collected early in the period was done on the Orsat apparatus. The one-cut apparatus and four-cut fractional distillation equipment were added later. In 1949, a mass spectrometer was acquired and used for all gas analyses made after that time. Helium analyses throughout the period covered were made on special helium analytical equipment designed and built by the Bureau of Mines Helium Operations Laboratory. GPO Stock No. 024-004-02089-0. $19.

IC 8871. A Computer Program for Calculating Thermodynamic Properties From Spectroscopic Data, by R. P. Beyer. 1982. 19 pp. A FORTRAN IV computer program has been written to calculate thermodynamic properties over a desired temperature range from spectroscopic data. This program computes heat capacities, enthalpies, and entropies for monatomic, diatomic, linear, and nonlinear polyatomic gases. This research is part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology.

IC 8872. Minerals Health and Safety In-House and Contract Research, Development, and Demonstration in Fiscal Year 1982, by Staff, Division of Minerals Health and Safety Technology. 1982. 48 pp. This publication summarizes, for potential contractors and all other interested parties, the research, development, and demonstration of in-house and contract projects programed by the Bureau of Mines for fiscal year 1982 (October 1, 1981-September 30, 1982) under its Minerals Health and Safety Technology program. The objective of these projects is to provide an ordered and sequenced series of advance toward the Bureau's overall goal of providing the systems technology required to create a more healthful and safer working environment for the Nation's mining and minerals processing workers.

IC 8873. Computer Simulation Applied to the Separation of Porous Leach Residue Solids From Liquor by Horizontal Belt Filtration, by Daniel T. Rogers and Roy T. Sorensen, Jr. 1982. 27 pp. 6 figs. The Bureau of Mines, in its alumina miniplant project to investigate alumina recovery from domestic, nonbauxitic ores, has conducted research on the use of a hydrochloric acid leaching, gas sparging crystallization technology. An important element of this research is the efficient separation of undissolved, siliceous residue from $AlCl_3$-bearing leach liquors by continuous, horizontal, countercurrent vacuum belt filtration. In an effort to calculate material balances quickly and to predict material balances based on different belt filtration configurations, the perfect-mixing-cells-in-series model (PMCS) for calculating material balances around belt filters was used. Because of the porous nature of the solids, the model produced erroneous material balances. Therefore a reliable model, the shrinking voids model, was developed postulating the presence of an unwashable voids liquor volume that decreases with decreasing liquor $AlCl_3$ concentration. This volume decrease postulation is equivalent to assuming that dilute liquors flow more freely, causing more voids liquor volume to become washable. Least-squares based computer programs are provided, which are useful not only in producing material balances from plant data but also in predicting balances for untested configurations using the same feed materials. (*Out of print.*)

IC 8874. The Depletion Allowance and Domestic Minerals Availability. A Case Study in Copper, by Paul R. Thomas, Robert L. Davidoff, and Melinda M. Quinn. 1982. 15 pp. 8 figs. The Bureau of Mines evaluated the impact of the depletion allowance upon the economic availability of copper from domestic deposits. The potential long-run percentage depletion deduction, cumulated over the life of the properties, was estimated at approximately $2.5 billion for producing properties and up to $11.7 billion for nonproducers. The income transfer, in the form of higher Federal income tax payments if the allowance were repealed, was estimated at $1.5 billion for producing properties and up to $8 billion for nonproducers. The percentage depletion allowance, through its role in determining Federal income tax liability, was found to be very significant in affecting profitability. Repeal of the allowance could result in major domestic copper availability reductions at all price levels, now and in the future, as a result of reduced profit margins for current producers, and postponement of development decisions for nonproducers. It was demonstrated that a 50-percent reduction in the percentage depletion rate applicable to copper would also result in a significant decrease in profitability for nonproducing properties. For producing properties, the percentage depletion rate on copper was shown to be less significant than the income limitation that is placed upon the total amount of the depletion deduction. Repeal of the minimum Federal tax provision was shown to be significant in enhancing profitability for both producing and nonproducing deposits. The report concludes that the percentage depletion allowance operates as an important method of capital recovery and production incentive. (*Out of print.*)

IC 8875. Computerized, Remote Monitoring Systems for Underground Coal Mines. Fires and Explosive Atmospheres, by Jeffrey H. Welsh. 1982. 9 pp. This report presents a study on the use of computerized, continuous remote monitoring systems for fire and explosive atmosphere safety in underground coal mines. The effects of these systems on the safety level in mines are investigated, and the relationship between mine safety regulations and computerized, continuous, remote monitoring is analyzed.

IC 8876. Noise and Vibration Control for Surface Mines. Program Document, by Bradley V. Johnson, Richard J. Seibel, and David E. Siskind. 1982. 9 pp. This publication summarizes the in-house and contract research and development projects conducted since 1974 by the Bureau of Mines for the control of noise and vibrations from surface mine blasting.

IC 8877. SIC-Based Demand Information System for Nonfuel Minerals, by George K. Schenck, Balakrishnan K. Nair, and Kung-Lee Wang. 1982. 48 pp. 3 figs. This Bureau of Mines publication describes and evaluates a Standard Industrial Classification (SIC) based end-use data system for minerals that is designed to link the demand for minerals to economic activity in commercial uses. The new data system is two-dimensional. The first dimension of technical product classes (TPC's) measures the consumption of minerals in major primary intermediate products. The second dimension measures the consumption of these TPC's in SIC end-use sectors in sufficient detail to identify the major determinants of demand for each TPC. Intercommodity comparisons are achieved at the level of SIC two-digit major groups. The methodology was developed so that all available sources of information from Government and industry can be utilized at minimum cost. This information will be supplemented with additional data to be obtained by modifying existing Bureau of Mines canvasses so as to elicit additional quantitative responses from mineral producers. The new data system is expected to improve significantly the ability to forecast demand for minerals, and provide an information base that would, for the first time ever, permit resolution of such questions as trends in substitution among materials and the intensity-of-use of materials in end-use sectors. For the 42 TPC's identified in the report, data are available for the new system from current sources or, except for three TPC's that require new canvasses, can be obtained by modification of existing Bureau canvasses. (*Out of print.*)

IC 8878. Chemically Bonded Refractories—A Review of the State of the Art, by Rustu S. Kalyoncu. 1982. 20 pp. 2 figs. A major goal of the Bureau of Mines is to conserve the Nation's mineral resources by developing improved performance materials. In support of this mission, a survey of the state of the art of chemically bonded refractories has been made, covering the scientific literature, government reports, and patents. This review includes research and development results for phosphate, silicate, oxychloride, oxysulfate, and other bonding agents used in refractories manufacture. A significant finding of the review was that references on bonding mechanisms, bond formation kinetics, and other important process parameters and conditions were few and universally vague. As a result, recommendations are made to expand research efforts to investigate the kinetics and mechanisms of reactions in chemically bonded refractories.

IC 8879. State Severance Taxes: A Summary and an Analysis of the Impact of Rate Changes on Copper Recovery Costs, by Phillip N. Yasnowsky and Annette P. Graham. 1982. 23 pp. This Bureau of Mines report summarizes State severance taxes imposed on minerals and mineral fuels, provides a hypothetical example of how a State severance tax affects selected components of a firm's income statement, and uses the Bureau's Minerals Availability System (MAS) to estimate the effect of assumed changes in State severance tax rates on copper recovery cost at given levels of potential copper availability. A reduction of the rates to zero or a doubling of them results in changes in costs that are of the same order of magnitude as the cost of transporting copper to the United States from major foreign producing countries. (*Out of print.*)

IC 8880. Some Design Factors for Windows and Lenses Used in Explosion-Proof Enclosures, by Lawrence W. Scott. 1982. 9 pp. This Bureau of Mines report presents several factors that currently enter into the design, manufacture, and testing of windows and lenses used in explosion-proof enclosures. Emphasis is also given to the sealing concepts for lenses. Criteria for adhesives and sealants are suggested based on the survivability of an explosion-proof enclosure as a structure, rather than upon the minimum material properties of its constituents. Procedures for surface preparation of adherends are also discussed.

IC 8881. Minerals Data Source Directory, compiled by the Minerals Data Working Group, Interagency Minerals Information Coordinating Committee. 1982. 296 pp. The Minerals Data Source Directory is a compilation of descriptive informa-

tion on the availability, content, and location of minerals data in the Federal Government. It is intended to assist Government personnel and the general public in locating and acquiring minerals information. Included in the Directory are descriptions of data bases, publications, information systems, and information offices containing data pertaining to all aspects of mineral production, consumption, trade, and related information. These mineral data sources include the Federal agencies such as the Department of the Interior's Bureau of Mines and Geological Survey whose major mission is the collection and dissemination of mineral information. Also included are agencies such as the Departments of Agriculture, Commerce, Labor, State, and Treasury, and the Central Intelligence Agency, whose primary mission is the collection of data in nonmineral subject areas, but in which the mineral industry is a component. (*Out of print.*)

IC 8882. Reliability of Computerized Mine-Monitoring Systems, by Raymond M. Kacmar. 1982. 10 pp. 1 fig. This paper describes the Bureau of Mines research program on the reliability of computerized mine-monitoring systems. The basic concepts of computerized monitoring are introduced along with its advantages and limitations. Current Bureau projects covering mine-monitoring systems are described, and some of the major areas of concern that should be addressed by future projects are outlined.

IC 8883. Vibration Qualification of Electronic Instrumentation for Underground Coal Mining Machinery, by Roy C. Bartholomae, Bruce S. Murray, and Richard Madden. 1982. 9 pp. 6 figs. An accurate characterization of the vibration environment and a vibration qualification test derived from it will be a very useful tool for manufacturers of instrumentation for use on underground coal mining equipment. Recognizing this, the Bureau of Mines sponsored a study wherein vibration levels were measured on mining equipment to form a basis for developing the required vibration test. The data base was composed of 160 samples taken at different positions on a variety of underground machinery. The data were analyzed and presented in a format typical of military vibration qualification tests. The form was shown to be virtually identical to the swept sine test envelope specified in MIL-STD-810B for tracked vehicles.

IC 8884. Accomplishments in Waste Utilization. A Summary of the Seventh Mineral Waste Utilization Symposium, compiled by S. A. Bortz and R. S. DeCesare. 1982. 88 pp. 15 figs. With IIT Research Institute as a cosponsor, this Seventh Mineral Waste Utilization Symposium was funded by the Bureau of Mines through its Division of Mineral Resources Technology. Environmental scientists and engineers from five countries (Canada, Netherlands, Austria, England, Guatemala) besides the United States participated in the symposium, which was held October 20–21, 1980, at the Chicago campus of IIT Research Institute. Of the 25 papers presented on the reclamation and recycling of mining and mineral wastes, municipal solid waste, industrial waste, and scrap metal, 21 are summarized herein.

IC 8885. Characterization of U.S. Cement Kiln Dust, by Benjamin W. Haynes and Gary W. Kramer. 1982. 19 pp. Cement kiln dust (CKD) produced in the contiguous United States and Hawaii was characterized as part of the Bureau of Mines program in minerals environmental technology. The mineralogical and chemical composition was determined for 113 CKD samples from 102 plants that normally send CKD waste to landfill. Characterization included the determination of 28 elements, 7 anion species, carbon dioxide, noncarbonate carbon, and chemically bound water. Mercury was determined in 16 samples. Interelement correlation coefficients were determined for 23 elements, 5 anions, CO_2, noncarbonate carbon, and chemically bound water. To assess the hazardous waste potential of CKD, the U.S. Environmental Protection Agency Extraction Procedure (EP) toxicity test was performed on all 113 CKD samples. All but one sample were in compliance with the test; the noncomplying sample slightly exceeded the EP toxicity test criterion for lead.

IC 8886. Mine Illumination. Proceedings: Second International Mine Lighting Conference of the International Commission on Illumination (CIE), compiled by K. L. Whitehead and W. H. Lewis. 1982. 337 pp. 116 figs. The U.S. Bureau of Mines, U.S. Department of Labor, and United States National Committee of the CIE hosted the TC4.10 Mine Lighting Committee Meeting and Second International CIE Mine Lighting Conference at the MSHA Academy in Beckley, W. Va., October 12–16, 1981. This was the first time the meeting and conference had been held in the United States. The TC4.10 Mine Lighting Committee, chaired by Dr. Adam Peretiatkowicz of Poland, was attended by 15 committee members and 6 guests representing 8 countries. Discussion during the meeting covered mine lighting instrumentation, opencast (surface mine) lighting, and lighting sources. The committee also reviewed a draft of proposed lighting terminology and suggested changes to make the definitions more acceptable to representatives of the nations present. The mine lighting conference features 20 papers presented by 18 speakers representing 6 countries. The papers covered all phases of mine lighting, including research, hardware development and application, personnel acceptance, and requirements for system maintenance. The conference attracted 126 attendees and included displays by 8 lighting hardware manufacturers and 4 mining machine manufacturers. Papers from the conference are being published by the Government Printing Office, with copies presented to the conference attendees. Copies will be available to others interested through the National Technical Information Service. During the TC4.10 meetings and conference, committee members toured three mining equipment assembly plants, and six of the foreign representatives visited a longwall installation in an underground mine. Planning and administrative services for the meeting and conference were handled by Bituminous Coal Research, Inc., under Bureau of Mines contract H0318038.

IC 8887. The Bureau of Mines Minerals Availability System: An Update of Information Circular 8654, by Herbert R. Babitzke, Aldo F. Barsotti, Joseph S. Coffman, Jerrold G. Thompson, and Harold J. Bennett. 1982. 54 pp. 13 figs. The Minerals Availability System (MAS) was formally established by the Bureau of Mines in May 1975 to provide current appraisals of the engineering and economic availability of nonfuel minerals for consideration in the formulation of both domestic and foreign minerals policy. Domestic mineral property reports are developed by the Bureau's four Field Operations Centers, and foreign data are obtained under contract. This site-specific information is subsequently subjected to engineering verification and economic evaluation,

and the results are analyzed and published as Minerals Availability System Appraisals. The deposit-specific data are also entered into the computerized MAS data base, where a subset of this information, the Mineral Industry Location System (MILS), is available to the public in the form of computer graphics and listings. Other MAS products are also described. The Bureau's MAS personnel are frequently involved in special engineering and mineral economic projects for other Federal and State agencies. MAS personnel also work closely with the private sector, both in the area of mining and processing cost estimation, and as a source of nonproprietary mineral deposit information.

IC 8888. Preliminary Testing of a Prototype Portable X-Ray Fluorescence Spectrometer, by Lowell L. Patten, Neal B. Anderson, and John J. Stevenson. 1982. 33 pp. 15 figs. The Federal Bureau of Mines participated with the National Aeronautics and Space Administration and Martin Marietta Aerospace in developing, building, and testing a portable X-ray fluorescence spectrometer for use as an analyzer in mineral-resource investigative work. The prototype battery-powered spectrometer, measuring 11 by 12 by 5 inches and weighing only about 15 pounds, was designed specifically for field use. The spectrometer has two gas-proportional counters and two radioactive sources, ^{109}Cd and ^{55}Fe. Preliminary field and laboratory tests on rock specimens and rock pulps have demonstrated the capability of the spectrometer to detect 33 elements, to date. Characterisics of the system present some limitations, however, and further improvements are recommended.

IC 8889. Manganese Availability—Domestic. A Minerals Availability System Appraisal, by Catherine C. Kilgore and Paul R. Thomas. 1982. 14 pp. 4 figs. The Bureau of Mines investigated the availability of manganese from known domestic occurrences. Eight of these deposits were found to have demonstrated resources totaling 420 metric tons with an average grade of 10 percent contained manganese. They were found to be submarginally subeconomic. Economic evaluations of the eight deposits resulted in incentive prices ranging from $8 to almost $35 per long ton unit (22.4 pounds) of contained manganese. Comparing these prices with the current market value of $1.70 per long ton unit of manganese clearly illustrates the submarginal nature of the domestic ores analyzed. These domestic resources would probably not be developed except in the case of an extreme national emergency. Production from the eight deposits would take 3 to 6 years to develop, and the final product would be manganese ore concentrate, which could be used in the production of ferromanganese. If preproduction development began in 1981, annual production would peak in 1987 with 900,000 metric tons of recoverable manganese. Thereafter, production would see a steady decline unless additional resources were located or technologic improvements were made to allow processing of lower grade material, or unless mining and processing of ocean manganese nodules began to take place. (*Out of print.*)

IC 8890. Analyses of Natural Gases, 1981, by Richard D. Miller and Floyd R. Hertweck, Jr. 1982. 84 pp. 1 fig. This Bureau of Mines publication contains analyses and related source data for 224 natural gas samples from 18 States. Of the total, 191 samples were collected during calendar year 1981. The remaining 33 samples were collected during previous years, but releases granting permission to publish were not received until 1981. All samples were obtained and analyzed as part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted since 1917. The analyses published herein were made by the mass spectrometer and special helium apparatus described previously. (*Out of print.*)

IC 8891. Premining Investigations for Hardrock Mines. Proceedings: Bureau of Mines Technology Transfer Seminar, Denver, Colo., September 25, 1981, compiled by Staff, Bureau of Mines. 1982. 95 pp. 77 figs. These proceedings consist of papers presented at a Bureau of Mines Technology Transfer Seminar in September 1981 for the purpose of disseminating recent advances in mining technology in the area of premining research. The introduction and descriptive papers discuss techniques and instrumentation used in premining research for metal and nonmetal mining and shaft design and borehole control for premine planning. (*Out of print.*)

IC 8892. A Feasibility Study of the Use of Surface Redox Measurements To Detect Subsurface Methane, Coal Burns, and Hydrothermal Deposits, by Richard G. Burdick and Terry L. Radich. 1982. 15 pp. 16 figs. The Bureau of Mines conducted this research to determine the feasibility of using soil redox measurements, a relatively new method in mining geophysics, to locate or define a variety of conditions that are hazardous or otherwise of interest to the mining industry. The method was used in three widely separated areas in an attempt to define subsurface concentrations of methane, the edges of coal-burn areas, and a hydrothermal vein set. Both a description of the method used and test cases are given in this report.

IC 8893. Underground Coal Mine Power Systems. Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, Pa., September 16, 1982, compiled by Staff, Bureau of Mines. 1982. 88 pp. 50 figs. This Bureau of Mines publication presents an overview of mine electrical power systems research currently being conducted by the Bureau. The papers, given at a Technology Transfer Seminar, emphasize the increasing importance of research related to the safety considerations of underground coal mine electrical systems. Selected topics are included that summarize results of research in the areas of electrical shock prevention, explosion-proof enclosures and load centers, discriminating circuit breakers, and trailing cables. Other topics discussed at the seminar are published as separate sections of the Bureau of Mines Handbook "Application Notes—Mine Electrical Power Systems."

IC 8894. How To Evaluate Longwall Dust Sources With Gravimetric Personal Samplers, by Steven J. Page, Robert A. Jankowski, and Fred N. Kissell. 1982. 14 pp. 3 figs. Longwall double-drum shearers frequently have difficulty complying with the 2.0 mg/m^3 dust standard and, therefore, require the use of effective dust controls. However, before dust controls can be implemented effectively, the major individual dust sources must be determined and their relative severity evaluated. The Bureau of Mines has recently developed a sampling strategy, based upon short-term gravimetric sampling, that can identify the major dust sources contributing to the shearer operator's exposure. This technique utilizes approved gravimetric sampling equipment already available

to all mine operators and can be performed by two people in 2 days. Five examples, including data analysis, are discussed with respect to various cutting sequences. In addition, typical dust source contributions obtained from studies of double-drum shearer operations regularly in compliance are included. Mine operators can thereby compare their dust source evaluation results with those from these longwalls.

IC 8895. Chromium Availability—Domestic. A Minerals Availability System Appraisal, by Jim F. Lemons, Jr., Edward R. Boyle, Jr., and Catherine C. Kilgore. 1982. 14 pp. 7 figs. The Bureau of Mines Minerals Availability System collected and analyzed data for 34 nonlaterite and 9 nickeliferous laterite domestic chromite deposits in order to assess their viability as sources of chromium under present technologic and economic conditions. These 43 deposits, none currently in production, contain approximately 6.3 and 22.3 million metric tons of Cr_2O_3 at the demonstrated and identified resource levels, respectively. Approximately 4.6 and 15.6 million metric tons of Cr_2O_3 are recoverable at the demonstrated and identified levels, respectively, for the 34 nonlaterite deposits. None of these resources are economically recoverable at January 1981 market prices. Production of metallurgical-grade chromite (market price $128 to $144) would require a minimum chromite market price of $237 per metric ton. Chemical-grade chromite production (market price $74 to $85) would require a chromite market price in excess of $188 per metric ton. From the 34 nonlaterite deposits, roughly 5.4 and 17.6 million metric tons of ferrochrome could be produced at the demonstrated and identified resource levels, respectively; however, a minimum market price of $770 per metric ton of ferrochrome would be required to stimulate production. The nine nickeliferous laterite deposits were not evaluated through production stages because of uncertainties in process technology and cost.

IC 8896. Surface Subsidence Over Longwall Panels in the Western United States. Monitoring Program and Preliminary Results at the Deer Creek Mine, Utah, by Frederick K. Allgaier. 1982. 24 pp. 20 figs. This is the first in a series of progress reports on the longwall subsidence research program at the Bureau of Mines Denver Research Center. As part of this program, the Bureau and the Utah Power and Light Co. are cooperating on a study conducted at the Deer Creek Mine, which is directed toward developing the capability to estimate the surface subsidence resulting from longwall mining in a geologic, topographic, and mining environment common to coalfields in the Western United States. A monitoring network has been established at the Deer Creek Mine to measure subsidence over four adjacent longwall panels. To date, two panels have been mined. Subsidence began as the first panel was mined and continued for 1 year following completion of the panel, during which time the adjacent panel was mined. A maximum of 2.7 feet of subsidence occurred over the two longwall panels mined at a depth of 1,500 feet. Because of the length of time that subsidence continued after mining, the final subsidence profiles and angle of draw have not yet been determined.

IC 8897. Platinum Availability—Market Economy Countries. A Minerals Availability System Appraisal, by T. F. Anstett, D. I. Bleiwas, and C. Sheng-Fogg. 1982. 16 pp. 11 figs. The Bureau of Mines investigated the availability of platinum from known major deposits in market economy countries. Fifteen of these deposits contain demonstrated resources totaling 302 million troy ounces of platinum. Detailed geologic, engineering, and cost evaluations were performed on each deposit to determine its potential for platinum production. There are large amounts of demonstrated platinum potentially available from market economy deposits that were not analyzed owing to lack of adequate data or to technological limitations. These include 297 million troy ounces contained in the UG2 and Platreef of the Bushveld Complex, South Africa. This analysis indicates that about 110 million troy ounces (2.3 million ounces annually) of platinum are potentially available at the January 1980 producer price of $420 per troy ounce, nearly all from South Africa. An additional 85 million troy ounces occurring in Zimbabwean deposits would become available only through more than a quadrupling of that price. In order to meet projected world demand of 3.5 million troy ounces in 1990, platinum price may have to increase. Only one domestic deposit, the Salmon River in Alaska, is capable of producing platinum at $420 per troy ounce. Regardless of price, at assumed production capacities, domestic deposits could supply less than 10 percent of annual U.S. requirements.

IC 8898. Site-Specific and Regional Geologic Considerations for Coalbed Gas Drainage, by W. P. Diamond. 1982. 24 pp. 15 figs. The Bureau of Mines has been involved in the drilling of vertical, horizontal, and directional coalbed gas drainage boreholes for mine safety since 1964. In that time, boreholes have been drilled in most of the major coal regions of the United States under a wide variety of geologic conditions. Many of the geologic conditions that occur in the coal measures are detrimental to gas drainage; others may be beneficial. Analytical techniques to determine the gas content of coal samples and evaluate regional trends of gas distribution have been developed. Drilling techniques that maximize the acquisition of coalbed gas data and geologic information have been determined. Although some of the geologic factors influencing the placement and potential success of coalbed gas drainage boreholes have been reported in papers on individual projects, a complete, systematic compilation has not previously been available. The objective of this paper is to provide information on specific geologic factors that should be considered prior to, during, and after the drilling of coalbed gas drainage boreholes. Many of the commonsense considerations that have been learned through many years of Bureau of Mines experience, but have generally not been reported formally, are included for those who may be considering coalbed gas drainage drilling for the first time, or who have not had the opportunity to encounter a substantial number of geologic situations.

IC 8899. Evaluation of a Combined Face Ventilation System Used With a Remotely Operated Mining Machine, by E. Divers, N. Jayaraman, and J. Custer. 1982. 7 pp. 2 figs. This Bureau of Mines report presents results of an underground evaluation to determine the respirable dust and gas control effectiveness of a combined (push-pull) face ventilation system for coal mines. The system utilizes both blowing and exhaust curtain, continuous miners equipped with radio remote control, and flight conveyors. Bureau of Mines tests showed a 97% reduction in respirable dust concentrations from the usual cab position on the continuous miner to the remote control operator's position. This allowed the remote control operator to be well within, and the usual cab

position to exceed, Federal respirable dust standards. Tests utilizing a safe tracer gas, sulfur hexafluoride (SF_6), to determine the face ventilation effectiveness of the combined blowing and exhaust system showed that the system also has excellent methane dispersion capability. Where wide entries permit, this combined face ventilation system and use of remote control can be a very effective method for dust and gas control. (*Out of print.*)

IC 8900. Future Trends and Prospects for the Australian Mineral Processing Sector, by L. Nahai and Charlie Wyche. 1982. 41 pp. 2 figs. An important objective of the Australian Government's policies on resources development is to encourage further processing of raw materials domestically, to the extent that this is economically feasible and consistent with sound industrial development. This Bureau of Mines report examines the extent to which Australia is able to pursue this policy in terms of its own competitive advantages and the implications of such a policy for the United States. Such factors as the impact of other competing producers and their advantages, expected world demand, and infrastructural problem—which may limit pursuit of this policy to the fullest extent—are discussed. After a broad review of the resource, economic, social, and environmental factors, the perspective for increased processing is examined for a number of mineral commodities.

IC 8901. Real-Time Calculation of Product-of-Combustion Spread in a Multilevel Mine, by John C. Edwards and Rudolf E. Greuer. 1982. 117 pp. 2 figs. A computer program, developed for the Bureau of Mines under contract, predicts in a quasi-steady-state approximation the ventilation and contaminant concentrations and temperatures when a fire occurs in a multilevel mine. For periods of time in which there is no significant change in the ventilation, yet a fire is producing fumes, a real-time fume concentration throughout the mine is calculated. Multiple and time-variable contaminant sources can be simulated. Recirculation paths that can develop provide a mechanism for increasing the fume concentration in the mine network and are identified by the computer program. This report contains a listing of the Fortran computer program as well as the required format of the input data. Two examples are provided of the real-time spread of smoke from a fuel-rich fire throughout a multilevel mine. The first example considers an operational exhaust fan as well as a booster fan. The second example evaluates the real-time smoke spread following a failure in the exhaust fan; recirculation occurs in this latter case.

IC 8902. A Review of Methods for Identifying Scrap Metals, by R. Newell, R. E. Brown, D. M. Soboroff, and H. V. Makar. 1982. 19 pp. 5 figs. As part of the Bureau of Mines program for conserving domestic mineral resources, a survey was made of the methods used for identifying scrap metals. Because of the large number of alloys currently being scrapped, correct identification of these materials is essential if they are to be recycled effectively. The methods and instruments used to identify scrap metals are described and evaluated. These include object recognition, color, density, magnetic testing, spark testing, chemical spot testing, thermoelectric measurements, eddy current measurements, and elemental analysis by chemical and instrumental methods. Other potential techniques are discussed also. GPO Stock No. 024-004-02105-5. $3.25.

IC 8903. Alarm System for Radiation Working Level, Fan Operation, and Air Door Position, by J. C. Franklin, P. E. Barr, K. D. Weverstad, and C. T. Sheeran. 1982. 17 pp. 8 figs. A 32-channel continuous monitoring system has been developed to monitor radiation working level (WL), fan operation, and air door position. The system consists of a surface receiver unit and an underground transmitter that is connected to the various monitors. A continuous WL monitor used with the system can generate alarms at two different WL readings. One of these levels is variable from 0.00 to 0.99 WL and generates an alarm on the surface receiver. The other level, fixed at 1.0 WL, generates an underground alarm in the vicinity of the monitor. The detectors for fan operation and air door position work on the principle of a completed circuit to the underground transmitter (multiplexer). When the circuit is broken, as is the case when a fan is off or an air door is open, an alarm is generated at the surface receiver. This alarm remains in effect until the circuit is completed, signifying the fan has been turned on or the air door has been closed.

IC 8904. Predicted Characteristics of Waste Materials From the Processing of Manganese Nodules, by Benjamin W. Haynes and Stephen L. Law. 1982. 10 pp. 6 figs. As part of the first-order assessment of potential manganese nodule processing reject waste materials, the Bureau of Mines estimated the physical and chemical characteristics of reject waste materials that would be generated from each of five potential process flowsheets. These processes were chosen because of their economic and technical feasibility for first-generation nodule processing. A brief description of the five processes is given to show process inputs and outputs. The physical characteristics are predicted based on land-based laterite processing where applicable, and where no land-based analog exists, on the basis of process chemistry. The probable chemical characteristics such as element content and compound form are tabulated for each process for 16 elements: As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Tl, and Zn. These elements were chosen based on their presence on the toxic substance list of priority pollutants, extraction procedure (EP) toxicity criteria, and major and minor elements of economic importance (Co, Fe, Mn, and Mo). Physical and chemical analyses as well as results of the EP toxicity test of one industrially supplied pilot plant reject waste material are presented.

IC 8905. Acid Mine Drainage: Control and Abatement Research, by Ann G. Kim, Bernice S. Heisey, Robert L. P. Kleinmann, and Maurice Deul. 1982. 22 pp. 16 figs. Acid drainage from underground coal mines and coal refuse piles is one of the most persistent industrial pollution problems in the United States. This Bureau of Mines report reviews the acid mine drainage problem generally and describes research currently underway to combat it.

IC 8906. Mineralogical and Elemental Description of Pacific Manganese Nodules, by Benjamin W. Haynes, Stephen L. Law, and David C. Barron. 1982. 60 pp. 65 figs. This Bureau of Mines publication comprises a compilation of the state of the science in Pacific Ocean manganese nodule mineralogy and elemental composition. The report is divided into three sections: morphology, mineralogy, and elemental composition. The nodule morphology section defines what is considered a nodule for the study, and details the external characteristics and internal

structure. Nodule mineralogy is discussed in three sections: manganese minerals, iron oxide minerals, and accessory minerals. The major manganese minerals discussed are todorokite, birnessite, and vernadite. The iron oxide minerals are less well known and include feroxyhyte, geothite, and lepidocrocite. Accessory minerals present include quartz, clays, and other silicates and nonsilicates. A discussion on moisture content is also included. The elemental composition section presents data on 74 elements occurring as cations or anions. Summary data, histograms, and interelement correlation coefficients are presented. The elements are grouped as follows: major and minor elements of potential economic interest (8), other major and minor elements (9), elements of environmental interest (8), rare-earth elements (15), precious-metal-group elements (6), radioactive elements (3), other trace elements (17), and anion-forming elements (8). Cross sectional determinations of Ni, Cu, Zn, Co, Pb, Fe, Ce, and Ba are given for a single nodule to show the general tendency of different growth patterns within a nodule because of different element associations and composition. GPO Stock No. 024–004–02109–8. $5.

IC 8907. Postdisaster Survival and Rescue Research. Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, Pa., November 16, 1982, compiled by Staff, Bureau of Mines. 1982. 91 pp. 82 figs. These proceedings consist of papers presented at a Bureau of Mines technology transfer seminar on postdisaster survival and rescue research: (1) an overview of oxygen self-rescuer technology, (2) laboratory environmental testing of chemical oxygen self-rescuers for ruggedness and reliability, (3) chemical oxygen self-contained self-rescuer escape study, (4) medium frequency radio communication system for mine rescue, (5) finding and communicating with trapped miners, (6) Bureau of Mines borehole probes program, and (7) mine personnel locator and in-mine activity controller. Several technology transfer seminars are held each year to bring the latest results of Bureau research to the attention of the mining industry as quickly as possible. (*Out of print.*)

IC 8908. Health and Safety In-House and Contract Research and Development in Fiscal Year 1983, by Staff, Division of Health and Safety Technology. 1982. 36 pp. This publication summarizes, for potential contractors and all other interested parties, the research and development of in-house and contract projects programed by the Bureau of Mines for fiscal year 1983 (October 1, 1982-September 30, 1983) under its Health and Safety Technology program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the systems technology required to create a more healthful and safer working environment for the Nation's mining and minerals processing workers.

IC 8909. Historical Summary of Coal Mine Explosions in the United States, 1959-81, by J. K. Richmond, G. C. Price, M. J. Sapko, and E. M. Kawenski. 1983. 53 pp. 17 figs. This Bureau of Mines publication presents investigators' reports of all major coal mine explosion disasters that occurred in the United States from 1959 through November 1981, along with a brief analysis of common factors in these disasters. The report reviews the Federal mine health and safety acts of 1969 and 1977, and discusses how implementation of these acts has reduced the number of both fatalities and disasters. Current Bureau health and safety research is summarized, and an appendix lists most of the ignitions and explosions in the period of record. GPO Stock No. 024–004–02108–0. $4.75.

IC 8910. Thermodynamic Properties of Selected Transition Metal Sulfates and Their Hydrates, by Carroll W. DeKock. 1982. 45 pp. 3 figs. Thermodynamic data for selected metal sulfates were critically evaluated and compiled as part of the Bureau of Mines program to provide a scientific base for use in developing new technology and predicting the feasibility of new processes. Values for Cp°, S°, $H^\circ - H^\circ_{298}$, $-(G^\circ - H^\circ_{298})/T$, ΔHf°, ΔGf°, and log Kf as a function of temperature are given in tabular form. Thermodynamic data were compiled for $VOSO_4$, $Cr_2(SO_4)_3$, $MnSO_4$, $FeSO_4$, $Fe_2(SO_4)_3$, $CoSO_4$, $NiSO_4$, Cu_2SO_4, $CuSO_4$, $CuO{\cdot}CuSO_4$, $ZnSO_4$, and $ZnO{\cdot}2ZnSO_4$, together with their stable hydrates.

IC 8911. Lake Lynn Laboratory: Construction, Physical Description, and Capability, by Robert H. Mattes, Alex Bacho, and Lewis V. Wade. 1983. 40 pp. 55 figs. The Lake Lynn Laboratory is a multipurpose mining research laboratory operated by the Bureau of Mines and located in Fairchance, PA. It consists of both surface and underground facilities. The initial focus of the facility, scheduled for full operation in fall 1982, will be on the problems of fires and explosions in mines. The initial experimental explosion was fired on March 3, 1982. The intent of this document is to provide the reader with detailed information on the physical capabilities of the Lake Lynn Laboratory. Subsequent publications will focus on the capabilities of Lake Lynn as compared with those of other similar facilities worldwide, and a comparison of initial explosion test results realized at Lake Lynn and comparable results from the Bruceton Experimental Mines.

IC 8912. Design Criteria for Rapid-Response Pneumatic Monitoring Systems, by Charles D. Litton. 1983. 23 pp. 8 figs. This Bureau of Mines report presents a discussion of the essential components of pneumatic monitoring systems and their associated functions. Design criteria are presented that can be used for the design and fabrication of pneumatic monitoring systems having total system response times on the order of 15 to 30 min. To illustrate the utility of these design criteria, two detailed design examples are presented.

IC 8913. Dolomite Refractories, and Their Potential as Substitutes for Imported Chromite, by Timothy A. Clancy. 1983. 18 pp. 9 figs. To help reduce the Nation's dependence on imported chromite, the Bureau of Mines is conducting research on the use of dolomites as an alternate material. Dolomite is a plentiful domestic resource and offers certain advantages as a refractory raw material. A review of the literature has indicated that there are many sources of high-purity dolomite in this country and that European nations use a greater proportion of dolomite refractories, primarily in steelmaking, than the United States. The Bureau of Mines characterized 14 domestic dolomites as to chemistry, density, mineralogy, microstructure, and thermal behavior, to develop baseline data on their suitability as refractory raw materials. Research at the Tuscaloosa Research Center is carried out under a cooperative agreement between the U.S. Department of the Interior, Bureau of Mines, and the University of Alabama.

IC 8914. The Florida Phosphate Industry's Technological and Environmental Problems, A Review, by Staff, Bu-

reau of Mines, Tuscaloosa Research Center. 1983. 42 pp. 21 figs. The Florida phosphate industry currently produces more than 80 pct of the total U.S. marketable output of phosphate rock. Because phosphate is one of three principal nutrients used in formulating a complete fertilizer, it is imperative that an uninterrupted supply of this material be available to meet the agricultural requirements of the United States while maintaining a viable phosphate industry which is competitive in world markets. As a result of an evaluation made by the Bureau of Mines, five areas were identified that affect the overall production and projected growth of the phosphate industry in Florida. These areas relate to the technological ability of the industry to comply with environmental regulations and performance standards by using the best available technology. The most significant technical problem facing the industry is the management of the clay fraction rejected during the beneficiation of phosphate ores. Other areas of concern are environmental restrictions and regulatory requirements, issues associated with mining and reclamation of wetlands, reclamation of other disturbed lands, and consumptive water use. Each of these areas is reviewed, with major emphasis placed on the current state-of-the-art processes for treatment and management of phosphatic clays. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the U.S. Department of the Interior and the University of Alabama. GPO Stock No. 024-004-02110-1. $4.75.

IC 8915. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central Alaska. Part I: Reconnaissance Investigations, by Jeffrey Y. Foley and Mark M. McDermott. 1983. 27 pp. 24 figs. The Bureau of Mines sampled surface exposures of podiform chromite in the Caribou Mountain-Melozitna ultramafic belt in the Kokrines-Hodzana Highlands, central Alaska. Fieldwork began in 1979 as part of an assessment of the mineral potential of lands adjacent to the trans-Alaska pipeline corridor, for the Bureau of Land Management, and continued through 1981 as a Bureau of Mines investigation. The belt comprises six complexes of which the three closest to the pipeline corridor were investigated. Concentrations of chromite disseminated in dunite host rock make up mineralized intervals ranging in thickness from less than an inch to 5 ft and in grade from 3 to 23 pct chromium. The largest occurrence has an exposed strike length of 80 ft. Bulk surface samples were collected from 10 of these exposures, and beneficiation tests on the samples produced concentrates of metallurgical, refractory, and subindustrial grades. Part I—this report—describes the fieldwork; part II—IC 8916—describes the beneficiation work.

IC 8916. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central Alaska. Part II: Beneficiation, by D. C. Dahlin, L. L. Brown, and J. J. Kinney. 1983. 15 pp. 2 figs. The Bureau of Mines has investigated podiform chromite deposits in three ultramafic bodies in the Caribou Mountain and lower Kanuti River areas of central Alaska. The investigation, reported in two parts, was done as part of the Bureau's mission to help insure an adequate supply of minerals to meet the Nation's needs. Part I describes an extensive field investigation and mineralogical studies by personnel from the Bureau's Alaska Field Operations Center. This report, part II, describes the mineralogy of 11 samples that were high-graded from surface exposures at 10 sites and presents the results of laboratory batch beneficiation tests designed to concentrate the chromite. The 11 samples, peridotites and chromitites that consisted of variable amounts of chromite or chromium-bearing spinels, olivine, and serpentine, were beneficiated by grinding and sizing, gravity concentration, and electrodynamic separation. Three high-chromium chromite concentrates, two high-iron chromite concentrates, and one high-aluminum chromite concentrate were produced. Three other concentrates were marginal, and two were submarginal. Chromium recoveries ranged from 54 to 92 pct. These results indicate that the areas may be significant chromium resources. Potential platinum association with the chromite was also investigated. Analysis of these 11 samples indicates that the areas are not good platinum resources.

IC 8917. Aluminum Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by G. R. Peterson and S. J. Arbelbide. 1983. 31 pp. 10 figs. To determine the availability of aluminum from world bauxite resources, the Bureau of Mines investigated 139 bauxite deposits worldwide and evaluated the potential production of aluminum based on the demonstrated resources of bauxite ore from 91 mines and deposits in 22 market economy countries. The demonstrated resources of the bauxite mines and deposits included in this study represent an in situ resource of 20.2 billion metric tons of bauxite. Total identified bauxite resources in market economy countries amount to roughly 31.9 billion tons. Of the demonstrated resource, some 18.8 billion tons of bauxite considered minable provide a production potential of 3.6 billion tons of primary aluminum. Given the wide geographic distribution of bauxite deposits, stable supplies of bauxite for aluminum production seem assured well into the next century. However, a tight market situation could develop during the 1990's unless the real price of aluminum increases enough to stimulate massive new investments in production capacity, particularly in refining and smelting. This study indicates that a real price of at least $0.85 per pound (in January 1980 dollars) would be necessary to stimulate the required investments and provide a sufficient rate of return on invested capital.

IC 8918. A Guide to Geologic Features in Coal Mines in the Northern Appalachian Coal Basin, by Paul W. Jeran and Jacqueline H. Jansky. 1983. 16 pp. 22 figs. This Bureau of Mines report has been prepared to provide a means whereby mineworkers without specific geologic training can recognize and record the existence of potentially hazardous geologic features encountered in coal mines. Each geologic feature described in this report has been implicated in roof failure. Through the recording of the observations of mineworkers, based on this report, a geologic map of mine workings and the associated ground control problems can be compiled. From such maps, the trends of changes and features can be determined and projected ahead of mining. The face crew can be alerted to a potential problem and what to look for as the face is advanced.

IC 8919. Guidelines for Siting Product-of-Combustion Fire Sensors in Underground Mines, by C. D. Litton. 1983. 13 pp. 3 figs. This Bureau of Mines report presents a set of guidelines for determining the distribution of product-of-combustion fire sensors in underground mines. Sensor spacing is defined in terms of sensor alarm threshold, ventilation flow rate, and mine entry dimensions. Sensor spacing

guidelines are presented for detection of fires from two primary combustibles, coal and wood, which are common to the majority of underground mines. The guidelines are based on data from full-scale and intermediate-scale fire tests conducted by the Bureau of Mines.

IC 8920. Characteristics of the OTOX Model CTL Oxygen Sensor, by J. E. Chilton, G. H. Schnakenberg, Jr., and L. Spinetti. 1983. 16 pp. 11 figs. The Bureau of Mines has examined the operation of an oxygen sensor manufactured by the City University, London, England. The sensor produces a current proportional to the oxygen concentration by reacting oxygen at a nonconsumable cathode. The sensor design is unique in that the primary mode of oxygen transport to the cathode is by diffusion through a capillary. The sensor using this design has a stability of 0- to 0.02-pct reading change per day over a 4.7-month test, small temperature coefficient of 0.29-pct reading change per degree Celsius, and small pressure coefficient of 0.34-pct reading change per 1,000-ft altitude change. If this sensor were incorporated into an oxygen detector or monitor, this would be a distinct improvement in electrochemical-type oxygen analyzers and would be useful to the mining industry.

IC 8921. Methods for Determining Sources of Mercury Vapor in the Workplace, by D. L. Neylan, H. C. Triantafillou, and S. L. Law. 1983. 15 pp. 1 fig. The Bureau of Mines evaluated various methods for identifying sources of mercury vapor in excess of the threshold limit value (TLV) of 0.05 mg of mercury per cubic meter of air set by the American Council of Government and Industrial Hygienists (ACGIH) for mines and mineral processing plants. Chemical spot tests and portable devices for mercury determination were evaluated, based on information from published sources and performance in laboratory tests. Among the parameters examined were sensitivity, interferences, cost, ease of use, and other factors pertinent to field application. More than 50 methods were evaluated. The investigators found that many readily available methods are suitable for identifying sources of mercury vapor in mines and mineral processing plants. The best method appears to be one that uses a commercially available mercury test paper sensitive only to mercuric ions. For some of the more promising chemical spot tests, this report includes step-by-step instructions for field application.

IC 8922. Measuring Noise From a Continuous Mining Machine, by Roy Bartholomae, John Kovac, and John Robertson. 1983. 17 pp. 14 figs. Noise generated by continuous mining machines in underground coal production is an important health hazard. Bureau of Mines Contract J0387229 covers investigation of this noise through laboratory tests of simulated cutting operations and through in-mine noise measurements. The results of these investigations indicate that coal cutting noise and conveyor noise are dominant sources of mining machine operational noise. Typical noise levels for both cutting and conveying operations are approximately 97 dBA (decibels A-weighted). For full operation of all machine systems, the overall sound pressure level is approximately 101 dBA. In-mine and laboratory test results show excellent agreement in both A-weighted overall levels as well as in A-weighted one-third-octave band spectra.

IC 8923. Aluminum From Domestic Clay Via a Chloride Process. The State-of-the-Art, by A. Landsberg. 1983. 15 pp. 3 figs. Kaolinitic clays are potentially a vast domestic resource for aluminum. Utilization of this resource could decrease or eliminate the nearly complete dependence of the United States on foreign raw materials for this important metal. Furthermore, processing of clay to aluminum through anhydrous chloride metallurgy could reduce the high electrical energy requirements of the conventional Hall-Heroult aluminum reduction process. Several anhydrous chloride processes have been proposed; however, unresolved technical problems have prevented their commercialization. In particular, an acceptable chemical means has not been found to extract aluminum from clay as a highly pure anhydrous aluminum chloride. This Bureau of Mines report identifies and discusses the important chemical problems involved in achieving an acceptably rapid self-heating, selective chlorination reaction and the subsequent separation of iron chloride byproduct from the anhydrous aluminum chloride.

IC 8924. Updated Process Flowsheets for Manganese Nodule Processing, by Benjamin W. Haynes, Stephen L. Law and Riki Maeda. 1983. 100 pp. 73 figs. The Bureau of Mines, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), has updated a 1977 NOAA report prepared by Dames & Moore entitled, "Description of Manganese Nodule Processing Activities for Environmental Studies." This updated report contains detailed flowsheets and descriptions of the five potential first-generation nodule recovery schemes now considered most likely to be used by industry; they are high-temperature gas reduction and ammoniacal leach, cuprion ammoniacal leach, high-temperature and high-pressure H_2SO_4 leach, reduction and HCl leach, and smelting and H_2SO_4 leach. The first three processes are three-metal recovery schemes (Cu, Ni, and Co) with the option of Mn recovery from the tailings. The remaining two processes are four-metal (Cu, Ni, Co, and Mn) recovery schemes. All except the HCl process are assumed to use a nodule feed rate of 3 million tons per year (dry basis). Final metal products are Co powder and cathode Cu and Ni. A minor amount of Ni is also recovered as powder, and some Cu and Zn are recovered as mixed sulfides. Manganese in the four-metal processes is recovered as either manganese metal or ferromanganese. GPO Stock No. 024-004-02117-9. $4.75.

IC 8925. Explosives and Blasting Procedures Manual, by Richard A. Dick, Larry R. Fletcher, and Dennis V. D'Andrea. 1983. 105 pp. 102 figs. This Bureau of Mines report covers the latest technology in explosives and blasting procedures. It includes information and procedures developed by Bureau research, explosives manufacturers, and the mining industry. It is intended for use as a guide in developing training programs and also to provide experienced blasters an update on the latest state of technology in the broad field of explosives and blasting. Types of explosives and blasting agents and their key explosive and physical properties are discussed. Explosives selection criteria are described. The features of the traditional initiation systems—electrical, detonating cord, and cap and fuse—are pointed out, and the newer nonelectric initiation systems are described. Blasthole loading of various explosive types is covered. Blast design, including geologic considerations, for both surface and underground blasting is detailed. Environmental effects of blasting such as flyrock and air and ground vibrations are discussed along with techniques of measuring and alleviating these undesirable side

effects. Blasting safety procedures are detailed in the chronological order of the blasting process. The various Federal blasting regulations are enumerated along with their Code of Federal Regulations citations. An extensive glossary of blasting-related terms is included along with references to articles providing more detailed information on the aforementioned items. Emphasis in the report has been placed on practical considerations. GPO Stock No. 024-004-02113-6. $5.50.

IC 8926. Minerals Availability Commodity Directory on Phosphate, by Dale R. Spangenberg, Edward F. Carey, and Paul M. Takosky. 1983. 678 pp. This Bureau of Mines Information Circular on phosphate is one of a series of minerals availability commodity directories. Nonconfidential information from the Minerals Availability Program data base covering 148 domestic and 103 foreign phosphate properties and deposits has been abstracted for use in this directory. Abstracts include applicable data on location, published reserves and resources, geology, mine and beneficiation systems, and operational information.

IC 8927. Helium Resources of the United States, 1981, by Floyd R. Hertweck, Jr., and Richard D. Miller. 1983. 17 pp. 7 figs. The helium resources of the United States were estimated by the Bureau of Mines to be 1,037 Bcf as of January 1, 1981. These resources are divided into four categories, in decreasing degree of assurance of their existence: (1) helium in storage and in measured natural gas reserves, which totals 211 Bcf, (2) helium in indicated natural gas resources, which is estimated at 207 Bcf, (3) helium in hypothetical natural gas resources, which is estimated to be 318 Bcf, and (4) helium in speculative natural gas resources which makes up the remaining 301 Bcf. These helium resources are further divided into depleting, nondepleting, and stored classifications. The depleting resources are those associated with natural gasfields that are, or will be, produced for the natural gas they contain. All of the helium in undiscovered (hypothetical and speculative) natural gas resources is included in this classification. These depleting resources are estimated to contain 897 Bcf of the total helium resource base. Nondepleting resources are those in shut-in, abandoned, or otherwise nonproducing natural gasfields. Helium resources contained in nondepleting natural gas resources are estimated to total 100 Bcf. There is 40 Bcf of helium in storage in the Federal Government-owned Cliffside Gas Field near Amarillo, Tex.

IC 8928. Chemical Vapor Deposition of Group IVB, VB, and VIB Elements With Nonmetals. A Literature Review, by H. O. McDonald and J. B. Stephenson. 1983. 29 pp. The Bureau of Mines reviewed the chemical vapor deposition (CVD) literature on the nonmetal binary and ternary compounds of the group IVB, VB, and VIB elements, with emphasis directed to the following nonmetals: B, C, N, O, and Si. This review examines each of these binary and selected ternary compounds of the group IVB, VB, and VIB elements as coatings and gives some of their preparative methods, uses, and properties. A total of 259 references were found for these compounds of the nine elements. This review was utilized in the Bureau's research to provide abrasion-, erosion-, and corrosion-resistant coatings in order to conserve critical metals and protect various metallic surfaces in metallurgical, mining, and energy conversion systems.

IC 8929. Economic Evaluation of Borehole and Conventional Mining Systems in Phosphate Deposits, by Joseph A. Hrabik and Douglas J. Godesky. 1983. 34 pp. 5 figs. The Bureau of Mines compared the feasibility of mining deep phosphate deposits by a borehole mining system with mining by proven conventional techniques. An economic comparison of the borehole mining system with conventional dragline and bucket wheel excavator mining systems was completed at various mining depths and production rates. Hypothetical phosphate deposits, with various overburden thicknesses and reserve tonnages, were defined. Geologic conditions necessary for the application of the borehole system were identified. Discounted cash flow analyses based on derived capital and operating costs were used to generate rates of return and product prices. Borehole mining was found to be more economical where overburden thickness was 150 ft or greater; however, at 50- and 100-ft thicknesses, conventional surface mining was more economical. Overburden thickness has a great effect on the economic feasibility of the conventional mining systems but less effect on the economics of borehole mining. Economies of scale are only realized in conventional mining, since larger equipment is employed to achieve greater production, whereas increased production from borehole mining is achieved using additional equipment units. A comparison of the environmental effects of borehole and conventional surface mining systems showed that borehole mining is environmentally more desirable.

IC 8930. Copper Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by R. D. Rosenkranz, E. H. Boyle, Jr., and K. E. Porter. 1983. 30 pp. 16 figs. The Bureau of Mines has investigated the availability of copper from 272 deposits in market economy countries. The deposits studied have demonstrated resources totaling 413 million metric tons of contained copper and account for more than 90 pct of the reserve base for market economy countries. Using data gathered as part of its Minerals Availability Program, the Bureau performed geologic, engineering, and economic evaluations in order to determine the copper production potential of each deposit. At the 1981 copper market price of $0.85/lb, the deposits studied could economically produce an estimated 88 million metric tons of copper (allowing for profit computed at a 15-pct rate of return), primarily from mines operating at the time of the study (1981). At this price, producing mines in market economy countries could economically produce only 2.1 million metric tons of refined copper per year. However, actual 1981 production was 6.2 million metric tons, indicating that many mines continued to operate even though they were unable to cover all production costs. For U.S. producing mines, the estimated average cost of production per pound (including profit at a 15-pct rate of return) was $0.15 higher than the average cost in other market economy countries. GPO Stock No. 024-004-02128-4. $2.

IC 8931. Economic Evaluation of a Method To Regenerate Waste Chromic Acid-Sulfuric Acid Etchants, by Deborah A. Spotts. 1983. 7 pp. 3 figs. Researchers at the Bureau of Mines have developed a technique for regenerating chromic acid-sulfuric acid etching solutions used in metal surface treatment operations. The technique utilizes a diaphragm cell equipped with a cation-selective membrane to oxidize Cr^{3+} to Cr^{6+} at the anode and to remove copper, the major metallic contaminant, at the cathode. Normally,

spent etchant is discarded after approximately 3 days of use. Using the electrolytic cell, the etchant can be used for a year without replacement. From data obtained from industrial-scale cells, the installation of a regeneration cell with a 1,000-gal catholyte-holding tank has been estimated to save at least $240 per day. The payback period for the investment is estimated to be about 10 mo or less. Because the magnitude of these cost savings will vary at different locations, several graphs are presented to aid in calculating payback for a specific site. Using these graphs and the capital costs presented in this study, the payback period can be determined for installing a regeneration cell with a 500- or a 1,000-gal catholyte-holding tank in an existing surface treatment plant.

IC 8932. Costs and Effects of Environmental Protection Controls Regulating U.S. Phosphate Rock Mining, by Ronald F. Balazik. 1983. 37 pp. 1 fig. This Bureau of Mines study identifies and examines the costs of Federal, State, and local environmental protection controls on domestic phosphate rock mining. The costs include the expenditures needed to comply with government regulations and the effects that these expenditures and regulations have on supply. The study analyzes costs of environmental impact assessments, air and water quality standards, reclamation laws, potential solid waste controls, and local government restrictions. In addition, an industry survey and the Bureau's Minerals Availability System (MAS) are used to evaluate land management policies that restrict access to phosphate resources. Conclusions drawn from these analyses confirm that (1) domestic phosphate mining has incurred substantial control costs and may be subject to significant new regulatory costs in the next several years, (2) certain environmental controls can discourage mining investment, (3) environmental policies governing land-use controls affect the disposition of sizable phosphate resources and are key determinants in the development of those resources on the Federal domain, and (4) environmental costs could diminish the competitiveness of domestic producers.

IC 8933. Manganese Nodule Resources of Three Areas in the Northeast Pacific Ocean: With Proposed Mining-Beneficiation Systems and Costs. A Minerals Availability System Appraisal, by C. Thomas Hillman. 1983. 60 pp. 15 figs. The practical concern of economic minability of large, high-grade manganese nodule deposits in the northeast Pacific Ocean is addressed in this Bureau of Mines report. Principal objectives are to (1) estimate tonnage and grade of deposits with significant potential and (2) describe and estimate profitability of operations designed to mine and process deposits with greatest apparent potential. Analysis of data from over 800 ship stations identified three areas for detailed study. Average metal contents of these areas range from 1.30 to 1.45 wt pct nickel, 1.00 to 1.24 wt pct copper, 0.21 to 0.26 wt pct cobalt, and 26.8 to 27.8 wt pct manganese. Estimated recoverable nodule resources are 67.0, 66.9, and 148.8 million dry metric tons (t). A system to mine, transport, and process nodules from the three sites is described and costed. Although hypothetical, the system utilizes hydraulic mining and Cuprion (Kennecott) processing, which have been successfully tested at pilot scale. Nickel, copper, and cobalt are the three primary products, but ferromanganese is a considered option. Estimated capital requirements are approximately $1.5 to $1.7 billion for three-metal production. If ferromanganese were recovered, an additional investment of about $130 million would be required. Operating costs range from $71 to $83 per dry metric ton of nodules without manganese, and from $103 to $123 per dry metric ton with ferromanganese. Discounted cash flow analyses predict low returns, ranging from 2.7 to 5.2 pct with ferromanganese and from 4.1 to 6.0 pct without. GPO Stock No. 024-004-02120-9. $5.50.

IC 8934. A Dynamic Gas-Mixing System, by C. R. Carpenter, J. E. Chilton, and G. H. Schnakenberg, Jr. 1983. 30 pp. 28 figs. A dynamic gas-mixing system assembled by the Bureau of Mines for the generation of precise gas mixtures from sources of concentrated or pure gases and diluent gases is described. A set of electronic mass flow controllers with maximum flows ranging from 10 to 5,000 ml/min, a so-called Pure Air Generator, and gases in cylinders are used to generate differing gas concentrations. The repeatability of the delivery rate of a flow controller, measured on different days, has a precision of 0.3 pct of the setting. This dynamic gas-mixing system reduces the cylinder inventory and the demurrage charges for special gas mixtures. Gas mixtures that cannot be shipped commercially, such as flammable mixtures of methane in air, can be conveniently prepared by this system. The maximum dilution ratio is 2.5×10^4. Thus, gas mixtures can be made over a wide range of concentrations, from the percent region (by dilution of a pure single-component gas) to fractional parts per million (by dilution of a premixed standard, e.g., a 1,000-ppm mixture). This system is especially useful in determining the response of gas detection devices over the entire range of their measurement. Because the controllers are voltage controlled they lend themselves easily to automated control using computer-based systems.

IC 8935. Minerals Data Source Directory, January 1983. (An Update of IC 8881), compiled by the Minerals Data Working Group, Interagency Minerals Information Coordinating Committee. 1983. 376 pp. The Minerals Data Source Directory is a compilation of descriptive information on the availability, content, and location of minerals data in the Federal Government. It is intended to assist Government personnel and the general public in locating and acquiring minerals information. Included in the Directory are descriptions of data bases, publications, information systems, and information offices containing data pertaining to all aspects of mineral production, consumption, trade, and related information. These mineral data sources include the Federal agencies such as the Department of the Interior's Bureau of Mines and Geological Survey whose major mission is the collection and dissemination of mineral information. Also included are agencies such as the Departments of Agriculture, Commerce, Labor, State, Transportation, and Treasury, the Central Intelligence Agency, the Environmental Protection Agency, the Federal Reserve System, the Interstate Commerce Commission, and the Securities and Exchange Commission, whose primary mission is the collection of data in nonmineral subject areas, but in which the mineral industry is a component. GPO Stock No. 024-004-02116-1. $9.50.

IC 8936. Electron Microscopy Studies of Explosion and Fire Residues, by Daniel L. Ng, Kenneth L. Cashdollar, Martin Hertzberg, and Charles P. Lazzara. 1983. 63 pp. 52 figs. This Bureau of Mines report describes the results of scanning electron

microscopic (SEM) studies of the combustion residues of carbonaceous dust particles resulting from explosions and thermal ignitions in laboratory and full-scale mine tests. The dusts studied varied widely in rank and volatility: Pittsburgh seam bituminous coal (35% volatility), Pocahontas seam bituminous coal (16% volatility), anthracite (7% volatility), graphite, and diamond. The most systematic explosion studies were performed in an 8-L chamber with narrow size distributions of Pittsburgh coal dust with surface mean diameters of 2, 22, and 84 μm. Experiments were conducted mainly in air, with some data obtained in 50% O_2. Observations of the bituminous coal explosion residues showed particles with rounded edges, particles with blowholes, and some cenospheres. The lower volatility dust residues showed fewer changes from the original, unburned dust. In addition to the experimental studies, results of SEM observations of residues from a mine explosion disaster are reported. Comparison of such residues with those from the laboratory and experimental mine explosions can help investigators determine the extent of dust participation in the disaster and in identifying the possible ignition sources.

IC 8937. Phosphate Rock Availability—Domestic. Minerals Availability Program Appraisal, by R. J. Fantel, D. E. Sullivan, and G. R. Peterson. 1983. 57 pp. 20 figs. To determine the availability of phosphate rock from domestic resources, the Bureau of Mines evaluated the potential production of phosphate rock from the demonstrated resources of 130 mines and deposits. The evaluation included an estimation of resources, engineering methods, and capital and operating costs, and an economic analysis to determine each operation's average total cost of production over the life of the mine, including a 15-pct discounted-cash-flow rate of return on all investments. Quantified but not evaluated in this report are substantial phosphate resources at the inferred and hypothetical resource levels. The 130 mines and deposits contain 6.4 billion tons of recoverable phosphate rock product, about 20 pct from producing mines. At total production costs of under $30 per ton in January 1981 dollars, about 1.3 billion tons of phosphate rock product is potentially available, over 90 pct from producing mines. This study suggests that production from low-cost, high-grade phosphate mines now in operation will decline during the next decade, and new higher cost, lower grade mines will have to be developed to satisfy demand into the next century. In addition to the demonstrated resources evaluated in this study, 7 billion tons of inferred-level and 24 billion tons of hypothetical-level phosphate rock are potentially recoverable, which, in part, includes material containing high amounts of magnesium. Much of this material could likely become available in the near future.

IC 8938. New Developments in Personal Lighting Systems for Miners, by William H. Lewis and Elio Ferreira. 1983. 10 pp. 11 figs. Energy Research Corp., under contract to the Bureau of Mines, has developed a new miners' caplamp battery. The new battery is based on nickel-cadmium technology and offers significant improvements in performance with reduced size and weight when compared to the conventional lead-acid battery presently in use. This report describes the design and fabrication of the nickel-cadmium battery, which utilizes a roll-bonded electrode structure. The final battery design has a 15-A•h capacity in a 2½-lb package, which is over 2 lb lighter than the present lead-acid caplamp battery.

IC 8939. Passive Encoder for Range Knobs, by William H. Schiffbauer. 1983. 8 pp. 8 figs. The Bureau of Mines has developed a passive encoder for range knobs, a device that automates the task of obtaining the range settings from devices or instruments to be input to microcomputers. It is easily constructed and installed and will not disrupt the device to which it is being attached. It consists of a custom knob and a small printed circuit board that has light-emitting diodes and magnetic reed switches attached. A ribbon cable connects it to a microcomputer. This encoder eliminates one source of human error in an automated process.

IC 8940. Evaluation of Alumina Extraction From Coal Waste: Composition and Availability, by Roy T. Sorensen and John L. Schaller. 1983. 19 pp. 2 figs. This Bureau of Mines report presents the results of a study to rank technologies for extraction of alumina from bottom ash and coal shale. The available literature on composition and availability of coal waste was reviewed, and papers pertinent to alumina extraction are referenced. Types of coal waste were categorized by method of waste generation, coal content (heating value), location, coal type (ash nomenclature), and alkaline earth content. The differences and similarities among the categories of coal waste are summarized as to factors that may affect aluminum extraction, especially factors concerning chemical composition, current production, storage problems, and accumulated tonnage. Data available on physical characteristics and mineralogy did not correlate well with the individual categories of coal waste, and discussion on these two aspects is limited to the differences between coal ash and coal shale.

IC 8941. Field Determinations of a Probabilistic Density Function for Slope Stability Analysis of Tailings Embankments, by P. C. McWilliams and D. R. Tesarik. 1983. 26 pp. 12 figs. Theoreticians in soil mechanics have been pursuing a probabilistic approach to the factor of safety of an embankment or dam for the past 10 years. The motivation for this work is in contrast to the current practice of deterministically computing a factor of safety and treating it as an absolute with no regard to its inherent statistical variability. Basic to the probabilistic approach is the selection of an appropriate statistical model to represent the histogram or probability density function (PDF) of the factor of safety values. Rather than simply assuming which PDF is appropriate, the Bureau of Mines collected data at two waste disposal embankments for consideration. This report addresses three candidate models, using the techniques of nonlinear curve fitting, and identifies the "best" model. A propagation of error formula for estimating the variability of Fellenius' factor of safety is also discussed.

IC 8942. Analyses of Natural Gases, 1982, by Richard D. Miller and Floyd R. Hertweck, Jr. 1983. 100 pp. 1 fig. This Bureau of Mines publication contains analyses and related source data for 271 natural gas samples from 22 States collected during calendar year 1982. All samples were obtained and analyzed as part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted since 1917. The analyses published herein were made by the mass spectrometer and chromatograph.

IC 8943. Interim Performance Specifications for Transducer Modules Used With the Bureau of Mines Intrinsically Safe Mine Monitoring System. Carbon Monoxide, Methane, and Air Velocity, by J. E. Chilton and A. F. Cohen. 1983. 20 pp. 1 fig. Interim performance specifications are presented for carbon monoxide, methane, and air velocity transducers used in the Bureau of Mines intrinsically safe mine monitoring system. These specifications give quantitative values or qualitative descriptions of the transducers, including environmental parameters and monitoring system measurement and maintenance requirements as recommended by the Bureau of Mines. Commercially available transducer modules and prototype modules are listed together with selected characteristics.

IC 8944. Computerized, Remote Monitoring Systems for Underground Coal Mines. Faults in Power Systems, by Jeffrey H. Welsh. 1983. 11 pp. 2 figs. The Bureau of Mines studied the use of computerized, continuous, remote monitoring systems for safety from power system faults in underground coal mines. In this report the need to improve protection against power system faults is documented, and types of faults are identified. The relationship between mine safety regulations and computerized, continuous, remote monitoring is analyzed.

IC 8945. Agglomeration-Heap Leaching Operations in the Precious Metals Industry, by G. E. McClelland, D. L. Pool, and J. A. Eisele. 1983. 16 pp. 12 figs. During the 1970's, the Bureau of Mines investigated a particle agglomeration technique for improving the flow of leaching solution through heaps of clayey or crushed, low-grade gold-silver ores, wastes, and tailings. This technology has been adopted on a broad scale by the precious-metals-processing industry. This report presents information on five commercial operations that have benefited from agglomeration technology and that represent a cross section of current heap leaching practice. The technology is cost effective because of decreased leach times and improved precious metal recoveries.

IC 8946. Selected Raw Material Requirements for Japan's Specialty Steel Industry, by E. Chin, John C. Wu, L. Nahai, Gordon L. Kinney, and Charles L. Kimbell. 1983. 34 pp. Although Japan is a major producer of crude steel, it is poor in industrial raw materials. This Bureau of Mines report describes Japan's raw material needs for chromium, cobalt, manganese, nickel, and tungsten to produce ferroalloys and alloy steels. Japanese imports of these ores or metals by quantity and source are given for 1972–81, inclusive, to indicate (1) the changes in the consumption and supply pattern, and (2) the degree of Japan's dependence on foreign sources. This report also describes measures implemented by Japan to reduce the risk of supply interruption, and discusses the possible implications of supply shortages. GPO Stock No. 024–004–02122–5. $3.75.

IC 8947. Safety in the Use and Maintenance of Large Mobile Surface Mining Equipment. Proceedings: Bureau of Mines Technology Transfer Seminars, Tucson, AZ, August 16, 1983, Denver, CO, August 18, 1983, and St. Louis, MO, August 23, 1983, compiled by Staff, Bureau of Mines. 1983. 97 pp. 64 figs. These proceedings consist of papers presented at Bureau of Mines Technology Transfer Seminars in August 1983 for the purpose of disseminating recent advances in mining technology in the area of large mobile surface mining equipment safety and health. The following papers were either presented at the seminar or relate to the subject. The topics covered are ingress-egress safety, collision avoidance, novel truck design, operator alertness studies, rollover protective structures, operator restraint devices, maintenance safety, operator safety training, improved haul road berm design, stability indicators for front-end loaders, and retrofit noise control for bulldozers. The Bureau of Mines conducts several of these seminars each year in order to bring the latest results of Bureau research to the attention of the mining industry as quickly as possible.

IC 8948. Back Injuries. Proceedings: Bureau of Mines Technology Transfer Symposia, Pittsburgh, PA, August 9, 1983, and Reno, NV, August 15, 1983, compiled by James M. Peay. 1983. 110 pp. 43 figs. These proceedings consist of papers presented at two Bureau of Mines Technology Transfer symposia on reducing back injuries in the mining industry. The symposia were held in August 1983 and covered a wide range of topics related to a more fundamental understanding of factors that lead to back injuries and approaches for reducing the frequency and severity of such injuries.

IC 8949. New Techniques for Reducing Stopping Leakage, by Robert J. Timko and Edward D. Thimons. 1983. 15 pp. 14 figs. Because of leakage through and around permanent stoppings in underground mines, more air must be forced into a mine than would otherwise be required for ventilation. As power costs increase, costs resulting from air leakage add increasingly to the operating costs of mining. The Bureau of Mines evaluated four different stopping construction techniques based on the ideas that (1) airtightness could be enhanced by brushing rather than troweling on mortar sealant and that (2) modified mortars (mortars containing glass fibers and other additives for increased strength and adhesion) would improve sealing performance. Air leakage tests comparing conventional to modified stoppings were done when the stoppings were built, after 6 months, after 1 yr, and following simple maintenance. It was found that stoppings can be built and maintained better if (1) the area where a stopping is to be built is properly prepared; (2) stoppings are periodically examined for leaks; and (3) stoppings found to be leaking, especially at the perimeters, are resealed.

IC 8950. Fresnel Lens Blind Area Viewers for Improved Mine Equipment Safety and Productivity, by Guy A. Johnson. 1983. 15 pp. 20 figs. Combining contract and in-house research, the Bureau of Mines has developed and in-mine tested a novel device to improve the field-of-view of operators of off-highway mining equipment. This device utilizes a downward-looking, flat fresnel lens. The lens, plus louvers to reduce glare, is housed in a protective steel structure. The complete unit is called a blind area viewer. The viewer, when mounted on the right-front corner of the deck of most large haulage trucks, will increase a driver's direct field-of-view from about 35 pct (of where he/she has to drive) to about 80 pct. The improved visibility allows the driver to see possible collision hazards and roadway obstacles better, thus improving mine safety and increasing productivity. Economic analysis shows that the blind area viewers, which are now commercially available, pay for themselves in about a month on a 170-ton-capacity truck. The viewers are also ap-

plicable to other large mining equipment, such as front-end loaders, draglines, and downhole drills, or any place where seeing around a corner would be advantageous, such as along conveyor flights in processing plants during startups.

IC 8951. Bureau of Mines Coal Cutting Technology Facilities at the Twin Cities Research Center, by Wallace W. Roepke, Carl F. Wingquist, Richard C. Olson, and Bruce D. Hanson. 1983. 26 pp. 26 figs. Research on coal cutting at the Bureau of Mines Twin Cities Research Center (TCRC) has evolved from a purely mechanical approach, specifically to reduce dust or frictional methane ignitions, into an understanding of the complexity of the cutting system relationships. Achieving an understanding of these relationships requires a wide variety of testing techniques and equipment. Laboratory facilities and the associated equipment exist for shallow to deep cutting in both coal and coal-inclusive rock with any desired bit type. Research efforts with this equipment are providing insight for significant advances to help solve the problems of pneumoconiosis and frictional ignition. This effort will ultimately affect both respirable dust and methane ignitions at the face through better bit design and will increase the salable percent of run-of-mine coal processed. It will also affect the design of rotary-drum cutting continuous mining machines and longwall machines. This report describes the main features of the coal cutting research facilities at TCRC.

IC 8952. Rates of Chlorination of Aluminous Resources, by N. A. Gokcen. 1983. 14 pp. 8 figs. This Bureau of Mines report reviews and summarizes recent studies of the rates of chlorination of aluminous resources with CO and Cl_2 mixtures with and without $COCl_2$. No reaction mechanism could be obtained from the existing results; however, diffusional barriers in the gas and solid layers probably control the chlorination rate in thermogravimetric experiments. Fluidized beds of particles smaller than 0.1 mm appeared to show very little solid layer diffusional barrier. For optimum chlorination the particle size should probably be less than 8 mm, the calcination temperature approximately 700° C, and the chlorination temperature from 650° to 750° C. Relatively rapid chlorination with $COCl_2$ in thermogravimetric experiments was attributed partly to the simultaneous supply of reductant and chlorinator by one gas to the sample reaction site. Comparable results for chlorination of fluidized beds with $COCl_2$ are not available. Equimolar mixtures of CO and Cl_2 produced the optimum rate of reaction. Addition to the calcine of 10 to 20 wt-pct NaCl accelerated the rate of chlorination, and addition of $SiCl_4$ to the gas mixture decreased the rate of chlorination of SiO_2 drastically, but at the expense of chlorination of significant fractions of Al_2O_3. Further research in various areas is suggested.

IC 8953. Methods for Characterizing Manganese Nodules and Processing Wastes, by Benjamin W. Haynes, David C. Barron, Gary W. Kramer, and Stephen L. Law. 1983. 10 pp. Analytical procedures are described for the quantitative determination of 16 elements (As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Tl, and Zn) and 7 ionic species (NH_4^+, CO_3^{2-}, Cl^-, F^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}), identification of major and minor mineral components, and measurement of physical properties associated with manganese nodules and nodule processing reject waste materials. Compound identification methods discussed include X-ray diffraction, infrared spectroscopy, scanning and transmission electron microscopy, selective area electron diffraction, and optical and reflected light microscopy. Methods for elemental analysis include atomic absorption spectrophotometry, inductively coupled plasma emission spectroscopy, neutron activation analysis, fluorescent X-ray spectrography, and ion chromatography. Thermal gravimetric analysis, ultraviolet-visible spectrophotometry, ion specific electrodes, and standard wet chemical procedures are briefly discussed. Physical properties determined in manganese nodule materials include grain size distribution, specific gravity, triaxial shear, permeability, maximum density, Atterberg limits, and slurry density. The results of a round-robin analysis of an ammonia process waste material and manganese nodule standards demonstrate the applicability of the discussed methods. Tests discussed for the evaluation of the waste materials for disposal options include the Environmental Protection Agency (EPA) EP toxicity test, the ASTM shake extraction test, and the U.S. Army Corps of Engineers EPA seawater elutriant test.

IC 8954. Automatic Fire Protection for Mobile Underground Mining Equipment, by Guy A. Johnson. 1983. 12 pp. 17 figs. To improve productivity and cut costs, modern underground mining operations have become more mechanized. This mechanization has increased the usage of fuels, hydraulics, and electrical equipment associated with diesel-powered vehicles, thereby also increasing the hazards of underground mine fires. The Bureau of Mines evaluated the fire hazard problem and assembled prototype components for a system that would automatically sense and extinguish fires on mobile underground equipment. The prototype system and alternative designs were in-mine tested and proved effective. This report summarizes this technology, which can cost effectively help solve the problem of fire hazards on underground vehicles.

IC 8955. Underground Mine Communications, Control and Monitoring, by Staff, Bureau of Mines. 1984. 212 pp. 130 figs. Since 1969, the Bureau of Mines, U.S. Department of the Interior, has sponsored numerous programs aimed at improving methods of underground communication. As a result of these research and development programs, a wealth of information has been made available to the mining industry. Unfortunately, some of this material is highly analytical and most is written in terms best understood by communication specialists. Because of the volume of data (over 100 studies have been performed) and its highly technical nature, most of the information is not readily available for practical application by mine operators. This manual brings together relevant data from all previous reports, studies, and other sources, and presents these data in such a way that they may be applied by the mining industry to improve communications in underground mines. The report is intended as a guideline and not as a comprehensive documentary of mine equipment.

IC 8956. Health and Safety In-House and Contract Research in Fiscal Year 1984, by Staff, Division of Health and Safety Technology. 1983. 20 pp. This publi-

cation summarizes the research (in-house and contract projects) programed by the Bureau of Mines for fiscal year 1984 (October 1, 1983-September 30, 1984) under its Health and Safety Technology Program. The objective of these projects is to provide an ordered and sequenced advance toward the Bureau's overall goal of providing the systems technology required to create a more healthful and safer working environment for the Nation's mining and minerals processing workers.

IC 8957. Dust Sources and Controls on the Six U.S. Longwall Faces Having the Most Difficulty Complying With Dust Standards, by Robert A. Jankowski and John A. Organiscak. 1983. 19 pp. 11 figs. The Bureau of Mines has recently identified five major factors that contribute to high respirable dust levels on the six U.S. longwall faces having the most difficulty complying with Federal dust standards: (1) a poorly structured cutting sequence, (2) a poorly designed external water spray system, (3) marginal waterflow to the cutting drums, (4) minimal controls at the stage loader and crusher, and (5) the lack of effective controls for dust generated during support advance. The results of this survey illustrate the need to address all the major sources of longwall dust generation and the need for mine operators to implement a variety of control procedures to assure compliance. The Bureau of Mines will continue to assist mine operators in implementing improved dust controls and will work to identify and evaluate controls for dust generated during support advance.

IC 8958. Cost Estimate of the Bayer Process for Producing Alumina—Based on 1982 Equipment Prices, by Deborah A. Kramer and Frank A. Peters. 1983. 20 pp. 6 figs. This Bureau of Mines report presents a cost estimate of the Bayer process, which is used for virtually all cell-grade alumina production. The report will serve as a reference point to determine the economic merits of processes that have evolved from Bureau of Mines investigations on technology for producing alumina from domestic nonbauxitic raw materials. The Bayer process involves dissolving the alumina present in bauxite in a caustic solution at high temperature and pressure. After the undissolved impurities are removed, the solution is seeded to produce an alumina trihydrate precipitate. This precipitate is filtered, washed, and calcined to produce the cell-grade alumina product. This cost estimate is for a plant producing 1 million tons of alumina per year. The estimated operating cost is approximately $250 per ton of alumina.

IC 8959. Economic and Technical Evaluation of the Sulfurous Acid-Caustic Purification Process for Producing Alumina From Kaolinitic Clay, by Deborah A. Kramer. 1983. 26 pp. 9 figs. An economic and technical evaluation of a proposed process to recover alumina by leaching calcined kaolinitic clay with sulfurous acid is presented in this Bureau of Mines report. After the insoluble portion of the clay has been removed by leaching, monobasic aluminum sulfite is precipitated from the pregnant leach solution by partial hydrothermal decomposition. Further heating completes the decomposition to an impure alumina hydrate. This intermediate is purified in a modified Bayer process, which includes dissolving the alumina hydrate in a caustic solution at high temperature and pressure, then decreasing the temperature and pressure to precipitate alumina trihydrate. Calcining the trihydrate produces the alumina product. A cost estimate was prepared for a plant producing 1,000 tons of alumina per day, 350 d/yr. The estimated operating cost is approximately $475 per ton of alumina. This is substantially higher than a comparable estimated operating cost for the Bayer process of $250 per ton of alumina. The proposed process does not appear economically attractive, even as a method to modify a current Bayer processing plant to use a kaolinitic clay feed. High capital costs and high energy requirements make the process prohibitively expensive.

IC 8960. Microseismic Instrumentation Developments. A Tape-Triggering System and Energy Analyzer, by Bernard J. Steblay. 1983. 12 pp. 8 figs. Two instruments have been constructed that extend microseismic data collection and processing capability for Bureau of Mines research in rock burst, coal bounce and outburst, and roof fall monitoring. The first instrument is a 13-channel tape-triggering system. This system allows better utilization of instrumentation tape recorders by collecting data digitally, turning the tape on only when valid data are present, and increasing the dynamic range of the recorder by using digital data. A digital-to-analog converter is used to provide analog output of the recorded digital data. The instrument records a much larger time slice of transient events than do current commercial devices. The second instrument is a microseismic energy measurement device. This device uses recent developments in integrated circuits to overcome the dynamic range and accuracy limitations of previous instruments. The analog signal is converted to a digital one, and then high-speed multiplication techniques are used to square the amplitude value in real time and integrate it.

IC 8961. In Situ Copper Leaching in the United States: Case Histories of Operations, by Jon K. Ahlness and Michael G. Pojar. 1983. 37 pp. 16 figs. The copper industry has had a long and interesting history associated with leaching, involving vat, dump, heap, and in situ methods. The Bureau of Mines has also had an interest in copper leaching and has researched the techniques of solution recovery, particularly concentrating on in situ methods. In situ mining is a relatively low cost method and has been proven commercially successful by mine operations. It has been most commonly used for final recovery in old workings at the conclusion of conventional mining operations. This report brings together information about 10 commercial in situ operations as well as 14 experimental projects. These 24 sites comprise most of the in situ copper mining activities that have taken place in the United States. Background information, geology, ore preparation, solution application, and recovery and processing are provided for each operation. Production data and tables summarizing the engineering statistics for each operation and an extensive in situ mining bibliography are included. GPO Stock No. 024–004–02127–6. $2.

IC 8962. Lead and Zinc Availability—Domestic. A Minerals Availability Program Appraisal, by Catherine C. Kilgore, Sylvia J. Arbelbide, and Audrey A. Soja. 1983. 30 pp. 22 figs. The Bureau of Mines investigated the availability of lead and zinc from 104 domestic mines and deposits. Fourteen primary lead and fifty-three primary zinc operations with in situ demonstrated resources containing 27.3 million metric tons (t) of lead and 53 million t of zinc were subsequently evaluated. Potentially 17.5 million t of lead and 2.4 million t of byproduct zinc could be

recovered from 14 primary lead operations. Economic evaluations performed in constant January 1982 dollars determined a long-run total cost per pound of recoverable commodity. Including a 15-pct discounted-cash-flow rate of return (DCFROR), 59 pct of primary lead was potentially available at or below $0.32 per pound of lead. Potentially 40 million t of zinc and 5.6 million t of byproduct lead could be recovered from 53 primary zinc operations. Ninety percent of the recoverable zinc is potentially available from currently nonproducing mines and deposits, and a weighted average of their long-run total costs was determined at $0.98 per pound of zinc. At a break-even (0-pct) DCFROR, these nonproducing operations had a weighted average long-run total cost of $0.58 per pound of zinc. Sensitivity analyses illustrated that operations that recover byproducts were most sensitive to fluctuating metal prices, producing operations were more sensitive to increased smelter treatment charges, and nonproducing operations were impacted most by the DCFROR. GPO Stock No. 024-004-02126-8. $2.

IC 8963. Review of Anhydrous Zirconium-Hafnium Separation Techniques, by Robert L. Skaggs, Daniel T. Rogers, and Don B. Hunter. 1984. 25 pp. 9 figs. Sixteen nonaqueous techniques conceived to replace the current aqueous scheme for separating hafnium and zirconium tetrachlorides were reviewed and evaluated by the Bureau of Mines. The methods are divided into two classes: separation by fractional volatilization of the tetrachlorides, which takes advantage of the higher volatility of hafnium tetrachloride; and separation by chemical techniques, based on differences in chemical behavior of the two tetrachlorides. The criteria used to evaluate separation methods were temperature, pressure, separation factor per equilibrium stage, complexity, compatibility with existing technology, and potential for continuous operation. Three processes were selected as being most promising: (1) high-pressure distillation, (2) extractive distillation from a molten salt, and (3) preferential reduction of gaseous $ZrCl_4$. Any of the proposed nonaqueous Hf-Zr separation schemes must be supplemented with additional purification to remove trace impurities.

IC 8964. Ground Penetrating Radar. A Review of Its Application in the Mining Industry, by W. E. Pittman, Jr., R. H. Church, W. E. Webb, and J. T. McLendon. 1984. 23 pp. 4 figs. The Bureau of Mines, as part of its Health and Safety Technology Program, is conducting research on the use of ground penetrating radar (GPR) for mine hazard detection. GPR offers a possibility of mapping immediate below-surface geologic conditions, including faulting and other anomalies, thereby exposing potential safety hazards to miners. This report summarizes a literature review of the current status of GPR research in and outside the Bureau. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

IC 8965. Radiation Hazard Test Facilities at the Denver Research Center, by R. F. Droullard, T. H. Davis, E. E. Smith, and R. F. Holub. 1984. 22 pp. 51 figs. The Bureau of Mines has developed test facilities for use in a research program that deals with radiation hazards in mining. This report describes the radon test chamber located at the Denver Research Center and the Twilight experimental mine located near Uravan, CO.

IC 8966. Nonfuel Mineral Model Directory, by Staff, Bureau of Mines. 1984. 40 pp. This Bureau of Mines report is a compilation of information on computer models of mineral commodity markets in the Federal Government. The directory was compiled by the Analytic Systems Working Group of the Interagency Minerals Information Coordinating Committee to support the formulation of policies related to nonfuel minerals. (*Out of print.*)

IC 8967. Analysis of Data on Respirable Quartz Dust Samples Collected in Metal and Nonmetal Mines and Mills, by W. F. Watts, Jr., D. R. Parker, R. L. Johnson, and K. L. Jensen. 1984. 28 pp. 3 figs. This report describes a statistical analysis of 41,502 respirable quartz dust samples collected from 1974 through 1981 in metal and nonmetal mines and mills. The goal of this Bureau of Mines study was to identify commodities and occupations associated with high quartz dust exposure so that future enforcement and research activity can be focused on the high-exposure areas. For this analysis, the Bureau used its computerized Mine Inspection Data Analysis System (MIDAS), which contains data on nearly 350,000 air samples, including data for 61 contaminants in 45 commodities. The samples analyzed were collected by inspectors of the Mine Safety and Health Administration (MSHA). The data were entered into the MIDAS computer and coded according to commodity, occupation, location, and other categorical information. Occupations and commodities with high quartz dust exposure were identified by grouping the data by code categories. Workers at sandstone, clay and shale, and miscellaneous nonmetallic mineral mills had the highest quartz dust exposures. Within these mills, occupations with high exposures were baggers, general laborers, and persons involved in crushing, grinding, and sizing operations. Dust concentrations in these mills were not necessarily the highest, but because the dust contained a high percentage of quartz, the health risk from dust exposure was the greatest.

IC 8968. Performance Evaluation of a Real-Time Aerosol Monitor, by K. L. Williams and R. J. Timko. 1984. 20 pp. 14 figs. The Bureau of Mines laboratory tested the response of a commercially available real-time aerosol monitor (GCA RAM-1) to various dusts. Monitor measurements were recorded, averaged, and compared with simultaneous gravimetric measurements of each test dust. Tests usually lasted several hours. The test dusts of various particle size distributions used included coal, limestone, and a commercially available test dust. For each particular dust, the monitor response was linear and correlated well with mass concentration over the range of about 0.5 to 10 mg/m^3. The monitor can estimate a 2.0-mg/m^3 respirable coal dust concentration within as little as ± 6 pct with 95 pct confidence. The monitor must, however, be calibrated with the dust to be measured because the instrument response is affected by the type of dust particle. The average monitor response to a mass concentration of coal dust was approximately twice the average monitor response to the same mass concentration of limestone dust.

IC 8969. Gold and Silver Leaching Practices in the United States, by Peter G. Chamberlain and Michael G. Pojar. 1984. 47 pp. 13 figs. The surge in gold

and silver prices during the 1970's attracted many new mining operators and has rekindled interest among experienced ones. With its low capital investment requirements and fast payout, leaching has attracted many operators—particularly those with small or low-grade deposits. Although in certain situations leaching offers many advantages over conventional mining methods, many operators are uncertain how these relatively new techniques should be implemented. Consequently the Bureau of Mines has prepared this circular to disseminate information on gold and silver leaching practices, techniques, and problems. Engineering data gathered from 26 operations indicate that most ores are leached in heaps following crushing and distribution on pads. Metal values are recovered from cyanide leach solutions using either zinc precipitation or charcoal adsorption. Potential problems that may hamper on block development of a leaching operation are poor percolation characteristics of the ore, calcium salt buildup, low temperatures, and solution losses. An extensive bibliography on gold and silver leaching is appended. GPO Stock No. 024–004–02125–0. $2.25.

IC 8970. Mine Power System Analysis-Design Computer Programs, by Dean H. Ambrose. 1984. 5 pp. Computer programs are presented that provide mine electrical systems based on computer modeling for design and safety analysis suitable for large or small computer systems and handheld calculators. Bureau of Mines research has resulted in load-flow, fault, grounding, reliability, short-circuit, transient, and cable ampacity computer models that enable mine power system engineers to analyze their system or to design a system. This report describes the capabilities of the program.

IC 8971. Fabrication Manual for a Reduced-Noise Auger Miner Cutting Head, by Mark R. Pettitt and William W. Aljoe. 1984. 9 pp. 10 figs. After a long series of laboratory and in-mine tests, a cost-effective, mineworthy, reduced-noise auger miner cutting head was designed, fabricated, and field-tested by Wyle Laboratories under contract to the Bureau of Mines. Compared with standard auger cutting heads, the new heads reduced noise by 10 dBA at the jacksetter's position and by 6 dBA at the operator's position. This report contains detailed fabrication instructions, including engineering drawings, that show how a standard auger cutting head can be modified to produce a reduced-noise auger.

IC 8972. Review of Desliming Method and Equipment, by Christopher H. Roe. 1984. 60 pp. 32 figs. This Bureau of Mines report reviews the various methods of removing the liquid from tailings slurries that contain very fine grained solids. Gravitational settlement, centrifugation, filtration, and thermal drying methods are discussed in detail. Chemical additives, electrokinetic dewatering, and the rotary trommel screen are also mentioned. Lists of dewatering equipment and suppliers are given in the appendixes to assist the planner who must choose the most efficient, economic, and practical method of dewatering very fine grained mill tailings.

IC 8973. Mine Ground Control. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, PA, December 6-7, 1983, and Denver, CO, December 8-9, 1983, compiled by Staff, Bureau of Mines. 1984. 155 pp. 126 figs. These proceedings consist of papers presented at Bureau of Mines Technology Transfer Seminars in December 1983 to introduce to the mining industry the significant technological advances made in various aspects of ground control in mines. Papers were presented on mine design, hazard detection, ground installation equipment, and roof support systems. Emphasis was placed on those innovations that have been validated by industrial applications or by extensive field demonstrations. Although many of those studies and innovations were conducted in or designed for use in coal mine ground control, most of the new technologies can be adapted for use in various mining environments including metal and nonmetal mines.

IC 8974. Methods for Producing Platinum-Group Metal Coatings From Molten Alkali Cyanides, by Richard P. Walters and David R. Flinn. 1984. 17 pp. 10 figs. This Bureau of Mines report reviews and assesses the technology for preparing electrodeposited coatings of the platinum-group metals from molten alkali metal cyanide baths. Methods are described for the preparation and purification of the cyanide electrolyte. Vacuum drying, fusion, and purity of the cyanide salts are discussed. Use of a sodium borosilicate test tube as a sodium-ion-conducting membrane for the addition of the desired platinum-group metal is described. The optimum plating parameters of potential and current density for Pt, Pd, Rh, Ru, and Ir coatings that result in the best deposits are given. A method for producing platinum-rhodium alloy coatings of predetermined composition is also described. The importance of careful substrate surface preparation is illustrated. While problems still remain with respect to coating porosity, careful application of the methods described permits the preparation of adherent, coherent electrodeposited coatings of the platinum-group metals.

IC 8975. Retrofit Noise Control Modifications for Crushing and Screening Equipment in the Nonmetallic Mining Industry, an Applications Manual, by R. J. Pokora, T. G. Bobick, and T. L. Muldoon. 1984. 24 pp. 37 figs. This Bureau of Mines report is an applications manual that can be used by the nonmetallic mining industry for guidance in installing noise control materials into crushing and screening plants. These noise control modifications were installed and successfully tested at three operating quarries. This report identifies the major noise sources that can be encountered in crushing and screening plants, and discusses the applicable noise control materials and techniques that a plant operator can utilize on a retrofit basis to reduce equipment noise.

IC 8976. Geologic Factors in Coal Mine Roof Stability—A Progress Report, by Noel N. Moebs and Raymond M. Stateham. 1984. 27 pp. 10 figs. This report summarizes 10 selected Bureau of Mines research contract reports produced from 1970 to 1980 that consist largely of geologic studies of coal mine roof support problems. Significant highlights from the contract final reports are discussed and presented in practical terms. The selected reports focus on the Appalachian and Illinois coal mining regions. In the Appalachian coal region, two geologic structures, roof rolls and slickensides, predominate over all structures as features that directly contribute to roof falls. Studies of these and other structures are reviewed, and improved methods of utilizing drill core and core logs to prepare hazard maps are presented. Among the reports described are several on the weakening effects of moisture on shale roof, as determined from both laboratory and

underground measurements, and an assessment of air tempering as a humidity-control method. Also summarized are findings concerning the time lapse between roof exposure and permanent support installation as a factor in the effectiveness of roof bolting.

IC 8977. Chromium Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by P. R. Thomas and E. H. Boyle, Jr. 1984. 86 pp. 35 figs. The Bureau of Mines determined the costs associated with the production of chromium, in the form of chromite and high-carbon ferrochromium, from the demonstrated resources of 10 market economy nations. The analyses evaluated the relative geologic and economic position of these chromite resources contained within 80 producing or potential mining operations. This report presents cost evaluations of a demonstrated resource of chromite, contained within the nations studied, of approximately 1.2 billion metric tons. Of this, 70 pct is contained within the southern African nations of Zimbabwe and the Republic of South Africa. The majority of current chromium mining and smelting capacity is contained within these two countries as well. India and the Philippines have recently demonstrated greatly increased chromite resources and hold the most promise for expanding both chromite and ferrochromium production outside southern Africa. Their demonstrated resources represent approximately 7 and 16 pct, respectively, of the cost evaluated total tonnage. Chromite resources, on an identified or hypothetical basis worldwide, are highly concentrated within Zimbabwe and South Africa, with these two nations containing in excess of 95 pct of the total. Given the present market structure, a majority of chromium contained within the demonstrated chromite resources of the nations studied is economically recoverable; but from a long-term resource and economic perspective, South Africa should increasingly dominate the markets for both chromite and high-carbon ferrochromium. In addition, it is anticipated that an increasing percentage of chromium traded on the world market in the future will be in the form of high-carbon ferrochromium as opposed to chromite, as this additional processing stage continues to relocate from the industrial nations that account for a majority of chromium consumption to those nations that mine chromite. GPO Stock No. 024-004-02134-9. $3.25.

IC 8978. Manganese Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by Joseph S. Coffman and Cesar M. Palencia. 1984. 26 pp. 11 figs. To determine the availability of manganese for metallurgical purposes from selected world resources, the Bureau of Mines evaluated the potential production of contained manganese in concentrates based on the demonstrated resources of 23 foreign and 8 domestic mines and deposits in 9 market economy countries. All but 2 of the 23 foreign deposits are operating mines; none of the domestic deposits are in operation. The demonstrated resources of the mines and the deposits used in this study represent an in situ ore resource of approximately 2.2 billion tons, containing 780 million tons of manganese with a total recoverable production potential of 514 million tons of contained manganese in concentrates. The analyses of mines and deposits in this study indicate that about 213 million tons of the contained manganese (41 pct) is potentially available at a January 1981 constant dollar long-run total cost of up to $1.50 per long ton unit (22.4 lb, or 10.15 kg contained Mn), and 491 million tons (95 pct) is available at less than $3.30. The remaining 23 million tons, which is potentially available at much higher cost (about $8 to $35 per unit), represents the U.S. deposits. On an annual basis, with a cost range of up to $1.75 per long ton unit, the availability from currently operating mines would last at least 80 years based on 1980 world production data. Total manganese production costs are estimated to comprise mining—8 pct, beneficiation—3 pct, transportation—26 pct, and smelting—63 pct.

IC 8979. Mergers in the Nonfuel Minerals Industry: Trends and Motives, by James S. Grichar and Elizabeth H. Yaremchuk. 1984. 13 pp. 5 figs. Interest in mergers in the nonfuel mineral industry developed when 5 were listed among the 50 highest valued mergers in the United States in 1981. This report presents a Bureau of Mines study of trends in merger activity from 1960 to 1979 and explores motives for mergers in the nonfuel mining and mineral industry. The objective was to determine precedent for or a trend toward the 1981 acceleration in merger activity and to examine certain financial motives for nonfuel mineral mergers. Data indicate that the relative value of nonfuel mineral mergers has grown since 1972 although the number of mergers has remained proportionate to historical trends for all mergers. Since 1974, the assets acquired in "large," nonfuel mineral firm mergers, those of $10 million or more, have comprised at least 93 pct of assets acquired. More nonfuel mineral firm mergers involved mineral companies as the acquiring firm than vice versa but mining and minerals firms acquired were of higher value than nonmining firms. A major motivation for mergers involving large mineral firms was the acquisition of assets at less than replacement costs. Univariate statistical testing, a methodology chosen for its applicability to the data, confirms this hypothesis while rejecting other financial motives. The remainder of the work is devoted to a discussion of suggested areas for future study. GPO Stock No. 024-004-02133-1. $1.50.

IC 8980. A Review of Phosphatic Clay Dewatering Research, by Walter E. Pittman, Jr., Jerry T. McLendon, and John W. Sweeney. 1984. 29 pp. 11 figs. This Bureau of Mines study surveys the current state of technology and the various research efforts that have been undertaken to dewater the dilute phosphatic clays generated in the production of phosphate rock. The research described includes early dewatering experiments, fundamental studies of clays and of flocculation, and minor dewatering techniques such as freeze-thaw methods, the AND-CO process, moving screens, sand wick, crust development, and overburden pumping. Some methods that are currently being evaluated are described. They include the Estech sand-clay mix process using the Enviro-Clear thickener, sand-clay sandwiching, dredge mix, dredge process, and the sand-spray process. Developing technology for dewatering phosphatic clays also is described, including the Bureau of Mines rotary trommel method and the Gardinier process. This report is based upon work done under an agreement between the Florida Institute of Phosphate Research and the Bureau of Mines.

IC 8981. Microcomputer-Based Monitoring and Control System With Uranium Mining Application, by C. T. Sheeran and J. C. Franklin. 1984. 28 pp. 9 figs. The Bureau of Mines investigated a microprocessor-

based real-time control and monitoring system for uranium mining applications. The system is capable of controlling and monitoring up to 768 stations within 3 km of the central processor on a common four-wire cable. It can be used in conjunction with detectors to continuously monitor and display radiation working levels at points throughout the mine. Surface alarms are sounded for critical situations such as rapid radiation buildup, loss of power to monitors or fans, and changes in air door position. Permanent records of all changes are automatically printed out with their time of occurrence. Printouts can also be obtained for shift reports or trend logs. The system can be used to remotely control fan startup and shutdown, and also can alert miners of underground conditions by blowing horns or turning on lights. Battery backup keeps the system operative for up to 4 h in case of a mine power outage. A special software feature permits automatic, time-delayed, sequential restart of fans.

IC 8982. Conservation and Development In-House and Contract Research in Fiscal Year 1984, by Staff, Bureau of Mines. 1984. 21 pp. This publication summarizes the in-house and contract research projects programmed for fiscal year 1984 by the Bureau of Mines under its Conservation and Development activity. The document provides a mechanism for interested parties to gain insight into projects of the Bureau's Conservation and Development research program. The objective of the Conservation and Development Program is to provide the technological advances needed to stimulate the mining of domestic deposits containing critical, strategic, and other essential minerals in compliance with existing regulations and at costs sufficiently low to be competitive in world markets. Research efforts are directed toward improving the fundamental understanding of processes and procedures involved in the production of minerals. The overall goals will be accomplished by investigating alternative mining methods to increase domestic production of critical and strategic minerals from low-grade deposits; expanding the technology for the economic and efficient extraction of minerals consistent with cost-effective compliance with environmental regulations; and advancing the technologies needed to insure an adequate supply of coal.

IC 8983. Improved Personnel Access for Surface Mining Equipment, by Dennis A. Long. 1984. 20 pp. 13 figs. Slip and fall accidents are a major cause of lost-time injuries associated with large mobile equipment in surface mines. An evaluation of the safety hazards associated with getting on and off large surface mining vehicles showed that most of the accidents occur at the point where personnel attempt to mount or dismount the machine at ground level. The major hazardous design conditions were identified as excessively flexible supports for lower steps or rungs, inappropriate ground-level-to-first step distances, poor step designs, access designs that use vehicle components as steps or walkways, and inadequate handrail and guardrail designs. Additional hazards are introduced by the lack of proper maintenance of ladder hardware and the work practices of operators in carrying articles while mounting and dismounting the vehicle. This Bureau of Mines report describes the design and in-mine testing of improved access systems for large mobile mining equipment.

IC 8984. Selected Pneumatic Gunites for Use in Underground Mining: A Comparative Engineering Analysis, by Gary W. Krantz. 1984. 64 pp. 42 figs. Fibered, portland-cement-based gunite products were applied in the Bureau of Mines Lake Lynn Laboratory Experimental Mine using a variety of pneumatic guns and gunning crews. The demonstrated wet-mix (with silica fume), dry-mix, and surface bonding products were sampled by the Bureau and subjected to a suite of engineering analyses. Gunite flexural and compressive strength, rebound, permeability, porosity, dust loading, shooting rate, crew requirements, and cost factors were evaluated. Steel, fiberglass, or polypropylene fibers were contained in all but two of the gunites tested. Both Bureau and private testing laboratory analyses are provided for some products. Electron probe microanalysis and X-ray diffraction analysis were performed on the silica fume fraction of the wet-mix gunite to characterize the dust. Aggregate size fraction distribution analyses were performed to provide strength relationships. Results indicate that all of the commercially available fibered gunite materials tested can provide beneficial sealant, spill prevention, or roof stability control attributes for underground mining environments when applied by an experienced crew using a well-maintained gun, in accordance with product manufacturers' recommendations and when used for the designated purpose.

IC 8985. Pickling of Stainless Steels—A Review, by Bernard S. Covino, Jr., John V. Scalera, and Philip M. Fabis. 1984. 15 pp. 1 fig. The Bureau of Mines is conducting a study of methods to improve the efficiency of the process used to pickle stainless steels. A review of the literature on pickling of stainless steels showed that the chemistry of several process operations involved in the pickling of stainless steels is not fully understood and that further research could improve the pickling efficiency. The benefits of this research would be a reduction in the annual loss of several thousands of tons of critical minerals such as nickel and chromium, and a reduction in the amount of solids and spent acid solution that are currently discarded. The conclusion from this review is that further research is needed in four operations that either directly or indirectly influence the pickling process: hot working, annealing, conditioning, and the actual operation of pickling. Laboratory studies of the pickling operation are presently in progress.

IC 8986. Noise Control. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, PA, July 24, 1984, and Denver, CO, July 26, 1984, compiled by Staff, Bureau of Mines. 1984. 141 pp. 120 figs. Overexposure to noise is a widespread, serious health hazard in the mining industry and causes hearing losses to a large percentage of the mining population. Recognizing this fact, the Bureau has a major ongoing research effort to address this problem area. These proceedings include an overview of the Bureau noise control program and summarize nine selected noise control research programs.

IC 8987. Methane Emissions From U.S. Coal Mines in 1980, by Roy H. Grau III and John C. LaScola. 1984. 13 pp. 5 figs. This Bureau of Mines report contains a tabulation of methane emissions during 1980 for all coal mines located in the United States with emissions greater than 0.1 MMcfd. Listed for each mine are methane emission quantity, location,

and coalbed. The report also compares records of 1975 and 1980 and describes relationships between emissions in 1980 and the Bureau's coalbed gas content data on 11 mines.

IC 8988. Nickel Availability—Domestic. A Minerals Availability Program Appraisal, by D. A. Buckingham and Jim F. Lemons, Jr. 1984. 27 pp. 19 figs. The Bureau of Mines evaluated potential availability of domestic nickel from 23 deposits. Evaluations included an estimation of in situ and recoverable resources, applicable mining and processing technologies, and capital and operating costs. Discounted cash flow analysis with a 15-pct rate of return was used to determine the average total cost of production of each operation. Identified in situ resources contain 9.0 million metric tons (t) of nickel; 5.5 million t is recoverable as nickel metal or ferronickel. Demonstrated in situ resources contain 8.2 million t of nickel; 4.8 million t is recoverable as nickel metal or ferronickel. No nickel is available at a total cost of production equal to the January 1983 market price of $3.24 per pound. Analyses indicate that potential annual production can only meet current consumption levels at a total cost of production of $7.60 per pound of nickel. Nickel's availability is contingent on (1) successful adaptability of nickel processing methods to domestic resources, (2) location of a smelting facility, and (3) marketability of byproducts and coproducts. Analyses were performed on the effects of byproduct and coproduct revenues, energy, labor, and transportation costs, and metallurgical recoveries on nickel's availability.

IC 8989. Phosphate Rock Availability—World. A Minerals Availability Program Appraisal, by R. J. Fantel, T. F. Anstett, G. R. Peterson, K. E. Porter, and D. E. Sullivan. 1984. 65 pp. 28 figs. The Bureau of Mines investigated the resource potential of 201 mines and deposits in 28 market economy countries and 17 mines and deposits in the U.S.S.R. and China. The 201 mines and deposits evaluated from market economy countries contain an estimated 34.2 billion metric tons of recoverable phosphate rock (at the demonstrated resource level), with Morocco and Western Sahara accounting for 61% (21 billion tons), followed by the United States with 19% (6.4 billion tons). The 17 mines and deposits evaluated in the U.S.S.R. and China contain approximately 1.5 billion tons of potentially recoverable phosphate rock. Potential annual capacity from low-cost, high-grade producing mines in the United States is estimated to decline significantly during the latter half of the next decade, and the United States will have to develop new, higher cost, lower grade mines in order to satisfy demand into the next century. Of the world's new production capacity that could likely be developed over the next decade, slightly over one-third could be produced at an estimated 1981 cost of $40 per ton or less, and about two-thirds would cost in the $40 to $50 range (including a 15% rate of return). In comparison, most of the competing phosphate rock from producing mines in Morocco could be produced for under $40 per ton. The United States has sufficient demonstrated resources of phosphate rock (plus huge quantities at the identified and hypothetical resource levels) to satisfy domestic consumption for many years to come, but its future ability to compete in the major export markets against low-cost competitors is much more uncertain.

IC 8992. Use of Steel Sets in Underground Coal, by J. H. Stears, M. O. Serbousek, and K. E. Hay. 1984. 16 pp. 12 figs. This Bureau of Mines report presents information on the use of steel supports in U.S. coal mines, including accident statistics for a 3-yr period and a survey of present applications and problems. It also contains a summary of available steel arch configurations and a description of steel support design criteria for ground control applications.

IC 8993. Analyses of Natural Gases, 1983, by Floyd R. Hertweck, Jr., and Daphne D. Fox. 1984. 127 pp. 1 fig. This Bureau of Mines publication contains analyses and related source data for 349 natural gas samples from 26 States and 2 foreign countries. The 3 samples from foreign countries and 339 of the U.S. samples were collected during calendar year 1983. The remaining seven samples were collected earlier, but releases granting permission to publish were not received until 1983. All samples were obtained and analyzed as part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted since 1917. The analyses published herein were made by the mass spectrometer and chromatograph.

IC 8994. Task Training in the Iron Mining Industry: Two Approaches, by David T. Couillard and Bruce C. Nelson. 1984. 11 pp. 5 figs. Task training is increasingly important in mining operations because of the ever-accelerating pace of technological innovations and the concomitant increasing complexity of mining equipment. This Bureau of Mines report describes two successful task training programs in use in two open-pit taconite operations in northeastern Minnesota. The programs are different in approach, but both have improved safety and increased productivity while lowering costs. Methods of training both before and after passage of the 1977 Mine Safety and Health Act are described, and the impact of this act on task training at each operation is discussed. The report identifies four common principles that have contributed to the success of the two training programs and presents plans each operation has for improving future training through new technology.

IC 8995. Nickel Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by D. I. Bleiwas. 1984. 33 pp. 19 figs. Bureau of Mines personnel evaluated the potential availability of nickel from 151 deposits in 18 market economy countries and selected 126 for detailed analyses. An evaluation was made of tonnage-cost relationships indicating the quantity of nickel available at various total costs of production expressed in dollars per pound nickel, including a 15-pct rate of return on the invested capital. The 126 deposits studied contain approximately 73 million metric tons (t) of nickel. An estimated 52 million t is available from laterite deposits, of which less than 2 pct would be produced at $3.50/lb Ni, about equal to the average published price of nickel in 1981. Approximately 21 million t can be produced from sulfide deposits, of which about 10.0 million t can be produced at $3.50/lb. Sensitivity studies performed for both laterite deposits and sulfide deposits indicate that the total cost of nickel from laterites is most sensitive to increases in energy costs, and that sulfides are most sensitive to increases in labor costs; sulfides are also sensitive to changes in byproduct

revenues. In 1983, the Nickel Mountain Mine in Oregon was the only U.S. producer, although development continued on the Gasquet property in California. Of the total 5.1 million t of recoverable nickel in the United States, about 20 pct is available at or below $3.50/lb.

IC 9000. Overspeed Protection for Mine Diesels. A Literature Review, by Lito C. Mejia and Robert W. Waytulonis. 1984. 13 pp. 3 figs. Diesel-powered equipment operating in a gassy underground mine could conceivably ingest a methane-air mixture from the mine atmosphere that could cause the diesel engine to overspeed, or exceed its rated speed. Engine overspeed, particularly if extreme (engine runaway), could result in personal injury, a possible mine explosion, and/or catastrophic engine failure. In this report, the Bureau of Mines reviews the literature on the potential hazards of methane-induced diesel engine overspeed. Also included are the Bureau's findings from consultations with representatives of the diesel engine industry to determine the specific engine behavior that could be expected under the overspeed condition. The report summarizes data on mine accidents involving methane, discusses results of tests on the compression ignition of methane in diesel engines, and examines fuel governors and intake-air-cutoff devices, two kinds of devices used to prevent overspeed. Analysis of the information gathered suggests that the conditions necessary to cause a diesel engine to overspeed uncontrollably are not likely to occur, particularly if the engine is equipped with flameproofing devices. The available literature and lack of actual overspeed case histories suggest that the safety devices currently in use are sufficient to prevent diesel engine overspeed.

MINERAL ISSUES

The "Minerals Issues" series addresses contemporary mineral policy issues to assist Government and private sector decisionmakers. Reports in the series present nonfuel-mineral-base information in a form convenient for the support of policy formulation and analysis; identify options to achieve mineral-related national needs and goals and provide an assessment of their political, social, and economic effects; examine specific aspects of mineral economics or operations research methodology; and/or assess the impact of Federal and State mineral-related policies.

MI. The U.S. Copper Industry: Problems, Issues, and Outlook, by Louis J. Sousa. 1981. 86 pp. 9 figs. The domestic copper industry has been through a difficult period over much of the past decade. The numerous problems facing the copper industry have resulted in generally poor profitability, little improvement in productivity, and a trend of increasing imports. In this Bureau of Mines report, the principal problems facing the copper industry are identified and their impact on the industry's performance and outlook are assessed. The study revealed that the relatively low grade of U.S. copper ores and the high cost of labor compared with grades and costs in several developing countries are major problems hindering the domestic copper industry, that several smelters in this country are in need of renovation in order to better compete with foreign copper producers, and that several Government policies have had a negative effect on the copper industry. In spite of these problems, the magnitude of the U.S. copper reserve seems to assure that the country will remain a major producer. While the potential long-run outlook for copper mining in the United States is generally favorable, a major unknown is the future status of smelting in this country. (*Out of print.*)

MI. The Nonfuel Mineral Outlook for the U.S.S.R. Through 1990, by James S. Grichar, Richard Levine, and Lotfollah Nahai. 1981. 17 pp. The U.S.S.R. is one of the largest producers, consumers, and exporters of nonfuel minerals in the world. In addition, it has one of the world's largest resource bases. Recently, some analysts have concluded that the U.S.S.R. will become import dependent for a broad range of nonfuel minerals. To examine this question in greater detail, the Bureau of Mines held a symposium on this topic and had papers prepared on the subject. This study not only draws on those papers but sets forth an outlook for the Soviet Union's nonfuel mineral position through 1990. (*Out of print.*)

MI. Taxation and the Profitability of Mineral Operations in Seven Mountain States and Wisconsin: A Hypothetical Study, by Robert L. Davidoff and Ronald J. Hurdelbrink. 1983. 32 pp. 12 figs. The potential profitability level of a mineral property depends on the geologic, engineering, and economic characteristics of the deposit, but may also depend to a large extent on the local tax structure. This Bureau of Mines study uses the Bureau's Mine Simulator (MINSIM) economic evaluation computer program and three hypothetical mineral properties to examine the differential impact on profitability of the tax structures of eight mineral-producing States. Wide variations between States in calculated rates of return indicates that tax structure could in some instances be the determining factor (given identical deposits) in a decision on whether or not to develop a property. GPO Stock No. 024-004-02119-5. $3.75.

MI. The Copper Industry of the U.S.S.R.: Problems, Issues, and Outlook, by Vasilii V. Strishkov, with an appendix on Methodology, by Charles L. Kimbell. 1984. 80 pp. 2 figs. The U.S.S.R. is one of the world's largest producers and consumers of copper and is a significant exporter of the metal. In addition, its copper reserve base is one of the world's largest. According to Soviet sources cited in this Bureau of Mines report, the levels of production and export that have been achieved were reached in most instances only at the expense of goals set by the Central Planning Committee. This report summarizes the principal features of the Soviet copper industry, raw material sources, producing and processing facilities, policies and developmental programs under which it operates, and its involvement in world copper supply. The report assesses the impact of these aspects on the historic performance of the industry and on the outlook for short- and long-term future performance. GPO Stock No. 024-004-02137-3. $3.25.

OPEN FILE REPORTS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. For further information, contact the library, 202–343–5815.

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NOTE: The U.S. Department of Energy facility in Carbondale, IL, and the Bureau of Mines facilities in Avondale, MD, and Boulder City, NV, have been closed. Open file reports will not be available for reference at these sites. The Bureau of Mines facilities at Bruceton, PA, and Pittsburgh, PA, have been consolidated at the Bruceton site.

1980

OFR 1–80. Underground Disposal of Retorted Oil Shale for the Paraho Retorting Process, by H. W. Earnest, R. A. Heisler, H. L. Hoe, and V. Rajaram. May 1978. 379 pp. 51 figs. This report covers the results of a two-phase study to determine the feasibility of underground disposal of retorted oil shale. Two mining methods, chamber and pillar mining and sublevel stoping, were specified for backfilling. Phase I covered the evaluation of hydraulic, mechanical, and pneumatic transport and stowing systems, individually and in various combinations, and the selection of the most feasible methods. Conveyor transport and stowing and a combination conveyor transport and stowing with pneumatic topfilling were selected for detailed study. Phase II activities included detailed engineering analysis and design of the selected systems, an engineering economic analysis, and a cost comparison with total surface disposal of retorted oil shale. An extensive literature search was conducted and the bibliography is included. Research done under Contract No. J0265052 by Cleveland-Cliffs Iron Co. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W.Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–128739, paper copy price code A17.

OFR 2–80. Development of New Design Concepts for Construction of Valley Fills, by LeRoy D. Loy, Jr., Charles E. Ettinger, Michael R. Frakes, and Donald J. Kremer. Oct. 16, 1978. 160 pp. 37 figs. The disposal of excess overburden from surface mining can be accomplished by use of a reclamation technique entitled head-of-hollow or valley fill. This report attempts to assess current valley fill regulations and practices, identifies inherent benefits and deficiencies, and develops concepts to enhance fill technology. Research done under Contract J0177063 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–126055; paper copy price code A08.

OFR 3(1)–80. The Development of a Cross-Pit Overburden Handling System. Volume I—Preliminary Design, by J. Ritchey, F. H. Hagenbuch, and J. Mantel. October 1976. 68 pp. 18 figs. This report describes the engineering feasibility and economic advantages of using a mobile bridge-type, cross-pit belt conveyor system in conjunction with a large dragline to excavate and transport spoils in a typical western surface coal mine. The studies show that such a system could be built to survive operational and climatic mining conditions and that its implementation would offer a reduction in both acquisition and operating costs versus conventional mining units of comparable capacity. Reclamation costs can also be significantly reduced and the total reclamation process accelerated, making the cross-pit conveyor system attractive to mine owners and environmentalists alike. Research done under Contract No. J0255034 by FMC Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–132814; paper copy price code A04.

OFR 3(2)–80. The Development of a Cross-Pit Overburden Handling System. Volume II—Appendix, by J. Ritchey, F. Hagenbuch, and J. Mantel. October 1976. 117 pp. 19 figs. This report describes the engineering feasibility and economic advantages of using a mobile bridge-type, cross-pit belt conveyor system in conjunction with a large dragline to excavate and transport spoils in a typical western surface coal mine. The studies show that such a system could be built to survive operational and climatic mining conditions, and that its implementa-

tion would offer a reduction in both acquisition and operating costs versus conventional mining units of comparable capacity. Reclamation costs can also be significantly reduced and the total reclamation process accelerated, making the cross-pit conveyor system attractive to mine owners and environmentalists alike. Research done under Contract No. J0255034 by FMC Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-132822; paper copy price code A06.

OFR 4-80. The Influence of Mining Health and Safety and Environmental Legislation on Selected Domestic Metallic and Nonmetallic Minerals, by F. Albayrak, S. Lupton, T. McCrary, S. Mahmud, and G. Bierman. December 1978. 179 pp. 8 figs. This report is a study of the impact of Federal laws and regulations on the domestic supply of metallic and nonmetallic minerals. The study was confined to pertinent environmental legislation and the recently enacted Federal Mine Safety and Health Act of 1977. Legal requirements placed on individual selected mineral industries and the economic impact of these requirements are emphasized. Some attention was also directed toward particular environmental and health and safety problems generated by selected mineral industries. The study pinpointed a list of major problem areas that have a significant impact on the domestic mineral supply. Research done under Contract No. J0177124 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-131436; paper copy price code A09.

OFR 5-80. Development of Improved Multiseam Contour Haulback Mining, by Walter W. Kaufman and Wm. David Shrader. Mar. 30, 1979. 347 pp. 94 figs. This report summarizes a study conducted to develop improved techniques for haulback mining of multiple seam contour surface operations. The methods employed to perform contour haulback mining are discussed as are the implications of regulations requiring back to approximate original contour reclamation. Problems inherent to multiseam contour surface mines are defined and several potential solutions to those problems are introduced. Research done under Contract No. H0272025 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-149354; paper copy price code A15.

OFR 6-80. Study of Underground Coal Mine Waste Disposal Requirements in the United States, by Walter W. Kaufman and John R. Williams. Oct. 20, 1978. 250 pp. 17 figs. This report summarizes a study conducted to establish the nature and impact of regulations governing disposal of refuse from underground coal mines. The regulations affecting refuse disposal in eight major coal producing States are collected, summarized, and reviewed. Federal regulations applicable to refuse generated by underground coal mines are also included. Common refuse disposal practices are discussed as are the refuse quantities generated annually in each study State. Technical requirements of regulations are discussed and presented in tables. Economic implications are also assessed through cost analyses of three major types of disposal processes. The report also includes an assessment of future trends in regulation and refuse generation plus a series of recommendations concerning potential improvements in both the regulatory and refuse disposal processes. Research done under Contract No. J0275037 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-134646; paper copy price code A11.

OFR 7(1)-80. An Annotated Bibliography of Coal Mine Fire Reports. Volume I, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 93 pp. 3 figs. This three-volume report describes the method whereby data were gathered and analyzed on coal mine fire reports. The primary objective of the program was to develop an annotated bibliography of coal mine fire reports (1950-77). Two additional objectives were to gather data on nonreportable fires and to conduct statistical analyses on the data to delineate trends. The report does not include explosions or ignitions or fires that resulted from explosives. Data were acquired from three major sources: periodicals, MSHA (Mining Safety and Health Administration) fire reports, and mine safety directors. The primary data source was MSHA fire reports contained in the files of MSHA coal mine health and safety district and subdistrict offices. Data were separated into reportable fires (at least 30 minutes duration or injury), nonreportable fires, and opinion data. The data were then analyzed by time trends, State, ignition source, burning substance, location, equipment, detection, duration, injuries, fatalities, and successful extinguishing agents. Volume I contains data acquisition procedures, data analysis procedures, and conclusions and recommendations. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-140205; paper copy price code A05.

OFR 7(2)-80. An Annotated Bibliography of Coal Mine Fire Reports. Volume II, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 400 pp. Volume II of this three-volume report presents data on underground and surface coal mine fires occurring between 1950-77. The report contains a master list of all fire incidents obtained from MSHA (Mining Safety and Health Administration) reports; an annotated bibliography of all MSHA reports, journal articles on selected incidents, and

nonreportable fires; and indexes to be used in accessing incidents in the master list and annotated bibliography. These three types of information provide a complete summary of coal mine fires during the program and a convenient means to locate incidents of specific interest. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–140213; paper copy price code A17.

OFR 7(3)–80. An Annotated Bibliography of Coal Mine Fire Reports. Appendix, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 654 pp. This report is the appendix of a three-volume report that is intended to be used in conjunction with the tables and indexes contained in volume II, and as such should be considered an integral part of volume II. The indexes in the body of volume II provide a means of ready reference to the underground and surface mine incident report forms. For those readers with interests other than those indexed, tables II–1a and II–1b can be used to locate specific incidents of interest. Complete incident information can then be obtained from the corresponding report forms in the first two sections of this appendix. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–140221; paper copy price code A99.

OFR 8(1)–80. Availability of Critical Scrap Metals Containing Chromium in the United States. Part 1. Superalloys and Cast Heat and Corrosion-Resistant Alloys, by LeRoy R. Curwick, Walter A. Peterson, and Harry V. Makar. November 1979. 114 pp. 11 figs. A study was conducted to assess the domestic availability of chromium from superalloy and cast heat- and corrosion-resistant alloy scrap material. Six alloy classes included in this survey were investment cast, hardfacing, and wrought nickel- and cobalt-base alloys, wrought nickel-iron-base alloys, and heat- and corrosion-resistant alloy castings. Data were collected for 1976 on metallic scrap generation, use patterns, and production practices for these alloy producing and using industries. A model was developed that allowed an assessment of the materials flow circuits that produce these alloys. The types, amounts, sources, secondary products, and ultimate destinations of chromium-containing metallic scrap for the six alloy classes were determined. Research done under Contract No. J0188056 by INCO Research & Development Center. Available for reference at the Bureau of Mines Research Center in Avondale, Md.; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 8(2)–80. Availability of Critical Scrap Metals Containing Chromium in the United States. Part 2. Wrought Stainless Steel and Heat-Resisting Alloys, by C. L. Kusik, H. V. Makar, and M. R. Mounier. November 1979. 83 pp. 6 figs. As part of an effort to establish the extent of the domestic supply that could be exploited in case of adverse changes in international chromium production and trading patterns, this study was conducted for the Bureau of Mines to assess the domestic availability of critical scrap metals containing significant amounts of chromium. Data were collected on types of scrap, sources, amounts, and ultimate disposition, leading to the conclusion that in 1977 about 62,000 tons of contained chromium was unrecycled. Unrecovered obsolete stainless steel scrap accounts for most of these uncollected chromium values. In the methodology developed, chromium-containing metals are followed from the time they return as scrap. Data collected for 1977 and previous years are projected to 1990. Major losses are identified and estimated. Research done under Contract No. J0188170 by Arthur D. Little, Inc. Available for reference at the Bureau of Mines Research Center in Avondale, Md., and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 9(1)–80. Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas, by LFE Corp. Sept. 23, 1977. 87 pp. 4 figs. The objective of this handbook is to provide inspectors with guidance for recognizing hazards from inhalation contaminants in aboveground work areas of underground and surface metal and nonmetal mining and processing facilities and evaluating these hazards by collecting samples or making field determinations and interpreting the analytical results. Portions of the handbook that should prove most useful to the inspectors include a survey check list, rules for determining if sampling is required, list of most frequently encountered contaminants, list of candidate contaminants and their sampling conditions, interpretation of results, and a procedure for health and safety inspections. Research done under Contract J0255001. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–143969; paper copy price code A05.

OFR 9(2)–80. Surveying Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas. Instructor's Teaching Guide (For MSHA Inspectors), by Walter D. Holland. Sept. 23, 1977. 66 pp. 16 figs. This instructor's guide is intended for use in a course that teaches metal and nonmetal mine inspectors to perform surveys for inhalation contaminants in aboveground metal and nonmetal mine work areas. The handbook entitled "Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas" is used as a manual during the course. The manual contains a survey check list, rules for determining if sampling is required, a list of most frequently encountered contaminants, a list of candidate contaminants and their sampling conditions, and a description of control procedures and devices. There are several experiments in this guidebook that the trainees perform to acquaint them with the sampling systems. Research done under Contract No. J0255001 by LFE Corp. Avail-

able for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-142938; paper copy price code A04.

OFR 9(3)-80. Surveying Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas. Instructor's Teaching Guide (For Company Safety Officers), by Walter D. Holland. Sept. 23, 1977. 81 pp. 16 figs. This is one of a series of instruction guides developed to help instructors present health and safety training courses to workers in the metal and nonmetal mining industry. This course is intended for training those, usually the safety officers, who perform surveys for inhalation contaminants in aboveground work areas. The handbook entitled "Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas" is used as a manual for the course and is a prime reference when performing the actual surveys or interpreting the sampling results. There are six experiments for the students to perform during the course to familiarize them with the sampling devices routinely used during the surveys. Research done under Contract No. J0255001 by LFE Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-142946; paper copy price code A05.

OFR 10-80. Evaluation of Mine Parameters for Copper-Nickel Deposits of Northern Minnesota, by C. M. St. John, M. Christianson, and D. L. Peterson. Feb. 15, 1979. 112 pp. 54 figs. A series of analyses of possible mining excavations associated with the development of copper-nickel deposits of the MINNAMAX site in northeastern Minnesota is presented. Specific areas such as roof-and-pillar stability and excavation orientations are addressed. The majority of these analyses were conducted using a boundary element method but some cases were also analyzed using the finite element method. Comparable results were obtained using the two methods but the boundary element method required less data preparation time and computer run time. Results of the analyses, as well as indicating the capabilities of geotechnical numerical models, provide some insights into behavior around multiple excavations in jointed rock. Research done under Contract No. J0295003 by University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-144074; paper copy price code A06.

OFR 11-80. Application of Satellite Data to Surface Mine Monitoring in Selected Counties of South Carolina, by James N. Bayne and Hewson Lawrence. March 1979. 141 pp. 67 figs. The objective of this investigation was to examine the applicability of Landsat digital image processing to surface mine monitoring in South Carolina. Landsat data from computer compatible tapes were used to explore the capability of Landsat digital imagery to monitor mining and reclamation activity in several South Carolina mining operations. Differentiation between active-spoil and partially and completely reclaimed areas was successfully demonstrated including small mining operations of less than 30 acres. Supervised sequential discriminant analysis and unsupervised classifications at Stanford University and a parallelepiped classifier at the EROS Data Center were used. A high degree of accuracy was obtained in measuring several mines and mine segments with each system. Research done under Grant No. G0177166 by the South Carolina Land Resources Conservation Commission. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-144629; paper copy price code A07.

OFR 12-80. Design, Fabrication and Demonstration of an Inert Gas Generator, by John T. Dieckmann and Steven K. Ruggieri. April 1979. 106 pp. 30 figs. This report presents the work performed and results obtained in a 2-year development of a mobile inert gas generator for use in the Bureau of Mines remote sealing system for fighting underground coal mine fires. The performance requirements of an inert gas generating system for the remote sealing system were clearly established. A review of seven possible system designs meeting these requirements was conducted. An air-cooled, distillate oil-fired combustion inert gas generator was selected for further detailed design, hardware fabrication, and performance testing. The inert gas generator was tested and has been operated in the field for approximately 200 hours and the system has met or exceeded all important performance requirements. Research done under Contract No. H0155053 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-145881; paper copy price code A06.

OFR 13(1)-80. Survey of Surface Hydraulic Mining Technology. Volume 1—Final Report, by William C. Cooley and Viguen Ter-Minassian. July 30, 1976. 134 pp. 29 figs. A literature search and a survey were prepared on the technology of surface hydraulic mining with particular reference to its possible use in the United States for stripping overburden from surface coal mines. Extensive use was made of Russian references that were translated into English. The advantages and disadvantages of hydraulic mining and hydrotransport are identified as well as criteria for selecting potential applications. At present, the major U.S. application is in the phosphate industry of Florida and North Caro-

lina. Potential locations for hydraulic stripping of overburden from coal seams are identified in Alaska, Illinois, Montana, Washington, and Wyoming. Other potential applications include the hydraulic mining of peat in Minnesota, and the stripping of overburden from lignite in Texas, Montana, North Dakota, and South Dakota. Further research is recommended, particularly on the subject of dewatering of fine clay slimes to avoid water pollution and to permit rapid reclamation of mined areas. Research done under Contract No. J0265016 by Terraspace, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.: U.S. Department of Energy facilities in Carbondale Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 13(2)–80. Survey of Surface Hydraulic Mining Technology. Volume 2—Appendices to Final Report, by William C. Cooley and Viguen Ter-Minassian. July 30, 1976. 410 pp. 333 figs. A literature search and a survey were prepared on the technology of surface hydraulic mining with particular reference to its possible use in the United States for stripping overburden from surface coal mines. Extensive use was made of Russian references that were translated into English. The advantages and disadvantages of hydraulic mining and hydrotransport are identified as well as criteria for selecting potential applications. At present, the major U.S. application is in the phosphate industry of Florida and North Carolina. Potential locations for hydraulic stripping of overburden from coal seams are identified in Alaska, Illinois, Montana, Washington, and Wyoming. Other potential applications include the hydraulic mining of peat in Minnesota, and the stripping of overburden from lignite in Texas, Montana, North Dakota, and South Dakota. Volume 2 comprises the appendixes. Research done under Contract No. J0265016 by Terraspace, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 13(3)–80. Survey of Coal Preparation Technology for Hydraulic Coal Mines, by David C. Nunenkamp and William C. Cooley. Sept. 30, 1976. 455 pp. 84 figs. A literature search and a survey were prepared on the technology of coal preparation for use with hydraulic coal mines that produce a higher-than-usual content of fine coal fractions, increasing the difficulty of cleaning, dewatering, water clarification, and refuse disposal. Extensive use was made of Russian references that were translated into English. A review of U.S. coal preparation practices was made and the changes were identified that would be required to handle coarse coal that is produced by a hydraulic coal mine or transported by pipeline as a coarse coal slurry. The problems are most severe when the coal contains fine colloidal clay impurities. Research is recommended on improvement of dewatering equipment such as centrifuges and on the direct utilization of coal slurry for combustion to avoid the expense of dewatering. Research done under Contract No. J0265016 by Terraspace, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 14–80. A Study to Determine the Manpower and Training Needs of the Coal Mining Industry, by John Short, Jeffrey Harris, Judith Waldo, and Sharla Barber. December 1979. 145 pp. 6 figs. In response to anticipated increases in the demand for coal and the corresponding need for a rapidly expanding mining work force, this report provides an assessment of the current and future training needs of the coal mining industry generated by that work force. Using Department of Energy forecasts and an employment-turnover model (developed under a previous Bureau of Mines contract), estimates of the existing and future number of training incidences are presented. The existing supply of training is explored, and the primary sources of training are identified (for example, coal companies, schools, government, etc.). By matching the existing training supply with the anticipated demand, recommendations for ensuring adequate levels of training for the future coal mine work force are made. Research done under Contract No. J0395038 by John Short & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-164742; paper copy price code A07.

OFR 15–80. Technical and Economic Evaluation of Underground Disposal of Coal Mining Wastes, by M. F. Bucek, J. K. Clauser, J. A. Schad, and N. K. Charkavorti. January 1980. 372 pp. 62 figs. This report presents the activities performed and the results achieved during a two-phase investigation of the technical and economic feasibility of disposing of coal mine refuse underground in active mines. Three regions that are severely affected by coal refuse problems are southwestern Pennsylvania, southern West Virginia, and eastern Kentucky. A conceptual model mine is presented that describes the geologic conditions, mining methods, and environmental circumstances typical of each region. Procedures used in selecting the regions and in modeling typical mines are described. The report presents existing methods for stowing systems that would be appropriate for the model mine, discusses technical characteristics and environmental effects relative to the various systems, and evaluates the technical and economic feasibility of the three alternative disposal system designs. Comparisons of costs among systems and with costs of surface disposal systems are presented. Research done under Contract No. J0285008 by HRB-Singer, Inc. Avail-

able for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–154768; paper copy price code A16.

OFR 16(1)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume I. Three-Dimensional Finite Element Analysis of Crosscut and Entry Intersection of a Double-Entry Coal Mine, by M. B. Balanchandra. June 1976. 137 pp. 51 figs. The BMINES computer code was used to perform a three-dimensional finite element analysis of an instrumented section of a double-entry coal mine to provide a comparison between field measurements and existing analytic techniques. The sequence of excavation of the entries was considered as well as the installation of rock bolts and cribbing during the mining cycle. The materials in the region under investigation were idealized into four rock types and coal. The rocks were assumed to be isotropically elastic, perfectly plastic. Coal was represented by an elastically anisotropic (transverse isotropy) and plastically isotropic model. A fracture-yield criterion of the Coulomb form was used for all materials. The strength and stiffness of all materials were substantially reduced from available laboratory data to account for in situ properties. Research done under Contract No. H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–150345; paper copy price code A07.

OFR 16(2)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume II. User's Guide for a Computer Program for Analytical Modeling of Rock-Structure Interaction, by Robert D. Ewing and Edward M. Raney. June 1976. 291 pp. 66 figs. The computer program described in this user's guide provides for the static, three-dimensional, linear and nonlinear analysis of structural and geological systems by the finite element method. The guide shows how input is prepared. A number of recent advances in finite element theory and computer technology are incorporated in the program. Nonlinear material properties are provided for including isotropic, anisotropic, and time-dependent material properties, gravity loading, simulation of a sequence of excavation or construction, and a slip or joint element. The finite elements include beam, rod, axisymmetric and plane quadrilateral, hexahedron, thick shell, and axisymmetric and plane joint. The program also has an automatic mesh generator to minimize user input preparation for continuum finite element meshes. Research done under Contract No. H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–150352; paper copy price code A13.

OFR 16(3)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume III. Three-Dimensional Finite Element Analyses of Single- and Double-Entry Portions of Sunnyside Mine No. 1, by D. E. Van Dillen. 278 pp. 56 figs. Three-dimensional structural analyses of three instrumented areas of a deep longwall coal mine were performed using the finite element code BMINES. The three instrumented areas include two single-entry portions and one double-entry portion of the Sunnyside No. 1 mine, Sunnyside, Utah. The finite element models simulated the sequence of excavation in each test area: the advance of the entry, installation of structural supports, retreat of the longwall, caving behind the longwall, and accumulation and loading of the gob. The structural supports considered in these finite element models include rock bolts, wood cribs, concrete cribs, steel arch sets, and chocks. Mechanical simulation of the geologic environment is achieved through elastic-perfectly plastic material models employing anisotrophy to represent finely layered regions of the medium. The results of these calculations are compared with the instrumentation readings from the mine. These measurements include closures, crib loads, rock-bolt forces, and stress growth. Research done under Contract H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–150360; paper copy price code A13.

OFR 17–80. Development of a Cross Pit Overburden and Waste Material Handling System, by Russell J. Gartrell and Thomas J. Crocker. January 1977. 75 pp. 27 figs. This report describes the engineering feasibility and economic advantage of using a steep-angle conveyance (SAC) system in conjunction with medium and large draglines to transport spoil in a typical western coal mine. The SAC system, including a receiving hopper, a steep-angle conveyor, and a stacker-spreader, is capable of processing overburden material at the rate of 7,000 tons per hour. The unique feature of this system is the steep-angle conveyor that transports the overburden material from the pit bottom to the top of the spoil at angles up to 45°. Compared with other means of cross-pit conveyance considered during this study, the SAC system offers the advantage of easier operation, lower cost, and greater mobility. The results of the study show that integration of the SAC system into both established and planned new mines would improve the overall mining operation, expand the operating capability of existing equipment, and reduce mining and reclamation costs. Research done under Contract No. H0252084 by R. A. Hanson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National

Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-145998; paper copy price code A04.

OFR 18-80. Evaluation of Surface Mining Blasting Procedures, by Julius Roth, Keith C. Britton, Robert W. Campbell, and Warren R. Kettler. June 6, 1978. 162 pp. 8 figs. There are many potential hazards associated with surface blasting procedures that are not documented to a degree sufficient for the development and promulgation of safety standards. In addition, there are many operations where safer methods might be devised. The purpose of this program is to identify and document commonly used surface blasting practices and evaluate them in terms of their potential hazards with the objective of improving safety through the development of guidelines for safer blasting procedures in surface mining. Research done under Contract No. J0366017 by Management Science Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-148653; paper copy price code A08.

OFR 19-80. Development of Interindustry Transactions Data on the Structure of United States Mining Industries for 1967 and a Comparison of Techniques for Updating Related Input-Output Coefficients, by H. Craig Davis and Everard M. Lofting. Apr. 30, 1979. 49 pp. This paper deals with two problems associated with input-output models: disaggregation and updating. National input-output models are commonly designed as general purpose models. Analysts with specialized interests will at times find that the segment of the economy on which their particular interests are focused is too highly aggregated. In this context, the procedure used for disaggregating the 7 mining sectors in the 1967 U.S. input-output table to 47 sectors is discussed. A second potential problem associated with input-output models arises from changes over time in the relationships between economic sectors. If the technical coefficients of the input-output model are not accordingly adjusted to reflect these changes, significant errors in the model's output may result The two most prominent techniques designed to update the input-output model's technical coefficients, the RAS and linear programing (LP) methods, are compared with regard to changes in U.S. national coefficients between 1963 and 1967. Research done under Grant No. G0122078 by University of California. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-161425; paper copy price code A03.

OFR 20-80. The Input-Output Structure of the U.S. Mineral Industries for 1958 and 1963: Transactions, Employment, and Multipliers, by H. Craig Davis and Everard M. Lofting. April 1979. 60 pp. Input-output transactions tables for the economic years 1958 and 1963 for the United States are presented The tables were developed to show the detailed structure of the U.S. mineral industries at the 3- and 4-digit SIC code level. Output multipliers and types I and II employment and income multipliers were developed on a comparable basis and are presented for both years. Research done under Grant No. G0133091 by University of California. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-160286; paper copy price code A04.

OFR 21-80. Economic Impact of the Phosphate Rock Industry on Selected Florida Counties, Florida, and the United States. by E. Ray Canterbery, Carl W. Hale, and E. Joe Nosari. September 1978. 101 pp. 2 figs. This report assesses the economic impact of the phosphate rock industry on selected counties in Florida, the State of Florida, and the United States. The research uses economic base analysis at the county level and industrial complex (input-output) analysis at the Florida and national level. A profile of the industry is also developed. Research done under Grant No. G0177120 by Florida State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 22-80. Evaluation of Proximity Warning Devices, by J. E. Hipp, F. D. Henson, P. E. Martin, and G. N. Phillips. Feb. 22, 1980. 136 pp. 36 figs. Three electrostatic field sensing proximity warning devices were tested using full-scale cranes and powerline systems, a scaled model facility, environmental testing facilities, and theoretical-numerical analysis. The design objective of each device is to assist in safe crane operation near overhead powerlines. Several design deficiencies were noted, including inadequate overlap in sensitivity ranges, utilization of vacuum tubes and electromechanical parts, temperature sensitivity, and inaudible alarms. In addition, the testing showed major device limitations including sensitivity to boom orientations and length, polarization-dependent responses, and unreliable operation in the presence of multiple powerline circuits. The multiple powerline circuit problem is intrinsic to electrostatic sensing devices. The remaining deficiencies and limitations are correctable within a state-of-the-art design. Research done under Contract No. J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-144413, paper copy price code A07.

OFR 23-80. Investigation of a Reliable Central Lubrication System for Underground Mining Equipment, by M. S. Fleming and C. Geopferich. August 1979. 73 pp. 15 figs. The objective of this investigation was to evaluate central lubrication systems for potential use on underground mining equipment. Previous use on continuous mining equipment resulted in

poor system performance because of improper selection of lubricants, component failures, and an inconsistent delivery of lubricant to bearings. The principles and operational characteristics of systems are reviewed and evaluated, and it was concluded that systems are available that can provide a reliable central lubrication if properly applied, installed, and maintained. The procedures for applying a system to a continuous miner are discussed and recommendations are included for the continued development of systems for underground mining equipment. Research done under Contract No. H0282014 by Dayton T. Brown, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–149420; paper copy price code A04.

OFR 24–80. Determination of Breathing Zone Concentrations of Contaminants From Emissions From Diesel Powered Vehicles in Underground Mines, by Walter D. Holland. August 1978. 127 pp. 9 figs. The objective of this investigation was to determine miners' breathing zone concentrations of diesel exhaust components, to investigate any relationships between these concentrations and vehicle type, the presence of emission controls, vehicle usage, and ventilation conditions, and to make recommendations for monitoring and ventilation requirements. Twenty-four mines including two coal mines were surveyed. Sampling was done for CO_x, NO_x, SO_x, PNA, aldehydes, and particulates. In most mines, concentrations of at least one contaminant exceeded one-half of the standard or threshold limit value. The concentrations of gases are probably sufficiently reduced by a minimum air velocity of 50 fpm. A sufficient reduction of particulate concentrations may require as high as 400 fpm air velocity. Vehicle age, type, or usage appear to have little or no effect on contaminant concentrations. Polynuclear aromatic levels were below detection limits in all but a very few samples. Minimum requirements for routine monitoring should include formaldehyde, CO_x, and NO_2. It is further recommended that better definition of the minimum ventilation requirement be obtained. Research done under Contract No. J0255001 by LFE Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–150766; paper copy price code A07.

OFR 25–80. Cost and Time Analysis of the Mining and Environmental Requirements in the Premining Stage for Copper Mining in the Northern Highland, Wisconsin, by James P. Ludwig, Mervin C. Nelson, Catherine E. Ludwig, and Walfrid Been. Nov. 1, 1979. 185 pp. 26 figs. This report provides the results of a 2-year study of the projected time and cost requirements for new mine development in Wisconsin and is based on a unique blend of information from mining company officials, State regulatory agency officials, and contractor experience. Lists of the tasks and subtasks required to plan a new mine were developed and times and costs were assigned. Critical path method diagrams were then developed for a generalized mining project. Total time and cost for the premine planning process was estimated to be 25.12 years and 223 person-years of professional time excluding public affairs effort. By eliminating redundancies in the process and by increasing project efficiency through early public review and participation, recommendations were made to lessen the time and lower the cost of premine planning. The streamlining recommendations could shorten the overall critical path length to 17.16 years and lower the cost to 208 person-years of professional time excluding public affairs effort. The estimated distribution of professional effort for mine planning in Wisconsin approximates 50.5 pct for traditional mine and engineering tasks, 36.6 pct for environmental-regulatory tasks, and 12.9 pct for traditional geological-exploration tasks. Research done under Contract No. J0275011 by Mervin C. Nelson & Associates, Inc., and Ecological Research Services, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–159163; paper copy price code A09.

OFR 26–80. Low Velocity Performance of Anemometers, by L. P. Purtell. May 1979. 170 pp. 100 figs. To meet the need for a calibration capability with adequate accuracy at low air velocities, the performance of 10 anemometers of several types has been measured. Multiple calibration runs provided sufficient data for measuring random errors about the mean calibration curve in addition to the difference between indicated and true speeds. Measurements were also performed of the minimum operating speeds of the anemometers. This report summarizes the results and presents analyses of the instruments' performance. Research done under Contract No. H0166198 by National Bureau of Standards. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washintgon, D.C. Order ONLY from NTIS: PB 80–158801; paper copy price code A08.

OFR 27–80. Polychlorinated Biphenyls: Regulations and Substitutes. A Compliance Manual for the U.S. Mining Industry, by Robert A. Westin, Robert P. Burruss, and Bruce Woodcock. Sept. 28, 1979. 89 pp. 8 figs. Polychlorinated biphenyls (BCP's) have been widely used as fire-resistant, dielectric coolants in electrical equipment used in mining applications including transformers, capacitors, electric motors, and electromagnets. In addition, PCB's have been used in hydraulic and heat transfer fluids and are present in many oil-filled transformers. The Environmental Protection Agency (EPA) recently banned the manufacture of PCB's and equipment using PCB's and imposed strict requirements on the continued use and disposal of existing PCB equipment. This manual discusses the EPA requirements, suggests ways to decrease the risks resulting from

continued use of PCB equipment, and surveys the non-PCB equipment that is available as replacements for the PCB electrical equipment presently used in mines. Research done under Contract No. J0177046 by Versar Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-157340; paper copy price code A05.

OFR 28-80. Development of a Dual-Boom Semi-Automated Roof Bolter, by C. Hellar, W. Elliott, and D. Hamilton. Aug. 31, 1979. 49 pp. 11 figs. Recognizing the hazards associated with roof bolting in underground coal mines, and the need for improved technology to reduce these hazards, the Bureau of Mines entered into an agreement with contractors to build a production model, second-generation automated bolter that would utilize the basic technology of remotely conrolled single-boom bolters. This report describes a new dual-boom, remotely controlled roof bolter that was designed, fabricated, and tested in an underground coal mine. Research done under Contract No. H0166138 by FMC Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-158793; paper copy price code A03.

OFR 29-80. Aluminum and Silicon Interference During the Carbon Monoxide Reduction of Laterite Ores To Extract Nickel and Cobalt, by Dhanesh Chandra and Jacqueline Battles. August 1979. 102 pp. 28 figs. The report describes a study that was performed to better understand products extracted from low-grade domestic laterites using a carbon monoxide reduction and ammonia-ammonia sulfate leach. This understanding was gained through concerted applications of a combination of electron and optical microscopy, electron beam microanalyses, and X-ray techniques that revealed factors influencing low nickel extraction yields from certain laterites and the beneficial effect from the addition of sulfur compounds and halides. Research done under Grant No. G0274007 by University of Denver. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-162282; paper copy price code A06.

OFR 30(1)-80. Microseismic Monitoring of a Longwall Coal Mine. Volume I—Microseismic Field Studies, by H. Reginald Hardy, Jr., Gary L. Mowrey, and Edward J. Kimble, Jr. Aug. 31, 1978. 319 pp. 110 figs. Volume I of this three-volume report describes the detailed aspects of the microseismic field study conducted at a longwall coal mine at Greenwich Colleries, Barnesboro, Pa. The objectives of the study were to evaluate the feasibility of detecting microseismic activity originating from longwall mining operations using an approximately planar, near-surface, geophone array installed above the longwall and to attempt to locate sources of the various microseismic events. The investigation proved that using the techniques developed, it is possible to detect microseismic events at depths of more than 400 feet and at horizontal distances in excess of 800 feet from the source. Research done under Grant No. G0144013 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-163397; paper copy price code A14.

OFR 30(2)-80. Microseismic Monitoring of a Longwall Coal Mine. Volume II—Determination of Seismic Velocity, by H. Reginald Hardy, Jr., and Laurance A. Beck. Oct. 31, 1977. 232 pp. 70 figs. Volume II of this three-volume report describes the evaluation of a number of different field techniques and the seismic velocity data obtained at the Greenwich Colleries, Barnesboro, Pa., mine site where microseismic studies were carried out. Three methods were employed to evaluate seismic velocities; namely, surface refraction, downhole, and transmission. In all cases the seismic sources were either located on surface (mechanical impact) or near-surface (explosive charges). It was found that a mechanical source could be conveniently utilized to determine shallow velocities and make bedrock-regolith interface depth determinations. For deeper velocity determinations suitable explosive charge sources were required. In general, refraction data did not always plot in a linear manner and some subjective interpretation was necessary. The downhole method was useful for incremental vertical evaluation; however, the transmission method provided the most consistent average vertical velocity data. Research done under Grant No. G0144013 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-163405; paper copy price code A11.

OFR 30(3)-80. Microseismic Monitoring of a Longwall Coal Mine. Volume III—Field Study of Mine Subsidence, by H. Reginald Hardy, Jr., Bassam A. Anani, and Abdul W. Khair. Oct. 31, 1977. 140 pp. 38 figs. Volume III of this three-volume report presents the observed microseismic activity with surface subsidence. Field measurements of subsidence carried out at the Greenwich Colleries, Barnesboro, Pa., mine site are described. Comparative analysis of actual field results with data obtained using empirical and finite element techniques was undertaken. Comparison of field results with published National Coal Board data revealed

marked differences. The influence of stronger rock beds overlying the coal seam in the current study was assumed to be the main cause. Use of the Gaussian profile resulted in a satisfactory fit to the field data, provided the value of the maximum field subsidence was used in the analysis. In general, when low tensile strengths were assumed for the associated rocks, finite element techniques gave results that compared well with the field data. The study also indicated that at shallow depths there is a marked difference in subsidence over dip and rise sides of the coal face, maximum subsidence is shifted more towards the dip side. Finally, time-dependent deformations were insignificant shortly after mining operations ceased. Research done under Grant No. G0144013 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-163413; paper copy price code A07.

OFR 31-80. Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining. Phase I: Premining Hydrologic and Water Quality Conditions, by Gary E. McIntosh and W. R. Hamon. Dec. 22, 1979. 35 pp. 6 figs. Five watersheds, ranging in size from 29 to 52 acres, were selected in east-central Ohio to study the hydrologic and water quality conditions occurring before, during, and after surface mining. The average concentrations of the water quality parameters for all watersheds were as low or lower than the Environmental Protection Agency recommended maximum allowable concentrations in drinking water except for suspended solids. Premining ground water systems for each watershed were found to have two major perched aquifers within the top 250 feet. Recharge is mostly from local precipitation and discharge is mostly as spring flow, stream baseflow, evapotranspiration, or leakage through the underlying confining bed. The shallowest ground water is commonly of the calcium bicarbonate type; whereas, water in the deeper aquifers is of variable type. Although dissolved-solids concentration is generally 200 to 600 mg/l, brackish or salty ground water is present in several areas. A one-dimensional unsaturated flow model was developed for interfacing with a quasi-three-dimensional ground water model as part of a projected composite hydrologic model. The unsaturated flow model includes provisions for an evapotranspiration model. Research done under Contract Nos. J0166054 and J0166055 by U.S. Department of Agriculture and Ohio Agricultural Research and Development Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-159510; paper copy price code A03.

OFR 32-80. Dewatering Systems for Surface Coal Mines, by J. E. O'Rourke and K. O'Connor. Dec. 21, 1979. 260 pp. 50 figs. This report presents a review of available dewatering technology and an evaluation of its relevance to surface coal mines in the interior province of the United States. Guidelines for the selection, design, and construction of dewatering systems are included. On the basis of documented experience, candidate dewatering systems were selected and evaluated with respect to their anticipated impact on the environment and mine operations. Included in the discussion is a summary of laws and regulations that can impact on dewatering operations. Geologic and hydrogeologic conditions within the interior province are described and potential dewatering problems at surface coal mines are identified. Model mines were developed that exhibit the most difficult dewatering problems, and it is demonstrated how available technology can be utilized to deal with them. Dewatering of coarse-grained, high permeability terrace deposits might be economically feasible. Low permeability, saturated glacial tills or lake deposits appear to be significantly outside present economic feasibility for dewatering. Research done under Contract No. J0275025 by Woodward-Clyde Consultants. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-160153; paper copy, price code A12.

OFR 33-80. Fire-Resistant Hydraulic Fluid Safety, by E. C. Fitch and J. S. Campbell. Aug. 3, 1979. 51 pp. 15 figs. This report discusses fire-resistant hydraulic fluid safety from three different directions. First, results of a survey prepared for the Fire Resistant Hydraulic Journal by the staff of the Fluid Power Research Center are analyzed. Second, operational limitations of fire-resistant hydraulic fluids are examined. Finally, laws and standards of various foreign countries are investigated. The results show that a significant number of experts in the fluid power industry are not in agreement about aspects of fire-resistant hydraulic fluid fire-resistance and toxicity. This indicates a need for more in-depth research. The use of fire-resistant hydraulic fluids involves a compromise between the decreased fire hazards and increased toxicity and machine incompatibility problems. Major foreign governmental agencies have thorough laws and standards concerning fire-resistant hydraulic fluids. These laws and standards may provide a solid framework for further international research into fire-resistant hydraulic fluid safety. Research done under Contract No. J0188129 by Oklahoma State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-159486; paper copy price code A04.

OFR 34–80. Develop Safety Practices for Electrokinetic Treatment of Mine Waste, by Charles E. Green. July 1979. 75 pp. 3 figs. This study was conducted to identify, evaluate, and develop procedures to minimize or eliminate safety hazards associated with the electrokinetic dewatering process such as toxic and volatile gas emissions, electrical shock, accidental detonation of explosives, electromechanical corrosion of metal appurtenances, and possibly others. The study was based on pertinent literature, existing safety regulations, interviews with mine personnel, physical and mechanical properties of the electrokinetic dewatering process, and physical characteristics of the material to be dewatered. The electrokinetic dewatering process was described and potential safety hazards were identified and evaluated. Procedures and/or safety regulations were developed to minimize or eliminate the potential hazards. It was recommended that the electrokinetic dewatering process, when used in deep metal mines, be properly monitored to obtain additional information on other potential hazards. Research done under Contract No. H0272005 by U.S. Army Engineer Waterways Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: AD-A072925; paper copy price code A05.

OFR 35–80. Positive Indicator for Track Switch Point Position, by Andrew St. Amant. Feb. 28, 1978. 34 pp. 14 figs. The objective of this research was to develop and test a fail-safe device that would provide positive indication of track switch point position and be suitable for application in contemporary underground coal rail haulage systems. The effort was divided into four phases as follows: (1) evaluation, (2) design, (3) fabrication and surface testing, and (4) underground installation and testing. The results are described in Section 2 of the report and a sequential listing of the 53 steps employed in developing the system is Appendix A. Research done under Contract No. H0166046 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–160815; paper copy price code A03.

OFR 36–80. A Study of Roof Falls in Underground Mines on the Pocahontas #3 Seam, Southern West Virginia and Southwestern Virginia, by John C. Ferm, Robert A. Melton, Gloria D. Cummins, David Mathew, Linda McKenna, Charles Muir, and G. Norris. September 1978. 92 pp. 26 figs. This report summarizes the results of an investigation of geologic factors that contribute to roof quality in underground mines in the Pocahontas No. 3 coalbed in southern West Virginia and southwestern Virginia. The investigation consisted of three phases. The first was selecting for detailed study five mines that represented the range of roof conditions, mining practices, and geologic phenomena. This was accomplished by a statistical analysis of questionnaire data from 35 mines. The second consisted of detailed mapping in a "good" and a "bad" top area in each of the mines and resulted in a qualitative assessment of the geologic factors contributing to roof falls. In the third phase, five mines were selected in which most nongeologic factors believed to contribute to roof falls were relatively constant but displayed a wide variety of assessments from phase II. The primary results of this investigation is that slickensides arising from different geologic causes are the major geologic features leading to roof falls. These slickensides are found in ancient slump deposits, fire clays and sandy fire clays, and channel contacts. Falls also occur where thick sandstone bodies directly overlying the coal contain abundant shale or ironstone pebbles and coaly strips. The best top material is a sequence that consists of shale grading upward to sandy shale and sandstone within 30 feet of the top of the coal. Thick sandstone units without pebbles also provide good top material. Research done under Contract H0230028 by University of South Carolina. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–158983; paper copy price code A05.

OFR 37–80. Mineral Appraisal of the Proposed Utukok and Colville Wild and Scenic Rivers: A Summary Report. by Staff, Alaska Field Operations Center. Apr. 2, 1980. 8 pp. 2 figs. This is one of a series of summary reports that present the findings of reconnaissance-type mineral assessments of certain lands in Alaska. The Utukok and Colville Rivers rise near the eastern end of the De Long Mountains in the southern part of the National Petroleum Reserve-Alaska (NPR-A). Historically, both have been important surface travel routes. NPR-A has been closed to mineral entry since the 1920's. The Utukok River heads in a little known part of a mineralized trend characterized by stratiform zinc-lead-silver deposits with barite and fluorite. Exposures of coal, mostly bituminous, are known along the Utukok River generally from Archimedes Ridge and Carbon Creek downstream to the mouth. The Colville River valley is north of any recognized metallic mineral trends although most tributaries from the south head into mineralized areas. Dominantly bituminous coal occurrences are known from the mouth of the Etivluk River downstream to within 20 miles of Umiat. Subbituminous coals have been reported at intervals from there to the Beaufort Sea. Both the Utukok and Colville drainage basins have rock environments similar to those in which sedimentary uranium deposits occur elsewhere, but this possibility remains unevaluated. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 38–80. Mineral Investigations of the Misheguk Mountain and Howard Pass Quadrangles, National Petroleum Reserve-Alaska, by Uldis Jansons and Donald W. Baggs. Apr. 2, 1980. 76 pp. 11 figs. The 1977 Bureau of Mines mineral investigation program in the National Petroleum Reserve-Alaska (NPR-A) was designed to make a preliminary evaluation of known and reported mineral showings, a followup on the U.S. Geological Survey's 1977 regional geochemical results, and sample color anomalies—those due to oxidation of iron. Eighteen separate areas were examined during the 1977 field season. Significant mineralization was found at only one site, the Drenchwater Creek area, where concentrations of base metal sulfides occur in and near outcrop. The zinc-lead-silver bearing zone has been traced along strike and is at least 6,500 feet long and may possibly extend more than 10,000 feet. Minor mineralization has been found at other sites. These include fluorite at Mount Bupto, chromite at Siniktanneyak Mountain, and barite nodules near Safari Creek. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 39–80. Remote Operator Coal Mine Roof Bolter Concepts Utilizing Existing Techniques and Components, by G. Hakes and T. Haviland. September 1978. 169 pp. 37 figs. A data bank on bolter technology was assembled that included the state-of-the-art industrial equipment as well as new equipment currently under development for the Bureau of Mines. This information was augmented by visits to Bureau of Mines contractors, mine operators, and others to obtain a thorough understanding of present coal mine roof bolting safety and productivity problems. Using this background material and information, a series of roof bolter concepts was developed offering improved operator safety with minimum impact on productivity. The concepts developed utilize existing componentry and technology wherever possible. All of the concepts feature a fully protected operator station located 6 to 10 feet outby the active bolt line and the hazardous rotating machinery. Research done under Contract No. H0272028 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–167455; paper copy price code A08.

OFR 40–80. Effectiveness of Inclined Roof Bolts in Coal Mines, by Madan M. Singh. July 1978. 115 pp. 38 figs. This report presents the results of an investigation of inclined roof bolts, anchored over pillars, in room-and-pillar coal mines susceptible to shear failures of the roof. Although the field data do not support this contention, it is believed on the basis of analyses and other work that inclined roof bolts do offer potential under some circumstances. Research done under Contract No. J0275031 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–167430; paper copy price code A06.

OFR 41–80. Underground Vibrations From Surface Blasting at Jenny Mine, Kentucky, by Dennis E. Jensen, Robert D. Munson, Lewis L. Oriard, Jan D. Rietman, and Robert S. Wright. Nov. 1, 1979. 102 pp. 33 figs. As part of the Bureau of Mines program to develop criteria for the proximity of surface blasting to underground mines, field studies were performed during blasting operations for strip coal mining above room-and-pillar workings at Jenny mine in eastern Kentucky. Measurements and observations were made to identify physical changes in the mine. No change in the frequency of roof falls or any other indications of apparent damage was noted. Recordings of blast-induced vibrations were made using sensors on the roof and floor of the underground mine and at the ground surface. A maximum particle velocity of 17.5 inches per second was recorded on the mine roof. The vibration data were analyzed and comparisons were made between roof vibration levels and those recorded on the mine floor and at the ground surface. Results are compared with previous blast vibration studies. Recommendations are made for further study toward developing criteria. Research done under Contract No. J0275030 by Woodward-Clyde Consultants. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–168925; paper copy price code A06.

OFR 42–80. Mineral Deposits of the Cape Krusenstern Area, Alaska: A Preliminary Comment, by Staff, Alaska Field Operations Center. 1980. 19 pp. 3 figs. The geology of the Cape Krusenstern area has been mapped on a 1- to 1-million scale by the Geological Survey. Mining claims were mapped and data on private and Government-sponsored mineral exploration was compiled. The Energy Research and Development Administration had sampled waterborne sediments during a reconnaissance for uranium. Although the Bureau of Mines has done no field work in the area except for a very brief visit in 1976, the Bureau did arrange to have these samples analyzed for metallic and related elements. The resultant sample analyses and all other available data on mining and prospecting activity were considered in relation to the geology. The combined data indicates that lead, zinc, silver, tin, gold, nickel, and platinum-group metals occur in the area in amounts that warrant field investigation. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities

in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 43–80. Fortymile Placer District Resource Inventory, Alaska, by Douglas B. Colp. 1980. 16 pp. 10 figs. The Fortymile placer district comprises the Alaska part of the Fortymile River drainage basin, the Eagle district, and the Seventymile River drainage basin. Most of the district is underlain by Precambrian and Paleozoic gneiss and schist, of both sedimentary and igneous origin and minor crystalline limestone, and by Paleozoic, Mesozoic, and Tertiary felsic, mafic, and ultramafic igneous rocks. Gold in the placers is the result of weathering away of many mineralized quartz veins in metamorphic rocks near contact with felsic intrusive bodies. This report presents a resource inventory based on records research, visits to various parts of the Fortymile area, information accumulated by miners, personal interviews, and other publications. Research done by Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Fairbanks and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 44–80. Testing the Effects of Applied Behavioral Analysis and Applied Behavioral Management Techniques on the Safe Behaviors of Salt Mine Personnel, by S. Stephen Uslan, Harvey M. Adelman, and Robert S. Keller. Sept. 30, 1978. 44 pp. 8 figs. The purpose of this study was to demonstrate the effect of positive reinforcement, specifically, social reinforcement (SR) on the frequency of eye, hand, and back injuries at four experimental salt mines. Injury data were collected from January 1976 through September 1978 on a month-by-month basis. Approximately 100 managers and supervisors were trained in the use of positive reinforcement of occurrences of "safe behavior." Each was provided with manuals and other supportive materials and following training, they were provided coaching experience to help retain the knowledge and capabilities gained. The analysis showed significant injury reductions at two sites and no reductions at the other two. When the data were corrected for the work-hours expended in the post training period, a third site showed reductions in injuries. Similar findings were shown when the experimental sites were compared with other sites in the industry. The results support the hypothesis that the application of SR is related to a reduction in injuries. Research done under Contract No. J0166137 by the Salt Institute and Human Potential Development Corp. Available for reference at Bureau of Mines facilities at Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill. and Morgantown, W. Va.: National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–171309; paper copy, price code A03.

OFR 45–80. A Suggested Experimental Plan for the Determination of the Accuracy and Reliability of Coal Mine Dust Measurements, by Harry H. Ku and Joan R. Rosenblatt. October 1979. 48 pp. The work in this study was done under an agreement with the National Bureau of Standards and the Bureau of Mines with the objective to determine the accuracy and reliability of dust measurements when taken with the current equipment by coal miners in underground mines. The work is to be conducted in two phases. The first is to develop an experimental plan to determine the accuracy and reliability of coal mine dust measurements at three levels of funding and will serve as a basis for the second phase in which the experimental work will be conducted. Research done under Contract No. J0177013 by National Bureau of Standards. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–173891; paper copy price code A03.

OFR 46(1)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume I. Executive Summary and Literature Review, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 208 pp. 83 figs. The objective of this investigation is to identify factors governing the effectiveness of roof bolting systems using fully resin-grouted nontensioned bolts for reinforcement of bedded mine roofs and to develop design criteria for such plans. Volume I presents a summary of work done, a background study, and a literature review on resin bolting, mine analysis, and coal and rock properties. Strength and stiffness properties of resin bolts under both axial and shear loadings are considered in detail. Mechanisms of roof reinforcement using resin bolts are reviewed. Associated mine analyses including the effects of in situ conditions are included. Research done under Contract No. J0366004 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–180052; paper copy price code A10.

OFR 46(2)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume II. Field Survey, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 167 pp. 125 figs. This report presents field surveys obtained during visits to 38 mines, in the United States and abroad, 4 resin manufacturers, universities, and other research facilities to gain knowledge of roof control problems, the use of resin bolting to overcome those problems, and the shortcomings of resin bolting. Research done under Contract No. J0366004 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in

Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-180060; paper copy price code A08.

OFR 46(3)-80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume III. Experimental Model Studies, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 128 pp. 45 figs. The report presents experiments that were run on adhesion of resin to rock, pull tests of resin anchored rebars, and bending tests of thinly laminated beams reinforced with resin bolts. The effects of hole diameter, bolt diameter, resin annulus, and hole conditions on anchorage, and the effect of bolt spacing on beam bending were determined. Research done under Contract No. J0366004 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-180078; paper copy price code A07.

OFR 46(4)-80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume IV. Theoretical Analysis, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 81 pp. 41 figs. Investigations were conducted on axial and shear loading of resin bolts, the Voussoir rock arch, beam building, angle bolted roof trusses, jointed roofs, bolting of sloping joints, and stresses in roofs due to moisture changes. The analyses described here are supplemental to those described in volume I. Research done under Contract No. J0366004 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-180086; paper copy price code A05.

OFR 46(5)-80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume V. Synthesis and Design Criteria, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 129 pp. 104 figs. The design synthesis and the establishment of design criteria presented in this report is based on a critical review of the first four volumes of the report. The design synthesis points out some practical aspects of roof control using bolting but definitive design criteria were not obtained. The current Code of Federal Regulations Title 30, Part 75, is examined and recommended modifications are given. Research done under Contract No. J0366004 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-180094; paper copy price code A07.

OFR 47(1)-80. Interpretation of Rock Mechanics Data (Vol. I.) (A Two-Dimensional Finite Element Approach to the Evaluation of Underground Coal Mine Stability), by W. G. Pariseau. June 30, 1978. 172 pp. 99 figs. A two-dimensional finite element program was modified and extended to account for some of the rock mechanics complexities associated with single-entry development of longwall coal mine panels. The program includes arbitrary assignment of element properties without regard to element ordering, anisotropic elastic, plastic and brittle rock properties that may be time-dependent (aging), arbitrary mining sequences, and provisions for the effects of artificial support on the adjacent strata. Failure is according to an extended von Mises criterion that may be linear or quadratic in form; flow rules are obtained from the yield function taken as the plastic potential, but brittle behavior is treated as a discontinuous process of material properties change with deformation. The extent of failure is calculated from the external boundary conditions. Application of the program to essentially two-dimensional problems resulted in close agreement between calculated displacements and field measurements in the double-entry system. Bleeder entries were stable in one locality and not in another. Artificial support had little influence on stability. Research done under Contract No. H0220077 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 47(2)-80. Interpretation of Rock Mechanics Data (Vol. II.) (A Guide to Using UTAH2), by William G. Pariseau. June 30, 1978. 41 pp. 18 figs. A brief description of a two-dimensional elastic-plastic finite element program intended for mine stability analysis is presented that includes detailed instruction for input data preparation and how to obtain output. Research done under Contract No. H0220077 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev. Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 48-80. Field Test of Chemical Injection for Stabilizing Coal Mine Roof, by H. W. Brandt. Decem-

ber 1977. 57 pp. 5 figs. A field test was designed to inject a specially formulated two-compound epoxy resin into the roof rock ahead of a working face to cement fractures and formation interfaces at the Westmoreland Coal Co.'s No. 5 mine, Eccles, W. Va. Five 30-foot-long by 2-inch-diameter holes were drilled at a 10° angle above the plane of roof line from the face of a working entry. The epoxy resin compounds were pumped through a proportioning unit and mixed in-line before being discharged into the drill hole at injection pressures up to a maximum of 450 psig. When the coal face was advanced, an anomolus failure of roof rock occurred in the treated section. Further testing was suspended until the cause of the failure could be determined. The polymers were tested under confined conditions in 2-inch pipe columns. Extreme temperature and pressure up to 2,400 psig rises were recorded as they cured. It was concluded that this pressure source fractured the rock and caused the roof failure. The entire program was terminated after it was determined that the heat rise and resultant high pressures could not be controlled chemically or mechanically. Research done under Contract No. H0252034 by McCarthy Engineering & Construction, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 49–80. Evaluation of Chemical Agents for Inhibiting Acid Mine Drainage Formation, by John W. Nebgen and Douglas F. Weatherman. April 1979. 128 pp. 31 figs. This report contains findings from a Bureau of Mines study concerning the inhibition of acid mine drainage formation from underground coal mines. A series of experiments was performed in which three different pyritic materials (wastes from coal production plants) were evaluated using several candidate inhibiting agents. Data obtained from the inhibitor-treated pyrites were compared with data from control experiments in which untreated pyritic wastes were used. The experiments were conducted by placing treated and untreated pyrite in columns, passing moist air through the columns to promote oxidation of pyrite, and washing the columns weekly to collect oxidation products for analysis. The results indicate that quantities of acid mine drainage can be substantially reduced if soluble iron III (ferric) ion is controlled. Research done under Contract No. J0366036 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–176357; paper copy price code A07.

OFR 50–80. The Field Testing of Several Mine Roof Fall Alarm Systems in an Anticipated Natural Roof Fall in the White Pine Mined-Out Windpipe Area, by Walter L. Finlay. June 30, 1978 96 pp. 39 figs. The Bureau of Mines has developed prototype instruments promising to improve the ability to warn of imminent roof falls. An unusually good opportunity to test these comparatively under natural caving conditions was afforded by the forecasted caving in August 1977 of a mined-out region of the White Pine mine where the rock strata closely resembles those in many coal mines. The anticipated cave was of the competent roof-weak-pillar type and occurred as and when predicted. Automated convergence and bed separation gages agreed well with the standard manual convergence gage measurements. A microseismic gage was insensitive to the fall and may require different test conditions for effectiveness. A roof resistivity unit was tested under a separate Bureau of Mines contract. An unplanned addition to the field test, the tiltmeter, showed interesting potential. Research done under Contract No. H0272036 by White Pine Copper Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–174261; paper copy price code A05.

OFR 51–80. An Investigation of the Interaction of Rock and Types of Rock Bolts for Selected Loading Conditions, by Charles J. Haas, Robert L. Davis, H. Dean Keith, Janakkumar Dave, Wesley C. Patrick, and Jack R. Strosnider, Jr. June 15, 1976. 398 pp. 222 figs. This report presents five aspects of the interactions of rock bolts and surrounding rock to support coal mine roofs: (1) A finite element analysis of the bolted mine roof structure including the affects of bedding planes, inclined fractures, lateral stress, and bolt type (expansion anchored and fully grouted). (2) Theoretical and experimental studies of a split-ring forced into an undersize hole (split-set rock bolt) with elastic and plastic solutions. (3) Laboratory shear tests on resin-grouted bolts and split-set tubes with anchors with smooth and rough shear planes in limestone and shale rock. (4) Laboratory creep tests on resin-grouted bars to determine the initial load bleed off, creep under constant axial load, pull out stiffness, and ultimate strength. (5) Field tests with resin-grouted bolts instrumented with strain gages and placed in a coal mine roof. Roof sag stations were also installed in an attempt to relate bolt loading to vertical strata movement. Research done under Contract No. H0122110 by University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 52–80. Modeling of the Leaching of Copper Oxide Ores, by Dong G. Chae and Milton E. Wadsworth. Dec. 31, 1979. 62 pp. 16 figs. A model for the leaching of oxide ores is developed and correlated with laboratory tests for percolation

leaching of copper oxide ore. Using the model, recovery of metal values and lixiviant concentration of the effluent solution at any time may be evaluated. For the copper oxide ore, a simplified version of the model is examined for the leaching mechanism consisting of (1) a surface flush reaction with the highest rate of lixiviant consumption, (2) penetration of the lixiviant to react with copper minerals and gangue constituents, and (3) slow lixiviant consumption mostly by residual gangue materials. The simplified model is able to explain reasonably the leaching behavior of copper oxide ore by introducing a concept of effective initial size to correct for packing in a bed of fine particles. Research done under Grant No. G0166022 by University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–179120; paper copy price code A04.

OFR 53–80. Resistivity Roof Fall Warning System in the White Pine Mine, by Michael Gibbons, A. J. Farstad, and R. F. Kehrman. Mar. 15, 1979. 75 pp. 41 figs. A method of monitoring roof stability in underground mines by detecting the changes in resistivity of roof material was tested. The device was tested over a 16-month period at the White Pine copper mine in Michigan. Three falls of ground were monitored by as many as 11 sensors. Data indicate a correlation between changes in resistivity and impending structural failure. Problems were encountered with the high roof electrode impedance in the winter and spring due to the drying out of the roof material. Difficulties also developed in obtaining a permanent bond between the roof rock, the conductive epoxy, and the electrode plate. Some data were lost due to timer and fuse problems within the unit, but these were eventually rectified. Research done under contract H0272037 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–186547; paper copy price code A04.

OFR 54–80. Natural Cementation of Retorted Oil Shale, by Clifford B. Farris. May 1979. 131 pp. 20 figs. The natural cementation strength of retorted oil shale is the focus of this study. The optimum retorting temperature and residence time for development of cementation strength of minus 0.5-inch Green River oil shale are direct mode at 1,510° F and 2.0 hours or indirect mode at 1,530° F and 2.9 hours. Maximum obtained compressive strengths developed during moist curing were 270 and 326 psi, respectively. Use of a differential oil shale retort allowed close control and measurement of the retorting conditions. Correlations were developed for compressive strength as a function of curing time at 100° F, for compressive strength as a function of direct mode retorting temperature and time, and for compressive strength of indirect mode retorting temperature and time. Other information developed as functions of retorting temperature, time, and mode included optimum Proctor density, optimum Proctor moisture content, effect of compaction water composition (tapwater versus oil shale retort water), leachate composition from the retorted shale, and permeability of compacted but uncured retorted shale. The retorted shale apparently acted as an effective filter for many of the ions in the retort water. A petrographic analysis including optical microscopy, scanning electron microscopy, X-ray diffraction, and X-ray fluorescence indicated that the cementing mechanism is the interlocking growth of acicular crystals on the surface of the retorted shale fragments. The crystals appear to be composed of a hydrated calcium aluminum sulfate. Research done under Contract No. J0285001 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–179138; paper copy price code A07.

OFR 55–80. Analysis of Industry Research and Development Recommendations in Mining and Reclamation Technology, by Science Management Corp. Aug. 7, 1979. 168 pp. Recommendations from 44 mining industry workshops are summarized and reviewed in the context of Bureau of Mines research and development programs during 1974–77. Approximately 1,000 specific recommendations for research and development are summarized in a systematic and comprehensive format appropriate for review by mining research and development program managers. Relevant Bureau research programs are briefly described and some opportunities for future research and development are identified. Research done under Contract No. J0188063. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 56–80. Characterization of Respirable Coal Mine Dust by Computer Analysis of Scanning Electron Microscope Images, by G. G. Johnson, Jr., and E. W. White. July 1, 1979. 79 pp. 16 figs. The use of the scanning electron microscope (SEM) to characterize coal mine dust has been possible because of two circumstances. First, the imaging process of the SEM allows multiple signals (secondary and backscattered electrons, X-ray emission, etc.) to be viewed. Second, the use of a computer to analyze the signals and perform statistical tests on the results. The parameters described are size, shape, chemical composition, mass distributions, and particle thickness. Although the system is intended for particular systems, those of agglomerates are handled by special aspects of the computer programs. Research done under Grant No. G0101720 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa,

Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 57–80. Geophysical Techniques Applied to Oil Shale Mining Operations, by P. Jackson, H. Bennett, A. Liskow, R. Shuchman, R. Turpening, and L. Wilock. February 1978. 251 pp. 34 figs. To investigate the use of integrated geophysics for the placement of oil shale mines, data were gathered during four field trips to two test sites in the Piceance Creek Basin, Colo. Seismic, resistivity, audiomagnetotellurics (AMT), induced polarization (IP) gravity, and magnetic data were gathered. Available remote sensing data were used for reconnaissance. Landstat data indicated a linear zone that alined with faults found in both test sites. The faults, one of which was confirmed by an observation well, were indicated by resistivity, AMT, and closely spaced seismic arrays. With remote sensing for reconnaissance, resistivity or AMT, and then closely spaced seismic array are the sequence of geophysical measurements that should be undertaken in this region. For analysis of integrated geophysical data, interactive computer modeling was developed in which seismics, gravity, and resistivity data can be simultaneously simulated. Research done under Contract No. H0252062 by the Environmental Research Institute of Michigan. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 58–80. Oil Shale Mining Environmental Research Program Overview, by C. Ogasawara, G. F. Kuncir, and D. A. Lewis. June 1979. 64 pp. 14 figs. This report describes the direction and progress of the Bureau of Mines Oil Shale Mining Environmental Research Program as of January 31, 1979. The report focuses on the Bureau's role in environmental research supporting oil shale development with respect to the activities of other involved Government agencies and private industry. Environmental considerations in oil shale extraction, such as ecological disturbances, health and safety hazards, waste management, and socioeconomic impacts, are discussed along with the type of research known to be planned by organizations to ameliorate these problems. Research done under Contract No. J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–179112; paper copy price code A04.

OFR 59–80. Mine Materials Handling Vehicle (MMHV), by A. L. Foote and J. S. Schaefer. Aug. 18, 1978. 308 pp. 95 figs. The purpose of this investigation was to develop a mechanical device that could safely perform handling tasks that are normally done manually in underground bituminous coal mines. The report discusses studies leading to construction of a battery-operated, three-wheel vehicle with a 6° of freedom manipulator. Supportive design studies included collection and analysis of production, manual functions, and injury data on the underground bituminous coal mining industry. Transfer tasks in section storage and working places were the prime candidates for mechanical handling. Functional specifications were developed for two handling devices (one to handle existing unit loads and one to handle repackaged unit loads) and for a vehicle to mount the handling device. Design concepts for nine different handling devices were developed and a cost-benefit evaluation was made for each. Detail design, capital and operating costs, and method improvement savings data were developed for two battery-operated vehicles and for two different manipulators. The three-wheel vehicle with anthropomorphic manipulator was chosen for development. Research done under Contract No. H0242015 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–178890; paper copy price code A14.

OFR 60(1)–80. A Program Plan for Determining Optimum Roof Bolt Tension. Theory and Application of Rock Reinforcement in Coal Mines. Volume 1 of 2, by T. A. Lang, J. A. Bischoff and P. L. Wagner. March 1979. 257 pp. 82 figs. The objective of this investigation was to develop a program plan of analytical studies and tests to determine (1) the optimum installation tension of a coal mine roof bolt, (2) the most valid bolt support theory or theories, and (3) the most valid roof failure theory or theories. On this basis, a comprehensive literature search was made and significant material dealing with coal mine behavior, roof bolting, and roof support was collected, reviewed, classified, and analyzed. Emphasis was given to the influence of rock reinforcement on the control of deformation, stress field modification, and mine roof stability. An assessment was made of the effect of various parameters including bolt tension, bolt pattern, and time of installation on the effectiveness of rock reinforcement systems, and equations were developed for bolt tension as a function of these parameters and rock properties. From these studies, a major program plan of tests and studies was developed to verify and validate the most tenable theories of roof behavior and roof support and to determine optimum bolt installation tension. Research done under Contract No. J0285006 by Leeds, Hill and Jewett, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S.

Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-179195; paper copy price code A12.

OFR 60(2)-80. A Program Plan for Determining Optimum Roof Bolt Tension. Theory and Application of Rock Reinforcement Systems in Coal Mines. Volume 2 of 2 (General Bibliography), by T. A. Lang, J. A. Bischoff, and P. L. Wagner. March 1979. 43 pp. The objective of this investigation was to develop a program plan of analytical studies and tests to determine (1) the optimum installation tension of a coal mine roof bolt, (2) the most valid bolt support theory or theories, and (3) the most valid roof failure theory or theories. Volume 2 comprises the bibliography. Research done under Contract No. J0285006 by Leeds, Hill and Jewett, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-179187; paper copy price code A03.

OFR 61-80. Deep Cutting Miner Production Tests, by Mukund D. Gangal and Bani R. Banerjee. April 1979. 86 pp. 20 figs. A deep-cutting continuous miner was tested under production-mining conditions at the Joanne mine, Rachel, W. Va., for about 1-1/2 years (226 production days). The miner was run in a low-head revolution per minute, deep-cutting mode and a high revolution per minute, shallow-cutting mode. The tests confirmed that deep cutting and slow cutter speed reduce respirable dust significantly under production-mining conditions. Quantitative reductions in dust, in deep versus shallow cutting, were 73 percent in return air and 63 percent at the operator's location. Production rate (tons per shift) and bit consumption rate did not show any relationship to deep or shallow cutting. Reliability and maintainability of the miner were worse in deep-cutting mode because of cutter drive shaft failures; the cutter shaft problem was solved through improved material and design. Except for cutter shaft repairs, maintainability was similar for deep and shallow cutting. Research done under Contract No. J0177019 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-183932; paper copy price code A05.

OFR 62-80. Development of a Rapid Response Radon Monitor, by Richard I. Miller. Nov. 15, 1979. 69 pp. 15 figs. A rapid response radon monitor capable of accurately responding within 3 min to changing radon levels of magnitude from 100 to 10,000 pCi/l (typical of the levels in working uranium mines) was developed for the Bureau of Mines. The 12- by 10- by 6-inch instrument weighs 17 lb and is capable of 8 hours of continuous portable operation with a self-contained, rechargeable battery power source. Residual chamber contamination from a radon level allowed to remain in the chamber for 90 min is about 10 pct, decaying about a factor of 2 in 1 hour. The instrument sensitivity is a nominal 0.1 cpm (pCi/l), with a background count rate of less than 1 cpm. Research done under Contract No. H0262019 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-183924; paper copy price code A04.

OFR 63-80. State-of-the-Art of Sampling and Analysis for Diesel Exhaust Contaminants, by K. T. Menzies, P. L. Levins, M. G. Broome, and M. H. Fanucci. July 30, 1979. 174 pp. 19 figs. Over 1,500 literature citations related to diesel exhaust sampling and analysis were obtained as a result of computer and manual searches of 9 data bases. Abstracts and hard copies of relevant citations were reviewed and those considered appropriate for evaluation were included in a bibliography. Based on the literature collected, available sampling and analysis methods for the following diesel exhaust contaminants were evaluated: CO, CO_2, NO, NO_2, hydrocarbons, particulates, PNA, SO_4, and oxygenates. Emphasis was given to laboratory and field methods for these species. Methods were evaluated on the basis of sensitivity, selectivity, accuracy, and reliability and a selected list of preferred methods was developed for each compound class. The selected methods were additionally evaluated through communication with current investigators. Sampling and analysis methods for all compounds except CO and CO_2 showed some unreliability. Recommendations were made for future research to develop, improve, and validate methods. Research done under Contract No. J0387208 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-183353; paper copy price code A08.

OFR 64-80. Development of a Reliable Method for Evaluation of Deep Sea Manganese Nodule Deposits, by R. H. Fewkes, W. D. McFarland, W. R. Reinhart, and R. K. Sorem. Jan. 12, 1979. 94 pp. 9 figs. Methods of estimating manganese nodule grade and concentration were investigated using data from a well-explored east-central Pacific manganese nodule deposit. Bulk chemical analyses of 159 nodules recovered from 21 box cores show that the range in metal values between nodules from a single box core is commonly small but may be greater than the range in mean metal content of nodules from widely separated box cores. The metal exhibiting the greatest variability in the 21 box cores is Zn, followed in decreasing order by Cu, Mn, Co, Ni, and Fe.

Approximately half of the box cores required analyses of 11 nodules or more to predict metal content within ±10 percent of the mean value. Research done under Grant No. G0274013 by Washington State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-182116; paper copy price code A05.

OFR 65-80. Hoist Rope Lubrication Criteria, by Richard L. Jentgen. July 1978. 209 pp. 19 figs. The objective of this report was to search and organize world literature and industry practices connected with lubricants and lubricant-application techniques for wire ropes used in underground mine hoists. A secondary objective included the development of a rationale for selection of hoist-rope lubricants. Actual experiences in mines were concluded to offer a variety of lubricants and techniques that could be emulated by others in an effort to achieve improved hoist-rope reliability and life. When most of these lubricants were evaluated in the laboratory, it was found that they ranked highest in the majority of tests related to function. This led to the recommendation that low-viscosity oil-type lubricants are the materials of choice with which to maintain hoist ropes. A prototype specification covering the recommended lubricants was formed. The report contains conclusions and detailed recommendations resulting from each task including suggestions for needed research. Research done under Contract No. J0377011 by Battelle Columbus Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-182959; paper copy price code A10.

OFR 66-80. Tiltmeter Data Analysis Windpipe Project, White Pine, by C. G. Kirkpatrick. July 13, 1979. 45 pp. 19 figs. Analysis of the data produced by a wide-band, sensitive, horizontal, biaxial motion sensor revealed several distinctive patterns before, during, and after a roof fall. The signals prior to the roof fall are similar in spectra, but 1,000 times larger in amplitude, than those after the roof fall. Immediately preceding the roof fall, by 2 to 12 hours, five events occurred that were larger in amplitude and lower in frequency than even the large preroof fall background signals. An interpretation of these events is presented. Research done under Contract No. J0285007 by Rockwell International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-190572; paper copy price code A03.

OFR 67-80. Identify and Evaluate Lightweight Support Substitutes, by Gilbert L. Forst. Sept. 30, 1978. 68 pp. 13 figs. The objective of this program was to identify and evaluate superior, lightweight substitutes for selected coal mine roof support concepts such as crossbars, posts, and crib blocks. Engineering analysis and concept design identified, through tradeoff studies, that some materials are promising from a technical standpoint, as support substitutes such as E-glass reinforced polyester resin, high-strength low-alloy steel, aluminum, and very high early strength (VHE) cement. An economic analysis indicates that none of the lightweight substitutes are economically competitive with wood on an initial cost basis; however, in terms of life cycle costs based on current dollars, the high-strength, low-alloy steel appears competitive for crossbars, and the VHE cement and E-glass-resin appear competitive for posts. Research done under Contract No. J0275012 by FMC Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-190580; paper copy price code A04.

OFR 68-80. Possible Uses of Manganese Dioxide in Ceramic Applications. Literature Review and Analysis, by V. L. Burdick, R. A. Condrate, E. E. Mueller, D. R. Rossington, and D. B. Sass. Feb. 11, 1980. 71 pp. 1 fig. This report presents a literature review of current uses of MnO_2 and suggestions for future research. The historical background, oceanographic distribution, geology, exploitation, law, and politics of MnO_2 are included. Uses of MnO_2 in ferrites, semiconductors, catalytic processes, thermoluminescence, and photochromic materials are presented. A select bibliography of 33 items and 129 references are presented at the end of the report. Research done under Contract No. J0199130 by Alfred University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-192214; paper copy price code A04.

OFR 69-80. Process for Recovering Chromium and Other Metals From Superalloy Scrap, by J. J. de-Barbadillo, J. K. Pargeter, and H. V. Makar. Apr. 15, 1980. 156 pp. 31 figs. This report describes a process for recovering chromium and other metals from superalloy scrap. Part I contains the results of laboratory-scale experiments that were conducted to test a complex flowsheet utilizing a wide range of extractive metallurgical operations. The basis for the process is the formation of a sulfide matte in which chromium is concentrated as a discrete chromium sulfide phase. Mineral processing and hydrometallurgical procedures are used to separate chromium sulfide from the other matte constituents. Parf II encompasses a preliminary engineering design of a pilot plant capable of treating 100 pounds of superalloy scrap per hour. Also included is an economic analysis of the operation of the pilot plant.

Research done under Contract No. J0188056 by International Nickel Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 70–80. Occurrences and Potential for Lead and Zinc Mineralization in the Mt. Schwatka Region, by James C. Barker. 1980. 51 pp. 3 figs. The Mt. Schwatka region, located about 75 miles north of Fairbanks, was investigated to provide data on mineral potential for the Bureau of Land Management. The investigations were undertaken in early 1978 as a result of a tentative geological correlation of this area to the Selwyn Basin lead-zinc districts, eastern Alaska, and the Yukon Territory. Correlation is based on a reconstruction of approximately 450 km of right-lateral Mesozoic movement along the Tintina Fault system. Prior to the investigation, there was no recorded information concerning mineralization or mining-claim locations. Occurrences of lead and zinc were found in an area underlain by early to mid-Paleozoic marine sediments and volcanics. There appears to be an affinity between these occurrences and the succession of units known as the Fossil Creek volcanics-Ordovicians(Silurian?). In one case, volcanogenic zinc was found in a cherty, intermediate, tuffaceous breccia. Lead and zinc values also appear associated with the upper stratigraphic levels of the volcanics and controlled by the unconformity and/or fault contact with the overlying Tolovana limestone. Manganese mineralization was identified in undifferentiated Paleozoic (Permian?) cherts and mafic volcanics to the west. There also appears to be a potential for asbestos deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 71–80. Radon Daughter Dosimeter Tests in Active Uranium Mines, by William D. Dodge and Van B. Parr. May 1980. 112 pp. 11 figs. Six underground tests were conducted to evaluate the performance and determine the reliability of three different types of personal radon daughter dosimeter systems in active uranium mine usage. Mean-time-between-failures estimates from 194.4 to 276.2 hours were obtained, and advantages and disadvantages of each system are identified. Test results suggest one system is marginally acceptable for large-scale uranium mining usage. Recommendations are presented for improving the existing systems and for developing new and more satisfactory versions. Research done under Contract No. H0282031 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; Office of Surface Mining Library, South Interior Building, Washington, D.C.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–203599; paper copy price code A06.

OFR 72–80. Design, Fabrication and Demonstration of an Inert Gas Generator. Volume II. Operations and Maintenance Manual, by Steven K. Ruggieri and and John T. Dieckmann. January 1980. 150 pp. 56 figs. This report describes the operation and maintenance of a mobile inert gas generator for use in a remote sealing system for fighting underground coal mine fires. Seals are emplaced in mine passageways between the fire zone and the rest of the mine isolating the fire zone. The seals consist of fly ash that has been pneumatically conveyed by inert gas through a borehole connecting the surface and the passageway. Inert gas is used as the fly ash seal transport medium (instead of fresh air) since the introduction of large volumes of fresh air in the vicinity of the fire zone would be undesirable. The inert gas generator has been performance tested and operated in the field for approximately 200 hours. The system is currently available for fighting any future underground coal mine fires. Research done under Contract No. H0155053 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa. Ala.. Denver. Colo.. Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–207368; paper copy price code A07.

OFR 73–80. Topsoil Rock Removal Technology, by Walter W. Kaufman, Dale N. Reynolds, and John J. Noll. Oct. 31, 1979. 106 pp. 23 figs. This report summarizes a study conducted to determine the state-of-the-art of various rock removal systems and their capabilities. The objective of the study was to determine if currently manufactured equipment can adequately accomplish rock removal in surface mine reclamation applications. Evaluations of State reclamation regulations, with regard to topsoil rock content, were made to determine the rock removal requirements. The major categories of equipment studied are rock pickers and rock rakes. The impact of rock removal implementation on the reclamation operations is discussed in detail. Research done under contract J0285023 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown. W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–204571; paper copy price code A06.

OFR 74(1)–80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume I: Text, Appendixes A & B, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 171 pp. 16 figs. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground

mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume I contains the text and appendixes A and B. Research done under Contract No. J0295011 by NUS Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-204472; paper copy price code A08.

OFR 74(2)-80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume II: Appendix C. Abandoned Mine Identification Area A, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 289 pp. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume II contains appendix C, "Abandoned Mine Identification Area A." Research done under Contract No. J0295011 by NUS Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-204480; paper copy price code A13.

OFR 74(3)-80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume III: Appendix C. Abandoned Mine Identification Areas B, C, and D, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 389 pp. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume III contains appendix C, "Abandoned Mine Identification Areas B, C, and D." Research done under Contract No. J0295011 by NUS Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-204498; paper copy price code A17.

OFR 75-80. Pyrometallurgical Recovery of Chromium From Scrap Metals: Laboratory Studies and Pilot Plant Design, by Charles L. Kusik, Krishna Parameswaran, David J. Kinneberg, and Harry V. Makar. February 1980. 68 pp. 13 figs. The objective of this investigation was to experimentally determine the feasibility of recovering chromium from critical scrap metals containing significant quantities of this element. Based on a conceptual chromium recovery flowsheet, the program described in this report demonstrated key process steps for the recovery of chromium as ferrochromium in a batch process. The process involves oxidation of chromium into a slag phase, subsequent separation of the slag phase from the remaining metal, followed by reduction of chromium from the slag phase to produce ferrochromium. Descriptive material and cost estimates are developed for a pilot plant to demonstrate the process. Research done under Contract No. J0188170 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 76-80. The Application of Advanced Mine Air Monitoring Techniques to Mines Using Diesel Powered Equipment, by John H. Johnson, David H. Carlson, and Edward O. Reinbold. July 31, 1979. 191 pp. 161 figs. Stratification of exhaust from a load haul dump was studied in an 80-foot-long dead end heading located in the White Pine Mine section designated for exhaust emissions studies. The mine air monitoring laboratory was used to gather temperature and CO_2 concentration data at 10 locations. The data substantiate the presence of strong buoyant forces of the hot exhaust gases that result in stratification in dead end headings. Diesel mine-vehicle emissions were monitored in the laboratory by a portable tailpipe emissions measurement apparatus assembled for in-mine use. The results were compared with simultaneous measurements by standard laboratory exhaust monitoring instruments. These results indicate that accurate field source quality control measurements can be obtained for CO_2, CO, and NO but NO_2 results were low for all engine conditions. Diesel pollutant concentration data from the Orchard Valley Mine were analyzed and compared with data collected earlier in the White Pine and Brushy Creek Mines. Lognormal frequency distributions and CO_2-based concentration ratios and correlations were calculated. In the three mines compared, pollutant concentrations were distributed similarly, and concentrations appear to be controlled to present standards. Research done under Grant No. G0166027 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-207541; paper copy price code A09.

OFR 77-80. Development of a Deep Penetrating Borehole Geophysical Technique for Predicting Hazards

Ahead of Coal Mining, by Sidney A. Suhler, Thomas E. Owen, Jackie E. Hipp, and Wendell R. Peters. July 5, 1978. 124 pp. 29 figs. A field operable, breadboard model, borehole radar was developed to detect hazardous geological anomalies in and above a coal seam in advance of mining. A 4-inch-diameter downhole probe was fabricated and tested in several environments. The radar transmitter was also employed in a cross-hole or through-transmission mode to determine natural geotechnical and manufactured conditions between boreholes. Sensitivity to underground conditions in both modes of operation were indicated. Research done under contract H0252033 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS; PB 80–208614; paper copy price code A06.

OFR 78(1)–80. Surface Mine Spoil Stability Evaluation, Interior Coal Province. Volume I—Main Report. Glossary of Terms (Appendix A) & Annotated Bibliography (Appendix B), by Raymond P. Miller, Peter M. Douglass, Robert A. Robinson, David A. Roberts, and William T. Laprade. August 1979. 330 pp. 83 figs. This two-volume report addresses slope stability of surface mine spoils within the interior coal province. Sixteen mines were visited, pertinent data and samples were collected, and reported spoil instabilities were back-analyzed. Laboratory test results are compared to back-analyzed material properties. Available methods of slope stability analysis are reviewed and evaluated with respect to application to mine spoil stability evaluation and prediction. Correlation and tentative relationships among spoil material properties, highwall conditions, mining equipment and procedures, and empirical observations are presented. Slope stability sensitivity plots illustrate the relative significance of various input parameters on stability. Slope stability input parameters are correlated with site and mining conditions to identify the primary factors controlling spoil stability. Investigative methods, spoil stability enhancement techniques, spoil stability prediction procedures, and future study areas are discussed. Appendixes include a glossary of terms, an annotated bibliography, details of mine visits, and detailed laboratory test procedures and results. Research done under Contract No. J0275013 by Shannon & Wilson, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–211113; paper copy price code A15.

OFR 78(2)–80. Surface Mine Spoil Stability Evaluation, Interior Coal Province, Volume II—Details of Mine Visits & Detailed Procedures of Laboratory Testing (Appendix C), by Raymond P. Miller, Peter M. Douglass, Robert A. Robinson, David A. Roberts, and William T. Laprade. August 1979. 398 pp. 263 figs. This two-volume report addresses slope stability of surface mine spoils within the interior coal province. Volume II presents detailed discussions of the individual mine visits and laboratory testing procedures and results, the general approach to the mine visits, and the various methods used to obtain information at the surface mines. Research done under Contract No. J0275013 by Shannon & Wilson, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–211121; paper copy price code A17.

OFR 79–80. Improved Spontaneous Combustion Protection for Underground Metal Mines, by Ralph B. Stevens. November 1979. 262 pp. 66 figs. The objective of this 20-month program was to define the relationships between mine ventilation, temperature, humidity, ore properties, materials used in mine operations, etc., and the spontaneous combustion problem in underground metal mines. Tradeoff studies availability, reliability, cost, and maintenance of spontaneous combustion protection sensors and telemetry were conducted, after which a prototype system was selected from four design alternatives. This selected system was then laboratory tested and demonstrated in an underground copper mine. Research done under Contract No. H0282002 by FMC Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–210461, paper copy price code A12.

OFR 80–80. Splice Testing Using a Figure-S Machine and a New Shuttle Car Simulation, by J. Tomlinson, T. Rusnak, R. King, and L. Morley. July 31, 1979. 44 pp. Shuttle car trailing cable splices were tested for resistance to failure upon being subjected to repeated bending, abrasion, and tensile shocks using a new testing method that closely simulates shuttle car induced stress. The results show that under normal stress, splices can be made to withstand the equivalent of 3 months of operational use. Restoring the tensile strength to the conductors is as critical as restoring flexibility. Splices in which the conductors are of slightly unequal length did not present as serious a workmanshop problem as previously thought since test results show that the conductors tend to equalize when longer cables, in contrast to short cables employed in previous testing methods, were used. Dynamic recordings of cable tensile stresses are presented for a shuttle car and the new simulated testing method. Two simple but effective methods for removing insulation using a knife and a pair of pliers are described. None of the designs tested for a sacrificial splice covering were satisfactory. Research done under Grant No. G0188036 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in

Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-210222; paper copy price code A03.

OFR 81–80. Trailing Cables and Splices: Shielded Cables, by Robert H. King, Barry L. Fisher, and Lloyd A. Morley. Feb. 29, 1980. 69 pp. 16 figs. An analysis of low-voltage shielded trailing cables is performed to develop a method to calculate the differences in operating costs between shielded and nonshielded cables. Two types of shield construction are considered for the three major underground coal mining methods. Data from laboratory and in-mine tests are presented along with an analysis of safety benefits. Recommendations for further investigations include cost impact considerations. Research done under Grant No. G0188036 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-208135; paper copy price code A04.

OFR 82–80. Investigation of Shank Tension in Mine Roof Bolts, by R. K. Swanson and G. L. Burkhardt. May 1979. 29 pp. 12 figs. Samples of ⅝- by 60-inch mine roof bolts were measured under test loads by stress measurement instruments, one a magnetic system and the other an ultrasonic birefringence system. Both were designed to detect shank tensile stress by measurement of the induced compressive stress in the head of loaded, generally higher quality bridge bolts. Results of measurements made on the heads of roof bolts indicate that variations in dimensions and other head variables preclude accurate load determination on a random population of installed bolts by either method. However, the ultrasonic system offers a good prospect for recording a reference value from a specific bolt at the time of installation to be used as a basis for subsequent inspection through the life of the structure. Qualitatively, the ultrasonic system would also permit the determination of whether or not a bolt is nominally loaded. Use of a separate "stress washer," installed under the head of the bolt, would permit accurate measurement of the translated stress to provide post-installation inspection with good accuracy using either instrumentation system. The stress washer would be no more than a reasonably accurate steel collar within which a uniform stress would be developed from the loaded bolt. Research done under Contract No. H0292012 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-210016; paper copy price code A03.

OFR 83–80. Modelling and Data Analysis of 50 to 5000 kHz Radio Wave Propagation in Coal Mines. Technical Services for Mine Communications Research, by Robert L. Lagace, Alfred G. Emslie, and Michael A. Grossman. February 1980. 109 pp. 66 figs. The objective of this work was to formulate simple theoretical models characterizing medium frequency (MF) radio wave propagation in underground room-and-pillar coal mines to predict the most favorable operating frequencies and maximum communication ranges for portable radios carried by key miners. This was achieved and confirmed experimentally for conductor-free areas of coal mines. In areas where a conductor such as a power cable is present, applicable data must yet be taken before the propagation model can be confirmed. This report describes the theoretical models developed for MF radio propagation in coal mines, compares theoretical results with experimental measurements made in a large number of mines located in various coal seams, and summarizes the findings and their implications for portable radio communications between roving miners. Research done under Contract No. H0346045 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-209455; paper copy price code A06.

OFR 84–80. Alternatives for Technology Transfer to the Enterprise, by P. B. Grote, W. A. Coleman, and G. M. Guard. July 1980. 121 pp. 15 figs. This report provides a general description of deep ocean mining (DOM) technology, sources for DOM technology, and identifies approaches and requirements for acquisition by the Enterprise, the organ of the authority that will carry out ocean mining activities, of DOM technology by conventional means. The approaches identified assume the Enterprise enters into a contractual-joint venture arrangements with an uncommitted and competent systems management firm at various stages of the DOM system acquisition process. The approaches provide for training through work-study as well as through direct participation in acquisition programs. The potential success of the alternatives are evaluated in terms of the likelihood of the acquisition of an ongoing Enterprise economic DOM operational capability. The study concludes that sources exist and that the Enterprise should undertake the development of its own technical capability through conceptual design prior to selecting its source for systems management expertise. Research done under Contract No. J0100037 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.;

and Office of Surface Mining Library, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-209497; paper copy price code A06.

OFR 85-80. Evaluation of Selected Factors Impacting on the International Competitiveness of the U.S. Minerals Industry, by Spencer M. Beresford and Henry G. Edler. Nov. 13, 1978. 255 pp. 22 figs. This report compares U.S. and foreign water usage costs; internal transportation costs; antitrust policies, laws, and regulations; and environmental, health, and safety laws and regulations. The analysis is limited to 12 nonfuel minerals and to countries designated by the Bureau of Mines for which substantial data were found. Interviews that were held with representatives of nine companies were discussed. Research done under Contract No. J0188163 by International Technical Services, Inc. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 86-80. Potential Applications of Drill-Split Fragmentation Systems in Underground Mines, by Michael Kaplan and Dave Chazin. Aug. 20, 1979. 188 pp. 60 figs. An investigation was conducted on the use of a mechanical rock splitter as the primary means for rock fragmentation in underground hard rock mining systems. Analyses and scale model tests showed that reasonably sized splitters that could be mounted on the booms of conventional drill jumbos were capable of fragmenting over 1 ton of rock per cycle. Detailed drill-split mining systems were developed for entry development, room-and-pillar, bench mining, and cut and fill mining. Economic analyses of these systems showed them to be generally competitive with conventional drill-blast methods. Except for bench mining, drill-split offered substantial cost savings over drill-blast. The investigation also included a technical evaluation of the mechanical splitter, an analysis of health and safety, and a determination of the potential applicability of drilling and splitting. Research done under Contract No. J0285016 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-210792; paper copy price code A09.

OFR 87-80. A Technical Basis for the Development of Deep Ocean Mining Regulations, by Philip B. Grote and Wendell Gayman. Sept. 14, 1979. 310 pp. 33 figs. The deep ocean mining industry is in a precommercialization stage of development. In the context of a proper legal-regulatory regime, deep ocean mining system design, site survey, and operation technologies are capable of rapid evolution. This report recommends that the regulatory framework develop in parallel with the industry and presents a rationale to implement this approach. The Government has several interests in deep ocean mining technology: (1) as a potential regulator, sound regulations should be based on an understanding of the technology; (2) as a potential monitor, survey technologies are relevant; and (3) as an estimator of strategic mineral supplies, it is important to understand the technology that allows economic access to deep ocean minerals. Thus, the major portion of the report presents an in-depth review of systems design, operations, and survey equipment and techniques. Research done under Contract No. J0177131 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah; and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 88-80. Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining. Phase 1: Premining Hydrologic and Water Quality Conditions, by U.S. Department of Agriculture. July 1978. 347 pp. 95 figs. Five watersheds, ranging from 29 to 49 acres, were instrumented in east-central Ohio to investigate the hydrologic and water quality conditions occurring before, during, and after surface mining. Physical information was obtained for each watershed, and instrumentation was installed to obtain hydrologic and weather data and water quality samples. Premining ground water systems for each watershed had two major perched aquifers within the top 250 feet. Shallowest ground water is commonly of the calcium bicarbonate type; whereas, water in the deeper aquifers is of variable type. Although dissolved-solids concentration is generally 200 to 600 mg/l, brackish or salty water is present in several areas. A one-dimensional unsaturated flow model was developed to interface with a quasi-three-dimensional ground water model as part of a composite hydrologic model. The unsaturated flow model includes provisions for an evapotranspiration model. Research done under contracts J0166054 and J0166055. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 89-80. Geologic and Engineering Data Acquisition for Underground Coal Mine Ground Control, by David R. Alison, Edvard T. Ohlsson, and Kevin V. Whitney. January 1980. 100 pp. 10 figs. This study was conducted using field interview methods to determine the data and information requirements of the underground coal mining industry to improve mine ground control procedures in existing and future mines. The establishment of a central geologic and engineering information resource center with computer searchable abstract files that can locate and supply descriptive and case-study literature addressing specific mining problems is recommended. A bibliography of underground coal mine ground control literature is included. Research done under Contract No. J0395010 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avon-

dale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219272; paper copy price code A05.

OFR 90-80. Factory Integration of an Illumination System Into a Continuous Mining Machine, by Bruce Rock. Oct. 29, 1979. 75 pp. 35 figs. A continuous-mining machine was redesigned for the installation of an integrated illumination system. The illumination system was designed by first calculating the theoretical number of luminaires required to meet the Federal illumination standards. Luminaires initially were placed using isointensity diagrams. A darkroom was used for "fine tuning" and demonstrating that the system met the illumination requirements. The luminaire mounts were installed on a machine underground. The performance of the illumination system was monitored in the working environment of an operating coal mine, and design changes were made as necessary during the evaluation period to improve the system. Research done under Contract No. H0366066 by National Mine Service Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219496; paper copy price code A04.

OFR 91-80. Chromium Conservation in Leather Tanning, by Jean J. Tancous, Roger G. Bellingham, Waldo E. Kallenberger, and Alex E. McDonell. Dec. 17, 1979. 194 pp. 7 figs. Currently almost half of the chromium consumed by the U.S. tanning industry is being deposited at landfill sites. In 1978, this amounted to 27,300 tons of dichromate. The research presented in this report consisted of bench-scale tests directed towards ways to increase the usage of this wasted chromium. The report discusses the advantages and disadvantages of the methods tested for recovering chromium from leather scraps, tannery wastewater, and wastewater sludge. Research done under Contract No. H0272026 by Tanners' Council of America, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-222540; paper copy price code A09.

OFR 92-80. Flammability Evaluation of Noise Control Products for Use in Underground Coal Mines, by R. S. Norman, R. A. Hedeen, J. W. Kopec, and T. E. Waterman. June 1979. 95 pp. 117 figs. Noise control programs have been initiated on several types of mining equipment and vehicles that can be used in underground coal mines. The materials that are used in these programs have not been tested for flammability properties. The objective of this program was to select approximately 100 acoustic materials for flammability evaluation. A variety of materials were selected for measurement according to ASTM E-162 procedures. A radiant heat energy source was used to measure flammability properties of 15.2- by 45.7-cm samples. In the absorptive materials category, 45 percent of the materials tested had a flame spread index of less than 25. For barrier, damping, and isolation materials the corresponding values were 40, 43, and 9 percent. Research done under Contract No. J0177039 by IIT Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-101990; paper copy price code A05.

OFR 93-80. Effects of Subsidence From Thick Seam Coal Mining on Hydrology, by Richard C. Moore and Michael A. Nawrocki. Mar. 7, 1980. 245 pp. 59 figs. The Bureau of Mines contracted a study to estimate what effects the underground mining of thick coal seams in the Western United States would have on the surrounding water resources. Potential coal fields where this type of mining might occur were identified. Foreign literature was searched for studies of effects on hydrology from thick seam underground coal mining. Based on limited information obtained from the literature, estimates of the effects of this type of mining on the ground and surface water in the Western States were made. Research done under Contract No. J0295012 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219280; paper copy price code A11.

OFR 94-80. Containment Pond Technology. State-of-the-Art, by Vulli L. Gupta and Maurice J. Miles. December 1979. 74 pp. Ponds totaling more than 71,228 acres and within about 500 miles of Boulder City, Nev., were visited or otherwise investigated. This study was expected to indicate needed research relative to pond sealing to contain specific effluents and to conduct a systematic literature survey to assemble and summarize the state-of-the-art related to ponds for containment, treatment, and disposal of industrial effluents. A limited field survey of existing pond installations was also conducted to obtain data on some of the inherent problems and adopted strategies for solutions of such problems. Research done under Contract No. S0271043 by University of Nevada. Available for reference at Bureau of Mines facilities in Tuscaloosa Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane,

Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-223175; paper copy price code A04.

OFR 95(1)-80. Study of Deep Ocean Mining Operational Economics. Vol. I. Simulation Development and Study of Obstacle Effects, by David R. Peterson and Philip B. Grote. September 1979. 58 pp. 22 figs. This report presents a deep ocean mining operational simulation that is capable of describing the response of the bottom collection unit to specified mining ship maneuvers and the corresponding operation of the mining ship maneuvering system. Bathymetry, obstacles, collector and pipe dynamics, and ship maneuvering capabilities are included in the simulation. The simulation is capable of evaluating the technical requirements and operating costs for specified mine plans. Results are useful in assessing mine size requirements and provide operating cost estimates useful as inputs to deep ocean mining economic feasibility assessments. The simulation is used to determine the consequence of obstacles to mining system operations in terms of impact on mine size requirements and reduced production arising from obstacle avoidance maneuvers of a towed (unsteered) collector. Research done under Contract No. J0177131 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219470; paper copy price code A04.

OFR 95(2)-80. Study of Deep Ocean Mining Operational Economics. Vol. II. Deep Ocean Mining Operational Simulation (DOMOPS) User's Manual, by David R. Peterson and Philip B. Grote. September 1979. 56 pp. 4 figs. This report covers five computer codes that were generated during development of a simulation of deep ocean mining operational economics. In addition to a thorough description of each code, internal documentation is provided throughout each, except for the very simple codes, for ease of understanding or possible modification. Research done under Contract No. J0177131 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219488; paper copy, price code A04.

OFR 96(1)-80. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Volume 1—Summary Report, by H.-F. Krausse, H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T Ledvina, C. G. Treworgy, and W. A. White, with contributions by V. D. Brandow, H. M. Karara, and A. S. Nieto. June 1979. 67 pp. 48 figs. The objectives of this study were to find and describe geologic factors that influence roof conditions in underground mines. The primary method of study was detailed mapping in mines, supplemented by regional computer mapping using drill-hole data, close-range photogrammetry, physical testing of core samples, and clay mineralogical investigations of roof material. Over a period of 3 years, a large volume of data has been generated. The results are reported in two volumes. Volume 1 is a summary for general use of the major findings and conclusions; volume 2 includes a detailed account of the method of study, the data gathered, and the conclusions reached. Research done under Contract No. H0242017 by Illinois State Geological Survey and University of Illinois at Urbana-Champaign. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219454; paper copy, price code A04.

OFR 96(2)-80. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Volume 2—Detailed Report, by H.-F. Krausse, H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T. Ledvina, C. G. Treworgy, and W. A. White, with contributions by V. D. Brandow, H. M. Karara, and A. S. Nieto. June 1979. 218 pp. 179 figs. This report summarizes the status of knowledge on the influence of the geologic and structural fabric of roof strata on roof stability in underground mines in the Herrin No. 6 coal member. The report is based on past investigations and on information collected during recent visits to active mines. The objectives of this study were (1) to identify and describe geologic conditions that influence roof stability, (2) to relate roof performance to the geologic structure by detailed study within selected mines, (3) to present information on areal distribution of comparable geologic conditions that influence roof stability, (4) to compile from literature and files geotechnical data that pertain to roof stability, (5) to collect samples from study areas by diamond drilling, (6) to show how to recognize, both in mines and in diamond drill cores, the various geologic features that influence roof stability, and (7) to propose areas of future research on the subject. Research done under Contract No. H0242017 by Illinois State Geological Survey and University of Illinois at Urbana-Champaign. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219462; paper copy price code A10.

OFR 97(1)-80. The Effects of Underground Environment and Loading Conditions on Noise Levels

of Coal Mining Equipment. Final Report—Volume I, by Ervin P. Fuchs. March 1979. 230 pp. 50 figs. This report presents an evaluation of the acoustic imaging technique to determine the effect of underground environment on the sound pressure level of coal mining equipment. The equipment includes continuous miners, cutting machines, coal drills, loading machines, shuttle cars, roof bolters, and locomotives. The report presents the procedure for obtaining the aboveground and underground measurements, an analysis of noise sources, an assessment of the acoustic imaging technique, and the effect of loading on sound pressure levels. The acoustic imaging technique involves obtaining a value by adding the energy level of the direct sound wave and the energy levels of the reflected sound waves due to tunnel surface for a given source. The obtained value represents the theoretical increase in sound pressure level due to the underground environment. The appendixes provide detailed calculations concerning the evaluation of machine measurements and definitions of terms. The report concludes that the acoustic imaging technique appears to give good predictions of noise level increases due to the underground environment. Research done under Contract No. J0366030 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-227606; paper copy price code A11.

OFR 97(2)-80. The Effects of Underground Environment and Loading Conditions on Noise Levels of Coal Mining Equipment. Final Report—Volume II, by Ervin P. Fuchs. March 1979. 138 pp. 102 figs. This report presents the reduced vibration data from 10 mining machines that were tested to determine the effect of underground environment and loading conditions on acoustic noise levels of coal mining equipment. Vibration measurements were obtained on machine locations where control or sensing electronics may be mounted. The measurements included vibration data in the 20- to 3,500-Hz frequency range. The 10 mining machines include continuous miners, a loading machine, a coal drill, a roof bolter, and a 25-ton locomotive. A list describing the mining machine, geographic, test location, and test date is shown in table 1. The vibration data has been reduced to octave band, 1/3-octave band, and narrow band levels. Research done under Contract No. J0366030 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-227614; paper copy price code A07.

OFR 98-80. Concept Study Shuttle Car Cable Reel, by R. J. Gunderman. April 1980. 77 pp. 18 figs. Cable reel systems for shuttle cars were investigated to determine whether an improved system could be identified. Interviews and mine visits were conducted to better define limitations and problems with present systems. Although simple and relatively inexpensive, present cable reel systems are not fully satisfactory. Several concepts for a different technical configuration were formulated and evaluated. An all-electric system using electronic control and external sensors was recommended for further development. Research done under Contract No. J0395012 by Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219371; paper copy price code A05.

OFR 99-80. Uranium-Phosphorus Chemistry and Extraction of Uranium From Uraniferous Phosphorites, by M. Shamsuddin and Milton E. Wadsworth. Mar. 31, 1980. 83 pp. 12 figs. This report consists of a literature search and assessment related to the recovery of uranium from uraniferous phosphorites. It shows the importance of phosphorites as future uranium resources and the favorable cost comparison when recovered as a byproduct in fertilizer production. The needed research is described, including thermodynamic and mineral processing studies. Research done under Contract No. S0291069 by University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-229008; paper copy price code A05.

OFR 100-80. Portable Crusher for Underground Mining Applications and Design. Phase I—Design, by Harold J. Miller, Edward E. Laughbaum, and William R. Fisher. Aug. 31, 1978. 111 pp. 46 figs. This report summarizes proposals and findings made in conjunction with the newly designed M-44 low-head portable crusher which is believed well capable of meeting the requirements of a "portable, underground, hard rock" machine as previously defined in earlier reports. Data gathered by use of the ¼-scale model of the M-44 have substantiated and verified the concept sufficiently to justify construction of a full-size machine for further testing under actual mine conditions. Research done under Contract No. J0285003 by Eagle Crusher Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-227515; paper copy price code A06.

OFR 101–80. Environmental Assessment of In Situ Mining, by Dennis R. Kasper, Harry W. Martin, Larry D. Munsey, Roshan B. Bhappu, and Clement K. Chase. December 1979. 294 pp. 58 figs. This study evaluates selective environmental impacts of two distinct in situ mining techniques. In situ leaching of uranium, porphyry copper, and native copper and in situ borehole slurry mining of uranium, sandstone, and pebble phosphate ores are the techniques and minerals investigated. The potential impacts onsite in the desert southwest (porphyry copper), Michigan (native copper), Texas and Wyoming (uranium), and Florida and North Carolina (phosphate) are discussed. The study emphasizes those impacts that are unique to in situ solution leaching and borehole slurry mining. Impacts that are characteristic of all construction projects in the general geographical areas investigated, such as socioeconomic effects on surrounding communities and site-specific impacts such as rare and endangered species, are beyong the scope of this study. For each of the in situ processes and associated ores investigated, the physical and chemical characteristics of the systems are described, the toxicity of the leaching solutions are presented, and the potential impacts on the environment are developed. Research done under Contract No. J0265022 by PRC Toups. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash., U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va., and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–106783; paper copy price code A13.

OFR 102–80. Evaluation of the Kloswall Longwall Mining System, by Paul J. Guay. September 1978. 211 pp. 37 figs. This report presents the results of evaluating a longwall mining system specifically designed to extract a very deep web (60 inches or deeper) from a longwall panel. The report includes a productivity and cost analysis comparing the new mining system with a high-capacity conventional longwall operation taking a 30-inch-wide web. The analysis shows the new system will increase annual production 44 percent and decrease cost per ton off the face 21 percent. The report also includes conceptual drawings and specifications for a high-capacity four-drum shearer and a unique shield-type roof support specifically designed for very wide-web operation. The advantages and problems associated with wide-web mining are discussed in general and as they relate specifically to the equipment selected for the new mining system. The study concludes by recommending that surface coal loading tests be conducted as the follow-on work. Research done under Contract No. J0265028 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–227622; paper copy price code A10.

OFR 103–80. Mine Wide Test of the WVU Monitoring Concept. Phase II Final Report: Modular Mine Monitoring and Control System by R. S. Nutter, W. R. Voltz, and M. D. Aldridge. Feb. 29, 1980. 273 pp. 106 figs. The results of designing, constructing, and laboratory testing of a modular distributed, microprocessor-based mine monitoring and control system are presented. A standard computer communications protocol was utilized throughout the system. Tests were performed on the utilization of a high-level language for programing mine monitoring and control systems. Laboratory tests were run on a combined air velocity-methane sensor. Research done under Contract No. H0144114 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–227648; paper copy price code A12.

OFR 104(1)–80. Selective Placement of Coal Stripmine Overburden in Montana. I. Data Base, by D. J. Dollhopf, W. D. Hall, W. M. Schafer, E. J. DePuit, and R. L. Hodder. June 1977. 116 pp. 19 figs. The specific objective of this 3-year study is to investigate the means of reestablishing non-polluted hydrologic systems in areas where surface mining directly impacts shallow ground water resources. The research area chosen for the study is located near Colstrip, Mont., at a new mine site where chemical analysis of core samples from the overburden suggested that excessive concentrations of several elements would be encountered during the mining process. The report discusses local vegetation, soils, and regional geology and hydrology. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–103186; paper copy price code A06.

OFR 104(2)–80. Selective Placement of Coal Stripmine Overburden in Montana. II. Initial Field Demonstration, by D. J. Dollhopf, W. D. Hall, C. A. Cull, and R. L. Hodder. June 1977. 108 pp. 42 figs. A week-long selective overburden handling dragline operation was conducted at a strip mine near Colstrip, Mont. The objective of the demonstration was to hydrologically isolate a saline overburden zone during placement in the spoil piles. The saline zone had concentrations considered inimical to successful reclamation and was potentially dangerous to future water quality in the spoils aquifer. The zone was identified after review of chemical data for overburden samples collected from the intense 60-m-grid drilling pattern. The saline zone in the overburden was handled in a normal manner; segregated and buried; and segregated, buried, and covered with a relatively impermeable 1.0-m-thick clay cap. The method used to formulate this demon-

stration, the demonstration itself, and the monitoring and evaluation techniques are described in this report. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-103178; paper copy price code A06.

OFR 104(3)-80. Selective Placement of Coal Stripmine Overburden in Montana. III. Spoil Mixing Phenomena, by D. J. Dollhopf, J. D. Goering, C. J. Levine, B. J. Bauman, D. W. Hedberg, and R. L. Hodder. July 1978. 79 pp. 27 figs. An overburden handling dragline operation was conducted at a strip mine near Colstrip, Mont. The objective of the demonstration was to determine the degree a dragline could mix overburden inhibitory zones during the spoiling process. To quantify the mixing process the overburden was scatter spoiled, dump spoiled, and spoiled in a normal manner. This demonstration was part of an effort to investigate means of reestablishing nonpolluted hydrological systems in areas where surface mining directly impacts shallow ground water resources. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa. Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-103160; paper copy price code A05.

OFR 104(4)-80. Selective Placement of Coal Strip Mine Overburden in Montana. IV. Hydrogeologic Studies, by D. J. Dollhopf, J. D. Goering, C. J. Levine, B. J. Bauman, and R. L. Hodder. July 1979. 58 pp. 20 figs. The objective of this investigation is to establish nonpolluted hydrological systems in areas where surface mining directly impacts shallow ground water resources. Chemically undesirable overburden material was selectively backfilled with the intent that it would be below the future root zone, be above the reestablished aquifer, and would not be leached as a result of deep percolation. After 2 years the buried material remains above the spoil aquifer and below the maximum rooting depth. Unsaturated water flow from the land surface to the buried material occurred during wet climatological periods. However, no significant leaching of buried material was observed. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-103194; paper copy price code A04.

OFR 105-80. Structure Response and Damage Produced by Ground Vibration From Blasting, by D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding. Aug. 20, 1980. 176 pp. 68 figs. The Bureau of Mines studied blast-produced ground vibration from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Direct measurements were made of ground-vibration-produced structure responses and damage in 76 homes for 219 production blasts. The results were combined with damage data from nine other blasting studies, including three analyzed previously for Bureau of Mines Bulletin 656. Safe levels of ground vibration from blasting ranged from 0.5 to 2.0 in/sec peak particle velocity for residential-type structures. The damage threshold values are functions of the frequencies of the vibration transmitted into the residences and the types of construction. Particularly serious are the low-frequency vibrations existing in soft foundation materials and/or blast-to-residence distances that not only produce structural resonances, but also excessive levels of displacement and strain. Research done by Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 106-80. Measurement of Mine Roof Movement, by Ivor Hawkes. July 1978. 238 pp. 49 figs. This report describes the results of a study of instruments designed to monitor mine roof movements. The theory of such measurements is briefly reviewed and a detailed literature survey and a bibliography are presented. Eight different single and multipoint borehole extensometers that are either novel or improved versions of existing roof movement measurement instruments and permit remote or on-site reading are described in detail together with two novel instruments to monitor mine roof-to-floor convergence. Research done under contract H0366033 by Ivor Hawkes Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities. Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 107-80. Design and Develop Standardized Controls in Roof Bolting Machines—Preliminary Design, by Terry L. Muldoon, Steven Ruggieri, Thomas Gore, and L. Bruce McDonald. April 1980. 63 pp. 4 figs. This report describes the development of preliminary requirement specifications for standardized operating controls for roof bolting machines used in underground coal mining. Observations of roof bolting operations and discussions with roof bolter manufacturers coupled with detailed analyses of roof bolter control design specifications were performed. Detailed roof bolter operator task analyses, commonality of control analyses, and classical link

analyses were also performed. The results were then used to produce preliminary requirement specifications for standardized controls. Research done under Contract No. H0292041 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 108–80. Evaluation of Metal Resources at and Near Proposed Deep Sea Mine Sites, by R. H. Fewkes, W. D. McFarland, W. R. Reinhart, and R. K. Sorem. Feb. 15, 1980. 239 pp. 48 figs. The resource potential of three central Pacific manganese nodule deposits is evaluated using sea floor photographs and box core samples. Mean nodule concentration for the three deposits ranged from a low of 3.8 kg/m^2 (dry) near DOMES Site B to a high of 7.1 kg/m^2 (dry) near DOMES Site C. A nodule concentrations of 4.4 kg/m^2 (dry) was estimated for the area surrounding DOMES Site A. Nodules rich in Mn, Ni, and Cu characterize the Site B area, but low nodule abundance estimates suggest a limited resource potential. Nodule grade is lower and nodule abundance is slightly higher near Site A. The area surrounding Site C appears to have the greatest potential for supplying ocean floor metals. An extensive appendix is included listing metal values for 882 nodules recovered from 144 sample sites. Sample locations and mean metal values for each location are shown on 44 maps. The report also includes an extensive listing of nodule physical characteristics and population data derived from the analysis of sea floor photographs. Research done under Grant No. G0284008 by Washington State University. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–228992; paper copy, price code A11.

OFR 109–80. Estimation and Evaluation of the Iron Ore Reserves of the United States—A Partial Survey 1974–75. Iron Ore Reserves of the Mesabi Range, Minnesota. A Minerals Availability System Report, by Ralph W. Marsden. Jan. 23, 1980. 81 pp. 3 figs. This report is a comprehensive study of the iron ore reserves of the Mesabi Range, Minn. Iron ore has been classified into seven categories with descriptions of each category and the geologic factors affecting each reserve estimate. Iron ore reserves for all classes, grades, and probabilities are based on breakeven analysis and average 1974 dollars. The reserve estimate is reported on a township-range basis. Research done under Contract No. J0188074 by University of Minnesota—Duluth. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–228984; paper copy price code A05.

OFR 110–80. An Interactive Computer System for Evaluating Coal Mine Illumination, by Robert Goldstein. March 1980. 21 pp. 2 figs. A computer system for calculating the illumination on coal mine surfaces due to machine-mounted lights is described. Utilizing numerical models of mining machinery and measured data on luminaire output characteristics, the program computes the foot-candle levels incident on the the mine entry surfaces for any desired machine-luminaire-entry configuration. Shadowing effects of the machine are taken into account. Results are provided at 2-foot intervals on the face, left and right walls, floor, and roof. The system operates interactively from a Tektronix 4014 graphics terminal which handles all input-output functions. The software is installed on a Cyber 74 computer that communicates with the terminal by a telephone line. Research done under Contract No. S0271041 by Mathematical Applications Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–125528; paper copy price code A02.

OFR 111–80. Rapid Excavation of Rock With Small Charges of High Explosive, by George B. Clark, David W. Ashcom, and Kanaan Hanna. January 1980. 250 pp. 54 figs. The purpose of this investigation was to test a blast shield, develop a conceptual design for an automated drill and blast system (ADBS), and make an economic analysis of the ADBS compared with conventional drill, blast, and muck (DBM) systems. The ADBS tunneling concept was developed in an effort to design an excavation system of greater efficiency than the DBM systems conventionally used. The ADBS would minimize downtime and approach noncyclic efficiently by small charge blasting. Small charge blasting uses simultaneously detonated light charges in four to eight short holes, usually in a line. Limitation of the total explosive per blast reduced air blast overpressure, fly rock velocity, vibrations, and noise enabling the blast shield to adequately contain these side effects. Conceptual design for the ADBS included blast shield, chassis, hydraulic drills, automated explosive loading and firing system, and an armored cab. Horizontal and vertical blast shield alinement controls and ventilation are incorporated into the design. The economic analysis determined ADBS advance costs to be 17 to 20 pct lower than DBM on a per foot basis. Research done under Contract No. H0272020 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–125577; paper copy price code A11.

OFR 112–80. Evaluation of Fluorescent Lighting Systems for Various Underground Coal Mines, by A. E. Ketler. May 1979. 110 pp. 71 figs. This report describes a variety of coal mining lighting projects that were funded by the Bureau of Mines to obtain underground lighting experience in support of new lighting requirements for underground coal mines. Some of the variables covered were low and high

coal, narrow and wide entries, conventional and continuous mining, ac and dc power, bituminous and anthracite coal, machine mounting, and area lighting. Research done under Contract No. H0252058 by OCENCO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125262; paper copy price code A06.

OFR 113-80. Column Leaching of Low-Grade Chalcopyrite Ores Using Thermophilic Bacteria, by Corale L. Brierley. July 1979. 96 pp. 28 figs. Low-grade porphyry copper ores containing chalcopyrite as the primary mineral was leached by two strains of acidophilic, thermophilic microbes belonging to the genus *Sulfobus*. Leach tests were conducted in glass columns heated to 60° to 70° C. Ores sized to minus ½ inch plus 50 mesh were effectively leached by the thermophilic organisms, but ores sized to minus 2 inch plus ½ inch resisted leaching. Decreasing the pH of the leachate to about 1.8 enhanced the copper extraction from ore with the thermophilic microbes. The bacterium *Thiobacillus ferrooxidans* was relatively ineffective for extracting copper from the ore. Research done under Grant No. G0177100 by New Mexico Bureau of Mines and Mineral Resources, and New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-128498; paper copy price code A05.

OFR 114-80. An Illumination System for a Shortwall Mining Section, by Robert A. Harrow. Sept. 28, 1979. 177 pp. 70 figs. A program to develop, demonstrate, and evaluate a lighting system concept for a working shortwall coal mine section based on the application of lighting system components used in conventional, continuous, and longwall mining sections is described. The objective was achieved by employing an aboveground simulated working place to test and evaluate lighting systems prior to installation underground. The simulator tests were subsequently verified through actual underground tests. Research done under Contract No. H0366065 by General Energy Development Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-128019; paper copy price code A09.

OFR 115-80. Development of Roof Control Techniques for Massive Roof Problems in Longwall Operations, by Peter de Bakker, Andrew Harvey, Michael Cleary, and Timothy Hawkes. November 1979. 191 pp. 51 figs. The objective of this investigation was to design a mechanical roof-breaking device suitable for breaking massive roof and for use with the general range of roof support equipment in longwall operations. Given the state-of-the-art in rock mechanics of the loading requirements to break off massive overhung roof in a longwall operation, two different roof-breaker mechanisms were developed. The most popular roof supports were evaluated for their suitability to be equipped with either of the two mechanisms. The results indicate that the state-of-the-art rock mechanics is not sufficiently advanced to confidently predict roof breakage. Research done under Contract No. H0282045 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125270; paper copy price code A09.

OFR 116-80. Enhancement of Mine Power System Safety and Reliability, by E. K. Stanek. October 1979. 207 pp. 68 figs. This report contains the results of several related research efforts that were aimed at enhancement of mine power system safety and reliability. The largest single effort was on optimum spares and maintenance scheduling for various components of a mine power system. Two closely related tasks involved calculating the minimum arcing faults that could occur on dc trailing cables and the use of trippable load break switches to clear ground faults. Both of these tasks are concerned with reliable fault clearing to prevent shock and fire hazards. Three other closely related tasks were concerned with aspects of mine power system design—alternate network topologies, optimum voltage selection for mine power systems, and selection of system components. The final task consisted of laboratory tests to ascertain the effects of repetitive, low-level transients on insulation systems. Research done under Grant No. G0188097 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125361; paper copy price code A10.

OFR 117-80. Heap Leaching Studies on Uranium Ore. Phase VI: Field-Scale Heap Leaching Test Program, by Robert Merritt, Hal Peterson, Charles Wentz, Thomas Licht, and Michael Harris. February 1980. 130 pp. 33 figs. There is considerable interest in developing leaching techniques for low-grade uranium ores. For this study, a 2,500-ton low-grade uranium ore heap was tested to determine suitability of the heap leach extraction technique as a means of recovering uranium values. The results were compared with column leaches of the same ore. Flow rates were similar, and 96 pct of

the uranium was leached in each system. Research done under Contract No. H0252022 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-129751; paper copy price code A07.

OFR 118-80. Measurement and Control of Respirable Dust in Mines, by National Academy of Sciences 1980. 405 pp. 164 figs. As result of continuing national concern about the problem of respirable dust in underground mining operations, the National Materials Advisory Board formed a committee to prepare a study addressing the problem in a broad and fundamental manner. The objective of the study is to consolidate the information currently available on the subject, assess the active research program of the Bureau of Mines on the measurement and control of respirable dust in mines, and provide perspective settings for investigations needed in the future. This report describes the results of the study. Research done under Contract No. J0199002. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 119-80. Development of New Chemistry for the Vapor Phase Extraction of Metals From Ores and Secondary Materials, by John P. Hager, Bruce Schiller, Stephen E. James, Kent O. Peaslee, Jerry Fasso, and William A. May. May 16, 1980. 175 pp. 38 figs. To add to the basic information bank on volatalization methods for recovering metals from ores, a study was made of vapor complexes such as Cu_2NaCl_3, $AuCu_2Cl_3$, $AgCu_2Cl_3$, $AgFeCl_4$, $PbFe_2Cl_8$, $ZnFeCl_5$, and $CdFe_2Cl_8$. A special inlet system was devised that allowed equilibrated high-temperature vapors from an atmospheric-pressure flow reactor to be leaked into the ion source of a time-of-flight mass spectrometer without compositional changes. A modified transpiration system allowed the carrier gas to be equilibrated with two different condensed samples. Vapor pressures were measured for some species, and enthalpies and Gibbs energy changes were measured for some vapor reactions. Discrepancies in JANAF tables data for Cu_3Cl_3 and $PbCl_4$ were discovered. The major loss of lead chloride from a fused-salt bath containing $PbCl_2$ was shown to be possible due to $PbOCl_2(g)$. In the volatilization of antimony from oxide mixtures, the vapor species $SbCO^+$ was observed; it was speculated that this may have come from $Sb_2O_2CO_3(g)$. Research done under Grant No. G0166021 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125320; paper copy price code A08.

OFR 120-80. The Effect of In Situ Retorting on Oil Shale Pillars, by Russell J. Miller, Fun-Den Wang, Thomas Sladek, and Chapman Young. March 1979. 194 pp. 58 figs. The objective of this investigation is to determine the physical and thermal properties of oil shale at elevated temperatures and to provide the required background information and analyses required for effective mine design and subsidence prediction for an in situ oil shale retorting operation. The reported tests were performed under varying conditions of temperature, confining pressures, and kerogen content. Tests were conducted on samples taken parallel and perpendicular to the bedding at a temperature range of 20° to 500° C, confining pressures up to 1,500 psi were applied, and kerogen content ranged from 10 to 30 gallons per ton. A review of current activity in the area of in situ retorting is included as an appendix and a comprehensive list of references for literature related to in situ retorting is provided. Research done under Contract No. H0262031 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 121-80. Hydrothermal Precipitation of Boehmite From Aluminum Chloride Solutions, by Gopala N. Krishnan and Robert W. Bartlett. June 12, 1980. 30 pp. 7 figs. This report summarizes the results of phase I of a program to study the precipitation of boehmite from $AlCl_3$ solutions. The amount of boehmite precipitation from dilute $AlCl_3$ solutions is negligible below 200° C. Above 200° C the precipitation increases with increasing temperature approaching 40 pct at 300° C. Addition of HCl acid to the dilute $AlCl_3$ solution even in small quantities drastically reduces boehmite precipitation. Solution impurities such as Fe, Ca, Mg, or Na substantially promote the precipitation of boehmite. No precipitation is observed from concentrated $AlCl_3$ solution representing the leach liquor. Research done under Contract No. J0295025 by SRI International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 122(1)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume I. Process Technology and Costs, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 232 pp. 71 figs. This report provides the process technology, preliminary design, capital, and operating costs for a 25-ton-per-day pilot plant to produce cell-grade alumina using a clay-hydrochloric acid extraction-HCl gas induced crystallization process. The process was selected by the Bureau of Mines

as the more promising method to produce cell-grade alumina from clay based on the results of two previous reports. The pilot plant process utilizes a unique dual crystallization process to produce aluminum-chloride-hexahydrate crystals with sufficient purity when decomposed to meet stringent alumina product specifications. The size of the pilot plant was selected to permit scaleup to commercial size plants of equipment, technical, and economic parameters. Research done under Contract No. J0265048 by Kaiser Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125031; paper copy price code A11.

OFR 122(2)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume II. Appendix A. Equipment List, Specifications and Quotations. Areas 1 Through 7, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 281 pp. This appendix contains the list of equipment selected for the capitol cost investment, with quotations from vendors and manufacturers, described in volume I of this six-volume report. A vendor response report with a separate equipment and motor list is included. Research done under Contract No. J0265048 by Kaiser Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 122(3)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume III. Appendix A. Equipment List, Specifications and Quotations. Areas 8 Through 25, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 261 pp. This appendix contains the list of equipment, their corresponding numbers, and their specifications, with quotations from vendors and manufacturers who can supply the equipment, as described in volume I of this six-volume report. The listings are arranged by process plant areas. Research done under Contract No. J0265048 by Kaiser Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 122(4)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume IV. Appendix B. General Specifications, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 201 pp. This appendix contains the general specifications for a 25-ton-per-day pilot plant as described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 122(5)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume V. Appendix B. General Specifications, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 122 pp. This appendix contains the general specifications for building descriptions and general design procedures for a 25-ton-per-day pilot plant as described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 122(6)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume VI. Appendix C. Drawings, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 103 pp. 96 figs. This appendix contains the general drawings of the various process areas as well as the buildings and the general arrangement of the 25-ton-per-day pilot plant described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, Inc., Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 123-80. Evaluation of the Safety of One-Hour Chemical Self Rescuers, by R. W. Watson, W. J. Doyak, and A. L. Furno. November 1980. 184 pp. 70 figs. In January 1980, the Bureau of Mines initiated an experimental program to examine the fire and explosion hazards of 1-hour self-contained rescuers (SSRs). This action was prompted by a growing concern on the part of government and industrial safety officials over the potential hazards of these devices when deployed on a large scale in underground coal mines. Prior evaluation of the safety of these devices had been at best sporadic and usually limited to experimental models. The recent availability of preproduction models of a 1-hour SSR fabricated by the Mine Safety Appliance Co. and a production model manufactured by Dragerwerk Ag Lubeck of the Federal Republic of Germany allowed for a more comprehensive and meaningful evaluation of their safety in underground coal mines. This report summarizes the results of a 5-month study of the potential hazards of these two

devices. Research done by Pittsburgh Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 124–80. Novel Concepts for Recovery of Nuclear-Grade Zirconium Oxide From Bureau of Mines Zirconyl Chloride Strip Liquors, by E. P. Stambaugh, J. F. Miller, and R. K. Smith. June 1980. 62 pp. 18 figs. Results of research on the hydrothermal precipitation of zirconium oxide from the Bureau of Mines zirconyl chloride-sulfate strip liquors indicate that nuclear-grade material can be prepared by this process. Greater than 99 pct of the zirconium value can be precipitated at 250° to 260° C in short reaction time without consumption of acid value of the liquor. Thus, precipitation of zirconium dioxide on a continuous basis, that is, the zirconium dioxide is precipitated in a continuous mode of operation by pumping the strip liquor through a heated pressurized reactor and recycle of the acidic liquor to the process stage are favored. The results of accompanying studies of liquid-solid separation, product washing and dewatering, product purity, and chlorination of the product are presented and discussed. Research done under Contract No. J0295067 by Battelle Columbus Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–128837; paper copy price code A04.

OFR 125–80. Study of the Slate Mining Industry of Vermont/New York, by W. I. Watson, E. Ohlsson, C. E. Shorey, R. J. Miller, and A. J. Whittier. Oct. 15, 1980. 172 pp. 19 figs. This report presents results of a comprehensive analysis of the slate industry in Vermont-New York carried out to identify the present and future problems that are constraining the growth of the industry and to propose solutions to those constraints. All factors relevant to the industry's present and future status, such as markets and marketing techniques, competition from other producers both domestic and foreign, Federal and State regulations affecting the industry, quarrying and processing technologies, slate resources and reserves, and industry structure and economics were considered. Research done under Contract No. J0199075 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–128936; paper copy price code A08.

OFR 126–80. Environmental Assessment of Surface Shortwall Mining, by Ernest W. Hilton and Michael Frakes. Dec. 21, 1979. 255 pp. 46 figs. The purpose of this investigation was to assess the environmental impact of the surface mining methods currently used in the steep-sloped areas of central Appalachia—southern West Virginia, eastern Kentucky, southwestern Virginia, and northeastern Tennessee. Comparisons are made between mountaintop-cross ridge mining, contour strip, augering, and an innovative method—surface shortwall mining that was attempted at Julian, W. Va. Included in the report are a discussion and analysis of current Appalachian production, reserves, and the extent of land affected on a county-by-county basis. Additionally, the seams within the steep-sloped region were assessed according to minimal standards of thickness, surrounding lithology, and areal extent to determine their amenability to surface shortwall mining. The seams were tabulated with their ash, sulfur, and British thermal unit content. Only minimal statements are made concerning quantity because of the narrow set of conditions required by the shortwall method. Other sections deal with the possible technical failings of an operational surface shortwall system based on field studies, discussions with people experienced with shortwalls, and research into ground control problems at sites where shortwall and longwall operations have been monitored. Research done under contract J0285033 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–128928; paper copy price code A12.

OFR 127–80. Improved Light-Scattering Dust Monitor, by Byron S. Kutscher. January 1980. 99 pp. 26 figs. This report summarizes a program to develop and construct an improved light-scattering dust monitor (ILSDM). The ILSDM, which operates on the forward light-scattering principle, provides instantaneous measurements of airborne dust concentrations in units of milligrams per cubic meter. The program was divided into two phases. The first involved the design of the ILSDM and the other included the fabrication of a prototype based on the design. A description of the final ILSDM design, operating conditions, maintenance instructions, and recommendations for additional work are included in the report. Research done under Contract No. H0377020 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–128829; paper copy price code A05.

OFR 128–80. Development of a Device for Evaluation of Resin Bolt Installations, by R. Lusignea, K. Maser, and M. McCoy. December 1979. 125 pp. 62 figs. This report describes the development of a device for nondestructive testing of resin-grouted roof bolts by mechanical frequency response. Various alternative methods were evaluated and the

mechanical frequency response method was selected. An interactive program of design, testing, and development culminating in the current prototype instrument demonstrated the capabilities of the method and suggested potential applications. The resin bolt testing device utilizes a swept frequency dynamic compliance measurement in the 1 to 2 kHz range that is interpreted by an electronic signal processor to give a "GO" or "NO GO" readout. Field tests showed that the device can reliably determine the bond quality of the front half of the bolt (nearest the roof surface). Tests were carried out on both experimentally installed bolts and typical mine bolts installed by a conventional bolting machine. The program has led to recommendations for improvement of the prototype and future development work. Research done under Contract No. H0166014 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill, and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130841; paper copy price code A06.

OFR 129–80. Recommended Acceptance Testing Criteria for Adhesives and Sealants for Explosion-Proof Electrical Enclosures, by P. H. Francis and J. Lankford. Jan. 9, 1980. 67 pp. 7 figs. Factors that currently enter into the design, manufacture, and quality assurance of explosion-proof enclosures are reviewed with special emphasis given to sealing concepts and sealants-cements for lenses. The physical and mechanical properties of a number of representative sealants and adhesives are measured, and found to exhibit great variance, with few discernible trends that might afford a firm base on which to establish minimum property standards. Acceptance criteria for adhesives and sealants are suggested based on the survivability of an explosion-proof enclosure as a structure rather than on the minimum material properties of its constituents. Procedures for surface preparation of adherends and quality assurance are also proposed. Research done under Contract No. H0387009 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-128738; paper copy price code A04.

OFR 130–80. Lincoln Terminal System Support Facilities Development, by R. C. Butman and W. P. Harris. July 17, 1979. 43 pp. 14 figs. The Lincoln terminal system (LTS) is a stand-alone computerized training device that presents high-quality visual displays and audio messages to students. A keyboard for student input and a variety of student-machine interactive programs are provided. The programs allow the author-instructor to evaluate numerical entries and responses to simple and compound multiple-choice questions (where a compound choice is defined to be more than one choice, ordered or unordered, from one or more lists of choices). Descriptions of LTS applications, lesson development procedures, hardware provided, and support facilities required are given. A contract history summary and a bibliography of reports published under three successive contracts supporting LTS development is provided. Research done under contract J0366078 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130742; paper copy price code A08.

OFR 131–80. Interactive Mine-Power-System Analysis—APL Fault Program, by Frederick C. Trutt, Lloyd A. Morley, and Richard A. Rivell. Mar. 1, 1979. 109 pp. 6 figs. A guide to the development and utilization of an interactive mine-power-system fault program is presented. Theoretical foundations and implementation considerations are discussed with respect to the mine-power system. Alternative Kron reduction techniques are presented along with a triangular-storage method for storage conservation. Program capabilities include the analysis of balanced and unbalanced fault situations using symmetrical component theory. To account for phase shifting in delta-wye transformers and zero-sequence network constructions, transformer and load configurations are specified. The positive- and zero-sequence connections needed for network conformity are automatically constructed with the required impedances. Research done under Grant No. G0188035 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130858; paper copy price code A06.

OFR 132–80. Steering System Survey for Surface Mining Equipment, by Jack L. Woodward, Lawrence L. Owens, Robert J. McCracken, and Peter I. Maté. Apr. 20, 1979. 186 pp. 51 figs. The expansion of mine production has required the development of larger and more productive loaders, scrapers, haulage trucks, and similar equipment. These machines have required the development and production of more powerful and complex steering systems. Careful analysis of these systems was warranted to determine if steering-related safety problems have been introduced. The objectives of this program were to define the specific types of steering systems now in use in wheeled surface mining equipment, gather information on the mining accidents resulting from malfunctions of equipment steering systems, estimate the relative numbers and sizes of mobile mining equipment in use, and to evaluate the need for new research projects or additional health and safety regulations. A comprehensive literature survey was conducted concurrent

with extensive contacts with mining operations, mining equipment manufacturers, steering system component manufacturers, and government agencies. It was concluded that the steering systems in use on surface mining equipment are reliable and do not present a safety problem. Research done under contract J0275014 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130866; paper copy price code A09.

OFR 133-80. Noise Reduction of Chain Conveyors. Vol. I, by A. Galaitsis, R. Madden, and D. Andersen. December 1979. 144 pp. 56 figs. This report describes the noise source diagnosis of a Jeffrey 120M conveyor and the evaluation of several treatments all conducted in a test facility aboveground. The conveyor noise at the operator's position was gradually reduced from 101.5 to 93 dbA using damping, vibration isolation, sound barriers, and smoother discontinuities. Research done under Contract No. H0155113 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130833; paper copy price code A07.

OFR 134-80. Electrical Practices in Metal/Non-Metal Mines and Mills. Mine Power Systems, Mill Power Systems, Federal Regulations, Electrical Accidents, by David Bendersky and Vernon W. Klein. Mar. 4, 1980. 308 pp. 167 figs. The objectives of this study are to (1) survey electrical practices in metal and nonmetal mines and mills, (2) clarify the Federal regulations governing electrical practices, (3) analyze electrical accidents, and (4) make recommendations aimed at improving the safety of electrical practices. Information was obtained from literature searches, accident reports, visits to 27 mines and 12 mills, and discussions with knowledgeable industry and government people. The various electrical power systems and practices at the mines and mills visited are described. Similarities and differences based on the type of mining and the minerals being mined or milled are presented. The Federal regulations governing metal-nonmetal mine and mill electrical practices (Code of Federal Regulations, Title 30, Sections 55.12, 56.12, and 57.12) are presented and discussed. Explanations of each regulation are provided in an appendix. The attitudes of mine and mill operators towards the Federal regulations are described. An analysis of the electrical accidents in metal-nonmetal mines and mills during the period 1972-78 is presented. Recommendations including specific research and development activities aimed at improving electrical safety are submitted. Research done under Contract No. J0387203 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-130726; paper copy price code A14.

OFR 135(1)-80. Evaluation of Mine Roof Bolter Components. Volume I, by C. P. Fazio, W. J. Hargreaves, Jr., D. Kribs, and R. Wachtler. November 1978. 228 pp. 51 figs. The Bureau of Mines has made significant advances in developing roof bolter components to improve mining operation efficiency with respect to increased productivity and miner safety. Before now, no concentrated effort has been undertaken to systematically review and evaluate the results of these research activities and to utilize the advance designs generated in a total machine. This investigation researches Bureau-funded roof bolting component design contracts and commercially conducted research activities. Mining conditions considered for advance design application are low, medium, and high seam heights; rotary, rotary-percussive, and percussive drilling requirements of overburden; and bolting length capability of both less than seam height and greater than seam height. Six roof bolting system concepts are generated that meet these defined conditions and that encompass those roof bolting components considered most promising as a result of trade-off analyses performed. Research done under Contract No. H0272044 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 135(2)-80. Evaluation of Mine Roof Bolter Components. Volume II, by G. J. Hundman. November 1978. 122 pp. Analyses are presented for 24 roof bolter research projects for the system development costs and schedules to integrate advance design roof bolter components into a prototype second-generation roof bolter chassis. Data on existing roof bolter machine and utility vehicle chassis that were potential candidates for modification and component installation are also provided. Research done under Contract No. H0272044 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 136–80. Field Test of Hydraulic Borehole Mining Systems in Shallow Uranium Sands, by William R. Archibald. September 1978. 217 pp. 75 figs. This report presents the results of a program demonstrating the technical and economic feasibility of hydraulic borehole mining of uraniferous sandstone. A high-pressure cutting jet and a slurry jet pump make up the borehole mining tool, which is lowered down a borehole into the uranium-bearing sandstone. Water from the cutting jet cuts into the sandstone formation generating a water-sand slurry which is pumped to the surface, thereby forming a cavity in the formation. When the cavity size reaches a point beyond the effective radius of the cutting jet, the mining tool is moved to an adjacent borehole and the process is started again. Research done under contract H0272010 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–128969; paper copy price code A10.

OFR 137–80. 1979 Survey of Respirable Dust Control Research in Underground Coal Mines, by J. A. Kost and A. G. Mayton. May 1980. 145 pp. 5 figs. A survey of 80 coal producers was conducted to determine the extent and scope of respirable dust control research for underground coal mines and the current methods employed to control respirable dust. Results of the survey showed that proper face ventilation and an adequate water spray system are sufficient to comply with mandatory standards in room-and-pillar mining. Difficulties still exist with longwall equipment, auger miners, and boring machines. In these cases, known dust control techniques are not sufficient to obtain compliance. Present state-of-the-art face ventilation and water systems are discussed in addition to the sampling program. Research done under Contract No. J0199046 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–130106; paper copy price code A07.

OFR 138–80. Kinetics of Chlorine Leaching of Zinc-Lead Flotation Concentrates, by James L. Hendrix. Feb. 4, 1980. 25 pp. 11 figs. This report presents results of investigations on the kinetics of leaching zinc-lead concentrates with chlorine. The objective was to determine the kinetic order and mechanisms involved in the reactions between sphalerite (zinc sulfide) and galena (lead sulfide) with chlorine. The influence of copper on the extraction rates also was studied. The rates of reaction for both species were zero order at 100° C, the rate limiting step being the chemical reaction. The addition of cupric chloride increased the extraction of both zinc and lead. Research done under Grant No. G0284004 by University of Nevada. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–132482; paper copy price code A02.

OFR 139–80. Remote Sealing System Field Demonstration, by Steven R. Ruggieri and Adi Guzdar. June 1980. 65 pp. 21 figs. This report describes the work performed and results obtained during a field demonstration of a remote sealing system at the Bureau of Mines Jenny Mine near Inez, Ky., in the fall of 1978. Although portions of the remote sealing system has been used on a number of prior occasions, the demonstration at Jenny Mine marked the first use of the complete upgraded system including the use of an inert gas generating system for seal placement and the first application of a new froth foam system. The objective of the demonstration was to demonstrate the complete system by emplacing and evaluating several complete underground seals under conditions representing those of a mine fire situation. Of several critical sealing conditions identified, including high entry air flow, standing water in the entry, flowing water, irregular roof, and sealing a four-way intersection, four seals were successfully placed. Research done under Contract No. H0188105 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–132490; paper copy price code A04.

OFR 140(1)–80. Availability of Copper, Nickel, Cobalt and Manganese From Ocean Ferromanganese Nodules (II), by M. B. Fisk, J. Z. Frazer, J. S. Elliott, and L. L. Wilson. Aug. 24, 1979. 63 pp. 2 figs. Manganese nodule and crust elemental chemical data added to the Scripps Institution of Oceanography Sediment Data Bank from September 1978 through July 1979 are listed. The data include 280 samples assayed in the laboratory and 755 assays extracted from the literature. All available nodule abundance data are also listed. Characteristics and trends in the data are noted. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–145963; paper copy price code A04.

OFR 140(2)–80. Availability of Copper, Nickel, Cobalt and Manganese From Ocean Ferromanganese Nodules (III), by J. Z. Frazer and M. B. Fisk. Aug. 31, 1980. 112 pp. 22 figs. Manganese nodule elemental chemical data added to the Scripps Institution of Oceanography (SIO) Sediment Data Bank during the period September 1, 1978, to August 31, 1979, are listed. The data include compositions of 388 samples analyzed at SIO and 845 analyses taken from the literature. Information on analytical meth-

ods utilized for all nodule analyses stored in the data bank and their estimated precision and accuracy is presented. Data summaries for potential resource areas in the northeastern equatorial Pacific Ocean are updated to include information obtained in the past 2 years. Data summaries and maps of nodule distribution are presented for resource evaluation of additional areas in the Pacific and Atlantic Oceans. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-145971; paper copy price code A06.

OFR 141-80. Manganese Nodule Deposits in the Indian Ocean, by J. Z. Fraser and L. L. Wilson. Sept. 1, 1979. 70 pp. 16 figs. Available data on nodule composition and abundance in the Indian Ocean are presented. Five areas in which nodule deposits might meet the criteria for consideration as mineral resources are discussed. Only one of these areas, in the Central Indian Basin, offers possible sites for first generation seabed mining; the others are submarginal. It is extremely unlikely that minable deposits occur in the Indian Ocean outside of the areas studied. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-145849; paper copy price code A04.

OFR 142-80. Geological Factors Related to Characteristics of Seafloor Manganese Nodule Deposits, by J. Z. Frazer and M. B. Fisk. Apr. 30, 1980. 41 pp. 16 figs. The effect of geological factors such as environment of deposition, sediment type, water depth, and local topography on nodule abundance and composition are studied. Statistical analyses of data from the SIO Sediment Data Bank are presented. Nodule abundance is shown to be strongly dependent on sedimentation rates, with the most abundant deposits occurring where the sedimentation is lowest. Copper enrichment in nodules is found to be due to the concentration of this element by planktonic organisms which are limited to equatorial regions. Cobalt enrichment, generally greater in crusts than in nodules, is shown to be associated with volcanic seamounts in the mid-Pacific region. Regional variations in nickel and manganese contents, local variations in composition and abundance, and the inverse correlation between grade and abundance are discussed. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-145831; paper copy price code A03.

OFR 143-80. Determination of In Situ Horizontal Rock Stress on Both a Mine-Wide and District-Wide Basis, by Jose F. T. Agapito, Scott J. Mitchell, Michael P. Hardy, and William N. Hoskins. Mar. 1, 1980. 175 pp. 59 figs. Several underground coal mines currently operating in the Beckley district of West Virginia are experiencing serious roof and floor problems. A significant portion of the estimated 2 billion tons of coal resources may be lost as a result of these ground control problems. Preliminary studies by the Bureau of Mines indicated that these are due in part to a high horizontal stress field. Using the Bureau's strain-relief overcoring technique, 14 overcoring sites in five mines were drilled producing 53 data sets. Analysis of the data was done to provide in situ horizontal stresses for each of the five mines and for the district as a whole. Stress data indicate horizontal stresses far in excess of that predicted by theory and in some cases, up to six times the estimated vertical stress. Research done under Contract No. J0285020 by Tosco Research, Inc., and J. F. T. Agapito & Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-139735; paper copy price code A08.

OFR 144-80. Feasibility of Fatigue Assessment of Block Walls From Laboratory Scale Methods, by Robert M. Koerner and Jack L. Rosenfarb. Sept. 1, 1980. 99 pp. 39 figs. The feasibility of using small-scale models to simulate residential masonry foundation walls subject to fatigue loading was investigated. Five wall segments were modeled in one-quarter scale using dynamic similitude equations. The walls were dynamically loaded using a sinusoidal base motion and wall accelerations were monitored. The stiffness, natural frequency of response, and damping characteristics were measured. The number of cycles of testing necessary to cause initial visible cracking was recorded. Analysis of the data indicated the importance of the relationship between the forcing function and the natural frequencies of the structure in influencing cracking damage. Research done under Contract No. J0285013 by Drexel University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-140139; paper copy price code A05.

OFR 145-80. Instability of Contoured Surface-Mined Landscapes in the Northern Great Plains: Causes and Implications, by Gerald H. Groenewold and Bernd W. Rehm. Sept. 1, 1980. 26 pp. 12 figs. Reclamation of surface-mined landscapes is commonly defined only in terms of biological productivity. Other critical concerns associated with surface mining include the long-term quality of groundwater and stability of the postmining landscape. Meaningful reclamation design must address all of these concerns. Reconnaissance of postmining landscapes indicates three types of instability occur in these settings including area-wide settling, localized collapse, and piping. Area-wide settling is most pronounced during the first year after contouring but appears in precontouring valley areas where frozen materials are contoured with a dozer. Although

severe in some settings, development typically ends within 1 year. Piping appears to be a severe and long-term problem in some settings, usually beginning soon after contouring ceases and could continue for several years. In some postmining landscapes, piping has only started to develop after as many as 5 years of apparent stability. Piping is controlled by a combination of physical and chemical conditions in the spoil. A key factor is the presence of highly dispersive materials in the near surface. Research done under Contract No. J0275010 by North Dakota Geological Survey. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 146–80. Environmental Effects of Slaking of Surface Mine Spoils: Eastern & Central United States, by D. E. Andrews, J. L. Withiam, E. F. Perry, and H. L. Crouse. September 1980. 250 pp. 44 figs. The objective of this study was to investigate the environmental effects of slaking of surface mine spoils. Both field and laboratory programs were undertaken supplemented by a literature search. The field program consisted of drilling the highwall as well as test pitting in recent 2-, 5-, and 10-year-old spoil piles at four active mining sites in the eastern bituminous coal fields. Pertinent observations were made and samples collected for laboratory analysis consisting of several standard geotechnical, agronomic, and geochemical tests. Durability tests included jar slake, cyclic wet-dry, rate of slake, and slake durability tests. Correlation between field and laboratory portions was made and the results presented. The report concludes with a discussion of the slaking process and associated environmental impacts, proposal of a preliminary classification system for use in premine planning, and presentation of management techniques to optimize the slaking process. Research done under Contract No. J0285024 by D'Appolonia Consulting Engineers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168718; paper copy price code A11.

1981

OFR 1–81. Improved Ore Recovery From Phosphate Open-Pits in the Phosphoria Formation, by W. A. Young, G. M. Pugh, G. D. Vandersluis, and V. Lim. March 1980. 314 pp. 50 figs. To initiate this project, a critical evaluation of the present phosphate mining industry in the Western phosphate field was conducted. Mines were visited, mine operators were interviewed, and pertinent literature studied. Three phosphate mining enterprises were reviewed and mining cost estimates prepared. The report discusses the present state of phosphate processing, rock alteration, and location. New ideas and concepts are proposed to improve the recovery of phosphate rock from the Phosphoria Formation. The report evaluates two variations to the present phosphate open pit mining methods, which were developed to improve the economics of mining phosphate and to better accomplish necessary reclamation and accelerate the time for environmental recovery. A materials handling system using conveyor haulage will eliminate the need for trucks. Terrace haulback utilizes safety benches to haul and dispose of waste in the mined-out pit. Ore will be removed from the pit by an inclined, cable-supported mobile conveyor. Research done under Contract No. J0285017 by Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-167512; paper copy price code A14.

OFR 2(1)–81. Wire Rope Terminations. Volume I. Efficiency and Service Life of Wire Rope Terminations, by F. Matanzo. Aug. 10, 1978. 152 pp. 39 figs. Nine wire rope terminations were pull and fatigue tested to destruction to measure the termination efficiency and relative fatigue life. The terminations were selected on the basis of mine site visits and the specimens were assembled in a manner similar to industrial slings. To measure a termination's sensitivity to poor manufacturing, both standard and modified assembly specimens were tested. In static pull tests rope class, construction, and diameter interacted with the termination to influence the efficiency of the termination. In axial fatigue tests the effect of rope construction was negligible since failure was primarily dependent on the termination type. The swaged socket, a termination requiring a high-capacity hydraulic press, gave the best overall performance in terms of efficiency and fatigue life; the short body length of the zinc-poured socket was attributed with the short fatigue life. The use of thermosetting resins as a replacement for zinc was demonstrated successfully for some socket designs. The fatigue life of the termination, expressed as a percentage of the fatigue life of the wire rope, was shown to be a guide for the retirement of the wire rope where those applications are primarily in axial loading. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md. Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and

Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168825; paper copy price code A08.

OFR 2(2)-81. Wire Rope Terminations. Volume II. Selection and Inspection Guide for Wire Rope Terminations, by F. Matanzo. Aug. 10, 1978. 30 pp. 26 figs. This guide considers nine of the many wire rope terminations used in the mining industry, thus use of the information presented for terminations not specifically addressed can be done, but with some risk. The guide uses pull test data, axial fatique test data, and data on sensitivity to poor manufacturing to rank the terminations with respect to these performance measures. A selection procedure is suggested and illustrated with an example. Failure data are used to identify the common modes of failure of each termination and thus help direct attention toward the likely location for a failure and a projection of what should be looked for. The data on which this guide is based are included so that as new data become available, the ranking order can be adjusted accordingly. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168833: paper copy price code A03.

OFR 2(3)-81. Wire Rope Terminations. Volume III. Training and Inspection Manual for the Assembly of Wire Rope Terminations, by John T. Metcalf and F. Matanzo. Aug. 10, 1978. 49 pp. 73 figs. The assembly procedures for nine wire rope terminations used in the mining industry are presented in a format and manner to facilitate training and to provide points where inspection of the termination should be performed. The manual was prepared to be used primarily for field mining operations or training where high-capacity machinery is limited. It is not the intent of this manual to suggest that the procedures presented are those to be used by manufacturers or other commercial enterprises. A different set of procedures may be more appropriate where ideal space and equipment resources are available. The assembly procedures were derived from standard industrial practice, manufacturers' recommendations, and open literature on the subject. These same procedures were used to prepare test specimens for an extensive series of pull and axial fatigue tests. The results of these tests indicate that these procedures are satisfactory in all respects. The manual is to be used as part of a complete training program. Although a brief glossary is included, there has been no attempt to make this a primer on wire rope. The selection of wire rope termination hardware, like the selection of the wire rope, is a subject not covered by this manual; there are various sources for such hardware and this selection must be done carefully. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168841; paper copy price code A05.

OFR 3(1)-81. Oil Shale Mining Environmental Research Program Plan. Volume I. High Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 56 pp. 1 fig. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume I, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the high funding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy. Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168320: paper copy price code A04.

OFR 3(2)-81. Oil Shale Mining Environmental Research Program Plan. Volume II. Mid Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 50 pp. 7 figs. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume II, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the midfunding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168338: paper copy price code A03.

OFR 3(3)-81. Oil Shale Mining Environmental Research Program Plan. Volume III. Low Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 41 pp. 6 figs. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume III, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the low funding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City

and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168346; paper copy price code A03.

OFR 4-81. Backfilling of Cavities Produced in Borehole Mining Operations, by M. H. Marvin, G. S. Knoke, and W. R. Archibald. August 1979. 85 pp. 30 figs. This report presents the results of a program to develop backfilling techniques to mitigate undesirable effects of hydraulic borehole uranium mining. To prevent ground subsidence and to allow mining of adjacent uraniferous sandstone, large underground cavities, formed during the borehole mining process, can be backfilled. Three techniques that were tested in the laboratory and the field with sand and with sand and 1 wt-pct cement mixtures were bulk dumping of slurry into the boreholes from ground level, slurry injection under water, and slurry injection above the cavity water level. The project was accomplished by equipment preparation and transport, mining operation to generate a full-sized cavity, backfilling operations, and assessment through core samples and subsidence checks. The concentrations of cement mixed with sand were inadequate to bond the sand, and bulk dumping resulted in a 30° angle-of-repose, which was too steep to completely fill the cavity. Both slurry techniques filled the cavity satisfactorily; however, underwater injection is the recommended backfilling technique because the borehole water level does not need to be pumped down during backfilling. The borehole was filled by bulk dumping of slurry. Research done under contract J0285037 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-171308; paper copy price code A05.

OFR 5-81. Detection of Lixiviant Excursions With Geophysical Resistance Measurements During In Situ Uranium Leaching, by Robert F. Kehrman. December 1979. 157 pp. 60 figs. As with many new technologies, the rapid growth in solution mining for uranium has created uncertainties regarding the environmental impact of mining operations. In solution mining, the largest area of concern is the impact of the process on the quality of ground water supplies. A rapid and reliable technique of detecting lixiviant excursions would replace the periodic sampling technique and should provide a more or less continuous monitoring method. To this end, resistivity techniques were evaluated as an alternate means of tracking lixiviant movement. A program was devised with five specific tasks including (1) evaluation of the techniques, (2) development of most promising technique or techniques, (3) field testing of the techniques, (4) testing of the Bureau of Mines probe, and (5) reporting. The result of the analytical and field work is that various resistivity-resistance techniques do provide a means of detecting lixiviant movement in northern Wyoming. Surface and downhole galvanic surveys and controlled source audio magnetotellurics were evaluated. All three techniques showed some degree of success. Research done under Contract No. J0188080 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-171324; paper copy price code A08.

OFR 6(1)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. I—Transients in Mine Electrical Power Systems, by E. K. Stanek, W. Vilcheck, and A. Kunjara. August 1979. 169 pp. 89 figs. This report contains results of two major efforts related to electrical transients on mine electrical power systems. The first area concerns the use of digital computers to model mine electrical power systems and predict transients or duplicate field recordings of transients. Two existing general purpose circuit analysis programs were used. The first was the TRW Engineering System Simulator or TESS. The second was Electronic Circuit Analysis Program or ECAP. TESS proved to be superior to ECAP in several important characteristics, including system size limitations and modeling nonlinear elements. The second major topic covered in this report is the evaluation of commercially available surge suppression devices. These devices were quite acceptable and guidelines for the selection and placement of surge suppressors were included. The final important item is a listing of the worst-case transients, from a design point of view, for ac and dc utilization systems and ac distribution systems. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash. U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166761; paper copy price code A08.

OFR 6(2)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. II—Reliability of Mine Electrical Power Systems, by S. S. Venkata, M. Chinnarao, E. W. Collins, and E. U. Ibok. August 1979. 193 pp. 40 figs. This report describes a comprehensive program of research into the reliability of mine electrical power system components and the resultant reliability of the total system. The research effort encompassed analytical models and laboratory and field testing. The analytical work included definitions of terms, fail rate functions and distributions, failure rate estimation and techniques, and procedures for theoretical reliability assessment. One of the primary mine power system components was the ac-molded case circuit breaker. This device is known to have low reliability and

hence an unfavorable impact on mine safety and productivity. Ac-molded case circuit breaker reliability was studied analytically, laboratory tested, and field monitored. A similar three-pronged effort was made to study the reliability of undervoltage relays-releases. Particular emphasis was placed on new solid-state undervoltage relays. The reliability of bulk power components, such as trailing cables, motors, control gear, and other equipment, was assessed by gathering maintenance records from active mines. These data were compared to similar records from other industries. The work was extended to include the reliability, availability, maintainability, and safety of these components. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166779; paper copy price code A09.

OFR 6(3)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. III—Optimal Design of Mine Electrical Power Systems, by M. M. Hassan and E. K. Stanek., August 1979. 53 pp. 22 figs. This report describes the analysis tools developed at West Virginia University that can be implemented to optimally design coal mine electrical systems. The basic analytical tools for all power systems are the load-flow and short-circuit analysis. Well-known programs have been developed for analysis of ac transmission and distribution systems, but they are not applicable to a system that has combined ac-dc distribution, such as a coal mine power system. Furthermore, the topology of a coal mine electrical system changes continuously owing to the movement of locomotives on the track. In the first section of this report, algorithms for carrying out load-flow and short-circuit analysis of a coal mine electrical system are described. Results from the study of a typical coal mine system are presented. In the second section, a method is described to optimally size power cables for cyclic loads. This method is based on the development of a thermal-electric model for a low-voltage power cable. Results from experimental verification of the model are also presented. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166787; paper copy price code A04.

OFR 6(4)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. IV—Use of Programmable Calculators in Mine Power Systems Design and Analysis, by E. K. Stanek and Marc Cobert. August 1979. 113 pp. 10 figs. This report describes software developed for programmable calculators that is useful in the analysis and design of mine electrical power systems. The programs are equally useful for any industrial or commercial power system. All programs are written for both the HP-97 and TI-59 programmable calculators. Listings of both versions of the 12 programs that were developed appear in the report; each program can be broken into 2 groups. The first group encompasses design-oriented programs and the second encompasses analysis programs. For each program the following items are provided: a description of the program's capabilities, the solution technique used, instructions on how to use the program, a worked-out example with data and results, and listings of the programs for the HP-97 and TI-59 programmable calculators. Typical problems that can be attacked with these programs include ground bed design, selection of contactor size, fuse size, relay settings, instantaneous overcurrent trip settings for trailing cables, allowable cyclic cable loading, short circuit analyses, prediction of transient voltages, and others. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166795; paper copy price code A06.

OFR 6(5)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. V—Periodic Inspection of Mine Electrical Power Systems, by E. K. Stanek, M. M. Hassan, Y. C. Chou, and H. Shamash. August 1979. 113 pp. 55 figs. This report presents the results of an investigation into the feasibility of periodically measuring parameters of the insulation for a mine electrical power system to detect incipient faults. The variety of insulation parameters evaluated included insulation resistance, dissipation factor, power factor (versus applied voltage), current harmonics, leakage current, infrared radiation, as well as certain circuit breaker parameters and tests. To augment field tests, a program of accelerated life testing was also carried out. Apparent inconsistencies in data were identified as the result of environmental effects, primarily temperature and relative humidity. A series of environmental tests were conducted to develop correction factors that allow reference of measured parameters to standard conditions. A portable data collector was developed to aid in the accurate collection and analysis of laboratory and field data. It was concluded that insulation deterioration can be measured and failure predicted with reasonable confidence, and that most of the tests are impractical in the field although useful in the laboratory. Infrared sensing, insulation resistance, and dissipation factor are the best insulation field tests when portability is taken into account. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Depart-

ment of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166803; paper copy price code A06.

OFR 7-81. Intrinsically Safe Supporting Research, by Zsuzsanna Zborovszky. April 1980. 148 pp. 32 figs. The objective of this report is the evaluation of the tentative document entitled "Test Requirements for Instruments or Apparatus to be Considered for MESA Intrinsically Safe Certification." The evaluation is to cover only certain portions pertinent to gas ignition testing (portions dealing with coal dust ignitions are excluded). Wherever it seemed necessary, supporting data were generated to prove or disprove questionable points. Research done under Contract No. J0177111 by Denver Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-179384; paper copy, price code A07.

OFR 8-81. Feasibility of Control System Automation for a Drum Head Continuous Mining Machine, by John E. Lambert and Phillip Mighdoll. Aug. 10, 1979. 97 pp. 15 figs. Automatic control of drum head continuous mining machines was investigated as a means of reducing respirable dust generated and operator variability. Literature survey, manufacturer interviews, and mine visits were the major information sources. Technically feasible automation concepts were identified to control sump and shear rates, cutter head elevation limits, and sumping distance. These are the elements of a programed cutting cycle that maintains peak penetrating force on the cutter, to maximize depth of cut, and therefore reduce dust generation. Based on the industry surveys, successful underground hardware demonstrations must be completed to stimulate the market demand for these advanced control features. Research done under contract J0188084 by Booz-Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-168361; paper copy price code A05.

OFR 9-81. Trolley Line Power Transfer to Vehicles, by Andrew St. Amant. July 31, 1980. 80 pp. 8 figs. This report reviews the first three investigative and concept generation phases and details the task performance of phase IV of a trolley line power transfer to vehicles. This last phase integrated the most promising concepts from phases I, II, and III into a prototype detailed design, which was manufactured and then tested on a mine locomotive. The concepts developed during the first three phases provided "Improved Pole Tracking," automatic "Rapid Pole Retraction" in the event of dewirement, and servooperated "Remote Pole Repositioning" on the trolley wire. The appendix of the report supplies detailed information for the design and construction of the prototype system, which is comprised of an RCB (Remotely Controlled Base subassembly), and RCL (Remote Control Level subassembly), and an SAU (Servo Amplifier Unit) subassembly. Research done under Contract No. J0377057 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-178873; paper copy price code A05.

OFR 10-81. Development of Dual Input/Dual Purpose Power Converter for Trolley Wire Operation, by D. A. Paice, D. S. Kimmel, and R. P. Putkovich. October 1979. 62 pp. 27 figs. A power supply to operate fluorescent or mercury vapor lamps from 300-volt dc coal mine trolley wires was developed for the Bureau of Mines. A high-frequency regulated inverter unit incorporates ballasts for a mix of lamp loads up to 650 watts. For 600-volt trolley systems an additional power converter unit was developed to step down the dc voltage to 300 volts for the inverter unit. Both units have operated in a working coal mine for more than 12 months without need of servicing. The lamp load included two 100-watt mercury vapor head lamps and six 75-watt fluorescent lamps. Research done under Contract No. H0166031 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-179434; paper copy price code A04.

OFR 11-81. Exploratory Studies of Flame and Explosion Quenching. Volume II. User's Manual for Flame Propagation Code for Premixed Laminar Heterogeneous Systems, by Brent A. Whiting, L. Douglas Smoot, and Vern J. Crandall. Aug. 31, 1979. 296 pp. 4 figs. This report presents a computer code for predicting the characteristics of laminar, premixed, propagating, coal dust flames. The code is the result of a research program to improve understanding of the mechanisms of coal dust flame propagation and extinguishment. This work is a part of a larger Bureau of Mines research program on control of coal dust explosions in coal mines. This program, initiated in June 1972, comprised experimental coal dust flame measurements, together with development of the theory for laminar, premixed coal dust flames. Details of extensive experimental

results for methane-air, coal dust-air, and coal dust-air-suppressant tests are documented in volume I of this report. The theoretical basis for flame was also reported in volume I, together with the solution techniques and a summary of extensive code predictions and comparisons with experimental measurements. Research done under grant G0177034 by Brigham Young University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-183949; paper copy price code A13.

OFR 12-81. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars, by John D. Rockaway and Richard W. Stephenson. July 1979. 227 pp. 72 figs. Failure of a mine floor supporting coal pillars frequently occurs when the subcoal strata include "underclays" or other low-strength strata. The failure process has been studied to define the response of these materials to applied coal pillar loads and to determine the applicability of bearing capacity analysis to evaluate unsafe conditions. An investigation was conducted of both the intact and in situ geotechnical properties of the subcoal strata and the installation of floor movement monitoring instrumentation. The results of these studies indicated that both the shear strength of the underclay and the stratigraphy of the subcoal strata must be considered in the analysis. The shear strength was the major controlling factor determining the ultimate load-carrying ability of the materials, but the thickness and stratigraphic position of the weak layers influenced the mechanism of the failure process. Research done under Contract No. J0155153 by University of Missouri-Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo.. Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-181109; paper copy price code A11.

OFR 13-81. Statistical Studies—Metal/Nonmetal Mine Fatality Studies, by Thomas E. Doerfler. July 1980. 48 pp. 3 figs. This report contains an analysis of information and data related to the occurrence of fatalities due to major disasters in metal-nonmetal underground mines. Standard statistical methods were used to estimate the probability of occurrence of major disasters, and to examine the relationship of disasters to injury statistics published annually. Research done under Contract No. J0395086 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-167561; paper copy price code A04.

OFR 14-81. The Mechanism of Attachment of ^{218}Po(RaA) to Monodispersed Aerosols, by Philip K. Hopke and James J. Stukel. Jan. 31, 1980. 155 pp. 19 figs. A systematic study of the mechanism of interaction of ^{218}Po(RaA) formed by the decay of ^{222}Rn with airborne particulate matter has been made. The rate of attachment of RaA to particles in the diameter range of 0.1 μm to 10.0 μm was measured as a function of particle size, concentration, and composition, radon concentration, time of interaction, relative humidity, and temperature. It was found that under the conditions in these experiments the attachment rate was proportional to the square of the particle diameter and varied with temperature and relative humidity. The composition of the particles apparently has no effect on the attachment. The variation in attachment rate was related to a sticking probability coefficient of approximately 0.02 that varies systematically with temperature and humidity. In addition, the rate of deposition of RaA on the walls of the attachment kinetics system was measured and also found to change with temperature and relative humidity. Research done under grant G0264010 by University of Illinois at Urbana-Champaign. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166308; paper copy price code A08.

OFR 15-81. Development of a Personal CO_2 Detector, and a CH_4 Detector, by Irvin G. Burough. August 1979. 125 pp. 61 figs. This report describes four handheld CO_2 detectors and three handheld CH_4 detectors that were designed and manufactured for in-mine safety use. The detectors incorporated an optical-electronic analyzer design in which exceptional zero stability is achieved by pressure modulation of the sample gas and thus eliminating the need for daily calibration. The stability and miniature design of the CO_2 and CH_4 detectors provide practical instruments suitable for routine safety inspections. The report includes the theory and design of the instruments as well as studies of gas-pressure modulation by a piezoceramic-driven resonator. Research done under Contract No. H0377096 by Andros Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-163982; paper copy price code A07.

OFR 16–81. Development of a Lightweight Air Powered Drill Tool for Probe Drilling in Anthracite Mines, by William H. Hamilton and Jerry Brace. December 1979. 38 pp. 44 figs. This report describes the results and conclusions of the development and evaluation of a unique concept for a lightweight air-powered drill tool for probe drilling in anthracite mines. A concept model of the lightweight air-powered tool was constructed and evaluation testing conducted at the Kocher Coal Co. Porter Tunnel Mine. The unique anchoring method proved to be extremely satisfactory and the overall lightweight air-powered drill tool concept proved feasible. Based on the results of the concept model testing, two prototype production units were designed and manufactured. These prototype units met all design requirements of lightweight, portability, drilling controllability, structural integrity, and miner acceptance. The need for a better bit and drill steel system, however, became evident during testing and recommendations are made for further investigation and development of a bit and drill steel system suitable for this application. Research done under contract H0282044 by Hamilton Engineering, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166282; paper copy price code A03.

OFR 17–81. Design and Development of Protective Canopies for Underground Low Coal 48" and Under, by Peter P. Kopas. Mar. 1, 1980. 89 pp. 5 figs. This report comprises the study, analysis, fabrication, and testing for canopies on roof bolts and shuttle cars in coal seams under 48 inches high. The report includes 31 drawings showing the assembly and details of a roof bolter and 27 drawings showing the assembly and details of a shuttle car. Research done under Contract No. H0188014 by Kogen Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–167553; paper copy price code A05.

OFR 18–81. Preliminary Design and Cost Estimate for Field Worthy Simple Featured MMRDM Based on a Prototype Beta Attenuation/Filter Tape System Developed Under Contract Number H0166097, by Pedro Lilienfeld. May 16, 1980. 96 pp. 20 figs. This report presents a design and cost investigation for several alternative versions of a field-worthy mining machine-mounted respirable dust monitor. Three main design variations are light scattering sensing, Beta-filter tape sensing, and a combination of the two methods. Eventual instrument production costs as a function of design complexity are tabulated. Cost estimates for the development and field testing of field-worthy prototypes are also presented. A general discussion on the technical aspects of these design alternatives is included following a modular-hierarchical approach of progressive complexity. Research done under Contract No. J0199163 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166324; paper copy price code A05.

OFR 19–81. Improved Fire Safety of Coal Mine Hydraulic Systems, by F. C. Kohout, E. N. Ladov, and D. A. Law. March 1979. 155 pp. 52 figs. An advanced water-in-oil emulsion hydraulic fluid has been developed that meets defined laboratory performance criteria and gave fully satisfactory results in a 1-year underground mine test in two continuous miners. A novel method of monitoring fluid water content was demonstrated and incorporated into a test kit for use at or near the mine site. Test fluid fire resistance integrity as measured by the Mining Safety and Health Administration schedule 30 procedure was maintained during the test, and important fire resistance test variables were identified. Research done under Contract No. H0357108 by Mobil Research and Development Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166852; paper copy price code A08.

OFR 20–81. Combined Fire/Rot Retardant Treatment for Wood Mine Timber, by Bernard Baum and William Holley. October 1978. 105 pp. 3 figs. Combined preservative, and fire-retardant systems were pressure impregnated into Douglas fir and Ponderosa pine samples and evaluated for decay, flammability, and mechanical properties. The objective was to identify cost-effective systems for use with mine timber, and to provide an information and data base from which Federal code regulations could be established. Thirty systems, based on combinations of commercially available preservatives and fire-retardent impregnants and coatings, were applied to Douglas fir samples and evaluated for decay and flammability. The 10 most promising systems were applied to both fir and pine and reevaluated for decay and flammability before and after water leaching. The five best systems were evaluated in the laboratory using both pine and fir including flame spread, smoke density, toxic gases, decay, compressive strength, flammability after artificial weathering, and cost. All systems had acceptable toxic gas levels and smoke densities, but flame spread was only borderline acceptable for most of the samples tested. Recommendations are made for further large-scale testing using the two best systems. Research done under Contract No. J0166068 by Springborn Laboratories, Inc. Available for refer-

ence at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166381; paper copy price code A06.

OFR 21(1)-81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume I. Final Report, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P. A. Bilzi. April 1980. 218 pp. 20 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Of the 200 mines visited, 20 mine openings representative of varying geologic, environmental, access, and mining conditions were selected for detailed low-cost safeguard application. Volume I comprises descriptions of these safeguards, presented in narrative, itemized labor-materials-equipment tabulations, and illustrations. Research into the regulations of mine closure and safeguards was also undertaken to determine jurisdiction of public lands. Recommendations are suggested to improve the awareness and ability to continue this program into an implementation stage. Research done under contract J0295020 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington. D.C. Order ONLY from NTIS: PB 81-177909; paper copy price code A10.

OFR 21(2)-81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume II. Final Appendix A Through L, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P A. Bilzi. April 1980. 370 pp. 62 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Volume II contains quadrangle maps showing the locations of mines in counties, in alphabetical order, A through L. Research done under contract J0295020 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior Washington, D.C. Order ONLY from NTIS: PB 81-177917; paper copy price code A16.

OFR 21(3)-81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume III. Final Appendix M Through W, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P. A. Bilzi. April 1980. 334 pp. 43 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Volume III contains quadrangle maps showing the locations of mines in counties, in alphabetical order, M through W. Research done under contract J0295020 by Skelley and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-177925; paper copy price code A15.

OFR 22-81. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mine Drainage, by Fraser Walsh. November 1980. 122 pp. This study investigates the kinetics and the mechanics of the reactions that produce acid in coal mine drainage using fresh mine face samples from five Appalachian coal mines. The results of the study show that pyrite weathering is based on oxidation in the presence of water where the oxidants can be either ferric iron or oxygen. Iron bacteria, especially *T. ferrooxidans*, catalyze the rate of pyrite weathering by a factor of 3. An increase in initial iron concentration in a system that models the mine environment acts to inhibit bacterial catalysis of pyrite weathering. Research done under Contract No. J0387215 by ECO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-179418; paper copy price code A06.

OFR 23-81. Mine Grounding Systems. Evaluation of In-Mine Grounding System and Codification of Ground Bed Construction and Measurement Techniques, by Wils L. Cooley and Robert L. McConnell. June 30, 1979. 300 pp. 155 figs. The report describes two major grounding topics: mine ground systems and ground-check monitors. Performance characteristics of ground-check monitors for high-voltage surface mine distribution cables and low-voltage underground mine trailing cables are evaluated. Over 20 commercially available monitors are studied to determine their utility. Several monitoring concepts are

incorporated into an unusual monitor design; the prototype is described in detail. A comparative study of the effectiveness of several alternate methods of grounding surface mine equipment supports the system currently proposed by MSHA. An instrument design to measure earth voltage gradients is described, as well as an instrument design for measuring the effectiveness of dc haulage current return systems. An extreme analysis is made of techniques for measuring earth resistivity and resistance of safety ground beds. Electrolytic corrosion studies of earth electrodes are reported extensively also. Research done under Grant No. G0144138 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-178881; paper copy price code A14.

OFR 24–81. Electrical Practices in Metal/Non-Metal Mines and Mills. Old Electrical Power Systems, Equipment, and Practices, by David Bendersky, Vernon W. Klein, and Daniel R. Keyes. October 1980. 102 pp. 86 figs. This report covers a technical and economic investigation of old electrical power systems, equipment, and practices being used in the metal-nonmetal mining industry. The principal sources of information were the MSHA district offices, visits to representative mines and mills, equipment manufacturers, and the literature. A list of 85 mines and mills, submitted by the MSHA districts as candidates for this study, is given and their characteristics are analyzed. The electrical power systems and practices at the 10 mines and 9 mills that were visited are described. The principal areas that do not conform to standard electrical practices are discussed with emphasis on the safety aspects of these practices. The costs to update electrical power systems and practices in metal-nonmetal mines and mills are given. The principal findings of the study are summarized and recommendations are submitted. Research done under Contract No. J0387203 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-179400; paper copy price code A06.

OFR 25–81. Development and Validation of a Miner's Instructional Procedure for Improved Safety Training, by Kay E. Goldberg and Roger Silliman. July 1980. 37 pp. This report presents the results of a study conducted by the Bureau of Mines to develop and evaluate a training workshop for mine safety training personnel. The workshop was based on the Instructional Development Institute, which has been used for nearly 10 years to train educators and administrators in the application of a nine-step model for defining, developing, and evaluating instruction. Recommendations for further research are included. Research done under Contract No. H0188052 by University of Southern California. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-179426; paper copy price code A03.

OFR 26–81. 1978 Mineral Investigations in the Misheguk Mountain and Howard Pass Quadrangles, Alaska, by Uldis Jansons and Mary Ann Parke. 1980. 295 pp. 38 figs. In 1977–78 the U.S. Bureau of Mines and the U.S. Geological Survey formed study teams to investigate mineralization and geology related to mineralization in the National Petroleum Reserve in Alaska (NPR-A) The work area is north of the confluence of Driftwood Creek and the Utukok River, in the southwestern part of the NPR-A. The 1977 fieldwork consisted of geological mapping, geochemical sampling, aerial geologic reconnaissance, and site specific investigations and sampling. During the 44-day 1978 field season, Bureau professionals prospected and sampled areas where results of the 1977 geochemical survey indicated the presence of anomalously high metal concentrations. The prospecting consisted primarily of creek traverses in search of mineralized rock that could account for the geochemical anomalies. Stream sediment samples were collected from tributaries of the geochemically anomalous drainages. The report summarizes the 1978 Bureau fieldwork and presents analytical results. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 27–81. Mineral Investigations in the Porcupine River Drainage, Alaska, by James C. Barker. March 1981. 201 pp. 31 figs. Between 1976 and 1978, the Bureau of Mines conducted a mineral resource investigation in the Porcupine River drainage of northeastern Alaska. The study area is divided into three generalized geologic terrains. Potential deposit types of each terrain are described as they are indicated by mineral occurrences and other data. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 28–81. Preliminary Evaluation of Geochemical Data From the Proposed Chukchi Imuruk National Reserve, Alaska, by Uldis Jansons. March 1981. 8 pp. 2 figs. Water and waterborne sediment samples from the proposed Chukchi Imuruk National

Reserve were analyzed for the Bureau of Mines. The antimony, bismuth, gold, lead, silver, uranium, and zinc contents of the sediment samples were studied to determine if samples with anomalous element concentrations are present, to outline the distribution of the anomalous samples, and to evaluate the use of the geochemically anomalous samples, as indicators of known and potential zones of mineralization. Extensive uranium and zinc geochemical anomalies were identified in the southeastern part of the proposed reserve. Less extensive geochemical anomalies of gold and other elements were also identified. Some anomalous samples come from areas of known mineralization and suggest that the trends extending into the proposed withdrawal may have associated mineralization. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Asessment, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 29–81. Tungsten Investigations Near VABM Bend, Eastern Alaska, by Jeff Foley and James C. Barker. March 1981. 24 pp. 5 figs. Numerous scheelite occurrences in the Charley River area of east-central Alaska suggest the existence of a broad geographic zone with a potential for economic deposits of tungsten. The trend strikes northwesterly across a region of diverse geology from the Seventymile district to Pinnell Mountain. Tungsten mineralization occurs on a tributary of Crescent Creek in the Charley River drainage as disseminated grains and aggregates up to 2 cm across in banded, hornfelsic calc-silicates; disseminated grains in biotite-quartz monzonite; and concentrations in siliceous veins less than 1 cm across in leucocratic, igneous rocks. Weathering of these rocks has led to concentration of scheelite in placer deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 30–81. An Evaluation of Leaky Feeder Communication in Underground Mines, by D. T. Updyke, W. C. Muhler, and H. C. Turnage. June 1980. 104 pp. 40 figs. The objective of this project was to develop technical data and evaluate performance and utility of leaky feeder communications systems currently used in U.S. underground mines. The desired information was obtained principally through on-site surveys. Six of the seven mining companies known to be using leaky feeder communications were visited. This report covers the findings of these surveys. In addition, the report provides a brief background summary of mine communications, a technical discussion of leaky feeder systems, and conclusions and recommendations based on the results of the survey. Research done under Contract No. J0199048 by Atlantic Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194466; paper copy price code A06.

OFR 31–81. Development and Evaluation of an Illumination System for Continuous Miners That Are Utilized in the Extraction of Trona, by William F. Hahn and Stanley J. Ryba. Mar. 25, 1980. 73 pp. 31 figs. This report describes two illumination system designs and their demonstration and evaluation on a Jeffrey 120HR continuous-mining machine in an active trona mine in Wyoming. Research done under Contract No. J0387202 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194474; paper copy price code A04.

OFR 32–81. Electromagnetic Fields in Mine Environments, by James R. Wait and David A. Hill. May 1, 1980. 448 pp. 362 figs. This report comprises the total productivity of a series of related investigations performed during 1971–79. The first phase concentrated on the analytical studies of techniques relevant to mine rescue. The second phase dealt with the fundamental character of how electromagnetic waves propagate in mine tunnels. The third phase was devoted to the analyses of various specific geophysical engineering problems. The fourth phase concerned the general subject of nondestructive testing of wire ropes used for mine hoists. Research done under contract J0199115 by Institute for Telecommunication Science. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 33–81. Detection Instrumentation for Cable Shield Defects, by James R. Cosby, Gerard B. Gilbert, and Jay H. Stoudenmire. Aug. 29, 1980. 50 pp. 6 figs. This report describes work performed for the Bureau of Mines to evaluate available portable instruments for their effectiveness in detecting and locating damaged metallic shields in types SHD and SHC cables. A second phase of the program covers several instruments of a type that could prove effective and were purchased for modification and testing to verify their performance. Research done under Contract No. J0188081 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane,

Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194540; paper copy price code A03.

OFR 34–81. Development of a Manually Operated Rescue Team Vehicle, by Mervin D. Marshall. Feb. 2, 1978. 183 pp. 55 figs. A quick-reaction, mine-permissible rescue vehicle (MERV) was developed for use by rescue teams. The MERV, a six-wheeled, battery-powered unit with life support equipment and instrumentation, is designed for a two-person team with provisions for handling two victims or tools in a trailer. The MERV, which is 100 inches long, 56 inches wide, and a maximum height of 34 inches, can be lowered down most mine shafts and has clearance to travel mine railways. The MERV has power to all six wheels that can be transmitted separately to either or both sets of wheels. Low-pressure, high-traction tires give the vehicle the ability to handle soft, muddy mine floors, flooded areas and significant obstacles, and can negotiate a 45° grade. Power and life support are sufficient for a 4-hour mission. The life support system is a commercially available, approved unit currently used by MSHA rescue personnel. A payout wire system provided communication between the MERV and home base over a distance of 10,000 feet. On-board monitoring of carbon monoxide, methane, and oxygen is provided, with master and individual alarms to warn of gas concentrations outside preset limits. A lightweight, water-tight trailer was developed for carrying victims or hauling tools and equipment. Research done under Contract No. H0122063 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194482; paper copy price code A09.

OFR 35–81. Reclamation and Pollution Control: Planning for Smaller Sand and Gravel Mining Operations, by Paul T. Banks, Robert E. Nickel, and Donald A. Blome. Jan. 31, 1981. 159 pp. 44 figs. This guide is designed for use in planning pollution control and reclamation activities on small sand and gravel operations. The purpose is to assist operators in selecting environmentally desirable pollution control and reclamation procedures based on a particular mining situation. The guide includes information on interpreting physical and cultural factors that must be considered in planning and implementing a mining and reclamation program, achieving environmental protection objectives, and improving community-industry cooperations. A summary of State laws and a list of additional readings on the subject are included. Research done under Contract No. J0199052 by Hittman Associates, Inc., and Interstate Mining Compact Commission. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-190241; paper copy price code A08.

OFR 36–81. Preliminary Report on the Mineral Potential of the Alaska Peninsula, by Eric Hanson, Greg Sherman, and Jeff Knaebel. April 1981. 39 pp. 7 figs. This report summarizes the mineral potential of the Alaska Peninsula and adjacent islands from Kamishak Bay westward to False Pass. Despite sporadic mining, prospecting, and oil drilling since the late 1800's, the area remains essentially unprospected. Geologically, the Alaska Peninsula is an uplifted island arc that has had a long and continuing history of igneous activity. Consequently, the area has a high potential for geothermal energy and sulfur deposits are common. The Alaska Peninsula also has a favorable environment of copper porphyry, copper-molybdenum, and several other types of deposits of metallic minerals. Gold was mined on Unga and Popof Islands and prospects containing gold, silver, copper, lead, zinc, iron, and titanium are reported. The Alaska Peninsula is not considered highly favorable for uranium but has some potential that remains essentially untested. Research done under Purchase Order P4670242 by Resource Associates of Alaska, Inc. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 37–81. Mineral Investigations of Certain Lands in the Eastern Brooks Range, 1978, by James C. Barker. April 1981. 288 pp. 16 figs. This is an interim report on the findings of a mineral resource study in the eastern Brooks Range, Alaska, involving 4,300,000 acres of lands. The study area is divided into five geologic terrains and limited field work was undertaken during the 1976–78 field seasons. A sample survey was undertaken throughout the major portion of the project area to more adequately define regions of mineral potential and 1,109 stream sediments and 85 rock samples were analyzed. Select anomalies and prospects were field checked. Further multielement analyses of these samples are being made by the U.S. Department of Energy and will be reported separately by that agency. Research done by Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 38–81. Procedures for the Performance Evaluation of Gas Detection Devices Including Preliminary Test Methods, by Jeffrey S. Newman. May 23, 1980. 251 pp. 18 figs. This report establishes a methodology for the evaluation of gas detection devices and is the result of a critical investigation into the basic principles defining gas detector performance. A scheme is presented to evaluate the performance of a test sample of gas detectors based on the detector type and intended application. Test procedures, worksheets, test apparatus, glossary, and statistical

methods for handling test data are given. In addition, evaluation standards and test parameters are identified. It is intended for this report to serve as a comprehensive framework for the eventual certification of all gas detectors for mine applications. A plan is proposed and recommended for the quantification and implementation of evaluation standards for gas detection device certification. Research done under Contract No. J0387211 by Factory Mutual Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194961; paper copy price code A12.

OFR 39(1)-81. Environmental Factors Affecting Surface Mining of Steeply Pitching Coal Seams. Volume I/Overview, by Grant R. Brown, William J. Douglas, Edward T. Schroeder, David H. Dike, Albert H. Hirsch, and John T. Urban. April 1980. 131 pp. 11 figs. With renewed demand for coal to supply today's energy needs, many coal mining operations are being developed that previously would have been deemed uneconomic. One of the most challenging areas of coal recovery is coal seams that pitch in excess of 25°. Thus, the Bureau of Mines conducted in-depth analyses of the environmental, operational, and reclamation problems in terms of the resource potential associated with the surface mining of steeply pitching coal seams. This report presents the analyses of five surface mines located in three geologically distinct basins of the United States. Research done under Contract No. J0199006 by Ketron, Inc., and WAPORA, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194987; paper copy price code A07.

OFR 39(2)-81. Environmental Factors Affecting Surface Mining of Steeply Pitching Coal Seams. Volume II/Site Analyses, by Grant R. Brown, William J. Douglas, Edward W. Schroeder, David H. Dike, Albert H. Hirsch, and John T. Urban. April 1980. 129 pp. 52 figs. This report provides guidance to determine the environmental impacts associated with the surface mining of steeply pitching coal seams. Four additional issues discussed are time and motion studies of those coal mining systems employed in mining seams that pitch in excess of 25°, assessment of those mining techniques, development of rationale for the mining methods employed, and identification of the reclamation practices and determining whether they are in compliance with appropriate and Federal and State regulations. Research done under Contract No. J0199006 by Ketron, Inc., and WAPORA, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194995; paper copy price code A07.

OFR 40(1)-81. Coal Mine Equipment Population Characterization and Protective Structure Status. Volume I, by Gary R. Gavan, C. William Harpur, Louis Schaffer, and Jack L. Woodward. Oct. 20, 1978. 222 pp. 17 figs. This report presents the results of a research project that gathered detailed information on the composition of the population of mobile equipment used in U.S. coal mines. A computerized data bank containing over 19,000 pieces of coal mine equipment in use in 1976 was prepared with a data retrieval program. Operator protective structure technology is reviewed and field problems experienced with rollover protective structures are discussed. Research done under contract J0366016 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194946; paper copy price code A11.

OFR 40(2)-81. Coal Mine Equipment Population Characterization and Protective Structure Status. Volume II, by Gary R. Gavan and Ken Winters. Mar. 15, 1979. 125 pp. 20 figs. This report presents the documentation and User's Manual for a data retrieval and report generation computer program, that is described in volume I. The program operates on a data base containing over 19,000 pieces of coal mine equipment in use in 1976. Research done under contract J0366016 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194953; paper copy price code A07.

OFR 41-81. Analytical Modeling of Coal Mine Roof Behavior, by R. T. Langland. October 1978. 99 pp. 73 figs. Using a finite element computer code developed for the Bureau of Mines to calculate roof sag, convergence, roof bolt load change, and standard engineering property information, a comprehensive series of three-dimensional calculations at three different sites in a room-and-pillar coal mine were performed. The calculated results were then compared with experimental results obtained from an extensive in-site field measurement program. General agreement was obtained between the analytical and field results showing that three-

dimensional, finite element modeling of mining can be an extremely useful tool for understanding mine behavior. A series of parametric studies were also performed that examined the effects of changing the viscoelastic time parameters, varying the preload on the bolts, and changing the effective stiffness of the bolts. Research done under Contract No. H0242043 by Lawrence Livermore Laboratory. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities,, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: UCRL-52586; paper copy price code A05.

OFR 42-81. An Interactive Computer System for Evaluating Coal Mine Illumination, by Mathematical Applications Group, Inc. December 1978. 15 pp. 8 figs. A computer system for calculating the illumination on coal mine surfaces due to machine-mounted lights is described. Utilizing numerical models of mining machinery and measured data on luminaire output characteristics, the program computes the foot-candle levels incident on the mine entry surfaces for any desired machine-luminaire-entry configuration, and shadowing effects of the machine are taken into account. Results are provided at 2-foot intervals on the face, left and right walls, floor, and roof. The system operates, interactively from a Tektronix 4014 graphics terminal which handles all input-output functions. The software is installed on a Cyber 74 computer that communicates with the terminal by a telephone line. Research done under contract S0271041. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-195687; paper copy price code A02.

OFR 43-81. Centrifugal Model Analysis of Coal Waste Embankment Stability, by Frank C. Townsend, Deborah J. Goodings, Andrew N. Schofield, and Mosaid M. Al-Hussaini. August 1980. 118 pp. 71 figs. Centrifugal model embankments with varying geometries and materials were constructed of coal waste material, accelerated from 100 to 120 times Earth's gravity, and subjected to various throughflow rates until failure occurred. Complementary laboratory tests were performed on the waste materials to obtain strength and permeability parameters for analytical calculations to predict observed centrifugal model behavior. Failures in the form of deep-seated failure, or erosion and sediment transport or a combination of both, occurred in model embankments with IV:1-1/2H and IV:2H slopes when the phreatic surface due to seepage exited on the downstream slope. Positive seepage control, that is, a toe drain, successfully prevented sloughing and failures. Slope stability analyses agreed conservatively well with observed model performance. Factors of safety ranged from 0.7 to 1.02 at the instant of failure for models with retrogressing slips as compared with 1.05 to 1.7 for stable embankments. These models verified existing criteria of a minimum safety factor of 1.3 and the necessity of positive seepage control. Research done under Contract No. H0282018 by U.S. Army Engineer Waterways Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81 194524; paper copy price code A06.

OFR 44-81. Improved Tire Inspection for Large Mobile Mining Equipment, by Robert M. Jones, William G. Freeman, Monty L. Christo, and Larry Attebery. September 1979. 140 pp. 40 figs. Guidelines were developed to provide mine management with recommended tire inspection procedures for operating, maintenance, and supervisory personnel. These guidelines were developed from accident statistics that indicated when, how, and where the accident occurred; industry contributions resulting from mine and manufacturers visits; and the evaluation of the preliminary guidelines by three operating mines. This report describes the basic aspects of tire and rim selection and use. Tire users are provided with a tire evaluation program that can contribute to improved safety and better tire application. Statistical accident data, accident reports, and a bibliography are included to emphasize the mining industry's contribution and concern with tire operation and safety. Research done under contract J0285004 by International Mining Consultants, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194532; paper copy price code A07.

OFR 45-81. Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining, by F. S. Kendorski, I. Khosla, and M. M. Singh. Aug. 31, 1979. 363 pp. 101 figs. This report covers the work on developing criteria for determining when a hazard exists when mining stratified mineral deposits beneath bodies of surface water. The nature of water bodies is considered, the disturbance to the strata induced by mining is described, inundation case histories reviewed, reasonable water inflows derived, and methods of mining to prevent or minimize the hazard are presented. Criteria are given whereby affected industries and agencies can recognize a potential hazard and plan a mine accordingly, releasing considerable mineral reserves otherwise considered unminable. Research done under Contract No. J0285011 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver,

Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194938; paper copy price code A16.

OFR 46(1)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part I. Distribution of Rock Mass Properties, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 200 pp. 85 figs. The objective of this research was to collect in situ data from exploration programs and published literature, and to empirically establish distributional patterns for these variables. Since discontinuities in a rock mass govern its engineering properties to a large extent and thus the performance of any slope in the mass, work has been devoted to determining the appropriate distributional forms for attitude, spacing and length of discontinuities, and to distributional properties of resistance and deformability parameters. The conclusion from these analyses is that trace lengths are log-normally distributed and that joint spacing is exponentially distributed, regardless of orientation of the sampling line, and regardless of whether each joint set is considered separately or not. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201592; paper copy price code A09.

OFR 46(2)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part II. Limit Equilibrium Analysis for Rock Wedge Stability, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 182 pp. 78 figs. Instability of rock slopes often occurs in the form of excessive movement of bodies that are bounded by discontinuities. The well-known limit equilibrium analysis for wedges and blocks suffer from procedural simplifications and from the basic deficiency of limit equilibrium analysis—the rigid body assumption. Thus, stability analysis for two- and three-plane wedges with a wide range of additional features regarding failure mode and external forces have been developed. The deficiency, due to the rigid body assumption, was corrected by an approach that includes the effects of the in situ stress field and of the stiffness of discontinuities. The final step in making limit equilibrium approaches more valid was achieved with artificial supports which makes it possible to identify the most critical failure mode and to determine the corresponding factor to safety. The analytical development includes the creation of appropriate computer codes and routines for programmable pocket calculators. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo, Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201600; paper copy price code A09.

OFR 46(3)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part III. Reliability Analysis of Rock Slope Stability, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 354 pp. 162 figs. The innate variability of natural materials and processes causes uncertainty in the models representing the natural phenomena and uncertainty in estimating the parameters that are used. Reliability analyses are well-suited to a rational incorporation of uncertainty in design and exploration decisions. Probabilistic kinetic and kinematic analyses were developed and combined to form reliability analysis methods. With one method the reliability (the probability of failure) of an individual two-plane wedge in a slope can be determined. The other method is aimed at slopes with a single-slope parallel set of joints. In each case two approaches were developed, an encompassing one relying on computer codes and a simplified approach relying on charts or pocket calculator computation. A major contribution of these approaches is the treatment of joint persistance. Instead of having to assume a certain persistance, it is now possible to use exploration data on joint geometry and to include the persistence effect rigorously. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201618; paper copy price code A16.

OFR 46(4)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part IV. Field Exploration To Determine Rock Mass Properties, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 176 pp. 85 figs. Sampling plans and methods of statistical inference for rock mass properties are developed aimed at overcoming statistical biases in drawing inferences from joint survey data. The approach to exploration strategy analysis (optimization) is through the "expected value of information" (EVI) of decision theory and two cases are analyzed: the

one-joint set (parallel to slope) case and the general shear case. In conjunction with the analysis of optimal exploration strategies for single slopes, a graphical risk screening procedure was developed to determine those slope sections within a pit for which increased exploration would beneficially reduce risk. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201626; paper copy price code A09.

OFR 46(5)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part V. Probablistic Models of Jointed Rock Mass Deformation and Their Implications, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 113 pp. 49 figs. Rock mass deformability is commonly predicted using correlations with RQD or other indices of rock mass quality or by extrapolation from large in situ tests. Based on the probabilistic description of rock masses empirically developed, a new approach was attempted in modeling for predictions of deformability. This approach decomposes the rock mass into spatially variable joints described by probability distributions and intact rock blocks. Stiffnesses and elastic parameters are associated with the joints and intact blocks and deformations are built up by adding the contributions of each. This allows relaxation of many of the simplistic geometric assumptions that constrain parallel attempts to model deformation in rock masses. The model has been applied to four standard cases to test its results against previously existing models and to check whether it replicates empirical correlations. When joints are taken as parallel, common empirical correlations are closely approximated by the model output. However, the closeness to empirical correlation breaks down when variability of the jointing geometry is increased. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201634; paper copy price code A06.

OFR 46(6)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VI. Executive Summary, Introduction and Technical Summary, Bibliography, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 63 pp. The purpose of this report is to provide a summary overview of the research goals and results of this investigation in an executive summary followed by a detailed introduction to the research and a comprehensive summary of the work performed. The structure of the summary reflects that of the entire report, devoting a section to each part and subdividing each section into paragraphs corresponding to the chapters in the particular part. Although there is a systematic relation between chapters and parts, the report is written such that each chapter can be used individually, providing a method or reporting results that can be practically applied. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash., U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201642; paper copy price code A04.

OFR 46(7)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VII. Appendices A Through M, Detailed Geologic Data Underlying Developments, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 394 pp. 144 figs. Appendices A through M of this eight-volume report contain information that is the basis for many developments reported in the main text. The information is, however, not needed in applying the research results. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201659; paper copy price code A18.

OFR 46(8)-81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VIII. Appendix UM, User's Manuals for Computer Programs, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 453 pp. 40 figs. This report contains the documentation for 11 computer programs representing the entire computer documentation for the eight-volume report entitled "Risk Analysis for Rock Slopes in Open Pit Mines." A detailed summary of the programs is included. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.,

and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-201667: paper copy price code A20.

OFR 47-81. Geotechnical Properties of Oil Shale Retorted by the Paraho and Tosco Processes, by Frank C. Townsend and Richard W. Peterson. November 1979. 271 pp. 77 figs. The objective of this investigation was to determine the physical and geotechnical properties and composition of spent oil shale by the Paraho and Tosco processes. The program was divided into three categories: physical properties, engineering properties, and compositional and durability characteristics. The physical properties tests consisted of typical classification tests for identifying and comparing the retorted shales with other materials. The engineering characterization investigated compaction, consolidation, shear strength, self-cementing tendencies, particle breakage and abrasion, dynamic properties, and earthquake resistance. Compositional tests consisted of X-ray diffraction, petrographic and scanning electron microscopy, and differential thermal and chemical analyses. Research done under Contract No. H0262064 by U.S. Army Engineer Waterways Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: ADA-082317; paper price code A12.

OFR 48-81. Electromagnetic Retransmission System for Locating Trapped Mine Workers, by Frederick H. Raab and Per Krogh Hansen. February 1980. 268 pp. 71 figs. The electromagnetic retransmission system is a new, automated method of locating trapped mine workers. This technique overcomes many limitations inherent in electromagnetic direction finding by reducing the effects of the conducting ground to an acceptable maximum, by finding position accurately in the presence of antenna tilt, and by eliminating the need for the receiver to be located directly above the subsurface transmitter. Three transportable three-axis magnetic-dipole transmitters on the surface create a system of electronic grids in which the phases of the downlink signals convey position information. The subsurface retransmitter modulates the uplink carrier of the existing beacon transmitter with the received downlink signal; the coal-pillar loop antenna is used for both receiving and transmitting. The uplink receiver uses a three-axis antenna and extensive digital signal processing. A small computer integrates data, estimates position, and controls system operation through VHF-FM communications. Both coal-mine and deep-mine operations are possible by selecting appropriate transmitting power and signal frequencies. Research done under contract H0188071 by Polhemus Navigation Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215329; paper copy price code A12.

OFR 49-81. Improved Hardware for Trolley Wire Phone Systems, by Joseph L. Harley, Jr. March 1979. 55 pp. 17 figs. This report presents the investigation and engineering of state-of-the-art trolley wire phone hardware. The various problem areas of trolley wire communication systems are discussed with the objective of improving circuit performance to compensate for the poor transmission characteristics of the line. Relatively inexpensive hardware designed for this purpose is detailed and documented. Research done under contract H0166144 by GAI-Tronics Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214363; paper copy price code A04.

OFR 50-81. Borehole Mining: An Environmentally Compatible Method for Mining Oil Sands, by G. S. Knoke and W. R. Archibald. February 1980. 114 pp. 32 figs. This report presents the results of a demonstration of the technical, economic, and environmental feasibility of hydraulic borehole mining of shallow oil sands. Borehole mining offers a method for extracting the oil sands with minimal disturbance to environmental quality. This project consisted of two concurrent tasks: mining operations and environmental monitoring. To generate the environmental impact, nearly 1,000 tons of oil sands were mined from two boreholes. Water quality and ground subsidence were monitored. No significant changes occurred in the chemical composition of the process water, indicating that the borehole mining process does not dissolve the mined material. The average subsidence in the immediate vicinity of the boreholes was about ½ inch, although some points were slightly elevated. In general, the amount of subsidence increased with time and decreased with distance from the borehole. A mining cost analysis was used to project an estimated cost for production mining of about $38 per barrel of oil. Research done under contract J0295064 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214231; paper copy price code A06.

OFR 51-81. Preconditioning an Entire Stope Block for Rock Burst Control, by Wilson Blake. May

1980. 32 pp. 15 figs. Rock preconditioning in advance of mining has been an effective means of rock-burst control based on small-scale field demonstrations. The objective of this investigation was to test the effectiveness of rock preconditioning on a larger scale and to determine whether the preconditioning would be effective over a specific period of time. Preconditioning in 8 and 12 crosscuts on the 7900 level of the Hecla Mining Co.'s Star Mine involved about 7,232 feet of drilling and the blasting of about 10,055 pounds of high explosives to precondition a block of ground along the main vein of about 450 feet long, 50 feet above, and 40 feet below the level. The slight amount of seismic energy accompanying the initial raiseup in the preconditioned stopes indicates that this preconditioning was successful. Continued monitoring should be carried out to determine whether the preconditioning remains effective over the length of time required for the completion of mining in a stope block. Research done under contract J0295080. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214983; paper copy price code A03.

OFR 52–81. Wallrock Reactions to Mining Beyond a Preconditioned Zone at the Star Mine, Burke, Idaho, by Wilson Blake. April 1980. 45 pp. Rock preconditioning in advance of mining has been an effective means of rock-burst control based on the results of field demonstrations carried out on the 7700 level of the Hecla Mining Co.'s Star Mine. Mining through the preconditioned zone was characterized by greatly reduced rates of released seismic energy and no bumping or rock bursting occurred within the preconditioned zone. Mining above the preconditioned zone was characterized by greatly increased rates of released seismic energy and rock bursting, particularly where the vein became very narrow in waste zones. This increased incidence of rock bursting points out the need for stope preconditioning to be carried out on an entire stope block basis. Research done under contract H0262039. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214355; paper copy price code A03.

OFR 53–81. Survey of Attractive Energy Storage and Power Averaging Concepts Applicable to Mining Machines, by William N. Patterson, Leslie Travis, and Lawrence Owens. July 31, 1980. 154 pp. 15 figs. Drive systems for mining machines are usually sized to accommodate anticipated peak loads. Usually, the average power requirements are considerably less. Energy storage and power averaging are attractive concepts for mining machinery and could have far-reaching implications. The purpose of this program was to identify truly feasible concepts; identify advantages and/or disadvantages, limitations, and constraints; evaluate feasibility based on today's technology; identify anticipated safety problems; and provide the designer with a comprehensive literature base. Concepts evaluated include flywheels, high energy batteries, gas-charged accumulators, inductive storage, capacitive storage, springs and counterweights, thermal, closed cycles, internal combustion engines, and trolley and hybrid systems. A comprehensive index is provided, and an appendix is included containing abstracts of pertinent literature. Research done under contract J0285041 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–217002; paper copy price code A08.

OFR 54–81. Improving Surface Coal Refuse Disposal Site Inspections, by R. A. Meister and R. L. Hoffman. September 1980. 297 pp. 169 figs. The study on improving surface coal refuse disposal site inspections included surface inspections of 15 refuse disposal sites. Monthly aerial photos were taken of the sites and computer methods were used to determine elevation changes. Photogrammetric techniques that were used are described in detail. A comparison of the results of each of these inspection techniques is included. A detailed evaluation of the photogrammetric techniques was made and conclusions were drawn concerning the advantages and disadvantages of using aerial photography and photogrammetry as part of the inspection procedure. Operators' opinions of the aerial photography methods are included. Research done under contract J0188027 by Chicago Aerial Survey. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215402; paper copy price code A13.

OFR 55–81. Detection of Coal Mine Workings Using High-Resolution Earth Resistivity Techniques, by Wendell R. Peters, Thomas M. Campbell, and Vernon R. Sturdivant. Sept. 26, 1980. 80 pp. 25 figs. Shallow underground voids resulting from early coal mining and other resource recovery activities over the past several decades are now being recognized as a significant cause of ground subsidence problems in developing urban areas. Uncertain knowledge of abandoned coal mines also imposes potential hazards in coal excavation operations since water inundation or the release of methane gas is a principal hazard when mine excavation operations break into an abandoned mine. U.S. Army requirements for an effective method for detecting and

mapping subversive abandoned tunnels have resulted in a surface-operated automatic earth resistivity survey system with a digital computer data processing system. Field tests aimed at demonstrating the system performance resulted in successful detection of tunnels having depth-to-diameter ratios up to 15 to 1. Under the sponsorship of the Bureau of Mines, a similar system was designed and constructed for use in the detection of coal mine workings. This report discusses the hardware and software aspects of the system and the application of the high-resolution earth resistivity method to the survey and mapping of abandoned coal mine workings. In the field tests reported, the targets of interest were both air- and water-filled workings. Research done under contract H0292030 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215378; paper copy price code A06.

OFR 56-81. Feasibility Analysis of Implementing Rail Car Brakes in Underground Coal Mines, by Charles G. Howard, Bruce H. W. Pinkston, and Fujio Hayashi. Oct. 1, 1979. 119 pp. 25 figs. Accidents involving underground rail transport were analyzed to quantify the magnitude and operational requirements for individual mine car braking systems. The results showed that the brake preventable accidents represent only 2 pct of the total underground fatal accidents and less than 1 pct of the total underground nonfatal accidents. In addition, brake preventable accidents are expected to decline over the next decade. The costs of accidents involving deaths and injuries were determined using various well-accepted methods. The costs of a brake retrofit program for all operating underground coal cars were developed separately for small and large coal mines. Costs of retrofit brakes, new car brakes, maintenance, inspection, and repair facilities were included in the estimates. The analysis showed that a retrofit program would not significantly increase safety, and that the program cost would greatly exceed the corresponding expected benefits. Research done under contract J0188085 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215360; paper copy price code A06.

OFR 57-81. Dust Collector on Longwall Shearer, by Dennis J. Grigal. February 1980. 81 pp. 36 figs. The goal of this program is to develop a dust collector system mounted on a ranging drum or arm shearer that will reduce the respirable dust level of the shearer operator by at least 75 pct, be easily and economically mounted on an existing shearer, and will not, through modifications to the shearer, reduce its safety or productive capability. The development program consists of three phases covering the activities of the design of the dust collector system, fabricating and installing it on the ranging arm or drum shearer, and conducting underground field tests on the modified mining machine. Research done under contract H0242012 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214926; paper copy price code A05.

OFR 58-81. Electrochemical Gas Sensors for Mine Atmospheres: Portable Detectors for Carbon Monoxide and for Nitric Oxide/Nitrogen Dioxide Mixtures, by John Kosek and Stanley Bruckenstein. February 1979. 212 pp. 31 figs. A portable detector for mixtures of nitric oxide and nitrogen dioxide was developed using a porous silver cathode in sulfuric acid supporting electrolyte. Nitrogen dioxide was determined in the gas stream by electroreduction. The nitric oxide in the gas stream was oxidized to nitrogen dioxide by passing it over Cr (VI) on firebrick. Electroreduction gave the sum of NO + NO_2. Analog circuitry was used to display the amounts of NO and NO_2 separately. Two ranges available for each gas were, in parts per million, 0 to 10 and 0 to 50 for NO, and 0 to 2 and 0 to 10 for NO_2. Research done under grant G0155007 by State University of New York at Buffalo. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214934; paper copy price code A10.

OFR 59-81. Considerations for the Certification of Blasters, by John R. Coulson and Larry T. Southall, II. February 1980. 79 pp. The objective of this report was to determine the existing Federal and State requirements for blasters working on the surface or underground in metal, nonmetal, and coal mine operations; determine industry needs for blasting personnel and recommend licensing requirements for blasters; determine the types of training now available and compare the training needs with the training available; and consolidate the above and make recommendations. The Federal Government and each State were surveyed for existing certification requirements and the industry was surveyed for the needs for training blasters and for available training. Recommendations for training and certification for blasters are made. Research done under contract J0285012 by E. I. du Pont de Nemours & Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder

City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214116; paper copy price code A05.

OFR 60-81. An Investigation of the Mechanics and Noise Associated With Coal Cutting, by Robert S. Becker and Granville R. Anderson II. Feb. 15, 1980. 275 pp. 171 figs. The results of a laboratory investigation of coal cutting mechanics and noise are presented. The experiments were performed using a linear cutting apparatus that operates over a broad cutting speed range. The influence of several coal cutting parameters on the noise, force, productivity, and specific energy associated with linear cuts was ascertained. Some basic theoretical aspects of coal cutting mechanics and noise generation are discussed, and the results of the laboratory experiments are used to formulate analytical models of the coal cutting forces and noise. Research done under contract J0177060 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215394; paper copy price code A12.

OFR 61-81. The Impact of Eliminating Safety Fuse From Metal/Nonmetal Mines, by Dipak Sengupta, Gordon French, Mir Heydari, and Kanaan Hanna. August 1980. 211 pp. 25 figs. This study analyzes the safety, technology, and economic impact of eliminating safety fuse from metal and nonmetal mines based on operation and manufacturer experience over the past 5 to 10 years. If safety fuse is eliminated, blasting accidents will decrease with no technical impact except for some limited, specific applications. The economic impact will be minor for large operations, but will be significant enough that some small operations will likely close rather than change. The majority of the mines would probably change over, with the extra cost absorbed by the market. Elimination of safety fuse would have obvious impact on the two manufacturers of safety fuse; one manufacturer already produces an alternative system, and will remain unaffected. The other manufacturer will be affected if they do not change their production strategy. There will be a very minor effect on the mining industry as a whole due to abolishment of safety fuse from the standpoint of employment or production. Research done under contract J0295010 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215386; paper copy price code A10.

OFR 62-81. Direct Calcination of $AlCl_3.6H_2O$ With Off-Gas Use for Crystallization, by L. Keith Hudson and Jamie K. Carnevale. Jan. 12, 1979. 30 pp. 5 figs. This report describes the results of a study to provide data that would demonstrate the decomposition of aluminum chloride hexahydrate using the Alcoa flash calciner design, and to show that hydrogen chloride in the off-gas from the calciner could be absorbed into process solutions to effect crystallization of aluminum chloride hexahydrate. Research done under contract J0188096 by Aluminum Co. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214827; paper copy price code A03.

OFR 63-81. Investigation of the Formation of Vapor Complexes Between Alumina Chloride and Impurity Elements Associated With Aluminum Raw Materials, by John P. Hager and Harry S. Patsos. Dec. 22, 1980. 79 pp. 3 figs. This study investigated the formation of vapor complexes between aluminum chloride and the chlorides of iron, titanium, and silicon. For the Al-Fe-Cl system the proposed gaseous complex species is $Al_2Fe_2Cl_{12(g)}$. In the Al-Ti-Cl and Al-Si-Cl systems the proposed vapor complex species are $Al_2Ti_2Cl_{14(g)}$ and $Al_2Ti_2Cl_{14(g)}$, respectively. Free energy expressions were estimated for the formation of the two complex species. Research done under contract J0199151 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214850; paper copy price code A05.

OFR 64-81. Evaluation, Modification & Application of Roadheaders in Underground Uranium Mines, by J. P. Connell, C. M. Gibbs, C. L. Livesay, D. C. Myntti, and J. M. Taipale. September 1980. 73 pp. 17 figs. This study evaluates the use of roadheaders in underground mining operations. The report identifies roadheader operating problems and offers suggestions for improved mechanical and electrical design along with manufacturer and owner responsibilities for improved availability. The development of a complex integrated excavation and ground support system is not warranted until the roadheader itself is made much more reliable. Research done under contract H0282024 by Morrison-Knudsen Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane,

Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214835; paper copy price code A04.

OFR 65–81. Calcia Stabilized Zirconia Castable, by J. Benzel, J. Cochran, R. Kolarik, K. Lee, E. McGee, and L. Smith. June 1980. 112 pp. 29 figs. This report presents the results of research on castable refractories made from calcium aluminate and zirconia suitable for use in high-temperature furnaces. The results indicated that reductions in the amounts of zirconia compared with conventional materials were possible with resultant materials and energy cost savings. The new formulations were demonstrated in producing refractory kiln furniture. Research done under grant G0177145 by Georgia Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214819; paper copy price code A06.

OFR 66–81. Innovative Technology for Fabrication of Ceramics: EDS Rapid Solidification Process Application to Specialized Materials, by Della M. Roy, Rustum Roy, and T. P. O'Holleran. Nov. 15, 1980. 52 pp. 8 figs. This report presents results of innovative research on a novel rapid solidification technology method to produce fine ceramic powders of many compositions with unique properties. The process uses salt solutions and includes two steps, the first to evaporate the liquid and the second to very rapidly decompose the salt to a very fine powder. The process has been demonstrated in terms of the following material applications: aluminates, ferrites, phosphors, ionic conductors, and cements. This new technique of producing ceramic powders offers a number of potential advantages over existing methods such as ability to produce complex compositions, lower energy requirements, and improved properties. Research done under grant G0155191 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214868; paper copy price code A04.

OFR 67–81. Coupled Transport Membranes for Metal Separations. Final Report, Phase IV, by W. C. Babcock, R. W. Baker, D. J. Kelly, E. D. LaChapelle, and H. K. Lonsdale. August 1979. 97 pp. 47 figs. This report presents the results of continuing innovative technology research to use coupled transport membranes to separate metals in solution, namely vanadium and uranium. The development of new hollow fiber membranes is described. Bench-scale tests demonstrated the clean separation of uranium from vanadium and iron. Future work will involve testing the membranes under actual field conditions. Research done under contract H0282023 by Bend Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214843; paper copy price code A05.

OFR 68(1)–81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Final Report, Volume I, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 64 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950–79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. Volume I contains data on acquisition and analysis procedures, conclusions, and recommendations. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223729; paper copy price code A04.

OFR 68(2)–81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Volume II, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 284 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950–79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. Volume II contains a chronological list of mine fires and 15 indexes to assist in locating fire incident reports of interest. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223737; paper copy price code A13.

OFR 68(3)–81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Final Report, Appendix, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 390 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950–79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. The appendix contains the annotated bibliography of over 300 metal and nonmetal mine fire reports, journal articles, and a list of nonreportable fires. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–223745; paper copy price code A17.

OFR 69–81. Trona Occurrences Within the Yukon Flats Basin, Alaska, by Karen H. Clautice and Thomas C. Mowatt. 1981. 34 pp. 5 figs. Fieldwork conducted by the Bureau of Mines as part of the mineral resource evaluation program of the Yukon-Tanana uplands and vicinity has delineated a northeasterly trend of evaporite deposits within the Yukon Flats Basin. The deposits occur locally as efflorescent salt films less than 1 cm deep about lake margins and dry lake beds within an area of approximately 240 km. The evaporites are precipitated from turbid lakes, which are in contrast with clear lakes elsewhere in the Flats. The mineral trona has been identified by X-ray diffraction techniques in major amounts in the evaporites from numerous locations. Calcite and/or dolomite are ubiquitous associates. Trona has also been identified in minor amounts within some lake sediments to a depth of 76 cm. X-ray emission spectrometric analysis has shown sodium to be the dominant element in all samples in the water soluble extract. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 70–81. Evaluation of the Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Environmental Aspects of Preliminary Pilot-Plant Design, by T. Bertke, D. Loudin, and D. Armentrout. December 1980. 48 pp. 4 figs. This report assesses the environmental aspects of a preliminary design for processing kaolin clay as the domestic resource for recovery of alumina by a hydrochloric acid leach-HCl gas-induced crystalization process. The report covers waste sources, control measures, and potential environmental and health effects applicable to the process technology. Research done under contract J0275047 by PEDCo Environmental, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225906; paper copy price code A03.

OFR 71–81. Application of Weathering Protection at the Face, by David C. McHuron. Aug. 19, 1980. 50 pp. 13 figs. Many underground coal mines are composed of shale layered directly over the coal that weathers severely immediately after exposure to the mine atmosphere. Condensation of ventilating air causes underground coal mines to become wet during warm months; during cool months, the mines become dry from evaporation. The fluctuating mine atmosphere is responsible for the severe shale break-up experienced during the summer and lessening of the break-up through the winter months. The objective of this investigation was to design and construct spray equipment to be mounted on a continuous miner for sealing the mine roof immediately after exposure. Selection of the sealant and a field evaluation of the equipment is included. Research done under contract H0272008 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–223380; paper copy price code A03.

OFR 72–81. The Input-Output Structure of the U.S. Mineral Industries for 1967 With RAS Updates to 1972 and 1977, by Everard M. Lofting, H. Craig Davis, and Werner O. Schink. February 1980. 47 pp. This report presents the detailed U.S. mineral interindustry transactions table for 1967 showing the 47 mineral subindustries along with the RAS updated tables for 1972 and 1977. The principal features of the updating technique and the data and procedures used are discussed. The output multipliers and types I and II income and employment multipliers are calculated and presented comparatively for each of the interindustry tables. Research done under grant G0155111 by Dry Lands Research Institute. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225898; paper copy price code A03.

OFR 73–81. Evaluation of Lixiviation of Mine Wastes, by K. L. Bainbridge, M. A. Wilkinson, and B. M. Mahar. December 1980. 239 pp. 12 figs. This report describes the results of a study to determine which types of, and to what extent, mining wastes can contaminate ground water through leaching of acid-forming or potentially toxic constituents. The primary focus of this study was on coal mining wastes, especially overburden spoils and preparation plant refuse. In addition, the potential for contamination by leachates from clean coal stockpiles was also examined. The study ap-

proach included investigation of the amounts and geographic locations of mining wastes in the United States; the chemical character of mining wastes, especially with regard to potentially acid-forming or toxic constituents; and the extent to which acid and/or toxic components are leached from mining wastes by rainwater. To evaluate the leachability of coal wastes, a laboratory waste-leaching method was developed to specifically simulate the leaching process over a long term. Waste samples were also leached by the EPA extraction procedure and ASTM waste leaching method. Results of the three leach-test methods were compared to evaluate their relative capabilities to predict the leachability of mining wastes. Research done under contract J0199057 by Calspan Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222515; paper copy price code A11.

OFR 74–81. A Study of the Behavior of Underground Openings During Block Caving Operations, by Giovanni Barla and Stefon H. Boshkov. June 1979. 400 pp. 250 figs. This report describes studies of the influence of block-caving operations on underground openings, and attempts to correlate observed behavior with mathematical models developed to explain this behavior. The studies proceeded by obtaining in situ stress measurements and attempting to relate the measured stress to field conditions by finite element modeling. A principal objective was to develop the capability to predict ground movement based upon stress measurement and an appropriate model; however, predictive capability is strongly influenced by the proper choice of rock strength properties used in the model. Some conclusions in the report, particularly those relating to stress distribution in supports, are potentially useful to mine designers. For example, a delay in support installation and better control of undercutting could be beneficial during mining by the block-caving method. Research done under contract J0275005 by H. Krumb School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 75–81. The Electrochemical Characterization of Metallic Calcium, Strontium, and Barium Electrodes, by Robert T. Foley and W. Timothy Adams. Sept. 30, 1980. 13 pp. The objective of this study was to evaluate the feasibility and economic potential of using the alkaline earth metals, calcium, strontium, and barium, in electrochemical cells. After searching the literature for reported research, and considering well-known properties of these metals, it was concluded that the metals are attractive for electrode uses based upon their physical and chemical properties, but not attractive from electrochemical considerations. Both aqueous and non-aqueous electrolytes were evaluated in the study. Research done under contract J0199022 by American University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 76–81. Data Security for In-Mine Transmission. Final Report—Part I, by Jon G. Bredeson, Jeffery L. Kohler, and Harvinder Singh. February 1981. 111 pp. 33 figs. The electromagnetic noise that exists in a mining environment is quite severe and has been reasonably well-documented by a number of resarchers. The noise level is such that prudent communication design requires the careful use of all the electromagnetic noise data available. A comprehensive survey was undertaken to determine techniques used in various industrial environments to achieve secure communications in the presence of electromagnetic interference. Several communication systems intended for use in a mining environment were examined, and the bit error rate as a function of distance was mathematically determined and plotted. The data communication protocol for these communication systems was examined and the probability of an undetected error versus distance was mathematically determined and plotted. The burst error detection capabilities are analyzed and presented. Conclusions and recommendations are presented for different communication systems, and significant mathematical developments and background information is included in the appendices. Research done under contract J0308024 by University of Oklahoma. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-221988; paper copy price code A06.

OFR 77–81. A Model for the Determination of Flyrock Range as a Function of Shot Conditions, by Julius Roth. Apr. 16, 1979. 97 pp. 19 figs. Flyrock is the source of most of the injuries and property damage in a majority of blasting accidents in surface mines. A quantitative correlation between shot conditions and maximum flyrock range can be used to define a blasting area in which no personnel or equipment should be present during a shot. The approach used was to develop a model that correlates shot conditions and initial flyrock velocities and permits computation of flyrock range from ballistic trajectories. The Gurney formula for velocity of explosively propelled plates or fragments was adapted to explosively propelled flyrock from vertical rock faces or from bench tops. The modified Gurney formula was then calibrated with measured flyrock velocities from mining and ex-

plosives literature. Charts were then developed for possible field use that gives maximum flyrock range as a function of shot conditions. Research done under contract J0387242 by Management Science Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222358; paper copy price code A05.

OFR 78-81. Development of a Visual Display and Control System, by Arthur D. Little, Inc. October 1980. 31 pp. 6 figs. The object of this program was to extend the capabilities of visual paging systems both in size and functions in mines. The system developed uses the mine pager phone line for communication, monitoring, and remote control. A central station, using a minicomputer, transmits signals by phase inversion modulation of a 16,384-Hz carrier to as many as 999 remote units. The remote unit addressed returns an echo to indicate that it is functioning and, in the case of monitor units, to convey the monitor data. Magnetically latched display disks, which can be seen from both sides when posted, are used for visual paging. Lists of the addresses of posted pages, unanswered pages, and nonechoing units are prepared by the central station computer. The system was designed to be intrinsically safe and should operate for 3 months on a 12-volt lantern battery. Research done under contract J0177020. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of the Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222374; paper copy price code A03.

OFR 79-81. Coal Mine Hazard Detection Using Synthetic Pulse Radar, by James C. Fowler, Steven D. Hale, and Richard T. Houck. January 1981. 86 pp. 55 figs. The purpose of this project was to prove the feasibility of detecting hazards in a coal seam using a synthetic pulse radar. The work was conducted in three phases. The first was an analysis of the type of errors that might cause problems, the second was to build a breadboard radar, and the third was to conduct a field test with the system. The work from each phase is discussed and the results of the field test are presented. The results show propagation of the radar signal through 200 feet of coal along with reflections from 50 feet away. The final section contains recommendations for future development. Research done under contract H0292025 by ENSCO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-224412; paper copy price code A05.

OFR 80(1)-81. Selective Interburden Handling Techniques. Volume I—Summary, by Robert L. Lappi and George M. Smrikarov. September 1980. 125 pp. 21 figs. Eight interburden handling concepts are developed for multiple seam area mine stripping operations in central and western United States. They are based on data gathered and analyzed during field surveys, literature reviews, and visits to State regulatory agencies in five States. It is concluded that improvement of reclamation practices through selective interburden handling techniques is possible at lower operating costs than currently incurred. Specific multiple seam mining systems are discussed in this report. Research done under contract J0285025 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-221905; paper copy price code A06.

OFR 80(2)-81. Selective Interburden Handling Techniques. Volume II—Appendices, by Robert L. Lappi and George M. Smrikarov. September 1980. 321 pp. 44 figs. A summary of the major findings of the literature survey for interburden handling concepts are presented. Literature pertaining to mine practices in multiseam strip mining operations were reviewed. The survey covered two coal regions: the Western coal region with emphasis on the Northern Great Plains coal province and the Interior Central coal region with emphasis on the tri-State area of Illinois, Indiana, and west Kentucky. Previous works on multiseam mining and selective handling techniques were identified and evaluated. The effects of the current proposed State and Federal surface mining laws on alternative interburden handling techniques employed in the Western and Central coal regions are discussed. Research done under contract J0285025 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-221913; paper copy price code A14.

OFR 81(1)-81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume I, by Rudolf E. Greuer. June 27, 1979. 85 pp. This report contains the practical application of a computer program for the simulation of ventilation

systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume I describes the program. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 81(2)–81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume II, Figures and Tables, by Rudolf E. Greuer. June 27, 1979. 182 pp. 45 figs. This report contains the practical application of a computer program for the simulation of ventilation systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume II comprises figures and tables for appendixes A and B. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 81(3)–81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume III, Figures and Tables, by Rudolf E. Greuer. June 27, 1979. 215 pp. 30 figs. This report contains the practical application of a computer program for the simulation of ventilation systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume III comprises figures and tables for appendixes C through E. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 82–81. Proceedings of the Fifth WVU Conference on Coal Mine Electrotechnology, July 30–31, August 1, 1980, ed. by Nelson S. Smith. October 1980. 396 pp. 209 figs. This report is a compilation of papers presented at the 5th West Virginia University conference on coal mine electrotechnology in Morgantown, W. Va., July 30–31 and August 1, 1980. The papers cover areas of electromagnetic-power systems, power systems, monitoring and control, and communications. Research done under contract J0100049 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 83–81. 1979 Bureau of Mines Sampling Sites and Analytical Results for Samples Collected in the Chugach National Forest, Alaska, by Uldis Jansons. 1981. 229 pp. 6 figs. The Bureau of Mines and the U.S. Geological Survey are conducting a mineral resource-reserve evaluation of the Chugach National Forest as part of an interagency resource evaluation under Roadless Area Review and Evaluation (RARE II) aegis mandated by the National Forest Management Act of 1976 (Public Law 91-190). The area was sampled extensively by the Bureau in 1979 and sample site locations and analytical results are presented in a computer listing and five maps. The samples were analyzed in Anchorage, Alaska, and Wheat Ridge, Colo., by commercial laboratories using standard techniques. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 84–81. In-Situ Leaching Studies of Uranium Ores—Phase V, by D. C. Grant. May 1980. 593 pp. 92 figs. In situ uranium leaching involves passing a lixiviant and oxidant solution through the uraniferous ore body. As the solution progresses through the ore body, the uranium is oxidized to a soluble state and taken into solution. The uranium-laden solution is removed from the ore body and the uranium is recovered in a plant on the surface. In this study, a laboratory technique for simulating the underground leaching process was developed and used to determine the effects of leaching variables on the permeability, uranium recovery, and ore-aquifer environment. Agitation and column leach tests were conducted using ore samples from Wyoming and Texas. The information obtained from these tests provides a better understanding of the leaching process. Research done under contract H0262004 by Westinghouse Electric Corp. R & D Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.;

and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS, PB 81-222739; paper copy price code A25.

OFR 85–81. Hazardous Surface Openings to Abandoned Underground Mine—Nevada, by W. G. Freeman, R. M. Jones, J. G. Babcock, M. L. Christo, and R. A. Noel. June 1980. 747 pp. 57 figs. The purpose of this study was to gather a representative sampling of underground mines in various counties in the State of Nevada and to determine which of these mines had openings representing a hazard or threat to the general public. Based on the selection of 157 target mining districts, 200 inactive mines were selected and visited as a representative sample. The sample was categorized and listings were made by county, type of opening, degree of risk associated with the opening, and the closure method recommended. Each mine site was photographed and the name, location, commodity, historical and geologic value, future mining potential, and degree of hazard was recorded. Laws, regulations, and ordinances pertinent to closure of inactive mines were researched and summarized. It was concluded that permanent mine closure is seldom desirable; low cost, easily installed closures of a semipermanent-to-temporary variety are most appropriate; and sufficient legal mechanisms exist to protect the public if and when applied. Research done under contract J0295039 by International Mining Consultants, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223414; paper copy price code A99.

OFR 86(1)–81. Recommended Guidelines for Oxygen Self-Rescuers—Volume I, Underground Coal Mining, by D. Randolph Berry and Donald W. Mitchell. June 1981. 52 pp. 4 figs. The Bureau of Mines awarded a contract for the provision of recommendations on the safest, most practical methods for complying with new regulations requiring that all underground coal miners have a self-contained, self-rescuer (SCSR)—a device capable of supplying, in an emergency, 1 hour of self-contained oxygen (no breathing of mine air). This report presents information and recommendations that could be used during the early stages of nationwide compliance, especially in the areas of inspection, testing, and underground storage of SCSR's. This volume contains an executive summary, introduction, definitions, recommended guidelines for district managers and mine operators, and a storage plan checklist and sample form. Research done under contract J0199118 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-225872; paper copy price code A04.

OFR 86(2)–81. Recommended Guidelines for Oxygen Self-Rescuers—Volume II, Appendices, by D. Randolph Berry and Donald W. Mitchell. June 1981. 265 pp. 31 figs. This report comprises the appendixes that explain and document the recommendations for the guidelines for oxygen self-rescuers. The report covers (1) a discussion of the recommended guidelines, (2) worldwide use of oxygen self-rescuers, (3) hypothetical use of oxygen self-rescuers in post-1972 coal mine explosions and fires, (4) vibration testing of self-contained, self-rescuers (SCSR's), (5) testing of in-service SCSR's, (6) discussions with representatives of underground coal mining, (7) recommendations for SCSR storage containers, (8) example SCSR storage plans, (9) testing of in-service compressed oxygen SCSR's, and (10) 30 CFR 75.1714, 30 regulations pertaining to self-rescuers. Research done under contract J0199118 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-225880; paper copy price code A12.

OFR 87–81. Development and Demonstration of Improved Truck Ladders, by G. Gavan, P. Mate, D. Strassel, and K. Conway. Sept. 28, 1979. 335 pp. 178 figs. Analysis of reported injuries for off-highway haul trucks indicated that 42.7 pct were slip and fall, and of these, 34.1 pct occurred mounting or dismounting the machine. Redesign of the lower steps was concluded to provide the most overall improvement for increased safety and accident reduction. Various existing, innovative, and conceptual designs were reviewed and evaluated. The most promising designs were the four-spring-supported lower steps and the center-tube-mounted lower steps. Both steps proved to be viable designs by passing human factors and survivability tests conducted at a large copper mine. Research done under contract H0282001 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223406; paper copy price code A11.

OFR 88–81. Evaluation of Intrinsically Safe Instruments and Apparatus for Use in Underground Coal Mines, by J. M. Kurtz, A. A. Bartkus, and P. J. Schram. May 1980. 479 pp. 22 figs. Ten methane monitoring systems and machine control circuits were examined and tested according to the requirements in CFR Title 30, Parts 17 and 27, the Standard UL 913, and the document "Test Requirements for Instruments or Apparatus to be Considered for M.E.S.A. Intrinsically Safe Certification (Tentative)." The test results indicate that none of the products complied with all parts of all requirements as interpreted. Research done under contract J0188046 by Underwriters Laboratories Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin

Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 89–81. Mineral Land Assessment of the West Portion of Western Chichagof Island, Southeast Alaska, by J. C. Still and K. R. Weir. 1981. 168 pp. 90 figs. During 1978–79, the Bureau of Mines surveyed the mineral potential of the west portion of western Chichagof Island as part of the examination of the western Chichagof and Yakobi Islands wilderness study area, Tongass National Forest, Southeast Alaska. The study included literature and claims records searches; field examinations of the reported mines, prospects, or claims; and field evaluation of geochemical anomalies noted by the U.S. Geological Survey during concurrent investigations. Two mineralized areas were found. One, called the Slocum Arm molybdenum area, is estimated to have moderate potential for the development of porphyry or vein-type molybdenum deposits. The other, called the West Coast gold area, is estimated to have moderate potential for the development of fault controlled gold-silver lode deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 90–81. Silencing the Flame Channelling Process, by James A. Browning. Feb. 27, 1980. 32 pp. 15 figs. Conventional flame channeling operates continuously at over 120 db—flame drill channeling operates at a maximum of 95 db. The latter process was developed under this program. Individual drill holes are spaced to leave narrow rock webs. Sound and dust passing from the holes are effectively treated by a muffler and water injection. Research done under contract H0387017 by Browning Engineering Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–221996; paper copy price code A03.

OFR 91–81. Recovery of Heavy Metals From High Salinity Geothermal Brine, by Eldon P. Farley, El Lorraine Watson, Digby D. MacDonald, Robert W. Bartlett, and Gopala N. Krishnan. December 1980. 130 pp. 48 figs. Large quantities of high salinity geothermal brine from the Salton Sea Geothermal Area, Calif., contain significant amounts of Pb, Zn, Fe, and Mn. A simple method of treating large volumes of spent brine is required to economically recover the valuable nonferrous metals. Results from a 2-year laboratory investigation of sulfide precipitation are discussed, including the condition for achieving maximum precipitation of the valuable heavy metals while minimizing precipitation of Fe and Mn, which have little economic value. In the first year, the study was initiated and guided by computer thermodynamic modeling. The second year has been devoted to the operation and optimization of the sulfidation process at a continuous bench scale. Research done under contract J0188076 by SRI International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–222218; paper copy price code A07.

OFR 92–81. Manpower and Training Model for the Mining Industry, by David Siedenstrang, Dwight Ellingwood, and John Short. April 1980. 219 pp. 18 figs. This report was prepared to illustrate a model for projecting employment and training demands in the coal mining industry. The report details a methodology developed to translate forecasts of regional coal production and mining productivity into estimates of training incidences necessary to meet both the MSHA safety regulations and internal skills training demands. The model is responsive to estimates of employment turnover and the job mobility of the coal mining work force as configured from a summarization of job histories of approximately 15,000 miners collected during a mine site assessment of 47 coal mining operations located throughout the Nation. In addition, historical production, productivity, and employment data are examined for the metal and nonmetal mining industries and projections of safety-related training demands are presented. Research done under contract J0357109 by John Short & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–222325; paper copy price code A10.

OFR 93–81. Development and Evaluation of Polymer Modified Portland Cement Concrete Lagging for Mine Openings, by R. D. Eash and H. W. Kirchner. Oct. 1, 1980. 127 pp. 38 figs. This report presents results of a study to develop and test a Saran latex modified portland cement concrete lagging to be used as a replacement for wood lagging in underground mining. Two hundred and twenty latex modified concrete lagging were produced and shipped to the Bunker Hill Co. in Kellogg, Idaho. for installation in their mine at the 17th level. The lagging are performing satisfactory after 22 months of exposure in the mine. The Dow concept replaces wood systems by using reinforced latex concrete which outperforms and outlives wood systems, is

more cost effective, and is completely nonflammable. Research done under contract H0262046 by The Dow Chemical Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223331; paper copy price code A07.

OFR 94(1)-81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 1 Through 4), by Michael Rieber, Robert Fuller, and Benjamin Okech. January 1981. 362 pp. 1 fig. This study develops the data base and an economic analysis of the primary sectors prerequisite to the regional projection of the supply side of the U.S. sulfur industry. The probable future course of sulfur pollution and process control in the United States and elsewhere as it impacts, by the production of sulfur values, the domestic Frasch industry, is estimated. A regional determination of the present and future U.S. sulfur supply market is presented. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222796; paper copy price code A16.

OFR 94(2)-81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 5 Through 7), by Michael Rieber, Roger Fuller, and Osmario Dellaretti. January 1981. 189 pp. Sulfur recovery from domestic sour natural gas and petroleum refining is estimated on a current basis and projected to the mid-1990's on a regional basis. The former depends importantly on gas production projections for the Overthrust Belt and the associated H_2S. The latter depends largely on projected increases in the sulfur content and weight of imported crude oils, total crude oil imports, and anticipated refinery response. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222804; paper copy price code A09.

OFR 94(3)-81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 8 and 9), by Michael Rieber, Benjamin Okech, and Roger Fuller. January 1981. 262 pp. Sulfuric acid production from sulfur-based acid plants and smelters is analyzed. Industry competition, with particular emphasis on voluntary versus abatement acid, is reviewed. Regionally, even though smelter acid is geographically limited, competition is at least moderate. Production costs for both acid plants and smelters are estimated. Due to the byproduct nature of the latter, assigned costs and acceptable producer price are much the lowest. Large-scale users will prefer sulfur-based acid production if the heat value of the reaction can be utilized as a steam credit. Additionally, voluntary acid is a more stable supply source than smelter acid. Voluntary acid output is a reaction to price and demand conditions. Abatement acid production depends on APC implementation and the state of the relevant metals markets. Even if copper, lead, and zinc output remains at current levels, if current EPA regulations are implemented, acid output will approximately double. An output forecast is made based on APC regulations, implementation, and estimated metals production. As a direct competitor to U.S. acid and as indirect competitors to Frasch sulfur, Canadian and rest-of-world acid output is reviewed. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222812; paper copy price code A12.

OFR 94(4)-81. Sulfur Pollution Control. Phase II. The Impact of Stack Gas Cleanup on the Sulfur Mining Industry of Texas and Louisiana, by Michael Rieber, James M. Barker, and Michael Worrall. January 1981. 114 pp. 5 figs. The impacts of various (reduced) levels of Frasch sulfur production on the States of Texas and Louisiana are analyzed. The analytic time basis is 1979. Industry labor and output characteristics are developed on a company and mine basis. State and local impacts (to the level of independent school districts) are developed on a scenario basis. The measures include income, unemployment, and taxes. Some data are presented on energy and water use. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222820; paper copy price code A06.

OFR 95-81. A Computer Program To Estimate Costs for Process Evaluation, by P. L. Placek and D. A. Elkins. March 1981. 233 pp. 14 figs. This report presents a computer program for cost estimation to evaluate many types of metallurgical and chemical processes. The program provides a convenient means of obtaining comparative costs for frequent process modifications needed to guide research. Estimation of overall process and unit operation costs call attention to sources of high cost that need further study. All costs except those for and factored from direct labor are scaled by material balance data so that effects of changes in the process flowsheet or in plant capacity can be determined easily. The report includes a description of the main routine, subroutines, and data cards needed and includes examples of computer output, a diagram of the program, and listings of all routines Research done by Salt Lake City Research Center. Available for reference at Bureau of Mines facilities in Salt Lake City, Utah, and Avondale, Md. Copies of this report will not be available for purchase.

OFR 96-81. Conceptual Designs of Retaining Structures for Open Pit Backfilling, by Serge Rudchenko, Ramon Upsahl, John P. Ashby, and G. A. Mathieson. February 1981. 170 pp. 71 figs. This report presents a study to determine the potential use of retaining structures in open pit backfilling. The report contains the results of research and review

of an open pit mine environment, mine waste disposal, and past and current use of retaining structures. The development of specific structures, the culvert-tunnel concept, and an anchor block retaining concept are included. In addition, the cost benefit of retaining structures used for in-pit backfilled waste is presented. Research done under contract J0205003 by Skilling, Helle, Christiansen, Robertson, Inc., and Golder Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md. Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225799; paper copy price code A08.

OFR 97–81. Market Instability in the Metal Industries, by John E. Tilton and William A. Vogely. September 1980. 191 pp. 7 figs. This study examines the underlying factors responsible for market instability in the metal industries; considers recent trends in inventory behavior and business cycle fluctuations that suggest instability is growing more severe; and investigates the consequences of instability for various metal markets, for investment in new mines and processing facilities, and for U.S. imports of mineral commodities. Research done under contract J0188044 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 98–81. Study of Respirable Dust Outby the Working Face of a Coal Mine, by R. L. Rankin and S. J. Rodgers. Mar. 31, 1980. 180 pp. 33 figs. The objective of this investigation was to conduct surveys of respirable dust concentrations in coal mining operations at locations outby the working face. The results of these surveys were directed toward (1) identifying outby dust sources, (2) evaluating the severity of the major dust sources, (3) establishing dust sampling frequency, (4) establishing dust sampler locations, and (5) assessing the areas of influence of the dust sources. The study included dust sampling of only nonhigh-risk personnel and areas at six different mines. Thirteen continuous mining, four longwall, and two conventional mining sections were sampled. The severity of outby respirable dust sources such as load points, runways, dump points, beltways, transfer points, and main haulage operations were characterized and areas within the mine ranked according to severity. Information on engineering controls was also acquired. Guidelines for implementing a dust sampling program are presented and include sampler locations, ventilation surveys, dust surveys, effects of shift-to-shift variations, and sampling frequency. Research done under contract J0366022 by MSA Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236762; paper copy price code A09.

OFR 99–81. Development of a Through-the-Earth Monitor System, by Arthur D. Little, Inc. December 1980. 31 pp. 7 figs. The objective of this program was to design and build a self-contained system for remote monitoring of the atmosphere in mines. The system developed uses the mine pager phone line as the primary communication channel and also has the capability of using 208 Hz in the ELF band for wireless transmission through the band. The depth for through-the-earth transmission is expected at about 80 to 90 meters in high conductivity soil and is limited by the noise level in the ELF band-pass filters. The underground components of the through-the-earth monitor system are energized by mine power through a battery charger-storage battery power supply. In the event of mine power failure, the battery capacity is more than sufficient for 1 week's operation with interrogations every 4 hours. Research done under contract H0177098. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237646; paper copy price code A03.

OFR 100–81. Development of Noise Control Technology for Pneumatic Jumbo Drills, by D. L. George and N. J. Matteo. November 1980. 61 pp. 19 figs. The objective of this program was to investigate, design, develop, and demonstrate noise control techniques that could be designed into new jumbo drills. Techniques used in this program were an isolated drill guide, damped acoustical enclosure, standard mufflers, and a specially designed silencer for the air egress of the enclosure. Conventional mufflers were used for the feed and rotational motor exhausts. The Ingersoll-Rand VL-120 drill with a standard UDM-14 slide were used as the test and development subjects. An enclosure was developed that encompassed the drill and slide, and at the same time did not interfere with performance or ease of operation. Standard construction materials were utilized throughout the program. Sound pressure levels of the unit as-received were 113 dbA at the operators position, and 101 dbA at a 7-meter location. After all of the noise reduction techniques had been implemented, the sound pressure levels were 102 dbA at the operators position, and 87 dbA at a 7-meter location. A conceptual design for an improved quiet drill is also presented. Research done under contract H0395029 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National

Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237414; paper copy price code A04.

OFR 101-81. Modifications Made to an Interactive Computer System for Evaluating Coal Mine Illumination, by Robert Goldstein. August 1980. 27 pp. 6 figs. A computer system for calculating the illumination on coal mine surfaces due to machine-mounted lights is described. Utilizing numerical models of mining machinery and measured data on luminaire output characteristics, the program computes the foot-candle levels incident on the mine surfaces. Shadowing effects of the machine are taken into account. The system operates, interactively from a Tektronix 4014 graphics terminal that handles all input-output functions. The software is installed on a Cyber 74 computer that communicates with the terminal by a telephone line. Several modifications to the system are described, the most important of which provides the ability to analyze surface mine lighting. Research done under contract H0282038 by Mathematical Applications Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-236754; paper copy price code A03.

OFR 102-81. An Assessment of Thin Seam Mining System Technology, by J. Clark and J. H. Caldon. July 1980. 379 pp. 55 figs. The objective of this study was to determine the state-of-the-art in underground, thin-seam mining systems, to identify new technology and procedures that would reduce the hazards in thin-seam mining, and to recommend areas for further research. The study was carried out in two phases, the first was devoted to a survey of authoritative literature. The practices adopted in various mining countries were analyzed and comparisons made to identify machines and methods with the potential for application in the United States. Published figures on U.S. bituminous coal reserves show the high proportion contained in thin seams and U.S. accident statistics demonstrate that the risk is greater in thin-seam operations. A comparison was made with the experiences of foreign operations. The second phase proceeded along two separate avenues to examine the distinctive problems associated with seam thicknesses above and below 30 inches. Current systems of mining appropriate to seams greater than 30 inches were elaborated and compared by a simulation exercise in terms of safety, production, and cost. For seams below 30 inches, less conventional systems, some presently disused, were studied and their potential evaluated; the research and development work necessary to make them viable are indicated. Research done under contract J0199122 by British Mining Consultants Ltd., Enfield, Middlesex, United Kingdom. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237455; paper copy price code A17.

OFR 103-81. Development of Tests and Criteria To Evaluate Grounding Systems, by Wils L. Cooley and Robert L. McConnell. November 1980. 176 pp. 77 figs. This report covers several aspects of mine safety ground systems, primarily for underground coal mines. The design of a combined ground fault-ground check monitoring system is presented. An analysis is made of grounding systems for dc shuttle cars. Complete resistance data and results of physical inspections of self-salting ground rods are presented. A detailed resistance and economic analysis is presented for the use of composite materials for building inexpensive and effective ground beds in high-resistivity areas. The desirability of penetrating the coal seam with a borehole safety ground is investigated. A report is made of a mine substation grounding and bonding workshop. Research done under contract J0199116 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-238354; paper copy price code A09.

OFR 104-81. Study To Determine the Feasibility of Man-Trip Training. Phase I Report, by Daniel R. Walton, Patricia F. Webb, and William T. Liggett. Jan. 23, 1979. 182 pp. 58 figs. This report presents a study to explore the potential of utilizing the transport time required to move coal miners to and from working sections. Consideration was given to all forms of training and presentation media, taking into account such environmental factors as noise, dynamic interferences, visibility, physical constraints, and contaminants. Indications of management and worker attitudes toward worker-trip training were also assessed. The final product was a proposed prototype training system for worker-trip training. Research done under contract J0188032 by Management Engineers, Inc., and Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburg, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237471; paper copy price code A09.

OFR 105-81. Development of a Personal Monitoring Field Kit for NO_2 and NO, by MDA Scientific, Inc. Jan. 30, 1981. 22 pp. 9 figs. A complete field kit for performing onsite determinations of individual employee time weighted average (TWA) exposures to nitrogen dioxide (NO_2) and nitric oxide (NO), has been developed. This report provides background information and experimental data validating the use of the kit with confidence to ± 10 percent accuracy. Research done under contract

H0387019. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237406; paper copy price code A02.

OFR 106-81. A Training Program for Conventional and Raise Drill Shaft Construction Personnel, by J. Bongarra, Jr., W. Carswell, K. Golas, E. Shriver, S. Shriver, and C. Condon. July 1979. 414 pp. 50 figs. This report describes the development of the instructional design and content of a training program for shaft construction miners and supervisers. The recommended training approach is based on the results of needs, tasks, and competency analyses of jobs performed by conventional shaft sinking and raise drill personnel. Learning objectives were derived from the task analyses and the appropriate training delivery system was chosen using a selection technique that employed learning algorithms. The training is directed toward improving the safety and efficiency of constructing shafts by new hired and experienced miners and supervisors. A self-paced, self-teaching, modular approach to training, using criterion-referenced tests was proposed. Training requirements for conventional shaft sinking and raise drilling were described. Training program content was detailed in the form of module and lesson design approaches. The report also recommends a method for developing, implementing, and validating the training program. Research done under contract J0387227 by Kinton, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg, Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237372; paper copy price code A18.

OFR 107-81. Proceedings of the Fourth WVU Conference on Coal Mine Electrotechnology, August 2-4, 1978, ed. by M. Dayne Aldridge. Oct. 1, 1978. 521 pp. 231 figs. This report is a compilation of papers presented at the 4th West Virgina University Conference on Coal Mine Electrotechnology in Morgantown, W. Va., on August 2-4, 1978. The papers cover areas of electric power, electronic communications, detection and location of trapped miners, and electronic sensors and monitoring systems. Report prepared under contract J0188034 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 108-81. Development of a Portable Gas Analyzer for In-Mine Personnel Monitoring, by Edward A. McClatchie and Irvin G. Burough. Aug. 15, 1980. 129 pp. 44 figs. Based on a pressure-modulated absorption technique, a novel nondispersive electrooptical gas analyzer has been designed, fabricated, and tested. Key features of this new gas analyzer technique include long-term zero and calibration stability. The technique was investigated for carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and nitrogen dioxide (NO_2). The analyzer was capable of measuring the three species CO, CO_2, and NO_2. It is a compact (300 cu in) package, is battery powered, and weighs 15 lb. Approximately 30 readings of each gas may be made on a single battery charge. Operating principles and performance data are included in the report. Research done under contract H0230050 by Andros Analyzers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-236770; paper copy price code A07.

OFR 109-81. Recovery of Metal Values Prior to Reclamation of Mined Areas in the Southwest, by David D. Rabb. June 30, 1980. 49 pp. 3 figs. The objective of this investigation was to determine the feasibility of recovering precious metals from abandoned mine dumps in Mohave County, Ariz. Thirteen mine dumps and/or tailings ponds were sampled in the vicinity of Oatman, Ariz. Analysis of 39 samples showed that two sites had sufficient gold and silver to merit metallurgical testing. Cyanide heap leaching tests showed that about 30 percent of the precious metals could be extracted in 10 days from either site. Lime and cyanide consumption were low. It was concluded that extraction might be economically feasible. Research done under contract J0295023 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.: and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-236796; paper copy price code A03.

OFR 110-81. Chromium Substitution in Stainless Steels, by S. Floreen. November 1980. 80 pp. 15 figs. A series of vacuum-melted austenitic stainless steels were investigated that contained zero to 18 percent Cr and additions of Mo, V, Cu, Si, Al, Mn, or N. The corrosion resistance was evaluated in a number of environments. The results indicate that it is feasible to develop a stainless steel containing approximately 9 percent Cr along with additions of Mo and possibly Cu and V that would have corrosion resistance comparable to 18 percent

Cr steels in less severe environments. The mechanical properties, fabricability, and weldability of such an alloy would be acceptable. Research done under contract J0295070 by Inco Research and Development Center, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-235475; paper copy price code A05.

OFR 111(1)-81. Analysis of Work Areas and Tasks To Establish Illumination Needs in Underground Metal and Nonmetal Mines. Volume I of II, by W. H. Crooks, K. L. Drake, T. J. Perry, N. D. Schwalm, B. F. Shaw, and B. R. Stone. Sept. 18, 1980. 254 pp. 55 figs. The objective of this study was to identify the characteristics of underground jobs and work locations in metal and nonmetal mining to determine the illumination needs and to suggest improvements for safety. Four analyses were conducted: (1) onsite measurement and evaluation of underground work sites, (2) task analysis of underground jobs, (3) laboratory analysis of the gonioreflectance of rocks and minerals from sampled mines, and (4) identification and analysis of the accidents and the employment distribution of this industry. The report describes the illumination characteristics of the underground jobs and locations and suggests that illumination needs are primarily determined by the tasks being performed. Research done under contract J0387230 by Perceptronics, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-236804; paper copy price code A12.

OFR 111(2)-81. Analysis of Work Areas and Tasks To Establish Illumination Needs in Underground Metal and Nonmetal Mines. Volume II of II: Appendices, by W. H. Crooks, K. L. Drake, T. J. Perry, N. D. Schwalm, B. F. Shaw, and B. R. Stone. Sept. 18, 1980. 239 pp. 19 figs. The objective of this study was to identify the characteristics of underground jobs and work locations in metal and nonmetal mining to determine the illumination needs and to suggest improvements for safety. Four analyses were conducted: (1) onsite measurement and evaluation of underground work sites, (2) task analysis of underground jobs, (3) laboratory analysis of the gonioreflectance of rocks and minerals from sampled mines, and (4) identification and analysis of the accidents and the employment distribution of this industry. Volume II contains the appendices. Research done under contract J0387230 by Perceptronics, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-236812; paper copy price code A11.

OFR 112-81. Evaluation of Proximity Warning Devices. Phase II, by T. C. Green, J. P. Cater, and J. H. Nixon. Feb. 13, 1981. 40 pp. 14 figs. A two-phase program evaluated commercial proximity warning devices and then served to design and develop an automatic electrostatic field strength measurement device with improved performance. The phase I program consisted of test and evaluation of three commercial proximity warning devices, all of which operate on the principle of electrostatic field intensity measurement for determining proximity to high-voltage powerlines. Performance testing of these devices utilized full-scale cranes and powerline systems and a scale-model facility. Under the phase II program, a microprocessor-based data acquisition system was designed and developed to collect and measure field strength at distributed points around the crane boom. This unit measures the field strength about a crane boom using 17 distributed sensors. Keyboard control is provided for the equipment operator. Measured field strength values are displayed on a line printer and recorded on magnetic tape. Laboratory testing of this unit demonstrated performance characteristics and field strength measurement accuracy within the design goals. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-237513; paper copy price code A03.

OFR 113-81. The Spontaneous Heating of Coal and the Role of Moisture Transfer, by J. B. Stott. July 1980. 78 pp. 26 figs. This report describes the occurrence of spontaneous heating in an 800-metric-ton heap of Wyoming coal. The major part of the report deals with the oxidation of Pittsburgh seam and Wyoming subbituminous coal and describes an experiment in which 1 metric ton of Wyoming coal is stored in a 5-meter-long insulated container while air is passed through. Temperature rises, rates of oxygen absorption, and gas compositions of the air stream are measured. The report relates the results of the experiments to a theory of spontaneous heating, which stresses the importance of the moisture content of coal and the relationship between the heat necessary to evaporate water to the heat available from coal oxidation. Research done under contract J0395146 by University of Canterbury, Christchurch, New Zealand. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; U.S. Department of

Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 114–81. Coal Waste Dewatering Systems, by Stanley P. Jacobsen, William Roushey, and Earl L. Rau. Feb. 6, 1981. 133 pp. 16 figs. Samples of fine coal refuse were obtained from 11 coal preparation plants throughout the United States. The samples were characterized by ash analysis, particle size, and mineral composition. From the characterization, geographical locations, and the dewatering equipment being used by the plants, five sites were selected for obtaining bulk fine refuse samples. The selected coal preparation plants were used for final dewatering thickeners followed by a vacuum disk filter, a filter press, a belt press filter, a centrifuge, and a settling pond. None were using thermal drying. The moisture content of the final cake ranged from approximately 23 to 50 pct, depending upon the feed material, flocculant addition, and the type of equipment. The filter press gave the lowest moisture content followed by a belt press and then either a centrifuge or vacuum filter. The centrifuge products were all dried to an approximate 5-pct moisture in a thermal dryer. Research done under contract J0205012 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–244501; paper copy price code A07.

OFR 115–81. Continued Research on Combined Fire/Rot Retardant Treatment for Wood Mine Timber, by William H. Holley. October 1980. 81 figs. Thirteen additional preservative-fire retardant systems were applied to Ponderosa pine and evaluated for flammability both before and after water leaching. The more promising four systems were given a thorough evaluation for flame spread, toxic gas and smoke density levels, resistance to decay, and compressive strength. The most promising system on the basis of history of usage in the mine, ease of application, and low cost as well as overall performance is the Fyreprufe-ACC Albi 107A-144 combination. A survey of inspection tools and instruments, identified equipment that could be assembled into an inspection kit for use in determining the extent of decay and/or impregnant retention levels in mine timber. A literature search identified those high fire hazard areas found in a typical mine. Timber and other wooden structures used in such areas should be treated with an acceptable fire-retardant system. A survey of insurance companies revealed that the use of such treated timber in the mines would probably have little or no impact on the rate structure. Research done under contract J0166068 by Springborn Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–244493; paper copy price code A05.

OFR 116–81. Tape Recording and Triggering Systems, by Kenneth R. Sites and Lawrence A. Millonzi. June 7, 1980. 16 pp. 2 figs. Under this program two tape recording and triggering systems were developed and delivered for use in the Bureau of Mines microseismic program. The systems are designed to improve the effectiveness of the Bureau-owned Sangamo 3500 series and SABRE VI instrumentation tape recorders. The system is designed to capture random microseismic data, digitize and temporarily store these data, start the tape recorder, and then transfer the data to magnetic tape for permanent storage. The system is designed to pack data on tape such that the tape may be simply played back through galvo drivers onto an oscillograph such that a continuous series of analog records, with corresponding time of day information, are reproduced without excessive oscillograph paper waste or the need for the operator to search for valid events. Research done under contract H0282026 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–243248; paper copy price code A02.

OFR 117–81. Application of a Hydraulic Borehole Mining Apparatus to the Remote Extraction of Coal. Interim Report, by John B. Cheung, George H. Hurlburt, Lowell E. Scott, and Scott D. Veenhuizen. September 1976. 87 pp. 52 figs. This report presents the results of a program to demonstrate the technical feasibility of hydraulic borehole coal mining. The hydraulic borehole method of coal mining involves inserting a hydraulic mining device into a borehole that has been drilled from the surface into the underground coalbed. The borehole mining device issues a jet of water under high pressure, which breaks the coal. The pieces of coal and water form a slurry that flows to the base of the borehole where it is pumped to the surface. Phase I of the program encompassed the design, fabrication, and factory-testing of a hydraulic borehole mining device. The program was successfully completed at the Wilkeson-Carbonado Coalfield near Wilkeson, Wash. The technical feasibility of hydraulic borehole coal mining was demonstrated by mining 32 tons of coal at a depth of about 75 feet over a period of 4 hours. Research done under contract H0252007 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and

Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 118–81. Field Test of Deep Cutting Double Arm Shearer, by Jonathan E. Ludlow. March 1981. 159 pp. 53 figs. A field test was conducted to demonstrate the deep cutting principle in relation to the creation of airborne respirable dust when longwall mining with a double-ended, ranging drum shearer. The test was carried out on the 3 North longwall at the Quarto No. 4 Mine in Clairington, Ohio. Continuous recordings of dust levels were made at midface and near the tailgate on 27 shifts during which time 81 mining cycles took place. Drum speed and number of picks per line were varied systematically. At the midface position there was a strong association between drum speed and number of picks with the level of airborne respirable dust. Drum speed had a much stronger effect than the number of picks over the experimental range, since a halving of drum speed reduced dust levels by approximately 60 pct while removal of every other vane pick resulted in only a 20 pct reduction. At the tailgate position, however, neither effect was strongly apparent. A tendency for the slower drum speeds to be associated with reduced power consumption and higher haulage speeds (and therefore production rates) was also noted. It is recommended that longwall operators operate at the lowest available drum speed wherever possible. Research done under contract J0199092 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-246480; paper copy price code A08.

OFR 119–81. Retractable Bit System, by Walter W. Svendsen, Ronald E. Cozad, and John F. Hoffmeister. Dec. 20, 1980. 105 pp. 22 figs. A prototype retractable bit system was developed consisting of a one-piece replaceable diamond set bit, a modified core barrel, bit changing tools, and surface components that allow activation of the system. Drilling with the retractable bit system is conducted in the same manner as present core drilling, except when the bit becomes worn the bit is changed with the drill string left in the hole. The operations in changing the bit are similar to those required in changing inner core tube assemblies with the wireline cable. The prototype testing indicates that this retractable bit system is feasible. It has shown reasonable reliability, but an extensive research program will be required to determine if sufficient reliability and increased productivity can be achieved to justify development of the system as a commercial product. Research done under contract H0272004 by Longyear Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-104340; paper copy price code A06.

OFR 120–81. Rod Mill Grinding: Analysis of Size Reduction Kinetics and Material Transport, by Douglas W. Fuerstenau. July 1980. 33 pp. 9 figs. A detailed experimental study of breakage kinetics in a batch rodmill indicates that while the system is inherently nonlinear, the feed disappearance kinetics for the finer sizes and the coarser sizes at high holdups is well represented by first-order behavior. A linearized grinding model that results from the first-order Taylor's series expansion of the breakage rate expression was found to give good simulations of the mill product size distributions without recourse to any parameter improvement routine. Material transport through rodmills was evaluated by investigating the effect of operating variables on the holdup and residence time distribution of particulate solids flowing through the mill. Identical experiments performed in a continuos ballmill helped delineate the fundamental differences in particulate transport through these two types of mills. Mechanistic interpretations of the observed transport phenomena are presented, and their implications in the context of tumbling mill analysis and design are emphasized. Research done under grant G0177144 by University of California. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-104357; paper copy price code A03.

OFR 121–81. Innovations for Explosionproof Electrical Enclosures, by R. J. Gunderman. April 1980. 209 pp. 80 figs. Explosionproof electrical enclosures for coal mine face equipment have been of the same basic design for many years without significant change. With the goal of improving safety, health, and productivity, characteristics for potential improvement were investigated through interviews, visits to mines, and studies. Areas identified for improvement included rapid venting of pressure buildup due to an internal explosion, quick and easy entry or removal of cable entrances, and a quick and easy cover removal for rapid component access. Concepts were identified and evaluated, and the more promising devices were fabricated and tested. Encouraging results from initial tests led to further design refinement and establishment of design guidelines. These design guidelines for a pressure vent and for an elastometric grommet-type cable entry are described along with the testing used. Research done under contract H0357107 by Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale,

Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–104936; paper copy price code A06.

OFR 122–81. Study of Air Compressor Hazards in Underground and Surface Mines, by Martin B. Treuhaft and B. Chope Dial. January 1981. 93 pp. 4 figs. This report analyzes air compressor hazards in mines and presents guidelines for eliminating fires, explosions, and other operational hazards that can result when compressors are used in coal and metal-nonmetal mining applications. Government data bases and reports for mine accidents are reviewed and analyzed. Foreign and domestic standards, regulations, and codes governing air compressor usage are discussed and compared. Industry trends toward air compressor usage are discussed and their impact on compressor safety is analyzed. Recommendations are directed toward MSHA, mine management, and the Bureau of Mines regarding their involvement in accident reporting and prevention. Research done under contract J0100006 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; Mining Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–105164; paper copy price code A05.

OFR 123(1)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume I. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 143 pp. 54 figs. The purpose of this program was to find the relationships that define the load-sorting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluation of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume I contains an introduction and detailed objectives of the report. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 123(2)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume II. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 48 pp. 18 figs. The purpose of this program was to find the relationships that define the load-sorting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separation in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume II contains a description of input data for computer program SAP-S. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 123(3)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume III. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 88 pp. 24 figs. The purpose of this program was to find the relationships that define the load-supporting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume III contains a study of the fully grouted resin roof bolt under traverse loading. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa.,

Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 123(4)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume IV. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 103 pp. 7 figs. The purpose of this program was to find the relationships that define the load-supporting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume IV contains appendix D, a listing of computer program SAP-S. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Administration, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 124(1)–81. Longwall Subsidence Case History Number 1: Northern Appalachian Coal Region, by Larry R. Powell. August 1981. 12 pp. 5 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This report presents data for a longwall mining operation in the Northern Appalachian coal region. Vertical displacements and relative face positions are tabulated for 110 subsidence monuments. Measurements were taken 12 times during the 8 months it took to mine the panel. Brief physiographic and geological descriptions of the mining site are presented along with a general account of the mining and subsidence monitoring methods. Research done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 124(2)–81. Longwall Subsidence Case History Number 2: Northern Appalachian Coal Region, by Larry R. Powell. August 1981. 12 pp. 2 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This report presents data for a longwall mining operation in the Northern Appalachian coal region. Vertical displacement and relative face positions are tabulated for 160 subsidence monuments. Measurements were taken 32 times during the 2 years it took to mine the 2 panels. Brief physiographic and geological descriptions of the mining site are presented along with a general account of the mining and subsidence monitoring methods. Research done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 125–81. Infrared Imaging Borehole Probe (Infrared Borehole Imaging Probe), by C. L. Davies and E. H. Izen. April 1980. 89 pp. 50 figs. A thermal imaging borehole probe was designed and fabricated to obtain thermal images, through smoke, of objects and people in underground mines. The effort was basically unsuccessful; electrical noise, and possibly thermal noise, interfered with the desired signals to the extent that spatial resolution in the images was unacceptable. Research done under contract H0377009 by Xerox Electro-Optical Systems. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 126–81. Evaluation of Control and Protection Circuits, by E. C. Strycula and D. A. Paice. April 1981. 50 pp. 21 figs. Solid-state equipment offers a number of potential advantages in the coal mining industry. These advantages can only be realized, however, through careful and judicious design of the control and protection circuitry. Problems relating to the interaction of solid-state equipment on the electrical system and the special design considerations that apply to solid-state circuitry are examined. Design guidelines are provided for solid-state applications in the areas of (1) equipment operated from a dc trolley wire, (2) drive systems for surface mining equipment, (3) ac motor starters, and (4) electromagnetic interference. Research done under contract J0308035 by Westinghouse

Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-105065; paper copy price code A03.

OFR 127-81. Surface Chemical Technology for Improved Wetting of Coal Dust, by Nathan Feldstein. February 1981. 50 pp. 11 figs. The wetting of coal dust by aqueous solutions of surface active agents (surfactants) has been studied. Thirty coals and typical surfactants were selected from typical classes of anionic, nonionic, and cationics for study. Of these three classes the practical use of cationics in aqueous solutions was eliminated because of the inherent negative Zeta potential charge of the representative coals. The wetting of the coals was examined by column flow, contact angle, and settling rate measurements. Results indicated that both anionic and nonionic surfactants are to be considered viable for use; low critical micelle concentration values are also preferred for the surfactants. Study of native waters showed substantial variation in properties, i.e., pH, calcium ion concentration, and conductance. pH variations were also noted to affect the effectiveness of selected surfactants. Combinations of nonionic and anionic surfactants have, in certain instances, produced synergistic enhancement in the coal wetting superior to the effectiveness of each surfactant alone. Research done under contract J0199050 by Surface Technology, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-104654; paper copy price code A03.

OFR 128-81. Evaluation of Diesel Equipment Deployment in Underground Coal Mines. Volume III: Analysis of Diesel Deployment Schemes, by R. V. Ramani and G. W. Kenzy. Dec. 31, 1978. 202 pp. 39 figs. Procedures have been developed that permit determining in either existing or new mines the optimum diesel equipment deployment schemes and the effect of diesel exhaust on mine air quality. Specifically, the following areas are covered in the report: (1) Description of diesel deployment schemes in four underground coal mines that were visited. (2) Description of the analysis procedure to determine the number of shuttle cars required to maintain maximum theoretical continuous miner (or loader) production rates in typical room-and-pillar mining systems and the exhaust contamination resulting from the deployment of diesel-powered shuttle cars. (3) Sensitivity analyses to determine the effect of changes in input variables on production and contaminant concentrations are discussed. (4) Description of the analysis procedure to develop locomotive operating parameters and to assess production and the magnitude of diesel exhaust contamination. (5) Recommendations for extensions of this research to determine equipment duty cycles for diesel equipment, and to study the exhaust contamination of mine air on the basis of these duty cycles. Research done under grant G0166052 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-122151; paper copy price code A10.

OFR 129(1)-81. Development of a Man and Supply Hoisting System for Underground Metal and Nonmetal Mines. Volume I. Final Report, by David J. Hoadley and Billy C. Brunelle. April 1981. 148 pp. 37 figs. This report describes the development and underground operation of a semiautomatic, raise climber, human and supply hoist system designed for stope access in underground metal and nonmetal mines. Demonstrated capabilities of the system include a 4,000-lb payload capacity, control from the traveling cage and from up to five remote stations, operating in vertical or inclined raises 5 ft in diameter and up to 300 ft in length, and a travel speed of 50 ft/min. The system has the capability of operating in crooked raises because the conveyance climbs two stationary wire ropes suspended down the raise. The drive unit is electrically powered with power and control signals supplied to the drive unit through an armored cable also suspended down the raise. The system has been designed for portability, ease of installation, and minimum raise development. The system can be installed by two workers in five shifts. This report provides a detailed description of the hoist design and its demonstrated performance in two mine applications. Research done under contract H0252068 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-113366; paper copy price code A07.

OFR 129(2)-81. Development of a Man and Supply Hoisting System for Underground Metal and Nonmetal Mines. Operation and Maintenance Manual. Volume II. Final Report, by David J. Hoadley and Billy C. Brunelle. April 1981. 101 pp. 13 figs. This operation and maintenance manual for the man and supply hoist system applies a specific configuration designed to operate in a vertical raise bored shaft 5 ft in diameter. Guidance is provided by six pneumatic wheels mounted to the conveyance and bearing directly on the raise wall and by two sets of conveyance-mounted steel wheels that bear on a single raise-mounted 6-inch steel channel. The report gives a complete overall description of the system cross-referenced with maintenance procedures where appropriate. Research done under con-

tract H0252068 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 130–81. Dust Control for Haul Roads, by Russel Bohn, Thomas Cuscino, Dennis Lane, Frank Pendleton, and Richard Hackney. February 1981. 146 pp. 4 figs. The purpose of this study was to evaluate the various techniques for mine roadway dust control. The evaluation included (1) the types of dust suppressants available, (2) the interaction of the dust suppressants with the properties of the roadway surface, and (3) the costs and performance measures of the predominantly used dust suppressants. Over 30 products were identified with a wide range of effectiveness depending largely on the properties of the roadbase, subsurface, and wearing surface. The effectiveness of a dust suppressant was also found to depend on the application and maintenance procedures employed. As a result of this investigation, five dust suppressants were identified as being predominant in the surface mining industry: petroleum resins, wetting agents, lignin sulfonate, water, and calcium chloride. An approximate cost-effective analysis, limited by lack of quantitative field performance data, showed that the five suppressants ranked in the order given, with water being one of the least cost effective. This report also presents an analysis of applicable Federal and State regulations. Research done under contract J0285015 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–116666; paper copy price code A07.

OFR 131–81. The Implementation of UHF Radio Communications and CCTV Monitoring Systems in a Room and Pillar Metal/Non-Metal Mine, by R. A. Isberg, H. Kramer, and D. A. Parrish. March 1981. 132 pp. 52 figs. This report describes the design and implementation of radio and closed-circuit television systems in the Black River room-and-pillar limestone mine near Butler, Pendleton County, Ky. Prior to designing the radio system, measurements of signal attenuation on 812 and 466 MHz were made in the slope tunnel and in the straight and level crosscuts in the mine. Two distributed antenna systems fed by two sets of base stations provide approximately 75 pct coverage of the mine. Passive reflectors were used for extending signals into intersecting crosscuts and two-way signal boosters will be used to extend signals to the perimeter and obstructed areas of the mine. Fourteen mine vehicles were equipped with mobile radios with digital identification, alarm, and status encoders. Fifteen portable transceivers also were used. Six closed-circuit television cameras provide surveillance of critical transfer points of the belt conveyor system, the loading dock at the base of the slope, and an ash disposal area in the mine. Two-way radio communication and closed-circuit television have saved considerable work hours, increased production, reduced maintenance costs, and enhanced safety. Research done under contract J0377044 by Comsul Ltd. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–116674; paper copy price code A07.

OFR 132–81. Model Demonstration of Drainage Structures for Safety of Mine Waste Impoundments, by Mark P. Zaitsoff and Chao-Lin Chiu. June 1981. 51 pp. 22 figs. The objective of this investigation was to study the design, construction, and testing of hydraulic models of culvert, decant, and open spillway systems that are typical drainage structures used for protecting mine waste embankments. Test results and products in the forms of graphs, tables, and film demonstrating the principles and factors that govern the function and performance of the three types of drainage structure are included. Research done under contract J0205014 by University of Pittsburgh. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 133(1)–81. Energy Absorption Systems for Mine Cages. Final Report, Vol. 1. Free Fall Testing of Single Tooth Safety Dogs on Keruing Guides, by F. A. Penning, D. R. Sorensen, and D. W. Robertson. May 1980. 214 pp. 103 figs. A number of highly instrumented free-fall tests were performed on an arrestment system for a human cage in a vertical shaft. A single-tooth safety dog was used to stop on 4- by 6-in Keruing (Philippine mahogany) wet and dry wood guides. Twenty-seven free-fall tests were performed covering weights from 3½ to 10½ tons and hoisting velocities from 850 to 1,350 ft/min. Average g loads were measured from a low of 0.6 to a high of 3.4. The electronic instrumentation included piezoelectric and seismic mass accelerometers, strain gages on structural and mechanical elements, load cells in the guides, and distance measuring. Computer analysis was used to correlate with experimental measurements used to calculate stress. A statistical analysis gave no indication that the velocity or area affected the wood-crushing stress. The instrumentation revealed a chatter occurring during the stop that imposes loads much higher than the average g load, as shown by the accelerometers, strain gages, and load cells. Research

done under contract H0282049 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 133(2)–81. Energy Absorption Systems for Mine Cages. Final Report, Vol. II. Study Energy Absorption Characteristics of a Pit Bottom Buffer, by F. A. Penning, M. H. Brinkmann, and D. W. Robertson. August 1980. 139 pp. 93 figs. An experimental and analytical investigation was conducted on a recoverable pit bottom buffer using a free-fall test tower. The four-sided buffer was constructed of reinforced rubber slabs loaded along their edge. A series of constant energy and maximum design velocity tests were conducted. Static testing of the buffer established the load-deformation behavior. Creep was evident during the loading and unloading cycle. Electronic instrumentation measured deceleration using four accelerometers; overall and intermediate movement was found from four displacement transducers, bending strains were recorded at four locations, and base reactions were measured by using four load cells. Data were recorded on tape and played back on a recording oscillograph. Symmetry of response and rebounds, when they occurred, were noted. From the displacement and load-time data, maximum decelerations were calculated by four methods and different assumptions. Good agreement was found from these approaches. A dynamic computer model was written for the response of the buffer. Displacement- and acceleration-time plots show close correspondence with experimental data for the 10 experiments. Data from accelerometers, displacement transducers, strain gages, and load cells are included. The computer program listing and displacement- and acceleration-time plots are also presented. Research done under contract H0282049 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 134–81. Outcrop Barrier Design Guidelines for Appalachian Coal Mines, by Mary L. Pearson, Terje Preber, and Peter J. Conroy. Feb. 1981. 167 pp. 51 figs. This report includes summaries of existing legislation pertaining to outcrop barriers and state-of-the-art survey of outcrop barrier designs and related mine closure techniques. Six sites were inspected in the field and are presented as case histories. The data analysis presented includes a computer-modeled seepage analysis, an overburden blow-out analysis, and a wedge stability analysis. The results of these analyses are interpreted to form recommendations for coal outcrop barriers that will minimize seepage and the potential for failure. Supplementary support and reinforcement alternatives are also discussed. Research done under contract J0395069 by Dames & Moore. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–113838; paper copy price code A08.

OFR 135–81. Cables for Face Equipment Standardization of Requirements. Final Report, by R. Stefanko, C. Bise, G. Luxbacher, and K. Katen. June 1 1981. 49 pp. 6 figs. This paper covers the findings in three areas of research: cable protection, circuit breakers, and high-voltage cable couplers. Laboratory and analytical studies have been conducted in the three areas to determine proper circuit-breaker settings, cable sizes, and coupler performance. Also, an extensive field-monitoring program was established to relate in-mine experience to laboratory findings. Further, various pieces of equipment were designed for laboratory testing, particularly in the area of cable reeling and unreeling. Research done under contract H0377043 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–113820; paper copy price code A03.

OFR 136–81. Upgrade Stench Fire Warning System—System Development and Prototype Tests, by Terry L. Muldoon, Ted Lewtas, and Thomas E. Gore. April 1981. 142 pp. 37 figs. This report describes the development and demonstration of an upgraded stench fire warning system for underground mines. Current systems release an ethyl mercaptan mixture into the compressed and/or ventilation air of a mine during an emergency. When smelling ethyl mercaptan, miners evacuate the mine according to predetermined plans. These systems, while simple, have problems with safety and reliability that can be overcome with the upgraded system. Thiophane, which is a different stench agent used in the upgraded system, is less toxic, less nauseating, and less corrosive than ethyl mercaptan. These features, and because thiophane does not react with iron oxides, makes the upgraded system safer and more reliable. The system also uses a combination of two simple principles: a standpipe with pressure balancing to provide a constant head and a sized orifice to control the rate of release of the stench agent. The system enables mine operators to release the agent for a longer period, which provides better coverage and ensures that miners will not be exposed to potentially toxic concentrations of the

stench agent. Research done under contract H0292002 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-122128; paper copy price code A07.

OFR 137–81. Personal Samplers for CO, NO, and NO_2 in Air, by E. D. Palmes and C. Tomczyk. January 1980. 36 pp. A new type of personal sampler for quantitative estimation of atmospheric concentrations of contaminant gases was first reported from this laboratory in 1972. The sampler requires no pumps or flow regulators and employs instead the motion of the gas molecules themselves to furnish the power for sampling. Work was completed on development of a kit for the field determination of both NO_2 and NO. Detailed instructions for the preparation of the samplers and the use of the kit were supplied and attempts were made to adapt the same type of sampler to the measurement of SO_2 and CO. Both gas chromatographic and turbidimetric procedures for the final estimation of the SO_2 proved to be unsatisfactory. For CO no reagent was found that would react with sufficient rapidity with this gas to utilize the essential feature of the diffusion sampler, the maintenance of a diffusion gradient which is at least approximately numerically equal to the ambient concentration. A number of publications on use of the NO_2 sampler, both at occupational and community air pollution levels, have resulted from this work. Research done under grant G0177042 by New York University Medical Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-123597; paper copy price code A03.

OFR 138–81. Placer Sampling and Related Bureau of Mines Activities on the Kenai Peninsula, Alaska, by Robert B. Hoekzema. September 1981. 28 pp. 2 figs. During 1979-80, the Bureau of Mines evaluated the mineral potential of approximately 1,120,000 acres in the northeastern portion of the Kenai Peninsula and northwestern Prince William Sound, Alaska. Systematic placer sampling identified that several previously nonproducing drainages in the east-central portion of the Kenai Peninsula and on the east side of Port Wells contain highly anomalous values of gold. This placer gold mineralization led to the identity of two potentially mineralized, northeasterly striking belts of limonite-stained pyrrhotite-bearing metasediments that are characterized by the presence of numerous felsic sills and dikes and sulfide-bearing quartz veins. The rivers, and the basins they drain, should be explored further for placer and lode gold deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 139–81. Development of Improved Detection Instruments for Toxic Gas Contaminants in Mining Atmospheres, by J. A. Kosek and A. H. Gruber. February 1981. 115 pp. 47 figs. Work has been carried out under a Bureau of Mines contract to develop and fabricate gas sensors for mining applications. Promising new instruments have been designed, developed, tested, and supplied to meet Bureau requirements. These instruments include prototype (1) remote-sensing, diffusion-type CO monitors for mine operation that can be operated in conjunction with a surface computer, (2) control modules for alternate in-mine readout of the remote diffusion type CO monitors, (3) personal CO diffusion-type dosimeters, and (4) personal NO diffusion-type dosimeters. In addition, retrofit modifications were made to update and optimize operation of CO and NO_2 direct-reading type detectors provided under a previous contract. Studies were conducted to evaluate and demonstrate the availability of stable, portable NO_2 calibration sources for NO_2 instrumentation. The use of selected, commercially available cylinder sources for NO_2 instrument calibration were recommended. Additional studies were also conducted to investigate the feasibility of instrumentation for rapidly monitoring CO, NO, and NO_2 in diesel exhaust. Research done under contract H0395132 by General Electric Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-129578; paper copy price code A06.

OFR 140–81. Coal and Uranium Investigation of the Yukon Flats Cenozoic Basin, by James C. Barker. September 1981. 63 pp. 9 figs. The coal and uranium resource potential of the Western Yukon Flats was investigated by the Bureau of Mines during the 1978–79 field seasons. Previously, the mineral endowment of the area was largely unknown and there existed only partial 1:250,000-scale geologic reconnaissance mapping. The Yukon Flats is an extensively vegetated sedimentary basin of interior Alaska in which terrigenous sediments have been accumulating since Eocene (?) time. Preliminary evidence presented in this report suggests that sedimentation apparently has been taking place under climatic conditions typical of the mid-Tertiary at higher latitudes elsewhere. Conditions then were warm to paratropical and may have varied to rather hot and arid. Evidence includes relatively thick coal formations, the extensive occurrence of nonmarine evaporite minerals, undated but typical of continental arid saline lakes, stratiform tungsten enrichment, and fossil data that was previously reported. Research done by Alaska Field Operations Center. Available for

reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 141–81. Billings Glacier Molybdenum-Copper Occurrence, Whittier, Alaska, by Robert B. Hoekzema and Gary E. Sherman. 1981. 30 pp. 3 figs. A previously unreported occurrence of molybdenum and copper mineralization in a small granitic stock exposed at the toe of Billings Glacier, 5.5 miles northeast of Whittier, Alaska, was discovered and examined by the Bureau of Mines in July and August 1981. Molybdenite occurs as disseminated grains and crystalline clusters, up to 1½ inches across, apparently associated with hydrothermally altered portions and also along fractures in the granitic pluton. Molybdenite also occurs as disseminated grains in spheroidally weathering granitic xenoliths found in the pluton near its eastern contact. Minor pyrite and minor amounts of chalcopyrite are disseminated throughout marginal portions of the pluton. A high-grade sample of the mineralized granite contained 2,000 ppm Mo but other samples did not exceed 30 ppm. Copper did not exceed 90 ppm and generally was less than 50 ppm in samples of the stock analyzed. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 142–81. Portable Remote Control Circuit Breaker System for Mine Trolleylines, by John F. Burr and Harry M. Dushac. June 1, 1978. 117 pp. 42 figs. This report describes the various stages of the development of a portable remote control circuit breaker system. The report presents (1) the details and problems involved with the movement of off-track mining equipment in an underground coal mine, (2) a preliminary field test program, (3) details of the fabrication and field testing of the preliminary prototype remote control system, (4) the fabrication of the final prototype system, and (5) system features that include the ability to trip, reset, and adjust remote circuit breakers from a transmitter located on a mine locomotive. Research done under contract H0366029 by Consolidation Coal Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–128067; paper copy price code A06.

OFR 143–81. Investigation of a Copper Occurrence in the Rampart Diorites, by Mark M. McDermott, Jeffrey Y. Foley, and Dennis D. Southworth. 1981. 26 pp. 4 figs. During the 1976–79 field seasons, the Bureau of Mines made mineral evaluation studies of the trans-Alaska pipeline corridor for the Bureau of Land Management. Part of the work was done by the University of Alaska, who in 1977 reported a body of hornblende diorite in the Rampart Group south of Hess Creek in the Livengood quadrangle that locally contained as much as 10 pct sulfide. In 1979 the Bureau of Mines used a combination of geological, geophysical, and geochemical methods to evaluate the potential of this area for porphyry-type copper deposits. Low concentrations of copper were found as minor occurrences in small diorite dikes and sills. The low concentrations found and the low tonnages implied by this mode of occurrence suggest that the Rampart Group assemblage has little potential for porphyry-copper-type deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 144–81. Manganese Nodule Resource Data, Sea Scope Expedition, by R. H. Fewkes, W. D. McFarland, and R. K. Sorem. June 15, 1981. 230 pp. 10 figs. New information on possible resource value of sea floor manganese nodule deposits in the eastern North Pacific has been obtained by a study of records and collections of the 1972 Sea Scope Expedition. Nodule abundance (percent of sea floor covered) varies greatly, according to photographs from eight stations and data from other sources. All estimates considered reliable are plotted on a map of the region. Similar maps show the average content of Ni, Cu, Mn, and Co at 89 stations from which three or more nodules were analyzed. Variations in nodule metal content at each station are shown graphically in an appendix, where data on nodule sizes are also given. Results of new analyses of 420 nodules from 93 stations for Mn, Fe, Ni, Cu, Co, and Zn are listed in another appendix. Relatively high Ni + Cu content is restricted chiefly to four groups of stations in the equatorial region, where group averages are 1.86, 1.99, 2.47, and 2.55 weight-percent. Research done under grant G0284008 by Washington State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–142571; paper copy price code A11.

OFR 145–81. Longwall Subsidence Case History Numbers 3 and 4. Northern Appalachian Coal Region, by Larry R. Powell. February 1981. 17 pp. 4 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This publication presents data for two longwall mining operations in the Northern Appalachian Coal Region. Vertical displacements and relative face positions are tabulated for 104 subsidence monuments. Brief physiographic and geological descriptions of the mining sites are presented along with a general account of the mining and subsidence monitoring methods. Research done by Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo.,

Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 146–81. Massive Sulfide Tailing Disposal Using the Thickened Discharge Method, by Gerald M. Bandholz. June 1981. 229 pp. 31 figs. This report discusses the advantages of using the thickened discharge method for massive sulfide tailing disposal. The thickened discharge method is described along with other methods of massive sulfide tailing disposal and cost comparisons are given. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 147–81. Technological Investigations To Develop Design Criteria for the Optimum Size of Oil and Gas Well Blocks, by Kenneth Wardell, Peter Eynon, and Christopher Wardell. Feb. 8, 1980. 130 pp. 22 figs. This report presents criteria that have been developed to determine the optimum size of oil and gas well blocks. The criteria lead to the formation of well barrier pillars that are, of themselves, inherently stable and take account of variable mine roof and floor conditions. The criteria ensure that strains transmitted to well casings are within tolerable limits of specifications. The criteria cater for well barrier pillars in multiseam mining situations and where previous mining has taken place, maintains flexibility in being adaptable to local mine design situations. Research done under contract J0285010 by K. Wardell & Partners. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 148–81. Airborne Dust From Taconite Tailings, by D. H. Yardley, W. D. Lacabanne, and R. C. Nelson. November 1980. 53 pp. 18 figs. The objective of this report was to evaluate a variety of dust suppressants to determine their effectiveness in mitigating dust from taconite tailings. Field test plots were established on taconite tailings and wind tunnel laboratory tests were conducted. The tests consisted of comparing treated and untreated samples at wind velocities of 40 mph using a weight-loss method and direct dust emission measurements. It was shown that the emission of fine dust from taconite tailings in the 4.5- to 0.85-micrometer range could be reduced by 99 pct using certain chemical suppressants. It was also shown that a straight water spray on coarse tailings reduced dust emission by 95 pct. Although eight different chemicals were tested, most of the tests were made using Coherex, ammonium lignin sufonate, and sodium silicate. These dust suppressants were used singly and in combination on almost 75 field test plots. The Coherex appears to provide the best results in terms of economics and durability. Wind tunnel tests on treated and untreated Cu-Ni tailings showed that applications of dust suppressants reduced fugitive fine dust by better than 99 pct. Research done under contract J0265055 by University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143173; paper copy price code A04.

OFR 149–81. Development of an Explosion Proof High Voltage Cable Connector, by H. E. Dresch. Feb. 5, 1981. 32 pp. The objective of this report was to design and construct a high-voltage, explosion-proof cable connector for use on underground coal mine drag cables. A connector was constructed with elastomeric phase insulators that provide insulation shielding throughout the connector length. The connector housing was made of flame-resistant cast polyurethane with no exposed metal components. Electrical and mechanical testing of the completed coupler resulted in satisfactorily meeting most of the design testing requirements. Research done under contract H0188068 by The Scott & Fetzer Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–142589; paper copy price code A03.

OFR 150–81. Demonstration of a Dust Control System for Boom-Type Roadheader, by Mackenzie Burnett, Robert J. Pokora, and Terry Muldoon. September 1981. 54 pp. 16 figs. This program was initiated by the Bureau of Mines to quantify the respirable dust problem caused by the use of roadheaders in underground metal-nonmetal mines with special emphasis on this problem in uranium mines. The objective was to develop methods or equipment to alleviate respirable dust and to implement a solution in a mine. Attempts to quantify the dust problem were made by a survey of MSHA records, a survey of State mine enforcement agencies, a survey of mine records, and dust measurements taken at two mines using roadheaders. The results are not conclusive because of limited and sometimes less than useful data; however, the study does indicate that a serious dust problem could and may exist. The report discusses the available data concerning respirable dust problems and presents a solution that can potentially help to solve the problem. The solution requires the use of blowing ventilation, onboard dust extraction at the source,

filtration, and continued use of water sprays. Research done under contract J0199093 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143199; paper copy price code A04.

OFR 151–81. Evaluation and Demonstration of a New Post-Disaster EM Communication Technique for Mines, by M. P. Ristenbatt and E. K. Holland-Moritz. February 1981. 101 pp. 37 figs. The objective of this report was to quantitatively compare an existing emergency mine communication system with a proposed automated system that features extended signal processing and a novel signal. A new post-disaster system, intended to use through-the-earth EM propagation, was demonstrated at input signal-to-noise ratio (SNR) of −34 db. The system presently available requires an input SNR of + 6, and uses a human ear detector. The present work demonstrated coherent integration for the automated system in multiples of 17 seconds, up to 1,088 seconds (18 minutes). A repeating pseudorandom (or pseudonoise) signal is used that offers an ideal autocorrelation at the receiver matched-filter output. A novel decision-variable algorithm achieves the estimate of noise level by using those matched-filter output samples that occur between the signal autocorrelation peaks. Research done under contract J0199109 by University of Michigan. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143181; paper copy price code A05.

OFR 152–81. Production Engineering, Development, and Demonstration of the Draft Power Sensor. Volume I, by H. Stanley Benson. November 1980. 60 pp. 26 figs. This report describes research conducted to improve the performance of and then further field test draft power sensor (DPS) equipment. DPS equipment enables a bulldozer operator to optimize a machine's work rate. Significant improvements were made in DPS hardware, and extended field testing was conducted at two working strip mines. The report documents the increase of bulldozer work production by greater than 20 percent while using the DPS compared with baseline work production without benefit of the DPS. Research done under contract H0292016 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143165; paper copy price code A04.

OFR 153–81. Technical and Economic Evaluation of Mine Closure Procedures. Final Report, by George Akens, John Metz, and Paul Bilzi. June 1980. 281 pp. 19 figs. The purpose of this report is to provide industry with a document to aid in the selection of a closure method and to aid government officials in evaluating closure methods that have been used in the past. The types of seals presently in use for numerous engineering environmental and economic parameters were evaluated. A survey of State and Federal regulations pertaining to mine closure is included. Numerous drawings are also included along with several case histories of mine closures. Research done under contract J0285030 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–136995; paper copy price code A13.

OFR 154–81. Develop Grounding Practices for Metal/Nonmetal Mines, by Wils L. Cooley and Herman W. Hill, Jr. Feb. 27, 1981. 235 pp. 64 figs. This report analyzes electrical accident data in the metal-nonmetal mining industry. Accidents are categorized to determine the root causes. Special attention is given to accidents associated with inadequate or defective grounding of mine power systems. Recommendations are made concerning proper grounding practice, especially for dredges and for quarries in hard rock or sand. The costs of instituting the recommended practices are estimated for model mine power systems which are based on field data obtained from 37 mines and several electrical contractors. The expected benefits of various suggested safety practices are also estimated. Research done under contract J0308025 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137308; paper copy price code A11.

OFR 155–81. Noise Control of a Mine Operated Rail Personnel Carrier. Volume II. Underground Evaluation, by A. G. Galaitsis and D. Andersen. July 1980. 35 pp. 18 figs. The two volumes of this report summarize the noise control work performed on a rail personnel carrier operated in coal mines. Volume I describes the aboveground work performed to identify the noise sources, design, fabricate, and install and evaluate the treatments through noise and vibration tests. Volume II de-

scribes the underground work conducted to determine the deterioration, if any, of the treatments when the vehicle was operated normally in a mine. There were no significant changes in the acoustical performance or mechanical integrity of the treatments at the end of a 3-month period. Research done under contract H0166090 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137019; paper copy price code A03.

OFR 156–81. Water Handling Procedures for Reducing Acid Formation in Underground Coal Mines, by John R. Williams and Richard J. Keenan. Oct. 1, 1980. 106 pp. 17 figs. The treatment of acid mine drainage can amount to a considerable expense over the life of a mine where highly pyritic materials are present. Two possible options to reduce costs are reducing inflow to a mine or collecting and transporting the water once it has entered a mine to minimize its contact with acid-producing material. Planning the water-handling system should be part of the initial mine design. Adequate geologic and hydrologic data are necessary to avoid areas where high inflows may occur, or to plan for handling and treating the inflows. This report discusses several methods to reduce or prevent inflows, including surface and stream diversions, dewatering of aquifers, grouting and sealing, and leaving barrier pillars between adjacent mines. Mine closure and down-dip mining are also considered in reducing acid mine drainage formation. The design of water-handling systems in a mine is covered in detail. The system must be integrated throughout a mine. Methods of determining pump requirements and size, pipe sizing, and various types of acid mine drainage treatment are discussed. Research done under contract J0199027 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137324; paper copy price code A06.

OFR 157–81. Cable Handling in Surface Mines, by R. Marshall, C. Mertian, and R. Winkle. Sept. 19, 1980. 62 pp. 9 figs. Electrical trailing cable handling techniques and practices used in metal and nonmetal surface mines were investigated by obtaining information through visits to mine properties located in a variety of geological areas and climatic conditions. An analysis was made of all accidents related to cable handling that were cataloged by the Health Safety Analysis Center from 1978 through June 1980. Information was also collected from mine operators concerning near accidents and nonreported accidents. The results of this investigation were presented to the Bureau of Mines in an effort to outline recommended practices for cable handling in surface mines and to recommend additions and/or changes in the regulations now being enforced by the Mine Safety and Health Administration. These recommendations are also intended to assist the Bureau of Mines in evaluating the need for assisting mine operators in the areas of training and distribution of information related to material handling of trailing cables. Research done under contract J0395088 by Pincock, Allen & Holt, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139346; paper copy price code A04.

OFR 158–81. Ground Fault and Overcurrent Protection Criteria for Coal Mine AC Distribution Systems, by John A. Kiefer and Jeffery L. Kohler. Oct. 31, 1980. 174 pp. 55 figs. Ground fault and overcurrent protection criteria for coal mine ac distribution systems were examined by authorization of the Bureau of Mines. The report begins with a literature review that discusses relaying topics including instrument transformers, ground fault pickup methods, static relaying, and comparison of relaying techniques. A chapter on ground fault relaying provides recommendations for maximum and minimum pickup levels as a function of maximum ground current and power system line-to-ground capacitance. Research in the area of phase overcurrent protection has resulted in a complete set of procedural recommendations for the selection and setting of overcurrent relays and current transformers, molded-case circuit breakers, and distribution system fuses in coal mine power systems. The final chapter discusses relay system maintenance and introduces a unique test set that is used to test the performance of relaying systems in coal mines. Research done under contract J0395035 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137001; paper copy price code A08.

OFR 159–81. High Concentration Dust Monitor, by Pedro Lilienfeld. June 1981. 76 pp. 37 figs. The objective of this investigation was the development, design, fabrication, and testing of a portable, self-contained prototype monitoring instrument capable of detecting and measuring airborne coal dust levels as concentrations in the range of 20 to 500 g/m^3. The output of the high concentration dust monitor is essentially independent of particle size and composition, with a response time of 10 seconds. Direct concentration readout as well as internal memory or recording capabilities are

incorporated in the device. The operation of the instrument is based on direct sensing of the mass concentration of airborne dust by air-path beta radiation attenuation. The monitor is battery operated and incorporates a microprocessor that controls periodic automatic zero referencing, executes the mass computations, records the data for subsequent playback, and performs internal diagnostic checks. The design emphasizes ruggedness, simplicity of operation, and adherence to intrinsic safety requirements. Research done under contract H0308010 by GCA Corp. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139320; paper copy price code A05.

OFR 160–81. Final Report—Evaluation of Coal-Mine Electrical-System Safety, by Lloyd A. Morley, Frederick C. Trutt, and Jeffery A. Kohler. June 1, 1981. 202 pp. 23 figs. This final report concludes the documentation under grant G0155003 and details research not covered under foregoing report volumes. The first chapter lists all other reports. The following chapters are divided into three major research tasks: Continuous Safety Monitoring Systems, Battery and Battery-Charging Safety, and Mine Power System Transients. The monitoring chapter discusses the prediction of power-system failures. The battery chapter details work on battery-box stresses, battery chargers, and the elimination of electrocutions. The final chapter covers transient instrumentation, distribution transients sources and suppression, and utilization transients on mine power systems. Research done under grant G0155003 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139338; paper copy price code A06.

OFR 161(1)–81. Control of Water Pollution From Surface Mining Operations. Volume I, by David R. Jessey, Judith M. Stangl, David H. Dike, Grant R. Brown, and Edward W. Schroeder. Jan. 31, 1981. 172 pp. 43 figs. Water pollution problems associated with surface metal-nonmetal mines throughout the United States were assessed. Three major problems were identified: acid mine drainage, toxic concentrations of heavy metals, and excessive sedimentation. Among the factors that affect the type and amount of pollutants generated at mine sites are hydrologic regime, geology, mineralogy, topography, climate, size of the mineralized area, and mining methods. Nine surface mines situated in different settings were visited and the pollution problems were studied. A detailed evaluation of the pollution problems at one mine indicated that a diversion system and treatment plant would be the most effective means of abatement for the existing water quality problems. Based on this study and three other porphyry copper mines with differing problems, a water management plan was conceived for a new source copper mine. Research done under contract J0199089 by Wapora, Inc., and Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139304; paper copy price code A08.

OFR 161(2)–81. Control of Water Pollution From Surface Mining Operations. Volume II, by David R. Jessey, Judith M. Stangl, Alfred H. Hirsch, David H. Dike, Grant R. Brown, and Edward W. Schroeder. Jan. 31, 1981. 275 pp. 57 figs. Water pollution problems associated with surface metal-nonmetal mines throughout the United States were assessed. This work contains detailed reports on mines located in Morenci, Hayden, and Sauharita, Ariz.; Cobalt and Fernwood, Idaho; Spruce Pine, N.C.; Iron Mountain, Calif.; and DeLamar, Idaho-Oregon. Research done under contract J0199089 by Wapora, Inc., and Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139312; paper copy price code A13.

OFR 162(1)–81. Interactive Mine-Power-System Analysis. Volume I, by Frederick C. Trutt, Lloyd A. Morley, and Richard A. Rivell. Jan. 31, 1981. 209 pp. 9 figs. This report is intended as a reference for personnel interested in the computer analysis of coal mine electrical power systems under either normal operating conditions or fault situations. The procedures developed are described and implementation considerations are discussed. Considerations for choosing a solution technique and some examples are included. During program development, strict attention was given to the inclusion of core and/or time-saving techniques such that these algorithms may be implemented on small or large computers. Program languages include FORTRAN IV for batch processing applications and APL or BASIC for interactive applications. Research done under contract J0199060 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in

Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138298; paper copy price code A10.

OFR 162(2)–81. Interactive Mine-Power-System Analysis· User's Manual. Volume II, by Richard A. Rivell, Frederick C. Trutt, and Lloyd A. Morley. Jan. 28, 1980. 239 pp. 13 figs. This user's manual is intended as a reference for personnel interested in the analysis of coal mine electrical power systems. The interactive procedures developed for this purpose are described and implementation considerations are discussed. Considerations for choosing a solution technique and some examples are included. Procedures available include Gauss-Seidel and Newton-Raphson iterative techniques for analysis of normal operation or balanced faults and a noniterative Z-bus technique for analysis of unbalanced or balanced faults. Research done under contract J0199060 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138306; paper copy price code A11.

OFR 163(1)–81. Microseismic Roof Fall Warning System Development. Field Trials and Commercial Prototype Fabrication. Volume I. Final Report, by Carl Fisher, Jr., and Ramie H. Thompson. May 30, 1980. 197 pp 68 figs. A microseismic roof fall warning system was field tested in western and eastern coal mines in the United States to better define the capabilities and limitations of the microseismic method in predicting roof fall. Microseismic event and energy type data were obtained and documented for 23 coal mine roof falls. Field test results indicate that both the microseismic event and energy methods, as applied, have a high probability for successful application in a commercially practical roof fall warning system. Volume I contains details of the investigation. Research done under contract H0272009 by Integrated Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137837; paper copy price code A09.

OFR 163(2)–81. Microseismic Roof Fall Warning System Development. Field Trials and Commercial Prototype Fabrication. Volume II. Appendix C: Coal Mine Data Collection Summary. Final Report, by Carl Fisher, Jr. May 30, 1980. 228 pp. 36 figs. A microseismic roof fall warning system was field tested in western and eastern coal mines in the United States to better define the capabilities and limitations of the microseismic method in predicting roof fall. Microseismic event and energy type data were obtained and documented for 23 coal mine roof falls. Field test results indicate that both the microseismic event and energy methods, as applied, have a high probability for successful application in a commercially practical roof fall warning system. Volume II summarizes the data collected. Research done under contract H0272009 by Integrated Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137845; paper copy price code A11.

OFR 164–81. Development of Fuel Cell Gas Detection Instruments for Use in a Mine Atmosphere, by J. A. Kosek, A. B. LaConti, A. Goldstein, G. Schnakenberg, and E. Chilton. Mar. 23, 1979. 131 pp. 40 figs. The objective of this report was to develop instruments for detecting CO, NO, and NO_2 in a mine atmosphere using fuel cell technology. The approach was to optimize the fuel cell sensor configuration for the specific detection of CO, NO, and NO_2 in the presence of other mine gases utilizing recent advances in catalyst, electrode, and solid polymer electrolyte membrane technology. Parametric testing was conducted on three electrode sensor cells to define performance and life characteristics as a function of temperature, feed flow, and applied sensor voltage. Extended life testing was performed on sensor cell configurations exhibiting favorable characteristics. Reliable, efficient gas sampling and electronic control circuitry was fabricated for use with the sensor cells and integrated into devices to meet the performance and design specifications for portable, battery-operated, handheld direct-indicating gas detectors for use underground. Research done under contract H0357078 by General Electric Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137316; paper copy price code A07.

OFR 165(1)–81. Evaluation of Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Phase II Report: Assessment of Two Raw Material/Process Technology Options, by L. C. Tisdel, W. J. Roushey, A. G. Melcher, F. T. Davis, J. M. Link, and R. C. Barth. December 1979. 121 pp. 4 figs. This study provides information on the environmental factors of two options for production of alumina from kaolin clay raw material that were selected by the Bureau of Mines for further study from six raw material-process technology options considered in a previously issued report. The options under study are hydrochloric

acid leaching using HCl gas-induced crystallization and nitric acid leaching. This study concentrates on the hydrochloric acid leaching option because it has been identified as having a better potential for commercial development. Included in the assessment are mining and transportation of ore, construction and operation of the process plant, disposal of process wastes, and land reclamation considerations. The primary information sources for the study included process feasibility studies, Reports of Investigations, Information Circulars, and nonpublished material provided by the Bureau of Mines. The results indicate that the hydrochloric acid leaching option exhibits the least potential for adverse environmental effects. Research done under contract J0275040 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138264; paper copy price code A05.

OFR 165(2)–81. Evaluation of Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Phase III Report: Environmental Impact Criteria for Evaluating Potential Pilot Plant Sites: Clay/Hydrochloric Acid Extraction-Gas Induced Crystallization Process, by L. C. Tisdel, A. G. Melcher, and G. M. Hermsen. March 1981. 50 pp. 3 figs. This study provides information on criteria for use in environmental evaluation of potential sites for a pilot plant where production of alumina from domestic clay resources would be investigated. The study was based on a preliminary design for a pilot plant utilizing a hydrochloric acid extraction-gas induced crystallization process. The pilot plant would cover approximately 30 acres and construction would take approximately 2 years with a work force of 200 to 225 employees. An operating period of approximately 3 years is projected employing 160 to 170 people. The expected scale of the pilot plant is such that significant impact on most environmental factors of current concern could occur. Thus, selection of a suitable site would be an important part of the planning process for the project. The results indicate that, among the environmental evaluation criteria developed, those related to preventing or minimizing adverse impact on socioeconomic conditions and air and water quality are likely to be most pertinent in the selection of a suitable pilot plant site. Research done under contract J0275040 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138272; paper copy price code A03.

OFR 166–81. Delineation of Geologic Roof Hazards in Selected Coal Beds in Eastern Kentucky With Landsat Imagery Studies in Eastern Kentucky and the Dunkard Basin, by David K. Hylbert. Nov. 14, 1980. 100 pp. 47 figs. This study investigated stratigraphic and structural causes of roof falls in room-and-pillar drift coal mines in nine mines in eastern Kentucky. A contract modification provided for remote sensing studies in the Dunkard Basin of West Virginia and Pennsylvania. Results of stratigraphic and structural studies of an earlier study were applied to several new mines. It was found that similar rock sequences contributed to unstable roof conditions. Structure contour and isopach maps were useful in projecting these trends together with fence diagrams. Using Landsat imagery, a direct relationship was found between lineament direction and the trends of rock jointing, roof fall zones, "snap top" zones, and sandstone channels. From 50 to 65 percent coincided with roof falls when lineament intersections were analyzed. Research done under contract J0188002 by Morehead State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–140336; paper copy price code A05.

OFR 167-81. Pre-Mining Identification of Hazards Associated With Coal Mine Roof Measures, by Ronald W. Stingelin, Jeffrey R. Kern, and Stephen L. Morgan. Mar. 30, 1979. 208 pp. 84 figs. The geology of the roof of the Pittsburgh coalbed was studied and mapped in nine contiguous counties containing the bulk of the remaining reserves of this coalbed in the northern Appalachian coal basin. Drill core records from Belmont and Monroe Counties, Ohio; Washington and Greene Counties, Pa.; and Ohio, Marshall, Wetzel, Monongalia, and Marion Counties, W. Va., provided the data for 12 computer-generated regional geologic variable maps. Four of these geologic variables were used to estimate the risk of potential roof falls by a methodological scheme developed during this study. A hazard zone risk map was developed showing a generalized regional trend of increasing risk from west to east across the basin. The accuracy of the mapping is primarily dependent on the density of the drill core records. Geologic feature maps and the hazard risk map in this report are reduced versions of the larger scale maps prepared for the Bureau of Mines as map folios. Research done under contract J0177038 by HRB-Singer, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–140344; paper copy price code A10.

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OFR 1–82. Environmental Test Criteria for the Acceptability of Mine Instrumentation, by Kenneth Trelewicz. June 1981. 137 pp. 18 figs. This report describes a two-phase effort that went into developing environmental test criteria for general mine instrumentation. Phase I consisted of research and mine visits to develop an environmental profile for mine instrumentation that was translated into general and test requirements. A review of existing Government and commercial specifications was performed to determine if they matched the test requirements. Finally, a set of environmental test procedures was developed to test mine instrumentation. Phase II consisted of selecting and purchasing sample mine instrumentation and subjecting them to the previously developed tests to evaluate the criteria for use as an instrumentation test document and to determine the effects of the various criteria on a representative sample of both proven and new developed instrumentation. The test criteria were then modified, based on test results, and are included in the report. Research done under contract J0100040 by Dayton T. Brown, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington D.C. Order ONLY from NTIS: PB 82–146325; paper copy price code A07.

OFR 2–82. Demonstration of Coal Mine Illumination Systems, by Anthony D. Szpak, William F. Hahn, and Charles S. Skinner. January 1981. 127 pp. 72 figs. The purpose of this program was to demonstrate the feasibility of illuminating various types of underground coal mining machinery as required by the Federal Coal Mine Illumination Standards Part 75.1719 to 75.1719–4 Code of Federal Regulations Title 30. Nine various machines were illuminated and the illumination systems were evaluated for a 3-month period. Factors evaluated were ease of implementation, reliability, ease of maintenance, acceptance by mine workers and operators, illumination degradation, and durability. Research done under contract J0188006 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–147471; paper copy price code A07.

OFR 3–82. Monitoring of Mine Air Diesel Pollutants: Tailpipe Emissions Measurement Apparatus, Detector Tube Interferences, and Exhaust and Ventilation System Control, by John H. Johnson, David H. Carlson, Edward O. Reinbold, and Mark D. Osborne. July 31, 1980. 267 pp. 109 figs. The objective of this work was to develop and test engineering approaches to the control of air quality for the protection of miners health in dieselized underground mines. A general experimental approach was developed by which instruments could be compared for the measurement of diesel exhaust pollutant concentrations in the 0.5 to 5 threshold limit value (TLV) range. Dräger detector tube diluted exhaust CO, CO_2, NO, and NO_2 measurements were compared with simultaneously taken portable instrument measurements. The effects of two exhaust system configurations on the pollutant concentrations in a deadend heading were studied. Both directed gases toward the crosscut and improved the stratification of the air in the heading. Research done under contract J0199125 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–148388; paper copy price code A10.

OFR 4–82. Determination of the Products of the Oxidative Thermal Degradation of Variously Treated Woods and Mine Materials, by K. L. Paciorek, R. H. Kratzer, J. H. Nakahara, and D. H. Harris. July 1980. 182 pp. 91 figs. The objective of this program was to determine the toxic fume and fire hazards of variously treated mine materials compared with virgin or untreated compositions under conditions approximating those likely to be encountered in underground mines. An apparatus was designed and constructed that was capable of simulating varying conditions of temperature, flow, atmosphere in addition to provision for accommodating varying sample thicknesses, total and intermittent product collection, and continuous parameter monitoring. Toxic load assessments were obtained for all of the test conditions. The fire hazards presented by the conveyor belts were higher than that of the NCX-treated woods; toxic hazards were comparable. Research done under contract J0395008 by Ultrasystems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–146275; paper copy price code A09.

OFR 5–82. High Speed Drill Probe To Detect Abandoned Underground Workings, by Robert W. Gordon and Glen O. Baker. June 1981. 57 pp. 51 figs. This report describes the results and conclusions of the further development of a previously developed lightweight probe drill for use in anthracite mines.

The improvements included (1) better hole cleaning due to the development of an air-water mist flushing system, (2) the application of roof drill bits to allow drilling through rock seams and lenses, (3) the development of a quick coupling drill system that reduced total steel change time, and (4) adaptation of a swivel to the drill anchoring system that greatly reduced set-up time between holes. With these improvements, the probe drill drilled the required 11 holes in one shift and gained miner acceptance as a viable underground working tool. The probe drill proved to meet all design requirements of portability, low-weight drilling controllability, structural integrity, and reliability. In addition to drilling the required probe pattern, the probe drill is capable of drilling long holes. By drilling several holes over 80 feet deep the probe drill has the potential for use in robbing pillars and for methane drainage. Research done under contract H0292026 by Hamilton Engineering, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-146267; paper copy price code A04.

OFR 6–82. Flexible Liner for Use in Advancing Tailgate, by Kenneth C. Ko. November 1980. 191 pp. 82 figs. This report describes an investigation on the technical and economic feasibility of implementing flexible liner-backpacking support systems in an advancing tailgate longwall mine. The system consists of a circular tube constructed of liner plates and flyash backpacking. Flyash is pneumatically stowed into the tailgate. Small amounts of cement may be mixed to improve the support capability of the fill in difficult local ground conditions. Water is added inside the nozzle immediately prior to spraying. Results of theoretical analyses and a field test show that the designed system is technically feasible, and can increase productivity and coal recovery, compared with existing retreat longwall systems. In certain mine layouts, the system can reduce the direct mining costs by a significant amount and would be particularly applicable to deeper coalbeds with bad ground conditions. Research done under contract H0292014 by Kenneth C. Ko & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-149352; paper copy price code A09.

OFR 7–82. Developing a New Method for Roof Support Using Sonic Pin-Setting Machines, by Robert L. Morris and John C. Purcupile. Dec. 21, 1977. 95 pp. 42 figs. This report describes the activities conducted in the development and testing of a first-generation sonic pin-setting machine that uses an oscillating force to insert roof pins in a mine roof. A theoretical model was developed and is shown in the report. Research done under contract H0262061 by Carnegie-Mellon University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsbugh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 8(1)–82. Survey of Blasting Effects on Ground Water Supplies in Appalachia. Volume I, by Donelson A. Robertson, James A. Gould, Jeffery A. Straw, and Michael A. Dayton. November 1980. 161 pp. 51 figs. This report presents the results of a survey on blasting effects on ground water supplies in Appalachia. Literature was searched and cases of alleged water well damage were investigated. Occurrence of ground water in Appalachia is primarily in low yield, fractured, water table aquifers. Four test sites were chosen based on geographic and geologic diversity, and wells were drilled at each site. Base line data on water quality, static water level, and drawdown characteristics were obtained before surface mining commenced. Blast-induced ground vibrations were measured at the surface at levels up to 5.44 inches per second maximum resultant particle velocity. Measurements made at the bottom of the wells indicated that vibrations were considerably attenuated at depths of 140 to 160 feet. No direct evidence of change in water quality or well performance was produced by blast vibrations, but removal of downslope support by excavation does cause lateral stress relief which permits the water-bearing fractures to become more open. The additional storage capacity causes the static water level to drop and for well-bore permeability to improve. Static water level recovers if sufficient recharge is available and well performance is improved. Research done under contract J0285029 by Philip R. Berger and Associates Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-152125; paper copy price code A08.

OFR 8(2)–82. Survey of Blasting Effects on Ground Water Supplies in Appalachia. Volume II, by Donelson A. Robertson, James A. Gould, Jeffery A. Straw, and Michael A. Dayton. November 1980. 266 pp. This report presents the results of a survey on blasting effects on ground water supplies in Appalachia. Literature was searched and cases of alleged water well damage were investigated. Occurrence of ground water in Appalachia is primarily in low yield, fractured, water table acquifers. Four test sites were chosen based on geographic

and geologic diversity, and wells were drilled at each site. Base line data on water quality, static water level, and drawdown characteristics were obtained before surface mining commenced. Blast-induced ground vibrations were measured at the surface at levels up to 5.44 inches per second maximum resultant particle velocity. Measurements made at the bottom of the wells indicated that vibrations were considerably attenuated at depths of 140 to 160 feet. No direct evidence of change in water quality or well performance was produced by blast vibrations, but removal of downslope support by excavation does cause lateral stress relief which permits the water-bearing fractures to become more open. The additional storage capacity causes the static water level to drop and for well-bore permeability to improve. Static water level recovers if sufficient recharge is available and well performance is improved. Volume II contains appendixes B and C. Research done under contract J0285029 by Philip R. Berger and Associates Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-152133; paper copy price code A12.

OFR 9-82. Methane Telemetry System for Continuous Miners, by Terry S. Cory. June 22, 1979. 96 pp. 23 figs. This report describes a unique radio frequency telemetry system to enable the simultaneous remote monitoring of up to eight methane sensors positioned on a continuous-mining machine. The system employs medium frequency wireless radio transmission and the coupling of induced radio frequency currents into the miner trailing cables. The system is automatic and unattended and provides continuous hard copy recording of the sensor levels. The system employs serial digital transmission of the data under microprocessor control using frequency shift keying modulation. Research done under contract J0166094. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-163940; paper copy price code A05.

OFR 10-82. Automatic Trapped Miner Seismic Signal Detection and Analysis System, by Tim F. Dyson. May 21, 1981. 72 pp. 23 figs. The feasibility of employing automated processing and detection techniques in the mine disaster communications problem is demonstrated. Efficient processing methods are developed. The methods have been demonstrated both in a laboratory and in a field environment. Evaluation of existing computer capacity is given along with recommendations for expansion. Research done under contract J0395064 by Sonic Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-161936; paper copy price code A04.

OFR 11(1)-82. Recontouring of Steep-Slope Abandoned Contour Mines. Volume I—Summary, by Daniel I. Carey and Robert L. Lappi. August 1981. 65 pp. 16 figs. Current and potential dragline reclamation usage was evaluated for U.S. coalfields based on data gathered and analyzed during field surveys, literature reviews, and contacts with manufacturers. It was concluded that current mining plans have been adapted to Federal and State strip mine and reclamation laws in ways that limit the potential for dragline reclamation systems at active mine sites. At abandoned conventional contour mine sites in steep-sloping areas, such as central Appalachia, it was found that dragline reclamation systems have great potential application and may be the only practical solution to many reclamation problems. Alternative dragline systems were examined for restoring abandoned sites, and it was concluded that a tower excavator system offered superior characteristics and should be evaluated and developed under field conditions. A testing program was developed to provide a framework for the monitoring and analysis of cost, production, and environmental data during a field demonstration of a tower excavator system. Volume I contains a summary of the report. Research done under contract J0295018 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-168048; paper copy price code A04.

OFR 11(2)-82. Recontouring of Steep-Slope Abandoned Contour Mines. Volume II—Appendices, by Daniel I. Carey and Robert L. Lappi. August 1981. 227 pp. 49 figs. Current and potential dragline reclamation usage was evaluated for U.S. coalfields based on data gathered and analyzed during field surveys, literature reviews, and contacts with manufacturers. It was concluded that current mining plans have been adapted to Federal and State strip mine and reclamation laws in ways that limit the potential for dragline reclamation systems at active mine sites. At abandoned conventional contour mine sites in steep-sloping areas, such as central Appalachia, it was found that dragline reclamation systems have great potential application and may be the only practical solution to many reclamation problems. Alternative dragline systems were examined for restoring abandoned sites, and it was concluded that a tower excavator system offered superior characteristics and should be evaluated and developed under field conditions. A testing program was developed to provide a framework for the monitoring and analysis of cost, production, and environmental

data during a field demonstration of a tower excavator system. Volume II contains the appendices. Research done under contract J0295018 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-168055; paper copy price code A11.

OFR 12-82. Irrigation for Reclamation of Strip Mined Lands, by Roger M. Sherman, Jordan A. Kinkead, Gregory J. Campbell, and G. M. Adler. July 1980. 129 pp. 20 figs. Investigation of mine land characteristics, evaluation of irrigation systems, and evaluations by the mining industry determined that irrigation is a feasible method for aiding revegetation of coal mined lands in western arid and semiarid regions. The various regions studied displayed a commonality of characteristics that enables the recommendation of solid-set irrigation. Irrigation should be supplemental by complementing natural precipitation and should be implemented on a temporary basis. For germination, the vegetation requires application of small amounts of water in a gentle, frequent, and timely manner. For the establishment phase of growth, moisture should be applied and stored in the soil previous to germination through preirrigation. The nature of strip mining operations dictates a need for irrigation systems that are physically and operationally flexible, portable, and low in operation requirement. Portable solid-set sprinkler irrigation was identified as a feasible system to meet these requirements. Solid set can apply limited, but useful, quantities of water and has the flexibility to adapt to a variety of field shapes, topography, soil conditions, and irrigation timing requirements. The system also provides a means for wind erosion control and modification of problem soils. Research done under contract J0199088 by Sherman and Sullivan. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-163395; paper copy price code A07.

OFR 13-82. Engineering Property Changes and Environmental Effects on Coal Mine Wastes Due to Slaking, by Wahler Associates. May 1981. 281 pp. 64 figs. A preliminary review was conducted of the occurrence and importance of slaking in coal refuse dumps. Of 21 disposal sites visited to evaluate environmental problems of aging refuse dumps, 5 were selected for intensive study. Laboratory testing included specific gravity, gradation, maximum and minimum density tests, 9-inch drained triaxial tests, 9- and 10-inch permeability tests, slake-durability tests, and accelerated slaking tests. Some refuse sites had significantly lower shear strengths and permeabilities in old, slaked, or weathered material than in fresh refuse. Testing did not show useful correlations between strength and permeability changes and other material properties that could serve as predictors. Testing of refuse under accelerated slaking conditions showed promise as a comparative tool and as a potential means of preparing artificially aged samples for evaluations of long-term behavior. Research done under contract J0285028. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-163965; paper copy price code A13.

OFR 14-82. Cableless Electronic Surveying Systems for Horizontal Holes, by Dennis McLaughlin, John Millhiser, and Margaret Bonarek. March 1981. 235 pp. 27 figs. The purpose of this project was to enhance the Bureau of Mines cableless electronic survey system use to aid in the drilling of long boreholes in coal as part of the methane drainage program. The system that was ultimately developed was field tested and demonstrated in actual in-mine drilling activities. The significance of the system, compared with previous drill survey systems, is that it surveys without having to be inserted and removed for each survey point. The system is so designed that it can withstand the shock and vibration experienced by the drill string during drilling. Thus increased productivity is possible and drill operators can determine drill bit positioning in a near real-time environment. Research done under contract H0177069 by ENSCO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-164526; paper copy price code A11.

OFR 15(1)-82. Area Terrace Pit Coal Mining Systems. Volume 1—Technical & Economic Evaluation of Terrace Pit Mining Systems, by Fred Leonard, Craig Simon, Mike Stoddard, Mani Verma, Mike White, and Larry Welborn. October 1980. 296 pp. 82 figs. This report is principally concerned with the engineering and economic feasibility of area surface coal mining systems other than draglines. This analysis evaluates shovel trucks, shovel-crusher conveyors, and shovel-rail excavation and haulage systems for an assortment of geologic environments and production rates in the Powder River Basin. Shovel trucks, front-end loader trucks, and shovel-crusher conveyors were studied in a multiseam, dipping geologic area of the Four Corners region. The Texas lignite engineering and economic research involved bucket-wheel excavators (BWE), BWE backhoes, and scraper-backhoe combinations for overburden and coal excavation. The truck-shovel study utilized the most recent computer simulation available in both design and cost analyses. Detailed engineering anal-

yses, followed by in-depth operating costs, result in a complete evaluation of each mining system. Cost comparisons of the different mining systems under similar geologic and production constraints are presented to illustrate the estimated capital investment and production costs per ton of coal and bank cubic yard of overburden. Volume I contains a technical and economic evaluation of terrace pit mining systems. Research done under contract J0275017 by Dames & Moore and PD-NCB Consultants Ltd. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS, PB 82-166471; paper copy price code A13.

OFR 15(2)-82. Area Terrace Pit Coal Mining Systems. Volume 2—Appendices, by Fred Leonard, Craig Simon, Mike Stoddard, Mani Verma, Mike White, and Larry Welborn. October 1980. 448 pp. This report is principally concerned with the engineering and economic feasibility of area surface coal mining systems other than draglines. This analysis evaluates shovel trucks, shovel-crusher conveyors, and shovel-rail excavation and haulage systems for an assortment of geologic environments and production rates in the Powder River Basin. Shovel trucks, front-end loader trucks, and shovel-crusher conveyors were studied in a multiseam, dipping geologic area of the Four Corners region. The Texas lignite engineering and economic research involved bucket-wheel excavators (BWE), BWE backhoes, and scraper-backhoe combinations for overburden and coal excavation. The truck-shovel study utilized the most recent computer simulation available in both design and cost analyses. Detailed engineering analyses, followed by in-depth operating costs, result in a complete evaluation of each mining system. Cost comparisons of the different mining systems under similar geologic and production constraints are presented to illustrate the estimated capital investment and production costs per ton of coal and bank cubic yard of overburden. Volume 2 contains the appendices. Research done under contract J0275017 by Dames & Moore and PD-NCB Consultants Ltd. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-166489; paper copy price code A19.

OFR 16-82. Low Temperature Tests of Rescue Breathing Apparatus, by Richard L. Burse and Louis D. Strong. July 1981. 113 pp. 54 figs. The U.S. Army Research Institute of Environmental Medicine tested two samples each of three different types of rescue breathing apparatus (RBA) to determine how long both could be worn by operators in subfreezing temperatures. Phase I tests were performed after overnight cold soaking at the test temperature; phase II tests were performed after overnight storage at + 20° C. Successful performance was determined as proper operation for at least one-half the certified duration of the oxygen supply without exhaustion of the oxygen supply, increase of inspired CO_2 above physiologically acceptable levels, or increase in breathing resistance above tolerable levels. In phase I, the Scott "Rescue Pak R" operated successfully at — 20° C, while the Drager 174-A and the McCaa units operated successfully at — 10° C. In phase II, the Scott unit operated successfully at — 25° C, the Drager at — 20° C, and the McCaa at — 15° C. None of the RBA types appeared well designed for use in subfreezing temperatures. Research done under contract J0188026 by U.S. Army Research Institute of Environmental Medicine. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-172727; paper copy price code A06.

OFR 17-82. Field Survey of Float Dust in Coal Mining Operations, by J. A. Kost, J. F. Colinet, and G. A. Shirey. October 1981. 162 pp. 61 figs. The objectives of this investigation were to determine the amount, size, and deposition of float coal dust generated during the mining and transporting of coal in underground U.S. mining operations. Rock dust distributed by trickle dusters was also sampled. In addition to four belt-transfer points, two continuous and two conventional mining sections were sampled at five mines located in Pennsylvania, West Virginia, Kentucky, and Illinois. Float-dust samples were collected on deposition pans; total airborne dust was collected with MSA model G personal samplers equipped with Unico filter casettes; Andersen cascade impactors provided relative size distributions of the samples. Production, airflow, and waterflow were monitored to examine their effect on dust levels. Research done under contract J0308030 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Carbondale, Ill.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-172719; paper copy price code A08.

OFR 18-82. Temporary Face Support System, by R. O. Nichols and P. J. Hoet. May 1980. 155 pp. 28 figs. This report presents the engineering design, fabrication, and limited testing of a prototype temporary face support system. The system was designed to provide safer work environment for underground coal mining activities between the face and the last line of supported roof. The report provides operational and functional data on the

temporary face support system and contains layouts and engineering drawings of the major elements. Research done under contract H0262058 by Applied Engineering Resources, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 19–82. ADINA/BM—A General Computer Program for Nonlinear Analysis of Mine Structures, by K. J. Bathe. February 1978. 415 pp. 79 figs. The current version of the computer program Automatic Dynamic Incremental Nonlinear Analysis for the Bureau of Mines (ADINA/BM) for linear and nonlinear, static, and dynamic finite element analysis of mine structures is described. The complete report is divided into four parts. Part A discusses the program solution capabilities, the finite element library, and the logical construction of the program and storage allocations. Part B summarizes the theory and numerical techniques used in the program. Part C presents brief problem descriptions and solution results for some sample solutions that have been transmitted as data cases. Part D contains the user's manual. Research done under contract J0255008 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–180993; paper copy price code A18.

OFR 20–82. Development of an Impact Rock Breaker Shaft Sinking System, by Stephen H. E. Phillips. June 1981. 87 pp. 10 figs. The primary objective of this project was to demonstrate the feasibility of using a mechanical impact rock breaker to increase shaft sinking rates, reduce costs, and improve the safety and working conditions for shaft sinking. The specific objective was to improve the shaft sinking equipment developed during the initial phase of the project and to further develop it for sustained underground use. This report outlines the modifications that were made to the prototype rectangular shaft sinking equipment that was originally tested at Magma Copper Co.'s 3A shaft at San Manuel, Ariz. Research done under contract H0262021 by Cementation Co. of America Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 21–82. Baseline Environmental Monitoring Program for the Bear Creek Hydraulic Borehole Mining Demonstration Test, by Lyda W. Hersloff. April 1981. 24 pp. 5 figs. An environmental monitoring program was established to assess the baseline of parameters that may be impacted by a research and development hydraulic borehole mining operation. Two aquifers were identified at the borehole site with the overlying sand aquifer being distinct from the ore sand aquifer on the basis of radiological parameters. The direction of ground water flow was determined to be north 19° west at a rate of 1.82 feet per year. Tests to determine the effect of backfilling the boreholes indicated that using overburden from the open pit mining operation would not significantly increase the radiological constituents of the ore sand aquifer. Mining measurements of the radon flux from the borehole indicated that the actual release rate of 0.035 picocuries per second was several orders of magnitude less than the calculated estimate by the U.S. Environmental Protection Agency. Finally, a gamma survey conducted at the site indicated that the terrestrial component of background radiation was consistent with that in areas near uranium deposits. Research done under contract J0205029 by Rocky Mountain Energy Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 22–82. Real-Time Precalculation of the Distribution of Combustion Products and Other Contaminants in the Ventilation System of Mines, by Rudolf E. Greuer. Mar. 15, 1981. 263 pp. 10 figs. Two computer programs for the real-time calculation of concentration distributions in the ventilation system of underground mines were designed. The programs allow simulation of the movement of fumes or other contaminants with the ventilating air, the calculation of concentrations at any given time and location, and the determination of the total contaminant exposure at different places in the mine. Multiple and time variable contaminant sources can be handled and recirculation is no obstacle. The first program is based on an airflow distribution which has, in the input data, to be stated. The second program has been linked to an existing program for the calculation of airflow distributions. Two versions of the second program are provided to accommodate the two existing programs. Several executed examples demonstrate the program performance. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tusacaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Wash-

ington, D.C. Order ONLY from NTIS: PB 82–183104; paper copy price code A12.

OFR 23–82. Characterization of Accessory Minerals in the Birmingham Red Iron Ores and Eufaula Ferruginous Bauxite Deposits in Alabama, by Richard D. Hagni and Michelle Cooper. Mar. 29, 1981. 127 pp. 20 figs. The character of phosphorus-bearing minerals in the Birmingham red iron ores and iron-bearing minerals in the Eufaula bauxite deposits in Alabama were studied by petrographic, ore microscopic, luminescent microscopic, scanning microscopic, electron microprobe, and X-ray diffraction techniques. Fifteen types of phosphorus-bearing mineral grains were identified in Birmingham iron ores by the characteristic sizes, shapes, and distributions. Size measurements and model and texture analyses permitted an estimate of potential liberation of phosphorus from the iron ores by beneficiation to be 27% in areas of previous mining and 60% in areas of current iron reserves. Fine grinding, selective flocculation, and flotation may constitute the best beneficiation techniques for future research. Hematite and geothite are the most important iron minerals in Eufaula ferruginous bauxites, but pyrite, marcasite, and siderite are important iron minerals in some varieties, and lepidocrocite and ilmenite occur locally in minor quantities. Although simple screening will remove the coarsest iron-bearing grains, research on the utilization of high-gradient magnetic separation to reduce the amounts of iron-bearing grains is recommended. Research done under contract J0100015 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–183369; paper copy price code A07.

OFR 24–82. Fugitive Dust Study of an Open Pit Coal Mine, by Virgil Marple, Kenneth Rubow, and Orville Lantto. September 1980. 150 pp. 62 figs. In 1979 the University of Minnesota Mobile Laboratory (UMML), designed for the analysis of airborne particles and gases, was used to study fugitive dust from an open pit coal mine. The analysis consisted of determining the particle size distribution and concentration of dust from various mining operations such as blasting, draglines, loading, roadways, and bottom scrapers. For some operations the particles size distribution and concentrations were determined at varying distances. Details of the dust concentration within the plumes as the plume passed the UMML were measured with an optical particle counter. For line sources, such as roadways, these measurements enabled the calculation of the particle flux at the sampling location. In addition to the standard instruments associated with the UMML, the applicability of some new instruments was investigated. These included a uniform deposit cascade impactor and a flux meter. Finally, a technique in identifying plume origins that utilize elemental X-ray fluorescence analysis of filter samples was shown to be effective. Research done under contract J0295071 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–183112; paper copy price code A07.

OFR 25–82. Land Reclamation as Sculpture, by David Allen Jones. Feb. 12, 1981. 101 pp. 10 figs. The 1979 Sculpture Symposium, "Earthworks: Land Reclamation as Sculpture," was held in King County, Wash., to create a new tool in the rehabilitation of technologically abused land. Artists were given the opportunity to design for surplus gravel pits, surface mines, and landfill sites. Phase I of the project was the rehabilitation of an abandoned 4-acre pit in south King County. Phase II was a design symposium where artists were assigned a variety of damaged sites ranging from 200 to 400 acres. The artists were asked to create reclamation plans, conforming to all local and State reclamation standards, in the form of earthwork proposals. This report describes in detail the entire project as conceived, constructed, and completed. Research done under contract J0199134 by King County Arts Commission. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–183351; paper copy price code A06.

OFR 26–82. Feasibility Study of Partial Flooding in Mined Out Areas for Mine Drainage Pollution Abatement. Final Report, by John W. Mentz, John R. Williams, Gerald Ahnell, Terry L. Reed, and George W. Akens. September 1981. 143 pp. 14 figs. This study concentrated on the analyses of two potential means of partially inundating abandoned segments of active underground mines to reduce acid formation. Seal construction techniques were taken through five logical steps and the design details of both low-wall dams and section seals were discussed. The study showed that both concepts are feasible only in certain mines where the geologic-hydrologic-physical makeup is suitable to contain a mine pool. Low-wall dams in particular were found to have extremely limited applicability as a means of pollution reduction. Section seals, while clearly dependent upon site specific conditions, have a somewhat broader range of utility and are more effective in pollution reduction. Research done under contract J0285026 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–183401; paper copy price code A07.

OFR 27–82. Propagation of UHF Radio Waves in Limestone Room and Pillar Mines. Summary Report, by Robert L. Lagace and Alfred G. Emslie. January 1979. 43 pp. 12 figs. This report presents a

mathematical model for the propagation of UHF radio waves in the large cross section tunnels of a room-and-pillar limestone mine and describes the analysis of a small amount of propagation data obtained. The model and analysis is based on the waveguide mode theory, developed earlier for the transmission of UHF waves in coal mine tunnels, with allowance for propagation losses due to refraction into the tunnel walls. Propagation around corners and through pillars is also examined based on a ray theory approach together with the beneficial effects of placing reflectors at intersections to significantly reduce corner losses. The theory is found to be in fair agreement with the data; however, additional in-mine measurements are needed to provide a more conclusive test of the model. Research done under contract J0387217 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–190547; paper copy price code A03.

OFR 28–82. Borehole Location System Concept Demonstration Tests, by T. C. Moore, L. H. Rorden, and C. Kwong. May 5, 1978. 69 pp. 16 figs. This report describes the feasibility test of an electromagnetic method for locating boreholes, with or without casing, that have been drilled in conjunction with mining operations but without precisely known locations with respect to the tunnel. The first tests, conducted in cooperation with the Kerr-McGee Corp. near Gallup, N. Mex., in September 1977, demonstrated that accuracies of better than ±5 pct of range and ±1° of bearing can be achieved with a simple system and setup. Subsequent tests on a horizontally drilled pipeline river crossing application, by Titan Contractors of Sacramento, Calif., in January 1978, demonstrated that accuracies of better than 0.5 pct of range and a few tenths of 1° of bearing can be achieved by using refined techniques. The demonstration tests were done at ranges on the order of 100 to 200 feet, but the method is capable of working at much greater distances. Research done under contract J0177074 by Develco, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 29(1)–82. Visual Attention Locations for Operating Continuous Miners, Shuttle Cars, and Scoops. Volume I, by Mark S. Sanders and Gene R. Kelley. Jan. 31, 1981. 142 pp. 22 figs. The primary purpost of this investigation was to determine the visibility requirements for shuttle car and continuous miner operators. Scoops were considered, insofar as they fulfill functions in the mine similar to those carried out by shuttle cars (that is, loading, transporting, and unloading of coal). A second objective was to evaluate the actual field of visibility for a sample machine to develop a simple procedure for visibility evaluation of mobile equipment. A procedure was developed for assessing whether operators in existing machines could be expected to see the visual attention locations. The procedure makes use of a human eye reference measurement instrument (HERMI) designed for this project and an outside-in photographic procedure for documenting compliance with the recommendations. Samples of continuous miners, shuttle cars, and scoops were used to test the procedure and the results are presented. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–187964; paper copy price code A07.

OFR 29(2)–82. Visual Attention Locations for Operating Continuous Miners, Shuttle Cars, and Scoops: A Summary, by Mark S. Sanders. May 1, 1981. 67 pp. 9 figs. This report presents a summary of the work reported in volume I. A task analytic approach was used to define information requirements and visual features that served as sources of information. From this analysis, visual attention locations, containing one or more important visual features, were identified. The procedure makes use of a human eye reference measurement instrument (HERMI) designed for this project and an outside-in photographic procedure for documenting compliance with the recommendations. Samples of the test procedures and the results are presented. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–187949; paper copy price code A04.

OFR 30–82. In-Mine Tests for Wetting Agent Effectiveness, by J. A. Kost, G. A. Shirey, and C. T. Ford. December 1980. 190 pp. 39 figs. The objective of this research was to determine if the addition of a surfactant (wetting agent) to the water used for dust control in underground coal mines results in the reduction of airborne dust. Laboratory wettability tests (including the capillary rise test, a coal dust sinking test, and zeta potential measurements) were used to select a coal seam surfactant combination for in-mine testing. Four surfactants were selected for underground testing: Surfynol 465, Aerosol MA-80, DC-13, and Dustallay. The underground tests in the Lower Kittanning

seam, Indiana County, Pa., involved a Wilcox Mark 20 auger mining system equipped with spray nozzles located on the cutting augers, Conflow venturi sprays, and a spray manifold. Respirable dust samples were provided by MSA model G personal samplers and Simslin II instantaneous dust monitors; total airborne dust samples were provided by MSA model G samplers with UNICO filter cassettes. Based on data obtained from 24 test periods, surfacants, compared with plain water, reduced the airborne respirable dust an average of 27 percent and total airborne dust an average of 36 percent. Research done under contract J0295041 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–183344; paper copy price code A09.

OFR 31–82. Materials Requirements and Economic Growth: A Comparison of Consumption Patterns in Industrialized Countries, by S. Victor Radcliffe, Leonard L. Fischman, and Radford Schantz, Jr. Dec. 18, 1981. 333 pp. 49 figs. This study concerns the national consumption of nonenergy materials of all types in relation to economic growth. A quantitative method of measuring materials consumption by industry and consumers was developed for major individual materials and materials as a whole. This method accounted for the net trade flows of materials incorporated in manufactured consumer and capital goods and for the recycling of materials contained in scrap. The principal factors that have determined materials consumption intensities in relation to economic output over the historical development of the advanced industrialized countries were identified by relying on comparison of the experiences of four countries: the Federal Republic of Germany, Japan, the United Kingdom, and the United States. Hypotheses were formulated and tested for the relationships between materials consumption, economic activity, and the level of national well-being. Attention was given to the influence of technological factors and to clarifying the interplay between consumption of materials and energy, and the analysis was extended to developing countries. The correlation of domestic industrial consumption, as measured from input-output tables, to the national income from manufacturing and construction proved significant, and the structure of final demand proved to be a main determinant of demand for materials. Finally, the field of materials demand forecasting was comprehensively and critically surveyed and the study results were applied to improving methods of forecasting future requirements. Research done under contract J0177118 by Resources for the Future. Available for reference at the Bureau of Mines Division of Analytic Studies and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–196270; paper copy price code A15.

OFR 32–82. Systems Study of Metal and Non-Metal Mine Communications, by Roger G. Long, John D. Foulkes, Philip M. Kay, and Stuart J. Lipoff. August 1979. 231 pp. 77 figs. The purpose of this study was to categorize and characterize underground metal-nonmetal mining operations from the viewpoint of telecommunication requirements and practices. The objectives were to gather and analyze data, identify communication requirements, and recommend systems for operational emergency and post disaster telecommunications. The results represent a major step towards providing effective means for locating workers trapped underground following a mine disaster. Research done under contract J0166093 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 33–82. Environmental Instrumentation in Mining Air and Water, by Richard C. Moore, Nancy J. Opper, Marion Dodson Paul, and Robert L. Kort. Aug. 28, 1981. 335 pp. 35 figs. The U.S. Bureau of Mines contracted a study to review the air and water monitoring requirements of five Federal environmental acts (the Federal Water Pollution Control Act, the Safe Drinking Water Act, the Clean Air Act, the Surface Mining Control and Reclamation Act, and the Resource Conservation and Recovery Act) and to compile information on currently available monitoring instruments. A literature review of the acts and the associated regulations was conducted to determine applicability to the mining industry as well as any air and water monitoring requirements. In addition, an industry search and literature review was performed to assess the instrumentation available to comply with the monitoring regulations. Based on this research, the instruments are classified by general applicability to air, surface water, or ground water monitoring, then cataloged by monitoring parameters. A discussion is provided on recommended and innovative monitoring techniques Research done under contract J0205034 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–187139; paper copy price code A15.

OFR 34–82. Full Scale Model Roof Bolt Test System. Final Report, by Charles W. Maus. Jan. 31, 1980. 157 pp. 44 figs. A full-scale system for testing roof bolts has been furnished to the Bureau of Mines. The system uses a full-size model of a mine entry made from sand and portland cement concrete. A servosystem with hydraulic actuators and load pads provide lateral, vertical, and shear loads to simulate premining and postmining conditions. Instruments embedded in the model deter-

mine strains as affected by the installed roof bolts. To insure stability, pressure limit detectors make certain that vertical loads are at a safe level before horizontal loads are applied. Set points provide for interlocks and safety shutdown in the event of pressure or error signal in excess of preset limits. There is a data acquisition system and computer for control and compilation of data. Peripherals include a CRT console, a hard copy unit, and a magnetic tape unit. The control and data system can operate with input determined by the computer, or by manual or auxiliary means. Research done under contract S0271014 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-185471; paper copy price code A08.

OFR 35-82. In-Pit Crushing and Conveying With Movable Crushers, by R. N. Johnson. November 1980. 213 pp. 21 figs. This report is a summary of the work performed to evaluate the feasibility and desirability of a movable in-pit crusher combined with conveyors to substantially reduce or eliminate truck or train haulage in large open pit, nonfuel mineral mines. The report includes a background discussion of in-pit crushing concepts, the results of a multimine survey of needs and current haulage characteristics, concepts for a movable in-pit crusher that are in keeping with mine operation stated needs and requirements, descriptions of key areas of technology improvement that must be satisfied to meet mine operator requirements, economic and operational impact of such a system, and recommendations for future work to bring about the general availability of such systems. Research done under contract J0295004 by Gard, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-184714; paper copy price code A10.

OFR 36-82. SIC Based End-Use Data Scheme for Information Critical Minerals, by Balakrishnan K. Nair, George K. Schenck, and Fred Demler. September 1978. 464 pp. 21 figs. Management of and policy planning for minerals require reliable information on the flow of materials through the economy. This report describes several case studies of information-critical minerals and evaluates for each mineral the feasibility of implementng a SIC-based, end-use data scheme. The scheme proposed will lead to an improved information base for understanding the sectoral demand for minerals. The objectives of the data base are to improve the forecasting of demand for each mineral and to identify the extent of dependency between economic activity and materials demand. A two-dimensional information system is proposed. The first dimension measures the consumption of minerals in primary intermediate products (technical product classes). The second measures the consumption of technical product classes in SIC-based, end-use sectors. The scheme permits intercommodity comparisons at the SIC two-digit level. Research done under grant G0166213 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Reno, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS; PB 82-188707; paper copy price code A20.

OFR 37-82. Potential Effect of Ferrous Scrap Composition Changes on the Quality of Iron and Steel Castings, by W. L. Swager, H. W. Lownie, Jr., and C. E. Mobley. November 1981. 226 pp 14 figs. Tramp (undesirable) elements introduced into iron and steel castings through purchased ferrous scrap are evaluated as to their likely degree of future threat to the quality of castings. Conclusions are based on analysis of literature and on nonmail surveys of foundries, scrap processors, trade and technical associations, and others. The existing tramp-element problem is expected to be persistent, but amenable to improved control by foundries and their suppliers. Four recommendations for action are given. Research done under contract J0205002 by Battelle Columbus Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-194184; paper copy price code A11.

OFR 38-82. Development of Guidelines for Installation and Maintenance of Mine Illumination Systems, by K. L. Whitehead and J. C. Yingling. April 1981. 290 pp. 34 figs. An examination of 60 mines, 11 illumination hardware manufacturers, and 9 mobile face-equipment manufacturers was conducted to determine the state of the art of mine-illumination hardware, define lighting system installation and maintenance problems, and assess personnel acceptance of lighting. Major problems, with extreme variability in degree, on room-and-pillar installations include damage of exposed components, electrical failures, and reduced lamp life. While most mobile face-equipment operators approved of the machine lighting systems, many complained of glare and other problems. Longwall lighting systems were unanimously accepted by face personnel, and most complaints were minor. Based on the survey, general installation and maintenance guidelines have been established, addressing hardware design aspects, approaches proved effective to minimize problems, and noted improper practices that are detrimental to effective lighting. Research done under contract J0308040 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Mor-

gantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-192022; paper copy price code A13.

OFR 39(1)-82. Study of the Use of Personal Equipment in Low Coal. Use of Personal Equipment in Low Coal: A Review of the Personal Equipment Literature. Phase I Report, by Mark S. Sanders, Barry Beith, and Tyler Blake. Dec. 30, 1978. 100 pp. 1 fig. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. To accomplish this, three principal tasks were to (1) summarize the state of the art with respect to personal equipment and its use in low seam coal mines, (2) empirically validate alternative designs for personal equipment, and (3) make recommendations on redesign of personal equipment for low seam coal mines. The report is a summary of the literature dealing with personal protective equipment that is now, or could be used in the underground mining environment. Recommendations for further research and development are included. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218207; paper copy price code A05.

OFR 39(2)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners. I. Comparison of 10/60 and Standard Self-Rescue Devices. Phase II Report, No. 1, by Mark Sanders, Gregory Krohn, Kent Volkmer, Daniel Wick, Howard Miller, Tyler Blake, and Barry Beith. Jan. 31, 1980. 26 pp. 8 figs. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report compares a proposed 10/60 "piggyback" O_2-generating, self-rescue unit with the standard CO self-rescue unit with respect to work task interference. A simulated low seam coal mine was constructed and workers performed locomotion, shoveling, cart pushing, and timbering tasks with the 10/60 and standard self-rescue units attached to their belts. Task completion time was longer on all tasks when wearing the 10/60 units, although only locomotion was statistically significant. The 10/60 units were bumped over 100 pct more often than the standard self-rescuers. It is recommended that the design for the proposed 10/60 units include (1) extra durable containers to withstand the added abuse they are likely to receive by low coal miners and (2) extra consideration toward preventing the devices from slipping on the belts while working. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218140; paper copy price code A03.

OFR 39(3)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners: II. Dexterity, Protection and Performance With Padded Gloves. Phase II Report, No. 2, by Gregory Krohn, Mark Sanders, Kent Volkmer, Daniel Wick, Howard Miller, Barry Beith, and Tyler Blake. Jan. 31, 1980. 31 pp. 9 figs. The objective of this study was to determine the optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report investigates the effects of adding a layer of extra padding to the palm area of leather gloves typically worn by low seam coal miners. The first study showed that added glove padding provides more potential protection but does not affect manual dexterity. The second study, in a simulated low seam coal mine, showed no significant differences using padded and nonpadded gloves in crawling, shoveling, timbering, and cart pushing task completion times. In general, the workers preferred the padded gloves although they expressed some complaints about awkwardness and loss of sensitivity. It is recommended that the design for padded gloves provide comfort, protection, and maximum hand sensitivity. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218157; paper copy price code A03.

OFR 39(4)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners: III. Effect of Size and Weight of Battery Pack Performance. Phase II Report, No. 3, by Mark Sanders, Gregory Krohn, Daniel Wick, Kent Volkmer, and Barry Beith. Jan. 31, 1980. 33 pp. 9 figs. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report describes three experiments that were conducted to determine the effects of size and weight of battery packs. The first experiment tested the sensitivity of task measures; that is, workers performed locomotion, shoveling, cart pushing, and timbering tasks to detect variations in the size and weight of battery packs. The results showed that only locomotion was sensitive to size and weight variations. The second experiment focused on locomotion tasks and tested the effects of varying size and weight on task completion time. The third experiment compared the battery pack presently in use with a radically different configuration of power cells. The most important findings were that changes in weight affected locomotion times but changes in size and configuration had small and inconsistent effects. Workers indicated a strong preference for a battery pack belt

concept. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah., and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218165; paper copy price code A03.

OFR 39(5)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners: IV. Incorporating Coiled Cord Into Cap Lamp Battery Cords. Phase II Report, No. 4, by Tyler Blake, Mark Sanders, Gregory Krohn, Daniel Wick, Kent Volkmer, and Barry Beith. Jan. 31, 1980. 30 pp. 9 figs. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report describes a study designed to evaluate a proposed modification in the cap lamp battery cord intended to reduce the incidence of snagging and catching of the cord. A three-phase evaluation was performed comparing a prototype with the standard, currently available cord. In the first evaluation a "pull test" was performed to measure the reaction time of workers and the maximum force delivered to the helmet. The second evaluation was a body conformity experiment wherein the cords were studied to determine whether they conformed differently to workers bodies. The third evaluation involved workers performing common manual tasks in a low seam coal mine simulator. The results demonstrated significant safety advantages of incorporating coiled cords into the design of the cap cord. The coil cord presented a lesser snagging hazard, allowed the wearer more time to respond to a snag, and transmitted lower levels of force to the helmet when snagged. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218173; paper copy price code A03.

OFR 39(6)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners. V. Effect of Reflectorized Outer Garments on Detection and Conspicuity of Miners. Phase II Report, No. 5, by Barry Beith and Mark Sanders. Jan. 31, 1980. 43 pp. 14 figs. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report details a study that was designed to assess the effect of retroreflective material on the detection and form recognition of workers in a mining environment. The study involves a one-fifth-scale simulation of the perceptual task found in underground low seam coal mines. Under this simulation, different configurations of retroreflective material are examined in various body positions at three different locations in the visual field. The first experiment compares three different retroreflective configurations with the current cap only reflectorization currently used by miners. The second experiment attempts to determine an optimum cost-effective configuration. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218181; paper copy price code A03.

OFR 39(7)-82. Study of the Use of Personal Equipment in Low Coal. Experiments on Personal Equipment for Low Seam Coal Miners. VI. Comparison Bumping Hazards With High and Low Profile Helmets. Phase II Report, No. 6, by Mark Sanders, Daniel Wick, and Gregory Krohn. Jan. 31, 1980. 29 pp. 10 figs. The objective of this study was to determine optimal personal equipment design for use in low coal based on ergonomic, biomechanic, and safety considerations. This report describes an experiment that was conducted to compare the relative bumping hazards of a low- and high-profile hard hat (helmet) in a low seam mining environment. The study was specifically designed to assess the effect of lowering the helmet profile on frequency of head impacts. This involved workers performing four low coal mining tasks wearing the low- and high-profile helmets in a low seam simulator (36- to 48-inch heights). The results indicated that a low-profile helmet could reduce bumping frequency approximately 25 pct, and as much as 80 pct in selected tasks. It was beyond the scope of the study to measure the impact force, thus it was not possible to estimate the effect of the low-profile helmet on severity of impacts underground. Research done under contract J0387213 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218199; paper copy price code A03.

OFR 40(1)-82. Development of Methods for Reclaiming Tailings Ponds and Dams. Volume I, by Robert D. Perry and Frank C. Kresse. June 1981. 34 pp. This report describes methods of reclaiming abandoned or inactive tailings ponds and dams. The investigated sites were selected tailings deposits adjacent to metal mines in the Southwestern United States and the Pacific Northwest. The basic data developed for each site consisted of a review of existing literature, a site visit that included sampling of the tailings and surrounding materials, laboratory and engineering studies, and development of reclamation plans. Laboratory tests

determined the gold and silver content of each deposit and the chemistry of the tailings and surrounding materials. Reclamation plans that include approximate costs were developed for five deposit sites ranging from 52,000 to 103 million tons. Conclusions on the remaining potential of each site are based on the tailings assay and other technical data. This study concludes that remining as a reclamation tool is feasible at certain sites. Research done under contract J0199117 by Harding-Lawson Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-195736; paper copy price code A03.

OFR 40(2)-82. Development of Methods for Reclaiming Abandoned Tailings Ponds and Dams. Volume II, by Robert D. Perry and Frank C. Kresse. June 1981. 378 pp. 23 figs. This report describes the methods of reclaiming abandoned or inactive tailings ponds and dams. The investigated sites were selected tailings deposits adjacent to metal mines in the Southwestern United States and the Pacific Northwest. The basic data developed for each site consisted of a review of existing literature, a site visit that included sampling of the tailings and surrounding materials, laboratory and engineering studies, and development of reclamation plans. Volume II contains the appendixes. Research done under contract J0199117 by Harding-Lawson Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 41(1)-82. Control of Shale Roof Deterioration With Air Tempering. Volume I—Field and Laboratory Investigations, by R. A. Cummings, M. M. Singh, S. E. Sharp, and A. W. Laurito. Jan. 9, 1981. 164 pp. 72 figs Certain roof shales in coal mines deteriorate upon exposure to the atmosphere, causing difficulties in the mining operations and adding to the cost. This report presents the results of field investigations in a West Virginia mine and laboratory studies on the effects of atmospheric moisture on roof shales. Based on these observations, a conceptual procedure is presented on how shale deterioration might be predicted during exploration. Guidelines are given detailing how air tempering or conditioning chambers may be designed to reduce moisture effects. Recommendations for further studies are included. Research done under contract J0188028 by Engineers International Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS; PB 82-199985; paper copy price code A08.

OFR 41(2)-82. Control of Shale Roof Deterioration With Air Tempering. Volume II—Annotated Bibliography, by R. A. Cummings, M. M. Singh, S. E. Sharp, and A. W. Laurito. Jan. 9, 1981. 64 pp. 23 figs. This is the first documented study and assessment of air tempering or conditioning chambers as a means of reducing roof disintegration caused by moisture and humidity. Volume I contains the results of field and laboratory investigations. Volume II contains an annotated bibliography. Research done under contract J0188028 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avandale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-199993; paper copy price code A04.

OFR 42-82. Hoist Signaling Monitor and Display System, by Arnis Mangolds. Sept. 30, 1981. 93 pp. 10 figs. This report documents the work performed and the results obtained under a contract that included a mine and manufacturer survey to determine the functional requirements, problem areas, and state of the art of shaft communications. An interest in improved hoist communications was noted during the survey; areas of particular concern were increasing the reliability and decreasing the required maintenance. The manually operated bell-horn system of signaling the hoistroom was also deemed confusing and could result in risks of hazardous actions and inefficient operation. Several designs have been conceptually developed that include environmental protection of cage-mounted communication equipment, an on-board charging system to reduce battery handling, a level-to-hoistroom request display, and a monitoring system. The designs are configured to allow their simple adaptation into existing commercial or mine-constructed communication networks. Research done under contract J0308048 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-198557; paper copy price code A05.

OFR 43-82. Development of a Mobile, Hi-Rise Work Platform, by Edward E. Tate and Bennett O. Blout. April 1981. 56 pp. 9 figs. This report describes the design, development, and manufacture of a prototype roof bolting machine for high rise applications. The machine is designed to traverse a

32-inch entry and rebolt a roof fall area to a height of 28 feet and 10 inches. A chronology of the project, an explanation of design problems, and a description of the solutions are covered. It is concluded that the equipment as designed is suitable for the purpose intended and further testing is recommended. Research done under contract H0252074 by Barnes & Reinecke, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 44–82. Underground Mine Disaster Survival and Rescue: An Evaluation of Research Accomplishments and Needs, by the Commission on Sociotechnical Systems, National Academy of Sciences. 1981. 122 pp. 4 figs. Postdisaster survival and rescue research is a small component of the Bureau of Mines health and safety research program. The objectives of this study were to evaluate the Bureau's postdisaster research program and to recommend future efforts in this area. A definition of a disaster survival and rescue system that provides a frame of reference for the evaluation of research accomplishments and the assessment of future needs was developed and the essential components of a research and development program in the postdisaster area was outlined. It was found that to develop a more effective capability for postdisaster survival and rescue, the need for a systems approach to preparing for disaster response and special considerations that apply to government-sponsored research and development leading to the design of escape, survival, and rescue equipment must be considered. Research done under contract J0100014. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 45–82. Fundamentals of Chromite Flotation, by Ross W. Smith. June 30, 1981. 57 pp. 34 figs. Microflotation and surface chemical studies were conducted on chromite, and some of the minerals usually associated with such chromites, from the Stillwater Complex, Mont. Considering the chromite, it was found that aging the ground mineral in air or heating it markedly affected its flotation behavior. Much of the effects could be attributed to oxidation reactions involving surface chromium and iron species. Strongly acid pretreating the mineral appeared to reverse these effects. It can be concluded that the manner in which the mineral (or ore) is pretreated is of utmost importance in its flotation. Work carried out on associated gangue minerals determined how the minerals are likely to behave in a flotation environment and how certain foreign ions derived from chromite ore can affect the surface characteristics of the ions and presumably their behavior in a flotation circuit. Research done under grant G0274005 by the University of Nevada. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-197492; paper copy price code A04.

OFR 46–82. Dust Control for Cutter Machines, by Dennis J. Grigal, Michael D. Blom, and David F. Johnson. December 1981. 122 pp. 52 figs. The purpose of this program was to investigate the feasibility of wet and dry dust control techniques for controlling respirable dust generated by an underground mining cutter machine; to recommend the most practical wet and dry dust control system; and to fabricate, retrofit, and test the recommended dust control system. The program was divided into three phases. During phase I, three wet and two dry prototype dust control systems were designed. Because of a contract amendment, all work was suspended on the wet control system; therefore, phase II consisted of fabricating and laboratory testing one dry dust collection system. Laboratory tests included dust pickup capability and filter life. Phase III consisted of a field evaluation of the dry dust control system retrofitted to a Joy 15RU cutter machine in a salt mine. For the mine faces analyzed, reduction of dust concentration averaged 67 pct, with a system airflow of 4,000 ft^3/min. Filter life was unsatisfactory. A self-cleaning dry dust collector was recommended as more suitable for cutter machine application because of the large quantity of dust. Research done under contract H0387010 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-202706; paper copy price code A06.

OFR 47–82. Reliability and Effectiveness Analysis of the USBM Electromagnetic Location System for Coal Mines, Final Report, by R. F. Kehrman, A. J. Farstad, and D. Kalvels. Dec. 1, 1978. 153 pp. 23 figs. Voice frequency electromagnetic trapped miner location devices were tested for reliability and effectiveness in 93 coal mines. Tests included uplink pulsed carrier waves, downlink pulsed carrier waves, and downlink voice evaluations. Frequencies were 630, 1,050, 1,950, and 3,030 hertz. Overburden depths ranged from 70 to 1,550 feet. Successful communications were established at 91 of the 93 mines. Data indicate the transmitters and receivers will operate in practically all coal mine environments. Reliability and accuracy as location devices appear to depend on noise, depth, and presence of metallic objects that distort the magnetic field. In addition, theoretical models appear to define best case situations in terms of noise and conductivity. Minor hardware problems were encountered, mostly involving battery contacts, switches, and antenna cables on the receivers. No hardware problems occurred

with the transmitters. Research done under contract J0166060 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-201385; paper copy price code A08.

OFR 48–82. Detailed Design and Demonstration of Underground Disposal of Coal Mining Wastes. Phase I, by Foster-Miller Associates, Inc. April 1981. 87 pp. 28 figs. This report presents a design for a pneumatic underground disposal system for coal mine waste. This particular design is only applicable for use at the Hawk's Nest Mine in Somerset, Colo. Calculations, sketches, drawings, and estimated costs necessary to implement this design are presented in the report. Research done under contract J0205056. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 49–82. Innovative Techniques in Trolley Line Power Distribution, by B. Gillenwater and J. McCoy. May 1981. 79 pp. 23 figs. This report describes the results of investigations into four specific areas related to trolley wire power distribution in coal mines. Prototype devices or designs were developed in each area. In addition, a brief survey was made in an attempt to assess the future of mine trolley systems, and data was collected and reviewed in an attempt to analyze the nature of trolley wire related accidents. Other options for decreasing the risks associated with trolley systems that arose during the study are briefly discussed in the appendices. These include insulating equipment and miners from return and/or energized conductors and use of a segmented trolley wire with local control of current-delivering capability. Research done under contract J0188083 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-201815; paper copy price code A05.

OFR 50–82. Comparisons of Structural Stability for Entry Configurations and Ground Support for Longwall Panel Development, by D. E. Van Dillen and R. W. Fellner. February 1981. 225 pp. 55 figs. Seven configurations for panel entries of a longwall coal mine are compared and ranked according to structural stability. These entry configurations are analyzed using three-dimensional finite element modeling. The models include large dimensions to minimize boundary effects, elastoplastic constitutive relations, and simulated excavation and construction of support systems. The stability criteria are formulated in a quantitative manner to facilitate the ranking of the entry configurations. These criteria are based on the expected volume of caved rock in the entry openings. The stability ranking is applied to the entry excavation phase, the headgate phase, and the tailgate phase of the entry life cycle. Parametric variations are applied using two-dimensional finite element models to determine the sensitivity to changes in mining and design parameters. Research done under contract J0285014 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-201864; paper copy price code A10.

OFR 51–82. Technology for Environmental Noise Control in Surface Mines. Final Report, by Michael A. Staiano, William Benson, and Timothy A. Gates. August 1981. 122 pp. 18 figs. The objective of this study was to determine the magnitude and sources of environmental noise from mining operations near populated areas, to describe monitoring techniques, and to identify applicable existing noise abatement techniques. Noise surveys of a representative sample of mines and quarries were conducted and noise levels at site boundaries and near specific equipment and ensembles of equipment were measured. Noise exposures in terms of annual day-night sound level were calculated for the boundary noise measurement locations. In addition, the relative sound level contributions were estimated for the mining equipment noise sources affecting the boundary locations. Noise abatement methods falling into three categories were analyzed: equipment practices, operational-administrative practices, and equipment quieting. Selected applications of noise abatement methods were evaluated in hypothetical situations with emphasis upon machinery selection and use. Procedures for measuring noise around mining operations are provided. Research done under contract J0100001 by ORI, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 52–82. Mine Grounding Systems: Development of Tests and Criteria To Evaluate Grounding Systems,

by Wils L. Cooley and Robert L. McConnell. September 1979. 150 pp. 57 figs. This report covers tests and criteria for the establishment of safe grounding systems for coal mines. The work deals primarily with underground mines, but much is applicable to surface mines as well. Included is an extensive guide to grounding and bonding procedures for mine surface substations. Xit-Rods (chemically charged, hollow-rod electrodes that generate their own moisture and metallic salts and uses the resulting electrolyte as the interface medium between the conducting surface of the rods and outwardly in the soil and lowers resistance) are evaluated and shown to deviate from manufacturers claims. An analysis shows that very long cables are difficult to monitor using audiofrequency ground-check techniques. A method is developed to detect failing cable splices without removing the cable from service. Simulation and measurement are compared for a technique to detect bad rail bonds, and an assessment is made of grounding techniques for dc face equipment. Research done under grant G0188087 by the West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-209719; paper copy price code A07.

OFR 53–82. Modify and Evaluate a Self-Propelled Battery Powered Scoop, by William F. Hahn and Gary L. Bowen. Sept. 5, 1980. 73 pp. 32 figs. Previous field evaluations showed that the major cause of illumination system downtime was physical damage due to machine collisions with coal surfaces or other operating equipment. To insure good system reliability, durable mechanical protection of the illumination hardware must be incorporated into the machine structure. This required protection can best be integrated into mining equipment during design and fabrication of new machinery. The purpose of this study was to determine the best method to integrate an approved lighting system into a low seam battery-powered scoop and evaluate its performance. The report documents the work performed and the results obtained. Research done under contract H0387007 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-209727; paper copy price code A04.

OFR 54–82. Safety and Cost Benefits From Improved Highwall Blasting Practice, by F. S. Kendorski and M. F. Dunn. February 1981. 171 pp. 63 figs. This report presents the results of a program to improve unstable highwall conditions through better blasting practices in Appalachian strip coal mines using existing and proven technology. The objectives were better borehole blasting agent distribution and optimization of burden, spacing, and delay periods allowing satisfactory breakage with minimal backbreak. At a selected field site, geologic conditions were examined with regard to joint orientation and spacing, and resulting slope stability considerations. A test series of eight blasts was completed and the resultant highwall was monitored by repetitive photography. The study of drilling and blasting economics along with equipment performance led to an economic model of blast parameters and the identification of blast design cost and benefits. Research done under contract H0282011 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-205691; paper copy price code A08.

OFR 55–82. Design and Testing of Joining Sleeves for Trailing Cable Ground and Pilot Wires, by Walter Frank, Jr. August 1979. 121 pp. 88 figs. The purpose of this work was to develop a ground and pilot connector that will significantly improve mine trailing cable splice performance. The connector design includes connectors for splicing ground and pilot conductors. A distinction is made between connectors suitable for splicing round and flat ground and pilot conductors. A discussion on the suitability of round cable for trailing cable applications is included. A field test was conducted to confirm ground and pilot connector laboratory data. The tests proved the viability of the connector designs and recommended installation techniques in a mine environment. Research done under contract H0377042 by the Burndy Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-205725; paper copy price code A06.

OFR 56–82. Evaluation of Roof Trusses, Phase I, by Clark P. Mangelsdorf. February 1979. 111 pp. 66 figs. The objective of this program was to evaluate a number of roof support systems that have some physical similarity to the truss introduced by the Birmingham Bolt Co. in 1966. The report is in two parts: Part I is a state-of-the-art study of roof truss technology as of January 1979. Included are a history of the truss concept, a review of analysis techniques, a record of hardware available and equipment used in its installation, and examples of user experience. Part II is concerned with a study of the role of friction in the behavior

of a roof truss. Research done under grant G0166088 by the University of Pittsburgh. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–209768; paper copy price code A06.

OFR 57–82. Undercut and Fill System for Pitching Coal, by Arnis Mangolds and Allan Fisk. June 1981. 94 pp. 21 figs. A study of the technical and economic feasibility of using a unique undercut and fill system developed by Bureau of Mines engineers to mine steeply pitching coal is discussed. The undercut and fill system combines hydraulic coal cutting with unassisted gravity fluming of the coal slurry. Mining occurs across strike and the extended entry is backfilled to provide uniform strata control and an impermeable water and air barrier. Subsequent mining occurs beneath the previously filled stope such that the roof consists of a solid, controlled back. In addition to providing positive roof and hanging wall support, the backfill system eliminates subsidence potential, postmining drainage, and the danger of spontaneous combustion from naturally drafting air currents. A throughflowing ventilation system permits passage of return air through the production face through ducting located at the backfill-coal junction thus providing a constant supply of fresh air at the face, eliminating the need for brattice cloths, and provides an additional excapeway for miners. Research done under contract J0295028 by Foster-Miller Associates, Inc. Available for research at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–200486; paper copy price code A05.

OFR 58–82. Pilot Scale On-Site Evaluation of Activated Carbon for Rapid Oxidation of Ferrous Iron in Acid Mine Water, by Anthony E. Perrotti and Alvin J. Snyder. October 1981. 69 pp. 19 figs. A pilot plant for evaluating rapid oxidation of ferrous iron under acidic conditions was designed, fabricated, and operated at a typical mine site for 6 months. The effect of activated carbon as a catalyst on the oxidation reaction was tested using three fluidized carbon bed reactors in series. Test runs for iron oxidation were made at various pH levels with and without the presence of activated carbon. Runs were extended to evaluate the changes in oxidation rate in relation to carbon life. Results of the study indicated that initial enhancement of the oxidation of ferrous iron was not sustained. The increased removal of ferrous iron concentration was found to be due to adsorption by the carbon rather than due to catalysis. Research done under contract J0395036 by R. I. Analytical Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–200494; paper copy price code A04.

OFR 59–82. Design of a Portable Gas Analyzer for Monitoring During Mine Fires, by Clayton J. Bossart. May 10, 1978. 54 pp. 22 figs. The design and fabrication of an engineering model and three prototypes of a portable gas analyzer and sampling system is described. The design provides a battery-operated system that will indicate the degree of explosivity of return air and in the air beyond the seal during the course of fighting, sealing, and quenching a mine fire. Performance tests design criticisms, and recommendations for designs are included. Research done under contract H0155094 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–202748; paper copy price code A04.

OFR 60–82. TDRM Testing, by Eugene W. Bartel, Michael Fox, Edward Borgoyn, and Perry Wingfield. November 1980. 212 pp. 83 figs. This report describes the testing of the time domain reflectometry microcomputer (TDRM) system. The automated time domain reflectometry (ATDR) software is described and attempts to implement the same assembly language program in a higher level language (PLM) are documented along with two versions of the PLM program. One PLM program uses a data filtering approach to limit noise and the other uses data averaging to reduce noise. The field tests of the analog and digital ATDR units are described along with the hardware modifications that resulted. Tests indicate that the digital units are more consistent and less confusing to operate than the analog units. The results indicate that the digital units can locate an abnormality in a test cable to within 5% of the true location (provided the cable phase velocity is known). The digital units can consistently locate shunt faults less than 300 ohms and series faults greater than 30 ohms. Research done under contract J0377021 by Carnegie-Mellon University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. De-

partment of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 61–82. Design and Develop Feasible Lighting System for Conventional Slope Under Construction, by William F. Hahn and Charles G. Howard. September 1981. 83 pp. 16 figs. This report describes an illumination system suitable for use in a slope under construction. Simulator work was performed using actual lighting hardware to verify adequate light levels to meet MSHA proposed regulation (as published in the Federal Register, January 13, 1977). The sequence of operating activities for two different slope driving sites are discussed and lighting requirements are defined for each. Research done under contract H0377051 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 62–82. Integration of Quieting Technology Into New Mantrip Vehicles, by V. Ferrari and A. Galaitsis. October 1981. 164 pp. 74 figs. This report presents the three-phase program to design, fabricate, test, and demonstrate economical and practical methods of reducing noise levels on underground coal mining portal buses (mantrip vehicles). The noise-control treatments applied to a production-model portal bus were as follows: (1) Wheel-rail vibrations were isolated from the vehicle frame by inserting elastomeric materials between suspension components. (2) Vibration-induced noise was reduced by replacing all large sheet metal panels, except floor plates, with damped steel panels. (3) Motor noise was reduced by tight-fitting covers made from damped steel and lined with sound-absorbing material and elastomeric motor mounts. (4) The standard spur gears used in the traction drive system were replaced with helical gearsets. The program reduced the average sound level to below 85 dbA for typical operating conditions. Research done under contract J0199068 by ESD Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–203241; paper copy price code A08.

OFR 63–82. Electromagnetic Propagation in Low Coal Mines of Medium Frequencies, by Terry S. Cory. June 12, 1978. 96 pp. 42 figs. This report covers magnetic field strength measurements versus range and frequency in low to medium coal mines. Both quasi-conductor-free and conductor-proximity areas were investigated. The program covered five mines, four seams, six measurement sets, and three geographic areas. The results are summarized in terms of maximum communication range expected per seam and noise condition. Scatter gain is further explored as a simple measure of energy coupled to conductors. Research done under contract H0377053 by Rockwell International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–202656; paper copy price code A05.

OFR 64–82. Taconite Crusher Noise Reduction—Study of Acoustical Enclosure for Symons 7 Foot, Standard Head, Extra-Heavy Duty Cone Crusher, by James A. Morgan. September 1980. 40 pp. 9 figs. The objective of this study was to evaluate the acoustical and cost effectiveness and the operational practicality of prefabricated acoustical enclosures applied to a taconite crusher. The enclosures were designed for durability, ease of assembly, and ease of access for crusher maintenance. Field measurements of noise were made on the periphery of enclosures on a secondary crusher at the Jackson County Iron Co. in Black River Falls, Wis. Noise reduction achieved by the enclosures was sufficient to permit reduction of crusher room noise to 90 dbA, provided that other sources are appropriately treated and acoustical adsorption is provided in the crusher room. Secondary crusher noise was reduced 10 to 15 dbA by the enclosures. Research done under contract H0387016 by Industrial Acoustics Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–202649; paper copy price code A03.

OFR 65–82. Silencing the Flame Channelling Process. Project Orion. Volume II, by James A. Browning. Dec. 30, 1981. 16 pp. 5 figs. A continuous channeling method was designed that reduces operating sound levels in drill channeling machines to 100 db. This new method relies on a small-diameter, oxygen-enriched burner to produce narrow channels. Sound intensities are reduced substantially compared with conventional channel widths. Sound intensities are reduced further by a water spray directed immediately above the flame. Baffles placed along the top of the channel will reduce sound levels to below 90 db. Cutting rates are greater than those of existing channeling burners with costs per unit of channel area substantially reduced for those cases where oxygen costs are reasonable. Research done under contract H0387017 by Browning Engineering Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City,

Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-202664; paper copy price code A02.

OFR 66-82. Hybrid Computer System for Optimization of Extraction Procedures in Tabular Coal Deposits, by Michael P. Hardy and Mark C. Christianson. February 1977. 70 pp. 40 figs. The hybrid computer facility at the University of Minnesota was designed to analyze three-dimensional pillar stresses in coal mines. This report describes recent improvements and applications that include expansion of the capability to model nonlinear seam behavior, installation of a color video output display monitor, and further development of software capabilities. To demonstrate the capability of the system, the influence of nonlinear seam behavior response on the occurrence of coal mine bumps was fully investigated. Then the effect of improper mining sequence on bump occurrences was demonstrated. Also, the system was applied to the analysis of a series of practical coal mine problems. Mines in three coal seams were analyzed to investigate the parameters that contribute to the occurrence of coal mine bumps. Research done under contract H0252035 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-204868; paper copy price code A04.

OFR 67-82. Field Evaluation of Resiliently Clad Screen Decks, by Michael V. Markel. March 1981. 37 pp. 15 figs. This report describes the field evaluation of a composite material developed for use in coal screening applications. Tests were performed at the River King preparation plant of Peabody Coal Co. because it provided parallel process flow and met standard coal-cleaning requirements. Comparisons could be made between the adjacent resilient and steel screen decks under similar operating conditions. Noise reductions of 1 to 6 dbA were realized in the near field. Although the test period did not determine resilient screen life, indications are favorable for their longevity. Research done under contract J0100047 by B. F. Goodrich Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-204876; paper copy price code A03.

OFR 68-82. New Procedure for Recovering Nickel and Cobalt From Western Laterites. Economic Feasibility, by Mineral Sciences Div., UOP Inc. January 1982. 169 pp. 12 figs. Bureau of Mines roast-leach laterite processing technology was studied on a pilot plant scale. Data were scaled-up and incorporated into an economic feasibility study for a 5,000-ton-per-day grassroots processing facility. Estimated capital cost (± 30 pct) for a mine and plant is $367 million with an estimated $103 million per year operating cost. The study indicated that low-grade domestic laterite may be processed with marginal profitability. Research done under contract J0285021. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-245945; paper copy price code A08.

OFR 69-82. An Assessment of a Proposed Plant for Producing Direct Reduced Iron on the Minnesota Iron Range, by John J. Henn, Frank A. Peters, and Robert S. Kaplan. March 1982. 23 pp. 1 fig. The Bureau of Mines conducted a study of the cost of installing and operating both a natural gas- and a coal-based direct-reduction plant on the Mesabi iron range in Minnesota. The accuracy of the capital and operating costs are ±25 and ±15 percent, respectively. Product from the plants would be direct-reduced iron (DRI) pellets containing approximately 84 percent metallic iron. The pellets would compete with No. 1 bundle scrap in the Chicago, Ill., area. Because the quality of DRI is higher than scrap, the DRI will command a higher price, which has been estimated at approximately $10 per net ton (2,000 pounds) above the price of No. 1 bundles. An economic evaluation of installing a gas- or coal-based plant near an existing iron oxide pellet plant on the Mesabi iron range indicates that currently it is not economically viable. Available for reference at Bureau of Mines facilities in Twin Cities, Minn., Rolla, Mo., and Pittsburgh, Pa.; U.S. Department of Energy in Carbondale, Ill.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 70-82. Keep Alive Mercury Mine Lighting System, by J. C. Engel and G. F. Saletta. June 15, 1979. 57 pp. 20 figs. Recent innovations in mine safety include the use of mercury vapor lamps for mine vehicle illumination. Such lamps, however, extinguish whenever the line voltage at the machine momentarily sags or is interrupted. The lamps must then cool for several minutes before they will restart. By supplying reduced high-frequency power to the lamps from an auxiliary source, it is possible to maintain ionization in the arc tubes preventing the lamps from extinguishing. Essentially an auxiliary high-frequency supply, the keep alive system provides additional power to the lamps automatically whenever the lamps are in danger of dropping out. With this system, the lamps can be dimmed for periods up to 3 minutes by interrupting the 60-Hz power to the conventional ballasts. Each unit, housed in a steel explosion-proof enclosure with a volume of approximately 0.6 ft^3, is capable of servicing up to six 175-watt H-39 mercury lamps and two 100-watt H-75 reflector flood lamps. Research done under contract H0366074 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avon-

dale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 71–82. Feasibility Study of Coal Dust Measurement by Light Reflectance Photometry, by Irvin Pritts and Gregory A. Bertone. May 1981. 36 pp. 15 figs. This report describes the design, fabrication, and testing of a prototype instrument that demonstrates the feasibility of determining respirable coal dust concentrations by light reflectance photometry. Coal dust is collected on a filter and the amount collected is continuously monitored by reflectance photometry. Light emission and detection is accomplished by reflective object sensors, which have both light source and detector in one chip. The use of a pulsed light source insures low drift characteristics of the measuring circuitry. The collection of the respirable coal dust on filters facilitates accurate calibration and also allows measurement verification by well-accepted gravimetric methods. Research done under contract J0395082 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS. PB 82-213927; paper copy price code A03.

OFR 72–82. Research Study of Coal Mine Rock Reinforcement, by T. A. Lang and J. A. Bischoff. January 1981. 227 pp. 79 figs. Concepts and equations have been developed to quantitatively determine stability of a rock-bolted coal mine roof as a structural (beam-arch) member consisting of reinforced rock units. The equations took into account rock-bolt tension, length, spacing, and orientation; size of opening; strength and physical properties of the rock; and loads from distressed rock. Using sensitivity analyses and the results from relevant previous analytical and physical model investigations, the equations were critically reviewed. It was concluded that the equations can essentially be validated by using small-scale physical models and the full size mine entry model at the Bureau of Mines Spokane Research Center. Research done under contract J0295072 by Leeds, Hill and Jewett, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218041; paper copy price code A11.

OFR 73–82. Development of an Automatic Fire Protection System for Surface Vehicles. Final Report—Volume I, by W. D. Lease. Jan. 31, 1981. 74 pp. 24 figs. Automatic fire protection systems were designed, installed, and tested to protect three basic types of surface mining equipment: a large, rubber-tired front-end loader; a large and a small blast-hole drill; and a haul truck. The systems were tested after several months of installation and successfully discharged. The systems proved to be practical from the standpoint of protection, reliability, ease of maintenance, and cost effectiveness. Research done under contract H0262049 by Lease "AFEX", Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-215765; paper copy price code A04.

OFR 74–82. The Price-Responsiveness of Secondary Silver, by Thomas W. Wolfe, Bruce P. Malashevich, Clark Chandler, Clarisse Morgan, Brian Rubenking, and Vincent Honnold. March 1982. 146 pp. 3 figs. The objective of this research was to determine the volume of silver that might reasonably be expected to be supplied from secondary sources in the future by establishing and analyzing the price-supply relationship. It was determined that there are very large unreported U.S. stocks of silver bullion, coin, and sterling silver, which, under certain conditions, can become an important increment to the future market supply. The price-elasticity of supply of silver refined from both new and old scrap in the aggregate is relatively low—at 0.3. The supply of silver refined from coins, however, is highly price-elastic with an elasticity calculated at 1.6 to 2.7. It was also found that U.S. capacity to process and refine secondary silver has increased and that the infrastructure of the market is in a strong position to expedite the flow of silver from reserve stocks of coin and other high-grade scrap in the event of a substantial rise in demand and price. However, the availability of this incremental supply for industrial use will also be influenced by private investors in silver bullion, whose behavior can either offset or enhance the flow of secondary supply from other sources. Research done under contract J0113080 by Economic Consulting Services Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Federal Emergency Material Administration-General Services Administration, Washington, D.C.; Office of the Under Secretary of Defense for Research and Engineering Acquisitions Management-Industrial Resources, U.S. Department of Defense; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-208422; paper copy price code A07.

OFR 75–82. Abandoned Mine Reclamation. A Case Study at Live Oak, Florida, by T. A. Herbert and R. G. Turner. May 30, 1981. 115 pp. 34 figs.

A 2,338-acre mine site near Live Oak, Fla., was studied to determine the potential for reclamation and development. Present land uses of the area surrounding the abandoned mine were analyzed along with locations of abandoned cuts, spoil piles and tailings, and land ownership patterns. An abandoned economic analysis of the surrounding five-county area was conducted to determine what types of industries might relocate at the mine site. Methods commonly used to reclaim abandoned mines were discussed along with possible interim and end land uses; financial incentives available from the Federal, State, and local sources were discussed. Seven planning scenarios were developed, identifying 861 acres as suitable for industrial and commercial development and 964 acres as suitable for woodlands and agriculture. It was estimated that reclamation of industrial sites would cost $1.13 million and reclamation of areas to woodland-agriculture would cost $142,000. Research done under contract J0295007 by the Center for Resource Development. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-213901; paper copy price code A06.

OFR 76–82. The Effect of In Situ Retorting on Oil Shale Pillars, by L. Ozdemir, D. Ropchan, R. Miller, F. D. Wang, T. Sladek, C. Young, J. DuBow, and D. Fausett. October 1981. 387 pp. 155 figs. An investigation was made to determine the mechanical properties of oil shale at elevated temperatures and confining pressures, the thermal properties at elevated temperatures, and to provide mathematical models for mine design for in situ oil shale retorting. A review of current activity in in situ retorting is included with a comprehensive list of references. Tests were run at temperatures from 20° to 500° C and confining pressures to 1,500 psi with shale of 10 to 30 gal per ton. A major loss of strength occurred in heating at 140° C with a partial regain from 380° to 500° C. Higher grade shale had a lower compressive strength. Elastic properties showed large variations. Brazilian tensile strength showed a similar temperature sensitivity as the compressive strength. Equations were developed for each property in terms of grade, temperature, and pressure. Thermal, electrical, and acoustical properties showed anomalies through the temperature range. Creep is a major factor in overall deformation of heated shale. Oil shale was found to be an excellent insulator. Loss of pillar support area at 800 hr of heating would be about 10 pct. Good correlation was found between a finite element model using the developed properties and an in situ heater test. Research done under contract H0262031 by the Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Carbondale, Ill., and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-214099; paper copy price code A17.

OFR 77–82. Fiber Optics Technology for Underground Mine Communication Systems, by David Bendersky, John E. Golob, Vern W. Klein, and Dan R. Keyes. January 1982. 171 pp. 26 figs. This report covers the activities of a feasibility study of fiber optics technology for use in mines. The objective of the study was to evaluate, both technically and cost-wise, the possible use of fiber optic technology for underground mine communication and monitoring systems. The first phase of the study was devoted to the collection of information on the present underground mine communication systems and monitoring techniques and the status of applicable fiber optic technology. In the second phase, a communication and monitoring system for a hypothetical underground coal mine was designed and the costs were estimated. The significant findings and conclusions are presented. Research done under contract J0113003 by the Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175562; paper copy price code A08.

OFR 78–82. Benefit-Cost Analysis of Health and Safety Research and Development Projects in Coal, Metal and Non-Metal Mining, by R. P. Davis, G. R. Brown, and W. J. Douglas. May 1981. 108 pp. 14 figs. This report describes the development of an analytical procedure for evaluating the potential economic effects on the mining industry of Bureau of Mines sponsored health and safety projects. A number of economic measures were utilized, most of which involve discounted cash flow analysis. Problems were encountered in attempting to collect data that was both consistent and accurate in validating the modeling procedure. As a consequence, the benefit-cost procedure applies parametric analysis in evaluating projects. By varying parameters that have a high degree of uncertainty over a range of expected values, a corresponding set of benefit-cost indices can be obtained. The Benefit-Cost Index represents the economic output per unit of investment in the proposed technology by the mining industry sector. The Benefit-Cost Analysis Model, version 1 (BCAM/1) is a computerized procedure that has been installed at the Bureau's Pittsburgh Research Center computer facility. Research done under contract J0199042 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-218660; paper copy price code A06.

OFR 79–82. Bound Liquid Ion Exchange Membranes for the Extraction of Cobalt From Lateritic Leach Solutions, by Larry D. Nichols, Arthur S. Obermayer, and Marie B. Allen. Feb. 25, 1982. 59 pp. 6 figs. Poroplastic membranes containing ion exchange liquids were studied for separating cobalt from

nickel-containing solutions similar to ammoniacal laterite leaches. The driving force for cobalt transport was differences in pH and composition between the leach and extraction streams. Using a diketone ion exchange liquid, a leach pH of 6.5 to 7.0, and a strip pH of 2.3, cobalt was extracted from a 750-ppm solution containing 2,500 ppm of nickel at rates ranging from 1 to 10 $\mu g/cm^2 \cdot min$ in single membrane cells. Rates were variable, with evidence that cross-membrane flow patterns were a key factor; a reproducible rate of 30 $\mu g/cm^2 \cdot min$ would be economically viable. Loss of transport, observed after several days of continuous operation, was restored by flushing membranes with fresh ion exchange liquid. A major effort was devoted to preparing thin, leak-free membranes; the resulting membranes endured operating conditions without mechanical failure. Research done under contract J0295056 by Moleculon Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–218652; paper copy price code A04.

OFR 80–82. Mine Personnel Locator and Mine Activity Controller. Final Report, by A. J. Farstad, L. R. Robinson, and G. H. Saum. Dec. 17, 1981. 187 pp. 47 figs. Recent advances in microcomputer technology have opened the way for systems that can track the location of underground mining personnel from the surface. A computerized system was designed that is capable of not only tracking the location of the miner but also of monitoring underground parameters, communicating between work stations, and sounding alarms when underground conditions are judged to be unsafe. In this report the locations of underground personnel are detected by a network of underground terminals that routinely emit radiofrequency (RF) pulses to interrogate miniature transponders worn by the miners. Each transponder is uniquely programed to delay its response so that the RF terminal can identify the individual transponders by the time slots in which the responding pulses are received. The underground terminals are then interrogated by the host computer on the surface that keeps a running account on underground mine conditions and personnel. The underground portion of the system is designed to operate even during mine emergencies, deriving its power from rechargeable battery supplies that are float charged during normal operation. Research done under contract J0205059 by Nelson and Johnson Engineering, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration in Denver, Colo., Pittsburgh, Pa., and Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–235979; paper copy price code A09.

OFR 81–82. Assessment of Induction Fan Effectiveness, by Ted A. Lewtas. March 1980. 62 pp. 12 figs. The work performed in this program was based on prior efforts using induction (jet) fans to ventilate dead headings with the objective of refining the attachments to maximize fan effectiveness and to study the influence on the effectiveness of fan proximity to drift walls. Detailed anemometer surveys were designed to delineate the size and shape of the jet created by an induction fan, and tracer gas was used to determine the quality of fresh air that an induction fan can deliver to the face of a drift and the fan's effectiveness in removing contaminants from the drift. Fan locations of 2 and 4 feet from the drift wall and at the drift center line were evaluated in the laboratory and all mine testing was done with the fan as close to the wall as possible. It was concluded that (1) an aerodynamic nozzle increases jet penetration and any tubing length up to 15 feet, (2) locating the fan near the drift wall increases jet penetration, (3) airflow straighteners are ineffective in increasing penetration, and (4) induction fan installations in general are ineffective in removing contaminants from dead headings without sufficient main ventilation flow. Research done under contract J0387223 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-235987; paper copy price code A04.

OFR 82–82. Study To Develop Data for Review of Metal and Non-Metal Mine Methane Hazard Classification, by Alastair Lumsden and Richard Talbot. April 1982. 153 pp. The objective of this study was to assemble the largest possible body of information concerning the regulatory and classification process applying to the incidence of methane gas in metal and nonmetal mines in a number of foreign countries. An extensive literature search was performed to identify countries with appropriate experience. Of the 20 countries that were approached, 16 responded with information of varying degrees of detail. Eight of the 16 countries—Australia, the Republic of South Africa, the Federal Republic of Germany, Yugoslavia, France, Spain, Italy, and the United Kingdom—were visited to obtain firsthand information from industry representatives and the regulatory agencies. The results of the 8-month study are presented. Research done under contract J0100060 by Golder Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 83–82. Time Domain Reflectrometry Microcomputer (TDRM) Testing. Volume II, by Eugene W. Bartel, Perry Wingfield, and Martie Leister. August 1981. 23 pp. 3 figs. The calibration of the automated digital time domain deflectometer (ADTDR) units has been a persistent problem since

the first tests that were reported in Bureau of Mines Open File Report 60–82. Several problems appear to center around the high-speed ECL logic timing circuitry board; therefore, tests were conducted in this area to isolate the malfunction and to evaluate potential methods for accurate placement. Research done under contract J0377021 by Carnegie-Mellon University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–243940; paper copy price code A02.

OFR 84–82. Feasibility of Water Injection for Particulate Removal in Large Turbocharged Diesel Engines, by R. N. Hambright, R. W. Burrahm, and V. O. Markworth. Nov. 13, 1981. 216 pp. 115 figs. Gaseous and particulate exhaust emissions are characterized for a 1,200-bhp, two-stroke cycle diesel; a 1,000-bhp, four-stroke cycle precombustion chamber diesel; and a 900-bhp, four-stroke cycle, direct injection diesel using steady-state modal testing and a versatile exhaust dilution-collection system. In addition, a 150-bhp, four-stroke cycle, precombustion chamber, turbocharged diesel was characterized for use in experimental water injection evaluations. Water injection downstream of the turbocharger compressor and upstream of the turbocharger exhaust turbine are evaluated for their particulate removal effectiveness on a small turbocharged diesel engine. The water droplets are inertially separated using cyclone separators designed for minimum pressure drop and cutsize. Up to 50 percent of the total particulate mass generated was removed using a combination of both inlet and exhaust water injection techniques. Research done under contract J0100036 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–243932; paper copy price code A10.

OFR 85–82. Development of Continuous Spiral Drill and Blast Tunneler. Phase IV, by Carl R. Peterson, Allan T. Fisk, and Robert G. Lundquist. December 1978. 95 pp. 26 figs. A long-recognized goal in high-speed tunneling and mining has been the development of a continuous drill and blast excavation capability. This report presents the results of tests conducted on an integrated drill-load-shoot system in which the explosive and initiator are loaded directly through the drill steel as the latter is withdrawn from the hole. Research done under contract H0252047 by Rapidex, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–243957; paper copy price code A05.

OFR 86–82. A Clean Internal Combustion Engine for Underground Mining Machinery. A Technical Assessment and Program Plan. Final Phase I Report, by Ned Baker, Lee Houston, Frank Lynch, Lars Olavson, and Gary Sandrock. Dec. 31, 1981. 232 pp. 81 figs. This study assesses the feasibility of employing hydride-fueled internal combustion engines to power mobile underground mining machinery. Problems are identified and a solution and a development plan are proposed with the objective of constructing, testing, and demonstrating a nonpolluting engine suitable for underground use. Research done under contract H0202034 by EIMCO Mining Machinery International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–244724; paper copy price code A11.

OFR 87–82. Poisoning of Catalytic Methane Sensors, by M. Kawahata and R. Lazzaro. September 1981. 156 pp. 62 figs. Methane sensors using the principle of catalytic oxidation of methane are employed for the determination of methane content in ambient air of coal mines. Certain foreign gases or vapors in the air poison the catalyst of the sensors affecting the sensor response. After a literature search of poison compounds of platinum and palladium oxidation catalysts, experimental studies of catalyst poison kinetics were made for three siloxane compounds, tributyl phosphate, monobromotrifluoromethane, and hydrogen sulfide, that were selected as poison vapors. The concentration range of the poison vapors was varied from 3,000 to 0.1 ppb (v/v). Three siloxane vapors produced strong catalyst poison effect followed by tributyl phosphate, hydrogen sulfide, and monobromotrifluoromethane for the high concentration level of the poison vapors. Threshold poison vapor concentrations, where effect of the poison vapors on the sensor is minimal, were determined experimentally. Experimental studies were made further for a prevention method of catalyst poison by adsorption techniques. The use of activated carbon cloth inserted on the sensor head prevented catalyst poisoning efficiently. Research done under contract J0100003 by Environment/One Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–243973; paper copy price code A08.

OFR 88–82. Survey of Safety Procedures for Guarding Blast Affected Areas, by Jerry Bennett. Oct. 19, 1981. 74 pp. 19 figs. This report describes the results of a survey of current blast area guarding procedures at surface and underground metal and nonmetal mines. Five case histories of blast guarding methods considered to represent the best systems in use in the U.S. mining industry are featured. Elements of an effective blast guarding system are presented along with recommendations for improvements in current blast guarding practices. Industrial and military surveillance and detection technology was reviewed to determine whether parallel technology exists for immediate application to blasting site security. While it is concluded that immediate transfer of industrial security technology is limited, a number of recommendations are presented for new research to adapt some of that technology for application to the mining environment. Two research areas (computerized personnel tracking and blast area intrusion detection using infrared, microwave, or E-field type detection systems) that are considered to offer the most potential for improved blast guarding areas are presented. Research done under contract J0205019 by Mining & Marketing Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–246042; paper copy price code A04.

OFR 89–82. Trolley Carrier Phone Mine Communications. Adaptive Volume Control and Use of a Dedicated Wire or a Low Impedance Line for Improved Carrier Phone Communications in Mines. by Robert L. Lagace, Dennis C. Jeffreys, Richard H. Spencer, and James M. Williams. February 1979. 146 pp. 58 figs. This report presents the results of a program that was initiated to study, implement, and test the operation of an adaptive volume control circuit for the loudspeaker of a mine trolley carrier phone. The design goal was for the control to sense the ambient noise conditions and to operate the communications equipment such that the sound output would be loud under noisy conditions, and quieter under quiet conditions, thereby resulting in an understandable and nonstartling volume level under all normal operation conditions. Research done under contract J0377098 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-246034; paper copy price code A07.

OFR 90–82. Analysis of Groundwater Criteria and Recent Restoration Attempts After In Situ Uranium Leaching, by Grant Buma, Paul H. Johnson, Gerhard K. Bienek, C. Gordon Watson, Harold Noyes, and Regina Capuano. October 1981. 304 pp. 24 figs. Groundwater restoration is an important aspect of in situ uranium leaching. Information on the effectiveness of the current technology, costs, and the current State and Federal Government permitting regulations is of vital importance to in situ leach operators and firms considering in situ leaching. This study describes (1) all recent restoration attempts at commercial in situ leaching operations, (2) restoration costs reported by the industry, (3) empirical equations that predict the amount of groundwater flushing required to meet the current restoration criteria, and (4) in situ uranium permit requirements for the States of Texas, Wyoming, New Mexico, Utah, Montana, Colorado, and South Dakota, and Federal requirements. Research done under contract J0295019 by Resource Engineering & Development, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.;U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-246018; paper copy price code A14.

OFR 91–82. Analysis of Coal Mine Electrical Accidents, by W. L. Cooley, B. S. Tenney, and Z. Elrazaz. November 1981. 242 pp. 33 figs. Electrical accidents occurring in coal mines from 1975 through 1979 were categorized and analyzed. The data were searched for common electrical hazards, common activities by those injured, and common negligent or careless behavior. The accident data were combined with mine production statistics to form a normalized electrical accident rate. It was found that some mines have consistently more lost workdays per work-hour than other mines. Bureau of Mines electrical safety research contracts were reviewed to determine whether the research effort was directed toward those areas that are related to the most accidents; in some cases it was not. A method was devised and utilized to estimate the relative cost to the mining industry to implement certain safety measures developed through Bureau research and the potential safety benefits. MSHA regulations were reviewed for effectiveness in preventing electrical accidents and suggestions were made for discontinuing, clarifying, or otherwise modifying the regulations. Research done under contract J0100096 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–244740; paper copy price code A11.

OFR 92–82. Feasibility of Using Cemented Backfill in Active Underground Coal Mines To Prevent Subsidence, by D. V. Gaffney, M. M. Stewart, N. K. Chakravorti, and R. M. Hays. December 1981. 218 pp.

36 figs. This report presents the results of a three-phase investigation of the feasibility of using cemented coal waste in active underground coal mines to prevent mine subsidence. Coal waste was broadly defined to include waste from both coal preparation plants and coal-fired powerplants. Underground systems with potential for cemented backfill were determined through identification of current mining methods and available technologies for cemented backfilling and consideration of materials and systems constraints upon mining and backfilling integration. Technical concerns including operation, health and safety, materials utilization, environmental impact, applicability, and technical status were assessed for six systems that were identified as potentially feasible. Two of these systems were conceptualized in a hypothetical case history and developed to further assess their operational and economic feasibility. Comparisons of costs among both systems and with costs of surface disposal are presented. The conclusions concerning the present feasibility of using cemented backfill in active coal mines and potential avenues for further research are also presented. Research done under contract J0295001 by Michael Baker, Jr., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244252; paper copy price code A11.

OFR 93–82. Development of a Continuous Methane Monitor, by Irvin G. Burough. November 1981. 45 pp. 18 figs. Two prototype continuous methane monitors capable of being mounted on a mining machine were designed and built for in-mine safety use. The monitors incorporated a nondispersive infrared optical-electronic analyzer design in which the response to the sample gas was achieved by synchronous detection and measurement of the amplitude oscillations of the transmitted energy from an infrared source caused by the pressure modulation of the sample gas within the optical cell. Zero and span stability were to be achieved by the amplitude modulating of the infrared source and using the detected signal to correct for optical-electronic system variation. This design effort was to simplify and reduce the cost of the major components while eliminating the need for daily calibration. Research done under contract H0377072 by Andros Analyzers Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244245; paper copy price code A03.

OFR 94–82. Illumination of Electric Powered, Mobile Surface Mining Equipment, by David D. Hottinger. Jan. 9, 1981. 117 pp. 77 figs. Only a minimum amount of illumination is generally provided for many types of mobile surface mining equipment. This condition presents a hazard to personnel working on and around such equipment. To reduce the hazard, MSHA has proposed safety regulations requiring minimum levels of illumination for hazardous zones on and in the immediate area surrounding surface mining equipment. This report describes a Bureau of Mines sponsored project demonstrating the feasibility and effectiveness of providing dragline illumination in compliance with the proposed MSHA regulations. Descriptions of the computer-aided design, onsite installation, and field evaluation of individual lighting systems for each of three different size draglines are presented. Research done under contract H0387004 by Phoenix Products Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244237; paper copy price code A06.

OFR 95–82. Development and Prototype Production of a Trapped Miner Signalling Transmitter/Transceiver, by Charles H. Simmons. June 1981. 82 pp. 24 figs. Two versions of a VF transceiver to aid in locating trapped miners were developed and tested. A belt-worn model was produced in both transmitter and transceiver forms. In addition, a quantity of the belt-worn models were fabricated using aluminum wire instead of copper to reduce unit weight. Ten prototypes of a battery cap model VF transceiver were also fabricated demonstrating further unit size and weight reduction while maintaining electrical performance. Although both versions of the VF transceiver are similar electrically, and both are constructed using conventional manufacturing techniques, the battery cap model realizes a lower total weight, smaller volume, and lower production cost than the belt-worn version. Samples of both versions were tested environmentally, and the test data are included in this report. Research done under contract J0395017 by General Instrument Corp., Government Systems Div. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244260; paper copy price code A05.

OFR 96–82. Thixogelled Halon/Dry Powder Fire Supressants, by W. B. Tarpley, Jr., L. H. Lemon, and A. L. Tuno. April 1981. 46 pp. 3 figs. This program was conducted to demonstrate the unique advantages of suppressing methane ignition in underground mines by use of a thixogel fire extinguishing system, which stably suspends dry powder extinguishing agent in thixotropically gelled liquefied gas extinguishant. The project demonstrated thixogel system advantages of (1) the capability to dis-

perse state-of-the-art powders in thixogelled Halons, (2) a nonagglomerating stability for dependable expulsion, (3) stability in storage for long shelf life, (4) virtually instantaneous dispersion, (5) expansive cloud formation, (6) reach and reforming ground obstacles, (7) at least twice the extinguishant effectiveness, and (8) compatibility of use with Fenwal bottles and MSHA canisters. The demonstration showed the thixogel system to be a superior explosion-fire suppressant for coal face cutters and triggered barriers as well as for motorized equipment, electrical equipment, etc. Research done under contract H0395081 by Energy & Minerals Research Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-245937; paper copy price code A03.

OFR 97–82. Cost and Sensitivities Analysis for Uranium In Situ Leach Mining, by George W. Toth and John R. Annett. March 1981. 344 pp. 24 figs. This report presents the results of an assessment of uranium in situ leach mining costs through the application of process engineering and discounted cash flow analysis procedures. A computerized costing technique was developed to facilitate rapid cost analyses. Applications of the cost model will generate mine life capital and operating costs as well as solve for economic production cost per pound U_3O_8. Conversely, rate of return may be determined subject to a known selling price. The data bases of the cost model were designed to reflect variations in Texas versus Wyoming site applications. The results of applying the model under numerous ore deposit, operating, well field, and extraction plant conditions for Texas and Wyoming are summarized in the report. Sensitivity analyses of changes in key project parameters have also been tested and are included. Research done under contract J0199112 by NUS Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-243965; paper copy price code A15.

OFR 98–82. Compaction Criteria for Coal Waste Embankments, by N. S. Shah, S. K. Saxena, J. S. Rao, K. C. Singhal, and D. E. Lourie. August 1981. 200 pp. 98 figs. The purpose of this study is to evaluate the costs and resulting effects on the engineering properties of coal waste materials, utilizing different compaction methods, equipment passes, and lift thickness. The report describes a comprehensive literature search into the compaction of coal waste materials, field compaction programs, laboratory investigations, analysis of test data and conclusions, and recommendations for establishing the compaction criteria. Research done under contract J0100031 by Globetrotters Engineering Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa., Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244708; paper copy price code A09.

OFR 99–82. Detection of Trapped Miner Electromagnetic Signals Above Coal Mines, by Robert L. Lagace, James M. Dobbie, Thomas E. Doerfler, William S. Hawes, and Richard H. Spencer. July 1980. 281 pp. 44 figs. This report assesses the expected detectability, on the surface above mines, of electromagnetic signals produced in the 630- to 3,030-Hz frequency band by a rescue transmitter activated by miners trapper underground. The assessment is based on a statistical analysis of experimental signal and noise data taken at coal mine sites distributed over the U.S. underground coalfields. Regression analyses are performed to characterize the signal transmission behavior of overburdens as a function of depth and frequency. The predicted signal behavior is then combined with experimentally based distributions of the background noise, and aural detection characteristics of signals in noise, to generate curves of the expected probability of detection for trapped miner signals versus overburden depth and operating frequency. The implications of the results and associated recommendations are presented regarding the detectability of trapped miners, sensitivity analyses and confirmatory tests, and operational utilization considerations for the trapped miners and the search and rescue teams on the surface. Research done under contract J0188037 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244732; paper copy price code A13.

OFR 100(1)–82. Partial Listings of Coal Waste Embankments, Surface and Underground Openings. Final Report, by G. Ahnell, J. D. Hervol, J. W. Mentz, R. E. McClure, T. L. Reed, and C. Yuill. Feb. 2, 1982. 130 pp. 41 figs. Throughout portions of four heavily mined Appalachian States subdivided by the Mine Safety and Health Administration as (1) district 3, northern West Virginia and Maryland, (2) district 4, southern West Virginia, (3) district 5, Virginia, and (4) district 6, eastern Kentucky, active coal mine waste embankments associated with mechanical and/or chemical coal processing facilities of various levels of coal preparation were inventoried. For each site plant specifications, disposal techniques, embankment characteristics, and coal source data were accumulated. Mapping at 1:24,000 and 1:250,000 scale and disposal site characterization forms were developed to present the findings. Associated abandoned surface and underground openings near each site were also indicated as well as locational data for each site and the area environmental conditions. A state-of-the-art review of coal preparation, waste disposal, and alternative uses of coal

waste is included. Research done under contract J0205001 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244286; paper copy price code A07.

OFR 100(2)-82. Partial Listings of Coal Waste Embankments, Surface and Underground Openings. Final Report. Appendix Volume I, by G. Ahnell, J. D. Hervol, J. W. Mentz, R. E. McClure, T. L. Reed, and C. Yuill. Feb. 2, 1982. 245 pp. 1 fig. Volume 2 of this three-volume report contains brief descriptions of the terms and codes used for each of the inventoried sites in Mine Safety and Health Administration districts 3, 4, 5, and 6. Detailed site mapping and the disposal site characterization forms for districts 3 and 4 are included. Research done under contract J0205001 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244294; paper copy price code A11.

OFR 100(3)-82. Partial Listing of Coal Waste Embankments, Surface and Underground Openings. Final Report. Appendix Volume II, by G. Ahnell, J. D. Hervol, J. W. Mentz, R. E. McClure, T. L. Reed, and C. Yuill. Feb. 2, 1982. 232 pp. 1 fig. Volume 3 of this three-volume report contains brief descriptions of the terms and codes used for each of the inventoried sites in Mine Safety and Health Administration districts 3, 4, 5, and 6. Detailed site mapping and the disposal site characterization forms for districts 5 and 6 are included. Research done under contract J0205001 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-244302; paper copy price code A11.

OFR 101-82. Detailed Design and Demonstration of Underground Disposal of Coal Mining Wastes. Phase I Report, by GEX Colorado Inc. June 1981. 61 pp. 35 figs. This report presents a detailed design of an underground coal waste disposal system that was developed for a specific mine. Along with the design, an instrumentation plan and a monitoring system were developed to measure and record the performance of the underground disposal operation as well as the effect of underground disposal on the total mine environment. Research done under contract J0205069. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 102-82. Development and Testing of Self-Drilling Roof Bolts, by F. S. Kendorski, S. D. Singh, and M. M. Singh. August 1979. 225 pp. 80 figs. This report presents the results of a search for viable roof bolt concepts, detailed development, design, and manufacture of such bolts that drill their own holes. Testing in the laboratory and in the field in two different coal mines of three self-drilling roof bolts is described. Three new types of bolts, a spring-actuated mechanical expansion shell, a slot and wedge, and a self-contained resin anchor bolt, that drill their own holes and then anchor in a continuous operation were designed and tested. Such bolts, when fully developed for mine use, would allow safer and remote installation of ground support and increase productivity. Research done under contract H0272022 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 103(1)-82. Feasibility of Water Diversion and Overburden Dewatering. Volume I: Technical Report, by Michael L. Clar, John J. Ferrandino, and Connie Bosma. April 1981. 231 pp. 71 figs. This report presents the results of a study to determine the feasibility of water diversion and overburden dewatering for underground coal mines in the Appalachian region. An assessment of the impact of mine water with respect to health and safety, production, environment, and costs is included. Sources of water inflow into underground mines are described. The report contains a summary description and evaluation of techniques that can be used to reduce the amount of water entering underground coal mines. A review of engineering practices currently used to prevent the movement of ground and surface water in active coal workings is included. The major emphasis is on the identification of the geologic and hydrologic condition of the site, onsite inspection of the methods used, and an evaluation of their technical and cost effectiveness. Research done under contract J0395059 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pitts-

burgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 103(2)–82. Feasibility of Water Diversion and Overburden Dewatering. Volume II: Annotated Bibliography, by Michael L. Clar, John J. Ferrandino, and Connie Bosma. April 1981. 113 pp. This volume is an annotated bibliography of published literature pertaining to the occurrence and control of surface and ground water in underground coal mines. The literature was used to develop volume I of this report, which assesses the feasibility of water diversion and overburden dewatering for underground coal mines in the Appalachian region. Each abstract is followed by subject descriptors. The abstracts are listed alphabetically by title and are numbered consecutively. The numbers are used in the subject index to assist in locating the appropriate articles. Research done under contract J0395059 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 104–82. Exploratory Studies of Flame and Explosion Quenching. Volume I, by L. Douglas Smoot and M. Duane Horton. Aug. 31, 1979. 317 pp. 108 figs. This research program was a theoretical and experimental study of laminar flame propagation in pure methane air and coal dust air mixtures, and in such mixtures containing suppressant additives. The flames studied included methane air, coal dust air, coal dust air with size, volatiles content and concentration as variables, and coal dust air plus $KHCO_3$, KNO_3, KBr, NaCl, or $CaCO_3$. A variety of measurements were made of burning velocities, flammability limits, and flame structure. In support of the experimental work, a generalized flame propagation model was developed to describe the propagation in premixed, laminar gaseous, and particle-laden flames. Research done under grant G0177034 by Brigham Young University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 105–82. Diesel Exhaust Emissions From Engines for Use in Underground Mines, by B. H. Eccleston, D. E. Seizinger, and J. M. Clingenpeel. April 1981. 42 pp. 12 figs. Experimental data were obtained from two medium-duty diesel engines derated to qualify for use in underground mines. Gaseous and particulate emissions from these engines were measured and results provide information on the effect of exhaust treatment devices on the emissions. The devices in the study were a catalyst, a particulate trap, and an exhaust gas cooler of the water scrubber type. Emission levels of carbon monoxide and hydrocarbons were observed to be very low in comparison with emission levels of comparable engines in full-rated operation. Oxides of nitrogen and benzo(a)pyrene content of the exhaust also were found to be somewhat low in comparison with previous findings. For particulate reduction, the combination of a particulate trap and a scrubber was observed to be the most effective combination tried; in some cases, over 60 pct particulate reduction was effected by the trap-scrubber combination. Research done under contract J0166023 by the Bartlesville Energy Technology Center, U.S. Department of Energy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 106–82. Dredge Safety Hazard Analysis, by Louis Schaffer, William Patterson, and Catherine Davis. Apr. 27, 1981. 104 pp. 37 figs. A literature review concerning dredging hazards and dredge safety practices and an examination of MSHA accident and injury statistics on dredge mining in the United States provided the background for an analysis that was completed by visits to 31 dredge operations, dredge manufacturers, and dredging experts. The principal hazards are discussed and countermeasures are suggested in several areas. Drowning is the single largest fatal injury category. Special emphasis is given to the design, care, and use requirements of personal flotation devices. Research done under contract J0199072 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–244229; paper copy price code A06.

OFR 107–82. Machine Lighting Design for Coal Mine Applications, by William F. Hahn, Stanley Ryba, and Anthony D. Szpak. March 1982. 127 pp. 76 figs. This project focused effort on three separate areas including the demonstration of a low seam longwall illumination system, design of illumination systems for low coal auger miners, and an assessment of machine lighting systems for machinery used to mine low seam coal. Results indicated illumination systems can be purchased by mine operators of low coal seams. The systems can be

supplied with equipment as factory integrated systems or they can be retrofitted to the machines or longwall equipment. Research done under contract J0308009 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–257205; paper copy price code A07.

OFR 108–82. Feasibility and Applicability of Hydraulic Mining and Transport in Underground Noncoal Mines, by William C. Cooley. September 1981. 126 pp. 11 figs. This study identifies and evaluates deposits of noncoal minerals in the United States that are most amenable to be mined underground and transported hydraulically. A method was developed to screen and compare mineral deposits including economic comparisons. The most applicable minerals for hydraulic mining by borehole monitor jets from underground entries are soft uranium sandstones in locations where water is available. This method, with hydrotransport, could improve the safety, health, and economy of underground uranium mines. Soft oil-bearing sandstone could be mined and transported by this method more safely than by other underground mining methods. Many minerals are too hard to be mined by monitor jet but are amenable to hydraulic transport and hoisting. Uranium sandstone is of interest because of potentially improved health and safety in transport and lower transport cost. Increases in mine output for potash and trona can be achieved most economically by adding hydraulic hoisting when existing skip capacity is at its limit. Research is recommended to obtain site-specific data on the feasibility of mining uranium ores by monitor jets. Research done under contract J0205027 by Terraspace, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–250598; paper copy price code A07.

OFR 109–82. Bound Liquid Ion Exchange Membranes for Recovery of Chromium From Wastewater, by Larry D. Nichols, Arthur S. Obermayer, and Marie B. Allen. Oct. 28, 1980. 35 pp. 11 figs. The objective of this program was to investigate the feasibility of bound-liquid ion-exchange membrane systems for removal and recovery of chromate from plating rinse waters, thereby conserving an important resource and minimizing harmful chromate effluent levels. Experimental techniques employed liquid-liquid extraction and simple membrane immersion to assess candidate ion-exchange liquids, followed by chromate transport measurements in membrane test cells using simulated chromate rinse solutions. The transport process is chemically driven by passage of some counter-ion in the opposite direction; counter-ions studied included basic chloride, phosphate, and carbonate solutions. Chloride and carbonate are both effective, and the latter is preferable from a chromate-reuse standpoint. Measured transport rates are in a range suitable for practical use, but membrane lifetimes were limited by a phase-inversion process in which water droplets nucleate within the membrane and eventually halt ion exchange. This phase-inversion process, shown by solutions of quaternary amine in ion-exchange reagents in aromatic kerosines whether or not chromate is present, must be prevented to render chromate recovery systems feasible. Research done under contract J0295056 by Moleculon Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., and Salt Lake City, Utah, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–250580; paper copy price code A03.

OFR 110–82. Inventory of Waste Embankments of Surface and Underground Openings: Metal/Nonmetal Active Mines, by Eric Nordhausen, Frank Wojtasiak, Norman Dausinger, Barbara Howie, and William Derrenbacher. December 1981. 254 pp. 16 figs. This report and associated deliverables is the culmination of a comprehensive literature survey, data collection, and identification of over 500 metal-nonmetal active mines, mills, and smelters (over 50,000 tons per year production) in the contiguous 48 States. The purpose was to compile an inventory of the waste tonnages, thus forming a data base for future research and development in improving waste management and disposal techniques in the metal-nonmetal mining industry. The study specifically excluded any commodity that leaves basically no waste when mined and/or milled. The study provided for locating, mapping, encodating, and digitizing all of the mine, mill, and smelter information made available throughout the Nation as well as the climatological, land use, topographical, ecological, and vegetative data. Mine, mill, and smelter information also included acreage and/or volume, mining methods, primary ore and gangue minerals, waste composition and haulage, and methods and distance hauled. A discussion is provided concerning present and potential uses of various types of tailings as well as recommending possible research and development of problem areas in waste disposal techniques and management. Research done under contract J0199054 by Mountain States Research and Development, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–249939; paper copy price code A12.

OFR 111–82. Development of a Call Alert System for Paging Mine Personnel, by John Trombly, Stuart Lipoff, and Paul O'Brien. August 1978. 65 pp. 21 figs. This report presents system objectives and design criteria for an in-mine ultralow-frequency radio paging system. Coding formats,

frequency, and bandwidth selection criteria leading to the system design are discussed. The prototype call alert transmitter and pocket page receiver is functionally described. The report includes circuit descriptions, schematics, parts lists, printed circuit fabrication, and assembly drawings. The report concludes with an estimate of the manufacturing cost for each assembly. Research done under contract H0262026 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-251562; paper copy price code A04.

OFR 112(1)–82. Safety Analysis of the Impactor Shaft Sinking System, by C. A. Geffen, P. M. Daling, L. J. Defferding, J. J. Jacobsen, J. M. Oylear, S. H. E. Phillips, and D. P. Williams. March 1982. 394 pp. 48 figs. This report presents the results of an investigation on the safety of the impactor shaft-sinking system in comparison with conventional shaft-sinking technology. A detailed study of the impactor system was performed to identify and recommend design changes for optimum safety conditions. A comparison of the impactor machine and its support systems with conventional shaft sinking was made on the basis of relative risk levels. Risk incorporates measures of both the frequency and the potential consequence of accidents. An evaluation of the component operations of the impactor shaft-sinking system was performed using a Failure Modes and Effects Analysis (FMEA) methodology. The results of this analysis show generally that the impactor shaft-sinking system is safer than conventional shaft sinking. The potential risk of conventional shaft-sinking operations could be reduced by an average of over 35 percent with use of the impactor shaft-sinking system. Design change recommendations to further improve the safety of the impactor system include a revised fire suppression system, improved access to and from the operator cabs, reliable noise attenuation measures, and improved communication systems. Research done under contract J0100002 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-249699; paper copy price code A17.

OFR 112(2)–82. Safety Analysis of the Impactor Shaft Sinking System. Safety Manual, by P. M. Daling and C. A. Geffen. March 1982. 158 pp. 16 figs. This safety manual was developed for the impactor shaft-sinking system by combining the safety output of the comparative safety assessment and the Failure Modes and Effects Analysis (FMEA) with the application of Management Oversight and Risk Tree (MORT) techniques. MORT is a formal, disciplined logic that is used to systematically relate and integrate a wide variety of safety concepts. Research done under contract J0100002 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-249657; paper copy price code A08.

OFR 113–82. Final Design Report on a Remote Controlled Hi-Roof Bolting Machine for Use in High Roof Areas of Coal Mines, by W. Hermanson and R. Wachtler. July 1979. 114 pp. 41 figs. This report covers work done on the preliminary design of a remote controlled high roof bolting machine. The design program involved the investigation and analysis of roof fall characteristics to determine the feasibility of developing a remote control high roof bolting machine. Several conceptual machine designs were generated and evaluated. Trade studies were made and preliminary evaluation meetings were held to determine the most promising concept to be carried through to the preliminary design stage. Visits were made to several coal mines to observe and to become familiar with typical problems associated with roof fall and overcast areas. Results of the observations and further studies of data indicated that drilling and bolting from vertical to horizontal angles would be required to cover most roof fall areas. Research done under contract J0285009 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 114–82. A Directory of Computer Programs Applicable to U.S. Mining Practices and Problems (Period 1970–1981), by Richard L. Sanford and Michael R. Parrott. February 1982. 520 pp. 2 figs. This report summarizes the results of an update on a previous Bureau of Mines grant and includes 5 additional years of computer program development. The directory includes a sampling of computer usage in operating and manufacturing companies, consulting firms, computer companies, research organizations, universities, and various governmental agencies. References to computer applications throughout the industry are presented as well as comments on program availability. The work on the updated directory concentrated on programs that are available to the public and are well documented. Research done under contract J0205067 by the University of Alabama. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S.

Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-253030; paper copy price code A22.

OFR 115-82. Electromagnetic Location Systems for Metal/Non Metal Mines, by A. J. Farstad and R. F. Kehrman. Jan. 15, 1979. 119 pp. 15 figs. Characteristics of metal-nonmetal mines were evaluated to determine the suitability of applying the Bureau of Mines electromagnetic (EM) location system to the problem of locating trapped miners. Statistical distributions of mine depths and overburden conductivities show that the existing Bureau EM system is inadequate for most metal-nonmetal mines. Alternate approaches to trapped miner location in deep mines were identified, and subsequent field tests were conducted at six mines to evaluate their feasibility. The approach considered to be the most promising is one that uses the existing backpack transmitting system, modified slightly for a dual frequency output, in conjunction with a sophisticated signal processing receiver on the surface. The main advantage of staying with a "through-the-earth" approach is that the underground equipment can be kept simple, easily maintained, lightweight, and inexpensive. Research done under contract J0166100 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-254525; paper copy price code A06.

OFR 116-82. Sedimentological Controls on Distribution and Quality of Knobloch, Anderson, and Dietz Coals in Parts of Southeastern Montana, by Mark A. Sholes, Gary Cole, David Fine, John Daniel, and Robert Matson. May 1982. 105 pp. 66 figs. This report covers sedimentologic and resource evaluations of the Anderson, Dietz No. 1, and Dietz No. 2 coals in the Pearl School, Decker, and Holmes Ranch Quadrangles and of the Knobloch coal in the Willow Crossing, Coleman Draw, King Mountain, and Yager Butte Quadrangles. Portions of this study on the Anderson and Dietz coal were previously published. In this study, the interpretations and conclusions drawn from the two study areas will be integrated and an attempt will be made to assess the applicability of the interpretations and conclusions to other areas and coals in the Powder River Basin of Montana. Research done under grant G5195026 by the Montana College of Mineral Science and Technology. Available for reference at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 117-82. Techniques for Consistent Forecasting of Future Demand for Major Minerals Using an Input-Output Framework, by Wassily Leontief, James Koo, Silvia Nasar, and Ira Sohn. June 1982. 583 pp. 103 figs. The objective of this study was to project a set of future production and consumption levels of 26 major nonfuel minerals for the U.S. and world economy to 2030 under alternative assumptions regarding future U.S. and world economic growth and structural change. The main methodological tools used were the 1972 Input-Output Table of the U.S. Economy and a revised version of the U.N. World Input-Output Model. The report includes a discussion of the role of resources in the economy, a review of past U.S. minerals policy, and a short summary of previous studies undertaken to project future minerals requirements. The first part of the report concentrates exclusively on alternative projections of future levels of minerals production and consumption in the United States to 2000, while the second part integrates the 26 nonfuel minerals into a global framework to 2030. Questions regarding future regional and global resource depletion are in the last chapter. Research done under contract J0188147 by the Institute for Economic Analysis, New York University. Available for reference at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 118-82. Evaluation of Ceramic and Refractory Grade Raw Materials in Alabama: Gibbsite in Saprolites of East-Central Alabama, by Mirza A. Beg. Apr. 15, 1982. 80 pp. 10 figs. Gibbsite, a major source of alumina, occurs in the northern and inner sections of the Piedmont province of Alabama in soils and saprolite derived from amphibolites, granites, feldspathic hornblende gneiss, and other gneissic rocks. The major occurrences of gibbsite are in areas underlain by hornblende gneiss in Chambers and Randolph Counties. This region provides the proper physiographic and mineralogical setting for large areas containing up to 25 percent saprolitic gibbsite. These areas provide potential sources of alumina that could be used to meet the U.S. future needs. Narrow zones and pockets rich in gibbsite also occur in soil and saprolite derived from areally restricted feldspar-rich zones of narrow linear amphibolites in the inner Piedmont and feldspathic zones in various granites distributed throughout the Piedmont. Research done under contract J0113073 by the Geological Survey of Alabama. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-251984; paper copy price code A05.

OFR 119-82. Technology Exchange Seminar. Mining Information Systems, compiled by Alfred Weiss. April 1982. 342 pp. 173 figs. Information systems technology—computers, telecommunications, software, etc.—has been adapted in many productive and profitable uses in the minerals industry. A recent study for the Bureau of Mines found that opportunities exist for making even more extensive use of proven applications of the technology as well as for the development of new applications during the 1980's. A 2-day seminar was held to bring these opportunities to the attention of the industry and the public to facilitate technology transfer. This report is a compilation of the papers presented during the proceedings of the seminar. Research done under contract J0113093 by Mineral Systems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and

Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251943; paper copy price code A15.

OFR 120–82. Noise Abatement of Vibrating Screens. Using Non-Metallic Decks and Vibration Treatments, by K. Hennings. January 1980. 63 pp. 32 figs. Noise from vibrating screens is generated in two ways: (1) noise due to the material being processed, and (2) noise from the screen itself. Nonmetallic decks have reduced material noise. The noise reduction and change in screening performance was quantified for six nonmetallic decks using dolomite, granite, and coal as the materials. The nonmetallic decks were from 2 to 7 dbA quieter and from −1 to +10 percent less efficient compared with a steel wire cloth deck of the same open area. Damping the sidewalls and isolating the drive mechanisms has reduced the noise in the screen itself. Tests of four prototype damping treatments gave reductions up to 4.9 dbA, and the mechanism isolators gave an additional reduction of 2.1 dbA. Laboratory tests were conducted on samples of the treatments in a corrosive salt spray to simulate coal plant wash water up to 25,000 hours, and full-size treatments were run on a full-size screen for 5,000 hours. Research done under contract H0387018 by Allis-Chalmers Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251919; paper copy price code A04.

OFR 121(1)–82. Health and Safety Analysis on Support Walls. Volume 1, by Daniel R. Walton, Svend B. Rondum, Peter W. Kauffman, and Steven A. Hawkins. August 1980. 207 pp. 38 figs. This report documents support wall equipment and material characteristics, dimensions, and power and site requirements in underground mines. The report provides labor requirements data and identifies the health and safety issues associated with support wall use and construction. Potential applications for support walls such as advancing and retreating longwall, single entry, room and pillar, mains and submains, and stoppings are delineated, and an economic assessment is presented of the viability of employing support wall technology to increase the recovery rate on retreating longwalls, or to employ advancing longwall in deeply lying seams or difficult conditions. The sensitivity of mining costs to changes in key support wall parameters is also presented. Research done under contract J0295036 by Management Engineers Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251950; paper copy price code A10.

OFR 121(2)–82. Health and Safety Analysis on Support Walls. Volume 2. Steel Supports Design Criteria. A Summary of European Data, by Steven A. Hawkins. August 1980. 61 pp. 21 figs. This report presents the results of a 5-month study to collect data on the use of steel support for ground control in European underground coal mines. The report summarizes European steel support design practices and describes the applicability of steel supports to U.S. mining conditions. Research done under contract J0295036 by Management Engineers Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251968; paper copy price code A04.

OFR 122–82. Study of Parameters Which Influence the Energy Utilization Efficiency in the Grinding of Gabbro Ores, by S. Raghavan. Feb. 11, 1981. 34 pp. 11 figs. An investigation of the possibility of improving the grinding characteristics of gabbro ore containing copper and nickel sulfides through a thermal shock treatment technique was conducted. The results indicate that the breakage characteristics of the gabbro ore particles can be significantly improved by preheating the ore particles to a temperature around 400° C followed by rapid water quenching. For a given power input and feed size, the thermally treated material produces a product of much finer distribution than untreated material. An assessment of the improvement in grindability was made by calculating feed size selection functions for untreated and heat-treated materials. Research done under grant G0188143 by the University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251935; paper copy price code A03.

OFR 123–82. Conversion of Shale and Slate Wastes to Glass and Glass-Ceramic Products, by J. D. MacKenzie. Oct. 20, 1980. 32 pp. 11 figs. Experiments were conducted to convert spent oil shale, waste slate, and copper slag into glass and glass-ceramic products. Spent oil shale was easily melted at 1,300° C and converted into glass wool for insulation application. Glass-ceramics were prepared by the use of domestic chrome ore as a nucleating agent. Waste slate from Vermont was readily melted when mixed with limestone. The resultant glass fibers were highly resistant to alkali attack. Iron metal was recovered from copper slags by the use of coal powder as a reducing agent in the molten slag. The lowering of the iron content resulted in a melt that was glass-forming. Combinations of spent oil shale and copper slag also yielded useful glass and glass ceramic compositions. Research done under grant G0166020 by the Univer-

sity of California, Los Angeles. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251976; paper copy price code A03.

OFR 124–82. Development of Substitutes for Asbestos, by John D. Mackenzie. November 1981. 28 pp. 12 figs. Experiments were conducted to determine the feasibility of using waste slate and limestone as a substitute for asbestos when producing glass powders and fibers. Glasses were made from mixtures of Vermont slate and limestone. The alkali resistance of the glass powders and the glass fibers was superior to that of glass powders and glass fibers based on compositions containing large amounts of zirconia. Some of the present glass compositions have alkali-resistance almost as good as that of chrysotile asbestos. Because of the low cost, ready availability in the United States, low melting temperatures, and ease of rendering into glass fibers, waste slate and limestone can be considered as substitutes for asbestos for many cement-type applications. Research done under contract J0199056 by the University of California, Los Angeles. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–252016; paper copy price code A03.

OFR 125–82. Flotation and Selective Agglomeration of Western Coals, by Douglas W. Fuerstenau. May 1982. 125 pp. 41 figs. This report presents the results of an investigation undertaken to provide a basis for improving the beneficiation of raw coals, with particular attention to the processing of fine western coals by two surface chemical methods, froth flotation and selective oil agglomeration. Nine western coals from Utah, Colorado, and Wyoming, ranging from subbituminous, class C, to high-volatile bituminous, class A, were selected for study and were characterized with respect to chemical composition, physical structure, and wettability. Excellent correspondence was found between chemical composition, particularly the concentration of active oxygen functional groups, and the flotation response of the nine coals. In addition, it was shown that hydrophobic interactions also have an important role in the adsorption of frothers on coals. A process involving a combination of oil agglomeration followed by froth flotation, using viscous oils at dosage rates less than 1 percent, was demonstrated to have potential for cleaning "black water" from coal operations. Research done under grant G5105058 by the University of California. Available for reference at the Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-255480; paper copy price code A07.

OFR 126–82. Visual Methane Indicator for Underground Coal Mines, by Robert P. Bruno. September 1979. 147 pp. 86 figs. The objective of this investigation was to develop a hand-held device to remotely detect the presence of concentrations of methane gas in underground coal mines. Convenient "mapping" of methane from a remote location would allow rapid and safe corrective procedures for working personnel. Modified, commercially available equipment was evaluated both in the laboratory and in a working mine. Although readings were obtained and the general principle of operation demonstrated, the power levels necessary and the protective enclosures required would raise the weight of the instrument beyond practical limits of portability. Based on currently available technology, it was concluded that a practical, portable, hand-held visual methane indicator is beyond the state of the art. Research done under contract H0166084 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–255464; paper copy price code A07.

OFR 127–82. Improved Visibility Systems for Large Haulage Vehicles. Volume II, by James L. Eirls, Slade F. Hulbert, and A. L. Foote. January 1982. 122 pp. 70 figs. The objective of this project was to improve a driver's field of view for large trucks used in the mining industry. Rearward viewing was enhanced by improving the rearview mirror designs. Rear vision was accomplished using a closed-circuit television system. Views ahead, to the right, and downward were obtained with a blind area viewer (BAV). The BAV is a unique combination of fresnel lenses housed in a shielded, environmentally protected enclosure that produces an image of the area in front of and downward 70° and to either side of the BAV 30°. The improved visibility devices were evaluated by long-term, in-mine testing. The right side mirror (RSM) and BAV provide the greatest improvements for the least cost and are commercially available. Application of the RSM and BAV should achieve a reduction in accident potential and greater vehicle productivity by enlarging and improving the equipment operator's visibility and making previously blind areas and hazardous situations detectable. Research done under contract H0262022 by Tracor MBA. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–251927; paper copy price code A06.

OFR 128–82. Contamination of Ground and Surface Waters By Uranium Mining and Milling. Volume I. Biological Processes for Concentrating Trace Elements From Uranium Mine Waters, by Corale L. Brierley and James A. Brierley. October 1981. 104 pp. 1 fig. Wastewater from uranium mines in the Ambrosia Lake district near Grants, N. Mex., contains uranium, selenium, radium, and molybdenum. A novel treatment process for waters from two mines, sections 35 and 36, to reduce the concentrations

of the trace contaminants was developed. Particulates are settled by ponding and the waters are passed through an ion exchange resin to remove uranium; barium chloride is added to precipitate sulfate and radium from the mine waters. The mine waters are subsequently passed through three consecutive algae ponds prior to discharge. Water, sediment, and biological samples were collected over a 4-year period and analyzed to assess the role of biological agents in removal of inorganic trace contaminants from the mine waters. Research done under contract J0295033 by New Mexico Bureau of Mines and Mineral Resources. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-251992; paper copy price code A06.

OFR 129–82. Preparation and Evaluation of Self-Regenerative Carbon Monoxide Detection Gels, by G. N. Schrauzer and K. E. Shuler. Nov. 1, 1978. 36 pp. 9 figs. The objective of this investigation was to develop a carbon monoxide detecting substance to be used in badges that respond quickly to carbon monoxide by a definite color change. Carbon monoxide devices that use silica-gel were impregnated with metal salts. When carbon monoxide is present the detection gel (with the treated silica-gel) changes from yellow to blue-green or blue. The detection gel regenerates, that is, returns to its original yellow color within 4 to 24 hours after removal from air containing carbon monoxide. The detection gel exhibits a threshold response that can be adjusted over a wide range of carbon monoxide concentrations, typically from 50 to 500 ppm in air. Research done under grant G0177012 by the University of California. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 130–82. Bureau of Mines Practices in Fire Assaying, by W. L. Barry. February 1982. 18 pp. 31 figs. This report reviews the practices of analyzing for precious metals at the Reno Research Center, U.S. Bureau of Mines. A general description of fire assaying, the physical layout of a fire assay laboratory, and the use of fire assaying in combination with atomic absorption, induction coupled plasma, and emission spectroscopy is reviewed. The combination of techniques significantly decreases the detection limits for precious metal analyses and simplifies the analysis of the platinum-group metals. Methods of protecting personnel from ingestion of lead are also discussed. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 131–82. Development and Testing Results of Output Torque Indicator for Underground Mine Roof Bolting Machine, by C. J. H. Brest van Kempen and Robert M. Sweet. February 1978. 197 pp. 51 figs. The objective of this investigation was to provide thrust and torque control and visual output torque readout systems to an existing mine roof bolting machine and to test the consistency of torques obtained under actual field conditions. A Lee Norse TD1 roof bolter was modified by adding a simple torque sensing device to the drill rotation mechanism and a pneumatic logic control circuit that measures torque and controls the hydraulic circuit to the rotation motor. The modification controls and indicates the final installation torque of mine roof bolts. Over 5,000 mechanical roof bolts were installed in an operating coal mine. The installed torque of these bolts were within an error band (standard deviation) of 8 pct. Research done under contract H0262006 by Eimco Mining Machinery Div. of Envirotech Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 132–82. OFFCAT. Oscillating Full Face Cutting and Transporting System for Longwall Mining and Pillar Reclaiming, by James M. Wisner, Mukund D. Gangal, John F. Abel, Jr., and William G. Pariseau. June 1977. 257 pp. 88 figs. The oscillating full-face cutting and transporting (OFFCAT) system for longwall and pillar reclaiming was proposed as a mining system that would make a substantial improvement in production, productivity, and safety for U.S. coal mines. The OFFCAT system consists of several subsystems. A cutter assembly stretches across the full coal face and is powered by a reciprocating actuator in each entry gate. An armored face conveyor removes coal from the face to the section belt by a stage conveyor. Shields protect the face area from falling rock. As the face advances, an actuator in each entry pulls all of the shields forward simultaneously. No workers are at the face during operation. An initial technical and economic feasibility analysis showed that the OFFCAT system is technically feasible and has high promise for reducing capital investment and dollars per ton cost of coal, increasing production and face productivity, and maintaining a safe working environment. Research done under contract J0265036 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.;U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safetv Academv. Becklev. W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. De-

partment of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 133–82. Smelter Emission Controls: The Impact on Mining and the Market for Acid, by Michael Rieber, Erika M. L. Asante, Takato Hiraki, David B. Jennings, Douglas R. Knutson, Benjamin A. Okech, and Mark C. Roberts. March 1982. 687 pp. 18 figs. This report presents an overview of Federal and State regulations affecting SO_2 emissions from nonferrous metal smelters. Compliance strategies provide a study basis, and individual smelter requirements are reviewed. The report contains an overview of U.S. copper reserves and quality; mine and smelter productivity; facility ownership, capacity, and production; and acid and concentrate transport costs. Prior copper pricing practices were analyzed with respect to industry structure, current competitiveness, solvency, and possible response to Federal aid. Research done under grant G5105013 by the University of Arizona. Available for reference at the Office of Surface Mining Library and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–134866; paper copy price code A99.

OFR 134–82. Projections of Coal Demand From the Northern Great Plains Through the Year 2010, by John Duffield, Arnold J. Silverman, Bradley D. Harr, Michael H. Lee, Danny S. Parker, and Donald Snow. May 1982. 658 pp. 36 figs. The objective of this study was to identify most of the key economic and policy linkages that will determine the future level of the Northern Great Plains coal production. The basic model used here is the economic model of spatial markets; a different strategy than the linear programing approach most often used in the large national coal models. The results indicate a level of future coal production for the Northern Great Plains considerably lower than that predicted by the national coal model. Research done under grant G5105076 by Montana College of Mineral Science and Technology. Available for reference at the Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 135–82. Microprocessor TDR, by W. C. Blanchard. April 1980. 143 pp. 55 figs. Time domain reflectometry (TDR) is a remote sensing technique that uses active backscatter. The technique is applicable to testing for faults and multiple partial faults on cables. The battery-operated hardware developed during this study tailored this technique for testing mining equipment trailing electrical cables. Processing of the backscatter is accomplished using a microprocessor. The visual output from the hardware to the operator is the type, magnitude, and distance to the cable fault in a numerical format. Research done under contract H0366020 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–262460; paper copy price code A07.

OFR 136(1)–82. Coal Mine Dust Control. Cost Versus Effectiveness—Survey. Volume 1 of II, by Terry Muldoon, Dave Monaghan, and Rich Kline. November 1981. 188 pp. 36 figs. This report presents the results of a survey of the cost and effectiveness of dust control techniques used in underground coal mines. Respirable dust control techniques for longwalls, continuous miners, and secondary sources are evaluated and compared by cost and percent dust reduction. Where sufficient data are available, the relative effectiveness of various controls are plotted against relative present worth. The results indicate that existing data do not adequately document the effectiveness or costs of the various techniques. Research done under contract J0395115 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–100545; paper copy price code A09.

OFR 136(2)–82. Coal Mine Dust Control. Cost Versus Effectiveness—Field Sampling Manual. Volume II of II, by Steve Ruggieri, Terry Muldoon, Will Schroeder, and Rich Kline. November 1981. 101 pp. 39 figs. This manual specifies standard procedures for gathering and analyzing respirable dust data. The procedures were developed based on experience from numerous field surveys aimed at evaluating respirable dust conditions and control techniques. The procedures were then successfully used on an actual field evaluation of longwall dust control using water sprays at a western U.S. coal mine. Although the manual focuses on standardized procedures for longwall production faces, the procedures can be modified and adapted for other mining systems, including continuous miner and conventional sections. The procedures can be applied to identify the primary sources of respirable dust on a particular face and to objectively determine the effectiveness of a particular control method under the conditions in the study area. The manual also suggests a general approach that will maximize the value to the industry of the data collected by independent researchers or mine engineers. Research done under contract J0395115 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–101030; paper copy price code A06.

OFR 137–82. Development of Improved Detection Instruments for Toxic Gas Contaminants in Mining Atmospheres, by J. A. Kosek and A. B. LaConti. January 1982. 54 pp. 17 figs. The objective of this investigation was to develop improved sensor cells for use in direct-reading detectors and diffu-

sion-exposure meters. A pumped CO sensor cell was developed that has a shorter response time, improved temperature cycle characteristics, and improved linearity and stability at high CO concentrations. Diffusion CO sensor cells showed good response-level stability and linearity up to 1,000 ppm. In addition, a new sensor cell catalyst was developed for NO_2 sensor cells that has a much shorter response time and improved response stability characteristics. Research done under contract H0395132 by the General Electric Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-256223; paper copy price code A04.

OFR 138-82. Borehole Mining of Phosphate Ores, by Lowell E. Scott. August 1981. 217 pp. 56 figs. This report presents the results of a technical, economic, and environmental feasibility study of phosphate ore recovery by the hydraulic borehole mining method. The experiments resulted in the recovery of 1,696 tons of ore from three boreholes during a 65-hour operating period. The experiments were conducted with the hydraulic borehole mining tool operating submerged in borehole 1, in air in borehole 2, and submerged again but with an air-shielded cutting jet in borehole 3. A continuous monitoring program was conducted throughout the mining operation and for a period of 2 months after completion to assess the impact of the hydraulic borehole mining method on the environment. Environmental impact was assessed in terms of site ground subsidence, changes in ground water quality, and changes in radiological profile. The study indicated in-air mining to be technically feasible but not economically viable owing to the incidence of cavity roof failure. Submerged mining was shown to be both technically and economically feasible, particularly with the tool in the air-shielded cutting jet. The environmental monitoring program demonstrated hydraulic borehole mining to have a minor effect on the environment. Research done under contract J0205038 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-257841; paper copy price code A10.

OFR 139(1)-82. Development of Materials and Strategies for Pre-Shift Equipment Inspection. Volume I. Technical, by Louis Schaffer, Ernest J. Conway, Earl Johnson, and Catherine Davis. Dec. 27, 1979. 139 pp. 8 figs. This report describes the development of training materials for the operation of surface mining machines and the evaluation of the materials in the field. The objective was to determine the effectiveness and acceptability in surface mines of training aides designed to teach procedures for preshift inspection. Materials for nine mobile machine types were evaluated. A 10th module on personal protection equipment for operators was also evaluated. The "modules" are slides with synchronized sound on tape, student workbooks, and checklists. Research done under contract H0377101 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-259219; paper copy price code A07.

OFR 139(2)-82. Development of Materials and Strategies for Pre-Shift Equipment Inspection. Volume II. Appendices, by Louis Schaffer, Ernest J. Conway, Earl Johnson, and Catherine Davis. Dec. 27, 1979. 242 pp. 122 figs. Volume II of the Development of Materials and Strategies for Pre-Shift Inspection program contains examples of training module scripts and workbooks developed for the operation of surface mining machines and examples of the written tests employed during the field evaluation. Research done under contract H0377101 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-259227; paper copy price code A11.

OFR 139(3)-82. Development of Materials and Strategies for Pre-Shift Equipment Inspection. Volume III. Review of Sand and Gravel Operations and Training Needs, by Mary Ann Bennett and Louis Schaffer. Dec. 27, 1979. 40 pp. 7 figs. Volume III of the Development of Materials and Strategies for Preshift Equipment Inspection program describes a review of selected plants in the sand and gravel and crushed stone industries, conducted with the objective of identifying the preshift inspection and other training needs not covered by materials presently available. An analysis of the data acquired to characterize the work practices is included as well as recommendations for the development of training materials. Research done under contract H0377101 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-110965; paper copy price code A03.

OFR 140-82. Develop Data for Review of Metal and Nonmetal Mine Methane Hazard Classification. Summary of Phase II Visits to Gassy Metal/Nonmetal Mines in Europe. October-November 1981, by Alastair M. Lumsden. April 1982. 77 pp. 4 figs. A number of

gassy mines in France, the Federal Republic of Germany, Spain, the United Kingdom, and Poland were visited to obtain information on the ways mine operators and regulatory agencies deal with flammable and/or toxic gases in the work environment of underground mines. Meetings were held with technical experts of various mine staffs and with representatives of regulatory agencies. Details of gas types, sources, and intensities; types of occurrences; geologic environments; historical overviews; and remedial measures and their effectiveness and impact on operations were obtained. This report presents the results of these meetings and visits. Research done under contract J0100060 by Golder Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 141–82. Development of an Inclusion Gaged Sleeve for Use on a Cylindrical Pressure Cell, by L. Ozdemir and F. D. Wang. Mar. 1, 1981. 66 pp. 53 figs. This report describes a research program for the development of an inclusion-gaged sleeve for use on a cylindrical pressure cell. An extended laboratory test showed the full-gage model had superior performance over the three-gage model in terms of linearity, ease of application, and reliability. Although shallow-gage embedments produced a close reading to theoretical, deeper embedments were more advantageous from a viewpoint of adequate gage protection while the error generated from increased depth of embedment could be mathematically factored out. Research done under contract H0282020 by the Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 142–82. State of the Art of Solution Mining for Salt, Potash and Soda Ash, by Michael T. Nigbor. September 1981. 90 pp. 15 figs. This report was designed to acquaint Bureau of Mines personnel with the state of the art of solution mining for three nonmetallic commodities—salt, potash, and soda ash. The basic geologic and market position of each commodity is described and the current mining practices and research areas are outlined. Research needs and programs to alleviate them are identified. A glossary of terms used in the solution mining industry is included as well as a selected bibliography. Research done by the Denver Research Center. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., and Pittsburgh, Pa.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 143–82. By-Product Recovery From Copper-Nickel Bearing Duluth Gabbro, by I. Iwasaki, A. S. Malicsi, J. S. Walker, P. J. Ryan, T. Sabelin, R. J. Lipp, K. A. Natarajan, K. A. Smith, and S. C. Riemer. May 1, 1982. 283 pp. 73 figs. The purpose of this investigation was to recover potential byproducts flotation tailings of copper- and nickel-bearing Duluth gabbro, to isolate residual sulfide and fibrous minerals for utilization or disposal in an environmentally acceptable way, and to extract aluminum from plagioclase concentrate by chlorination. Research done under grants G5105072 and G5195023 by the University of Minnesota. Available for reference at the Bureau of Mines Twin Cities Research Center in Minnesota; the Office of the Assistant Director, Minerals and Materials Research, Bureau of Mines, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 144–82. Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries, by Michael Radnor, Durward Hofler, Catherine Aimone, Dimitrios Atmatzidis, Richard Lamm, Sumantra Mukherji, Elizabeth Olmsted, and Regan Romei. May 31, 1981. 350 pp. 51 figs. The purpose of this study was to (1) examine the social and economic impacts of surface mine blasting in relation to variations in conditions of terrain and geology, population density and type, levels of ground motion, and air blast; (2) consider technical, legal, and government policy issues; and (3) examine the potential, nature, and extent of surface mine blasting impacts and the regulations on both communities and surface mining companies. Phase one of the study included a workshop with a panel representing various concerned groups; field testing of social, legal, and technical-cost research design; and the development of a list of variables and indicators. Phase two consisted of a series of empirical studies and technical analyses. Field research teams collected onsite data from mine companies, local communities, and government agencies. A sample of current surface mine permits were analyzed for density patterns and technical analyses were developed concerning annoyance and damage classification. The report presents a summary of the findings of the study. Research done under contract J0285036 by Northwestern University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 145–82. Guidebook for Dust Control in Underground Mining, by J. A. Kost, J. C. Yingling, and B. J. Mondics. December 1981. 206 pp. 83 figs. This dust-control manual, prepared for use by mine operations personnel, summarizes state-of-the-art control techniques for mining operations including dust sampling and use of personal protective devices. The manual outlines the advantages and disadvantages of control techniques, design and operating specifications, and implementation and

maintenance guidelines. A list of selected references is included as well as the results of the work performed while preparing the manual. Research done under contract J0199046 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-109207; paper copy price code A10.

OFR 146(1)-82. Sprayfan System—Installation and Operation Manual—Volume II, by Steven K. Ruggieri. October 1981. 59 pp. 14 figs. This report describes the use of the sprayfan auxiliary ventilation system for methane and dust control on continuous miner sections. The sprayfan auxiliary ventilation system is a modified water spray system that directs intake air to and across the front of a continuous miner to prevent buildup of methane gas and dust concentrations. The report describes the practical aspects of the system including (1) description and capabilities, (2) design, (3) installation, (4) operation, and (5) maintenance. Research done under contract H0230023 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-120261; paper copy price code A04.

OFR 146(2)-82. Sprayfan System—Results of Mine Testing—Volume III, by W. E. Schroeder. October 1981. 96 pp. 33 figs. Two underground installations of the sprayfan system are described and evaluated. The report describes (1) a simple method to determine the most economical application of ventilation for face methane control, (2) the effect of place variables (primary ventilation, auxiliary ventilation, seam height, etc.) on methane concentrations, and (3) the correlation of methane concentrations with brattice setback. The results are used to suggest a safer and more economical approach to face methane control. Research done under contract H0230023 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-120279; paper copy price code A05.

OFR 147-82. State Input-Output Tables for 1977 Emphasizing the Mineral Industries: Arizona and Florida, by Everard M. Lofting and H. Craig Davis. February 1980. 93 pp. Detailed State input-output tables emphasizing the mineral industries of Arizona and Florida were simulated for 1977 using nonsurvey State economic data and a 1977 U.S. transactions table showing the mineral subindustries. The State tables were simulated by the Simple Location Quotient technique in which national technical coefficients are adjusted to simulate the State technologies. Similarly, national value-added coefficients were used to generate estimates of State value added for detailed industries. Type I and Type II employment and income multipliers were calculated and an analysis of the simulated results was carried out for each of the States under study. Research done under grant G0177119 by Dry Lands Research Institute, University of California. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-104661; paper copy price code E05.

OFR 148-82. Input-Output Structure of the U.S. Mineral Industries for 1972 With RAS Update to 1977, by Everard M. Lofting and Werner O. Schink. October 1981. 65 pp. The detailed interindustry transactions table for 1972 showing the 38 mineral subindustries as specified by the 1972 SIC codes is presented along with the updated table for 1977. The principal features of the updating technique and the data and procedures are discussed. The output multipliers and the Type I and Type II income and employment multipliers are calculated and presented comparatively for each of the interindustry tables. Research done under contract J0188156 by Dry Lands Research Institute, University of California. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-104679; paper copy price code E04.

OFR 149-82. Radiation Monitoring for Uranium Miners: Evaluation and Optimization, by Keith J. Schiager, Thomas B. Borak, and Janet A. Johnson. Nov. 18, 1981. 137 pp. 11 figs. Radiological health risks to uranium miners are reviewed. Radiation measurement methods and monitoring systems that are now, or soon could be, available are reviewed with respect to their reliability and cost for determining annual exposures. Criteria for optimization of radiation monitoring programs are presented and applied to the current exposure conditions and available monitoring methods. The following recommendations are offered: (1) Personal thermoluminescent dosimeters for gamma exposures should be provided to all underground employees in uranium mines. (2) Exposures to long-lived radionuclides in respirable dust and to airborne radon progeny should be measured by randomized grab sampling. (3) Regulations of the Mine Safety and Health Administration should place greater emphasis on exposure reduction, as opposed to documentation. Research done under contract J0295026 by Alara, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg, Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.;

Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-102681; paper copy price code A07.

OFR 150-82. Development of Ambient Cure Polyimide Foam, by P. A. Hogenson and C. L. Hamermesh. May 1978. 38 pp. 12 figs. The objective of this investigation was to develop a sprayable ambient curing polyimide foam for application to mine passageways. The first phase involved development of ambient cure foam formulations, evaluation of foam properties, selection of appropriate spray equipment, and test samples. The second phase involved development of continuous spray application, demonstration of reproducibility of properties, and spray application on a vertical surface. The program resulted in an ambient cure polyimide foam that can be dispensed by conventional spray equipment and that has excellent fire resistance and low flame spread. This composition can serve as the basis for the development of a practical, relatively low-cost, fire-resistant foam for mine applications. Research done under contracts H0166070 and NAS2-9469 by Rockwell International Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-110197; paper copy price code A03.

OFR 151-82. Extraction of Chromium From Low-Grade Chromium-Bearing Ores, by Dhanesh Chandra, Charles B. Magee, and LaRose Leffler. May 1982. 164 pp. 46 figs. In an effort to utilize domestic low-grade resources to extract chromium, Mouat chromite concentrates from Stillwater Complex, Mont., were subjected to a sodium hydroxide or caustic soda roast and water leach bench-scale method. Although the soda roasting method has been known for quite some time, there are some problems associated with the roasting, particularly with lower grade chromites with lattice and gangue impurities. Using advanced electron-optical and X-ray microanalytical and macroanalytical techniques, the mechanisms occurring in the soda roasting step have been revealed. The roasting step is the key to this overall process, and the rate-limiting steps have been identified, allowing substantial improvements in chromium extraction yields. Research done under grant G0284009 by the University of Denver, Denver Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-106781; paper copy price code A08.

OFR 152-82. Develop a Mechanical Scaling Bar, by J. S. Megahan. March 1982. 37 pp. 15 figs. This report covers the design, fabrication, and testing of a hand-held scaling bar that will make scaling safer, more effective, and less fatiguing for operators when removing loose rock from mine floors and walls. Discussions covering a survey of mine conditions and currently used hand-scaling bar types are included. Research done under contract H0282004 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 153(1)-82. Bureau of Mines Oil Shale Data Bank. Part I—Bibliography. Volume 1, by Richard E. Thill, Don N. West, Karen S. Radcliffe, and Orin M. Peterson. August 1982. 559 pp. 3 figs. The Bureau of Mines Oil Shale Data Bank (OSDB) was created in 1976 to serve as a centralized source for the storage, retrieval, and dissemination of technical literature, patents, and information on research projects in oil shale. Thousands of bibliographic references, patents, and research projects relating to the mining of oil shale have been identified, abstracted, and indexed according to selected keyword topics. The resulting data bank listings are contained in three sections, each with a separate keyword breakdown for use in rapidly identifying references pertaining to a specific subject. All references cited in the OSDB were published prior to an established cut-off date of May 1, 1981. This report contains the bibliographic listing B1 through B2713. Research done by the Bureau of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 153(2)-82. Bureau of Mines Oil Shale Data Bank. Part I—Bibliography. Volume 2, by Richard E. Thill, Don N. West, Karen S. Radcliffe, and Orin M. Peterson. August 1982. 552 pp. 3 figs. The Bureau of Mines Oil Shale Data Bank listing contain thousands of bibliographic references, patents, and recent research projects to assist in planning and coordinating oil shale research and for producing safe and environmentally acceptable mining and processing technologies. This report contains the bibliographic listing B2714 through B2030. Research done by the Bureau of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.;and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 153(3)-82. Bureau of Mines Oil Shale Data Bank. Part II—Patents, by Richard E. Thill, Don N. West, Karen S. Radcliffe, and Orin M. Peterson. August 1982. 147 pp. 3 figs. The Bureau of Mines Oil Shale Data Bank listings contain thousands of bibliographic references, patents, and recent research projects to assist in planning and co-

ordinating oil shale research and for producing safe and environmentally acceptable mining and processing technologies. This report contains a listing of patents pertaining to oil shale research. Research done by the Bureau of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 153(4)–82. Bureau of Mines Oil Shale Data Bank. Part III—Recent Research Projects, by Richard E. Thill, Don N. West, Karen S. Radcliffe, and Orin M. Peterson. August 1982. 596 pp. 3 figs. The Bureau of Mines Oil Shale Data Bank listings contain thousands of bibliographic references, patents, and recent research projects to assist in planning and coordinating oil shale research and for producing safe and environmentally acceptable mining and processing technologies. This report describes recent research projects that are continuing or that have been completed in recent years. Research done by the Bureau of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 154–82. Lightweight Rescue Breathing Apparatus. Final Report, by Elmer E. Buban and William C. Koenemund. December 1981. 58 pp. 13 figs. A lightweight compressed oxygen rescue breathing apparatus (RBA) for rescue and recovery missions in mine rescue work was developed for the Bureau of Mines. The RBA is a positive-pressure, closed-circuit system that lasts 4 hours. The weight of the complete RBA, including an optional cooler, is slightly over 30 pounds. Weight reduction over currently available RBA's is achieved by using lithium hydroxide for scrubbing CO_2 instead of conventional chemicals and using a composite glass fiber-aluminum shell cylinder for oxygen storage instead of a steel cylinder. Positive pressure is maintained in the breathing circuit at all times by applying a constant spring force to the breathing bag. The harness was designed to reduce the work of the wearer by redistributing the weight of the RBA to the wearer's hips. Research done under contract H0262041 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–107730; paper copy price code A04.

OFR 155–82. Longwall Mining Principles for Safely Working Steep Coal Seams, by Roger F. J. Adam, William J. Douglas, and Bryan J. Reese. June 30, 1981. 161 pp. 61 figs. This report summarizes the principles of safely working steep coal seams using longwall mining methods. The report presents the state of the art and identifies the problems that result from seam inclination. Details are given on foreign longwall faces achieving good records of safety and productivity when mining on 30° to 50° inclined seams. Recommendations for further research are suggested. Research done under contract J0205010 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–117887; paper copy price code A08.

OFR 156–82. A Communication and Monitoring System for an Underground Coal Mine, Iron Ore Mine, and Deep Underground Silver Mine, by Alan A. Bergeron, R. L. Collins, and J. L. Michels. November 1981. 293 pp. 98 figs. Advanced communication and monitoring systems were developed and demonstrated in three underground mines representing different mining techniques, geographical areas, and material mined. The first was a large coal mine in western Pennsylvania using room-and-pillar techniques and continuous mining methods. The system developed provided private telephone channels, environmental monitoring, and control of underground equipment, all on a single coaxial cable, with all system operations under the direction of a minicomputer. The second was a magnetite ore mine in eastern Pennsylvania that used block caving mining techniques. A radio system was developed that provided two-way communications between trackless vehicles and roving personnel. A unique system of uhf-vhf repeaters combined with a "leaky-feeder" transmission line offered operational and emergency features not previously found in mine communication systems. The third was a deep silver mine in the Cour d'Alene district of Idaho. This system utilizes a single wire pair to provide up to 14 voice channels. A combination of PBX, telephone carrier systems, and intercom offered private conversations, selective signaling, and emergency backup communications. Research done under contracts S0133035 and J0377076 by Rockwell International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–115865; paper copy price code A13.

OFR 157–82. Development of Lightweight Hydraulic Supports, by Paul T. Alexander. May 1982. 94 pp. 10 figs. After evaluating preceding studies and designs of lightweight supports, the all-hydraulic and the hydromechanical concepts were selected for detailed design and fabrication. Further analysis and testing showed that the all-hydraulic design was economically justified and met all the crucial engineering, manufacturing, and design criteria identified during the evaluation. Following

Bureau of Mines approval of the detailed design, four all-hydraulic support models were fabricated. When functional and structural testing was completed, 40 additional units were constructed and distributed for in-mine testing. The units were acceptable by three demonstration mines. The widespread interest in supports for seam heights greater than 8 feet led to expansion of the design data package. Four basic models were designed to cover the new height range, but no hardware has yet been fabricated. Research done under contract H0282042 by ESD Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–115840; paper copy price code A05.

OFR 158–82. A Mass Spectrometric Study of the Vapor Transport Reactions of Importance in the Carbo-Chlorination of Kaolinitic Clays, by John P. Hager and Harry S. Patsos. May 14, 1982. 236 pp. 13 figs. This study investigated the formation of vapor complexes between aluminum chloride and the chlorides of iron, potassium, and sodium using a Knudsen cell mass spectrometer. Fundamental thermodynamic data were determined from the mass spectrometric experiments. An equation relating vapor pressure of a species inside the Knudsen cell to mass spectrometric ion current was derived from viscous flow conditions. A technique was also developed for the correction of the ion current of a species of a certain mass due to the presence of isotopes with the same mass of nearby species in the mass spectrum. Research done under contract J0199151 by the Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., and Salt Lake City, Utah; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–115857; paper copy price code A11.

OFR 159–82. Automatic Fire Protection System for Mobile Underground Metal Mining Equipment. Vol. II. Long Term Validation Testing, by Lyle A. McDonald and Gene R. Reid. February 1981. 242 pp. 160 figs. The objective of this investigation was the development and in-mine testing of an automatic fire control system (AFCS) for mobile underground metal mining equipment. Volume I of this report described the tasks through the development of a first generation prototype AFCS that was installed on a ST-2B-LHD vehicle at the Hecla Lakeshore project at Casa Grande, Ariz., and on the demonstration of system performance on the vehicle in underground fire tests. Volume II primarily concerns the long-term validation testing of the prototype AFCS. Validation testing was performed on the demonstration system plus six additional subsequent generation prototype systems on vehicles in four mines. In addition, work was done to determine the possible personnel exposure hazard presented by multipurpose dry chemical fire extinquishants. Research done under contract H0252038 by The Ansul Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–114876; paper copy price code A11.

OFR 160–82. Improved Fire Protection System for Underground Fueling Areas. Volume II, by Lyle McDonald, Dennis Kennedy, and Gene Reid. October 1981. 111 pp. 12 figs. The objectives of this investigation were to (1) develop safe practice guidelines that will minimize the chance of fires in underground fueling areas and (2) to develop a low-cost, reliable, automatic fire control system (AFCS) for underground fueling areas. Volume I of the report covered the period from June 21, 1976, to September 30, 1977, and included (1) the preparation of safe practice guidelines for underground fueling areas; (2) preparation of recommended AFCS design concepts for underground fueling areas; and (3) the design, fabrication, and in-mine fire test of an AFCS at Pine Creek Mine, Bishop, Calif. Volume II of the report covers the period from September 30, 1977, to September 30, 1981, and includes (1) a long-term validation test of the AFCS in the Pine Creek Mine, (2) a study of the environmental effects of aqueous film-forming foam, (3) the design and installation of a system at AMAX Buick Mine, Boss, Mo., (4) the design of a system for enclosed fuel areas, and (5) the design of a system for semipermanent fueling areas. Research done under contract H0262023 by The Ansul Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–114744; paper copy price code A06.

OFR 161(1)–82. Probabilistic Modeling of Tailings Embankment Designs. Volume I. Model Development and Verification, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 233 pp. 57 figs. Traditionally, evaluation of the safety of slopes has been based on computing a safety factor against failure. In computing the safety factor, the geometry of the slope, the soil parameters, and the pore pressures were treated as deterministic quantities although they were known to be random variables. A pseudo-three-dimensional probabilistic slope stability model has been developed that treats shear strength as a random variable. The model uses the probability of a slope failure as an assessment of slope reliability. The model can accommodate zoned embankments of soil in which the strength is described by the Mohr-Coulomb strength envelope. Autocorrelation functions are used to describe the spatial correlation of the strength parameters, c and tan ϕ. Model error can also be included in the analysis. Examples are presented to illustrate the influence of the choice of the soil strength variability parameters on the probability of failure. The results show that the critical failure surface based on the minimum safety factor are not necessarily the failure surface that will yield the maximum proba-

bility of failure. The analysis of the tailings dam shows that variance reduction can be large and that the model error is the dominant source of uncertainty for the embankment analyzed. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-122598; paper copy price code A11.

OFR 161(2)-82. Probabilistic Modeling of Tailings Embankment Designs. Volume I. Appendix I. Cone Penetrometer Records, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 64 pp. 59 figs. Volume I, Appendix I of this six-volume report contains the results of the first phase of the electric cone penetrometer tests performed at Copper City No. 2 tailings dam near Globe, Ariz. The report includes computer-processed logs of all field soundings as well as a brief discussion of the equipment and procedures. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 161(3)-82. Probabilistic Modeling of Tailings Embankment Designs. Volume I. Appendix J. Cone Penetrometer Records, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 33 pp. 29 figs. Volume I, Appendix J of this six-volume report contains the results of the second phase of the electric cone penetrometer tests performed at Copper City No. 2 tailings dam near Miami, Ariz. The report includes computer-processed sounding logs as well as brief descriptions of equipment and procedures used on the project. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 161(4)-82. Probabilistic Modeling of Tailings Embankment Designs. Volume II. Model Application and Verification, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 43 pp. 15 figs. A probabilistic slope stability computer model was developed at Utah State University and evaluated by CH2M Hill Consulting Engineers as a design and analysis tool. Volume I of this report describes the model and volumes III and IV are users manuals for the computer programs. Volume II (this report) includes a description of a field investigation and stability analysis of an existing tailings dam. Based on the results, the tailings dam was evaluated for redesign using probabilistic considerations. Conclusions are made regarding the usefulness of the model as a design tool. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-122606; paper copy price code A03.

OFR 161(5)-82. Probabilistic Modeling of Tailings Embankment Designs. Volume III. User's Manual for Probabilistic Slope Stability Computer Program, PROBISH, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 66 pp. 16 figs. Volume III of this six-volume report is a user's manual for the probabilistic slope stability program PROBISH. PROBISH is an interactive program that is essentially self-tutorial. The program prompts the user for the required input data as it is needed and allows corrections of mistyped data before analysis is initiated. The program computes safety factor probable width of failing and probability of failure for a given circular failure surface. Four example problems are included. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 161(6)-82. Probabilistic Modeling of Tailings Embankment Designs. Volume IV. User's Manual for Cone Penetrometer Data Analysis Computer Programs, HORZ and VERT, by Loren R. Anderson, David S. Bowles, Ronald V. Canfield, and Kevan D. Sharp. January 1982. 45 pp. 5 figs. Volume IV of this six-volume report is a user's manual for the cone penetrometer data analysis computer programs VERT and HORZ. The programs are interactive and prompt the users for input data and allow corrections and modifications to be made. The programs read data from the results of cone penetrometer soundings and convert the data to values of tan ϕ. Mean, standard deviation, skew, kurtosis, linear trends, and autocorrelation are computed by the programs. Research done under contract J0295029 by Utah State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Aca-

demy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 162–82. Kinetic Studies Relevant to the Suppression of Coal Dust Explosions by Powdered Inhibitors, by Carol L. Steen and Eric M. Suuberg. September 1981. 49 pp. 6 figs. This report presents a summary of data on the kinetic behavior of four proposed explosion inhibitor dusts—rock dust (calcium carbonate), Purple-K (potassium bicarbonate), ABC powder (monoammonium phosphate), and BCD powder (sodium chloride). All four materials were tested under conditions chosen to be similar to those that might be encountered in coal dust explosions. As expected, the principal products of rock dust decomposition are CO_2 and CaO. Contrary to what is expected from literature data, the CO_2 is the only gaseous product observed during Purple-K decomposition. It appears that the BCD powder did little more than vaporize. The ABC powder gave a complex mixture of decomposition products. The strategy for later work on modeling the rate processes is outlined. Research done under contract J0308032 by Carnegie-Mellon University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 163–82. Development and Implementation of an Instructor Course, "Training the Trainer—An Update", by Robert T. Reeder and Rodney S. Fowler. November 1981. 153 pp. 14 figs. This manual was designed to aid mine instructors in presenting mandatory classes in the area of health and safety training and retraining of miners. The objective is to prepare students to be able to (1) develop and prepare a lesson plan for classroom use; (2) tailor material for class presentation; (3) select and prepare appropriate training aids to accompany presentations; (4) demonstrate the proper method of presentation to conduct a period of instruction given the topic, class background, time constraints, and physical properties of the classroom; (5) present a period of instruction before other course participants during microteaching; (6) employ good communication techniques during the microteaching period; and (7) prepare a personal critique and critique other course participants for techniques of instruction. The report includes recommendations for future research. Research done under contract J0205065 by the Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 164–82. Engineering Evaluation of Radon Daughter Removal Techniques, by Donald B. Lindsay, J. Ronald Lawter, and Indrakumar Jashnani. April 1978. 208 pp. 44 figs. This report presents the findings of an investigation of a number of techniques for cleaning ambient air with special emphasis on their applicability to the removal of the short-lived radioactive decay products of 222-radon, the so-called "radon daughters" that have been identified with the induction of lung cancer in underground uranium miners. The purpose of the study was to review the requirements for control of radon daughter concentrations in mine air, and to examine all techniques whose feasibility has been demonstrated in principle and that would be capable of meeting those requirements. The study included a review of all pertinent literature, both technical and proprietary, on the subject of the control of miner exposure to the radon daughters and in the area of potentially applicable air-cleaning technology. Information about the nature of the problem and about the experience of the uranium mining industry in applying air-cleaning methods to its solution was obtained by visiting mines where such methods are in use and by correspondence and telephone conversations with other industry sources. Information on performance characteristics and costs of applicable air-cleaning methods was obtained from an experienced engineering staff and by visits, interviews, and correspondence with manufacturers of industrial air-cleaning equipment. Research done under contract J0265011 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–114868; paper copy price code A10.

OFR 165–82. Predicting Suspended Solids Removal in Pilot Size Sediment Ponds Using Chemical Flocculation, by J. S. Tapp, B. J. Barfield, and M. L. Griffin. May 1981. 471 pp. 149 figs. Laboratory- and pilot-scale tests were conducted to evaluate the effectiveness of chemical-induced coagulation-flocculation on total suspended solids removal in mine sediment ponds and to evaluate commonly used procedures for designing the ponds. Laboratory-scale jar tests were conducted at total suspended solids concentrations ranging from 2,000 to 200,000 mg/l. Constant- and variable-flow pilot-scale test runs were made in a 4-foot-wide by 20-foot-long model pond at total suspended solids concentrations ranging from 2,000 to 200,000 mg/l. The laboratory- and pilot-scale tests showed that chemical coagulation-flocculation produced suspended solids removal to a concentration of approximately one order of magnitude less than when no chemical was added. The tests also showed that commonly used lumped design procedures DEPOSITS model and the overflow rate equations were not generally capable of predicting effluent suspended-solids concentrations similar to those measured. Research done under grants G5115004 and G5105003 by the University of Kentucky. Available for reference at the Office of the Assistant Director, Mining Research, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Tuscaloosa, Ala., Twin Cities, Minn., and Boulder City, Nev.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 166(1)–82. Selective Placement of Strip Mine Overburden in the United States. I. Contract Report, by J. Lyall Workman. October 1981. 292

pp. 48 figs. The selective placement of coal strip mine overburden is examined. Physical and chemical properties of spoil detrimental to revegetation and ground water are detailed. Five mining methods, already used in the industry, that are capable of selectively handling waste are examined. Technical and economic comparisons are made for the systems when applied to realistic mine settings. The same analysis is conducted for five novel methods capable of selectively handling waste. Comparisons are made between novel and existing methods. Suggestions for new and modified equipment are outlined and recommendations for further research are provided. Research done under contract J0199040 by Marston & Marston, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-115873; paper copy price code A13.

OFR 166(2)-82. Selective Placement of Strip Mine Overburden in the United States. II. Appendices, by J. Lyall Workman. October 1981. 196 pp. 4 figs. The selective placement of coal strip mine overburden is examined. Physical and chemical properties of spoil detrimental to revegetation and ground water are detailed. Volume I of the report contains the technical and economic comparisons of selected systems when applied to realistic mine settings. Volume II contains the appendices. Research done under contract J0199040 by Marston & Marston, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-115881; paper copy price code A09.

OFR 167-82. Selective Placement of Strip Mine Overburden in Montana. V. Summary Report, by D. J. Dollhopf, J. D. Goering, C. J. Levine, B. J. Bauman, D. W. Hedberg, and R. L. Hodder. June 1981. 211 pp. 68 figs. The objective of this study was to investigate the means of establishing nonpolluted ground water and root zone systems in areas where surface mining intercepts physiochemically unsuitable overburden materials Overburden may need to be sampled on a 60-m grid to delineate materials unsuitable for reclamation and to accurately implement selective handling operations. Unsuitable overburden materials were buried successfully in a dragline operation with a minimum of delays, but costs were increased 12 to 53 pct. After 3 years the buried material remains above the reestablished aquifer and below the root zone. It was shown that some unsuitable overburden materials do not have to be special handled. At least a portion of the postmine aquifer had hydraulic conductivity rates lower than the premine system, indicating the reestablished aquifer may, in part, conduct ground water very slowly. Postmine ground water chemical quality in spoil materials had poorer quality compared with premine ground water. Research done under contract H0262032 by the Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-114884; paper copy price code A10.

OFR 168-82. Equipping a Shaft and Mining Bulk Samples of Oil Shale, Nahcolite and Dawsonite, by R. W. Amstutz. April 1981. 81 pp. 31 figs. A 5-year program was planned for environmental research and geotechnical test work at the Oil Shale Mining Environmental Research Facility in the central Piceance Creek Basin, Rio Blanco County, Colo. The facility consisted of a small-diameter lined shaft that would be equipped with a head frame, a hoist, and a surface plant to provide access to the deep, thick deposits of oil shale and the associated saline minerals including nahcolite and dawsonite. The objective of the research was to determine the potential effects of oil shale extraction upon the natural environment and the living and working environment, and to develop the technology required to resolve or mitigate the adverse effects. This report describes the equipping of the shaft and the mining of bulk samples of oil shale, nahcolite, and dawsonite from two levels. Research done under contract S0271009 by Williams Brothers Engineering Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-114173; paper copy price code A05.

OFR 169-82. Guideline Manual for Front-End Loader Load-and-Carry Applications, by James W. Martin, Thomas J. Martin, Donald W. Gentry, Matthew J. Hrebar, Karl R. Nelson, and Thomas P. Bennett. May 1981. 253 pp. 52 figs. This user's manual analyzes the application, selection, and performance of front-end loaders in mining operations that can effectively utilize front-end loader load-and-carry capability. All aspects of the application are considered starting with a discussion of the load-and-carry system and alternate material handling methods. Site conditions such as the geology of the formation, material characteristics, alternative mine plans, and working conditions are identified. Selection considerations include machine design characteristics, production capabilities, ownership, and operating costs. Typical operating practices and safety procedures are discussed. Comprehensive machine specifications, together with a series of checklists and worksheets, are included for preliminary analysis. Research done under contract J0205045 by Martin Consultants, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order

ONLY from NTIS: PB 83-115014; paper copy price code A12.

OFR 170-82. Standardization of Controls for Roof Bolter Machines. Phase I. Human Factors Engineering Analysis, by Martin Helander, Ernest J. Conway, William Elliott, and Richard Curtin. October 1980. 192 pp. 24 figs. The objective of this study is to propose standardized arrangements for controls in roof bolters. It is expected that standardized control arrangements would increase safety, minimize training requirements, and promote productivity. This report provides a human factors analysis of roof bolter controls. Preliminary standards for control design include the adoption of design criteria such as functional grouping of controls; sequencing controls according to order of operation; standardizing control motion directions; and standardizing actuation force requirements, control sizes, and interspacing. The proposed control arrangements were reviewed by roof bolter manufacturers and MSHA roof control experts; the responses were favorable. Research done under contract H0292007 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-119149; paper copy price code A09.

OFR 171-82. Boulder Handling and Blasting for Greater Safety and Efficiency in Crushers, by Michael F. Dunn, Francis S. Kendorski, and Swapan Bhattacharya. November 1981. 122 pp. 39 figs. A study was carried out to identify and develop improved techniques to alleviate a major cause of accidents and work stoppages when an oversize rock or boulder lodges in the throat of a crusher. The configurations and operations of various crusher types and sources of boulders in a mining operation are described and a detailed review is made of mining, quarrying, and construction regulations for all States, Canada, and the Federal Government for applicable provisions. Representative mines were visited and other operations were contacted to determine boulder handling techniques where it was found that blasting techniques included mudcapping, bombs, and blockholing, often done crudely and inefficiently with poor practices. Various mechanical systems were used such as hooks on overhead cranes, impact hammers, and grapplers. Safety analyses of all methods pointed out the hazards associated with blasting in the open and the dangers of entering a crusher. Boulder blasting can be done in a safer fashion if a planned step-by-step procedure is followed and inherently safer blasting products such as exploding bridge wire blasting caps and improved blockholing techniques are followed. Research done under contract J0100007 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-119388; paper copy price code A06.

OFR 172-82. Sealant Tests to Control Radon Emanation in a Uranium Mine, by Donald B. Lindsay, James E. Oberholtzer, and Clifford H. Summers. December 1981. 90 pp. 13 figs. This report describes a field-test program to determine the effectiveness of a polymeric wall sealant to reduce the escape of naturally occurring radioactive gas radon from the walls of an underground uranium mine into the ventilation air. A 75-foot-long, dead-end drift with a surface area of about 6,000 ft^2 was used as the test site in which the average natural radon flux from the normally dry rock was 16 fCi/cm^2-s. The effect on radon emanation of wetting the walls with water to a depth of 3 inches was tested, after which the rock was completely covered with a coating of dry-mix concrete to provide a base for the sealant, an acrylic latex. Sealant was applied in two coats to about 0.25 mm thick. An overall reduction of average radon flux of about 75 pct was achieved. Radon production and other environmental values were measured continuously and automatically by a Bureau of Mines data acquisition system. A commercial microcomputer was programed to convert raw data to engineering units and to perform other useful operations while recording all data on magnetic diskettes. Direct measurements of radon flux from the rock surface were made by a charcoal adsorption technique. Research done under contract J0199041 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-122762; paper copy price code A05.

OFR 173-82. Development of Improved Topsoil Handling Techniques, by Michael Mancuso, Edward Lesney, and Thomas Simpson. Mar. 23, 1981. 313 pp. 17 figs. This report summarizes the problems of topsoil handling as related to present requirements of law and current equipment availability. The most prevalent topsoiling systems are reviewed along with a listing of advantages, disadvantages, and best features of each system. Seven mining regions are included along with an analysis of prevailing land use, types of soils, and attendant physical, chemical, and biological characteristics. There are several probable areas of future research outlined that can benefit mining, minimize the social impact of mined lands, and speed the return of mined lands to more productive long-term use. Research done under contract J0295047 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-120154; paper copy price code A14.

OFR 174–82. Impact of Surface Mining on Soil Compaction in the Midwestern U.S.A., by Steve C. Albrecht and E. Raymond Thompson. Feb. 28, 1982. 318 pp. 70 figs. The objective of this study is to assess the impact of surface mining on soil compaction in the Midwest. The study revolves around a unique field sampling program targeted at four mine sites utilizing four distinct types of soil movement of midwestern prime farmlands. Through the preparation of a report for use as a guidebook, an assessment is made of the degree to which surface mining operations contribute to the soil compaction problem. The report is formulated through the use of field study data as well as information gathered in an intense literature review. The report centers on applying collected data to practical field applications. Research done under contract J0208016 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–120170; paper copy price code A14.

OFR 175–82. Alternative Power-Line Proximity-Warning Techniques, by Frederick H. Raab. January 1982. 79 pp. 23 figs. The performance requirements for a powerline proximity-warning (PLPW) system include high probability of detection at a dependable alarm range, low probability of false alarm, no setup or calibration, and little maintenance or adjustment. These requirements can be met by a system that explicitly measures range to the line. Candidate techniques include microwave radar, optical radar, and sonar. The six specific concepts that appear to be technically feasible in the PLPW application are (1) microwave gated-pulse radar, (2) microwave chirp FM-CW (frequency-modulated, continuous-wave) radar, (3) baseband pulse radar, (4) optical chirp FM-CW radar, (5) optical gated-pulse radar, and (6) sonar. The performance of both optical-radar techniques is degraded by dirt and grime on the transmitter and receiver apertures. Proper operation in a construction environment necessitates either daily maintenance or a windshield wiper. The former is expensive and bothersome, while the latter reduces reliability. Baseband radar appears well suited to the PLPW application. The cost is expected to be comparable with that of an electric field PLPW system. Development and testing of an experimental model are therefore recommended. Research done under contract J0318064 by Green Mountain Radio Research Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–122754; paper copy price code A05.

OFR 176–82. Development of a DC Current Limiting Interrupting System for Mines, by Howard B. Hamilton. January 1982. 105 pp. 45 figs. A switching system for high fault current, 300- and 600-volt dc trolley and haulage systems, as used in the mining industry are presented. The system consists of paralleled main and auxiliary contactor circuits with a liquid metal current limiting device (CLD) in series with the auxiliary contactor. Upon detection of a fault, the current is commutated into the CLD circuit. The liquid metal vaporizes, increasing the CLD resistance and considerably decreasing the actual current to be interrupted. This system will materially reduce the wear and tear on contactors because of the reduced interrupting requirement. The CLD is pressurized; when the current is interrupted, liquid metal flows back into the bore, thus it is resetting. Electrical and mechanical design principles, that were found satisfactory in field tests, are presented as well as material for use. Research done under contract H0395047 by the University of Pittsburgh. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–120147; paper copy price code A06.

OFR 177–82. Wood Products Use in Coal Mining, by Christopher D. Risbrudt and Robert Chamberlin. Apr. 1, 1982. 58 pp. Because of the important role of wood products in coal mining, and the relative lack of information on quantities and types used, this study had several objectives. First, to provide an estimate of the present use of wood products in coal mining, with emphasis on underground mines where wood usage is greatest. Second, to gain information on the availability of wood products, and any associated problems, to the coal mining industry. Third, to estimate the cost of wood products peculiar to mining. Fourth, to make projections of future consumption of wood products used in mining. In this study, over 220 mines provided data by questionnaire. Wood use per ton of underground coal was found to vary substantially by mining process and region. Research done under contract J0205049 by the U.S. Department of Agriculture, Forest Service. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83–119370; paper copy price code A04.

OFR 178(1)–82. Mine Power Systems. Volume I, by Lloyd A. Morley. Jan. 31, 1982. 568 pp. 353 figs. This seven-chapter document is the first volume of a two-volume report that presents a comprehensive outline of coal mine electrical power systems from theory to practice. Together, the two volumes contain the vital aspects that go into planning and designing a mine power system. After a short introductory chapter, chapter 2 discusses the history of electrical use in mining and introduces typical mine power system arrangements. Chapters 3–5 supply basic information on electrical theory, circuit analysis, and motors. Chapters 6–7 detail unique aspects of mine power systems. Elements of surface and underground use are included in all chapters. An index concludes volume I and is cross referenced to both report volumes. Research done

under contract J0155009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-120378; paper copy price code A24.

OFR 178(2)–82. Mine Power Systems. Volume II, by Lloyd A. Morley. Jan. 31, 1982. 534 pp. 280 figs. This eight-chapter document is the second volume of a two-volume report that presents a comprehensive outline of coal mine electrical power systems from theory to practice. Together, the two volumes contain the vital aspects that go into planning and designing a mine power system. Building upon volume I, the subject of protective equipment and relaying starts volume II, first as an introduction in chapter 8, then by a treatment of device selection in chapter 9. Chapter 10 continues system protection in terms of transients and overvoltages. Chapter 11 describes the design of major power equipment, including power centers, switchhouses, and substations. Solid-state applications in mining are given in chapter 12, and batteries and battery charging are discussed in chapter 13. Chapter 14 covers electrical equipment in hazardous locations of mining operations. The report concludes with chapter 15, a discussion of electrical maintenance as well as some specific mine electrical problems. Information on surface and underground use is included in all chapters. An index finishes the documentation and is cross-referenced to both report volumes. Research done under contract J0155009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-120386; paper copy price code A23.

OFR 179–82. A Training Program for Fighting Small Fires in the Mining Industry, by William Laird, Suresh Bhatt, Tata Bajpayee, Zita Glasgow, and Daniel Frezza. February 1982. 89 pp. 4 figs. The objective of this project was to evaluate a 1-day, on-site training program that would enable miners to make rapid judgments on whether to attempt to extinguish small fires in mines and how best to use the firefighting equipment on hand. Project activities included the analysis of fire report data to define and delineate physical and behavioral variables that affect firefighting activities. These activities culminated in a description of the tasks involved in extinguishing small fires under various mine conditions. The course consists of slides, audiocassettes, case studies, and actual practice using fire extinguishers. Research done under contract J0395060 by Gates Engineering Co. and Applied Science Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: 83-170639; paper copy price code A05.

OFR 180–82. Guidelines for Environmental Monitoring in Underground Coal Mines. Phase 1 Report, by H. A. Wright, R. Madden, and M. N. Rubin. June 1982. 177 pp. 7 figs. This report assesses the economic, legal, institutional, and technical factors that affect the current and future status of implementation of mine monitoring systems in the United States. It begins with a description of a poll of the Mining Production Research Committee and the Mine Monitoring and Communications Committee of Bituminous Coal Research that was conducted to establish industry monitoring needs and constraints. Existing systems in the United States and foreign countries are then reviewed and compared with the requirements set forth by the industry committees. At the same time, State and Federal mining laws are reviewed, and equipment presently available from suppliers of mine monitoring systems and components is discussed. A framework for cost-benefit analysis is established and a series of case examples for various monitoring functions are presented. The total values of the market for mine monitoring systems in 1980 and 1990 are estimated on the basis of industry statistics and system cost estimates. Research done under contract J0100039 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library for Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-147777; paper copy price code A09.

OFR 181–82. In-Place Leaching of Uranium, Copper, and Evaporites, by T. G. Carnahan. November 1982. 34 pp. 7 figs. In-place leaching is being actively utilized to extract uranium, copper, and evaporites from low-grade and difficult-to-mine ores. This report discusses in-place leaching technology, its advantages and disadvantages, and gives an overview of past, current, and envisioned in-place leaching operations in the United States. Application of in-place leaching to uranium ores has been particularly successful. The sandstone ores are contained above and below by impermeable shales, and the uranium ore minerals are easily leached with oxidizing acid or base solutions. Copper is recovered from subgrade rock by dump or in-place leaching with acidified ferric sulfate solutions. The leaching solution migrates down through the rock and dissolves copper. The solution is collected from the base of the dumps, and copper is recovered by solvent extraction-electrowinning or by cementation on detinned steel cans. Solution mining of evaporites is being conducted commercially for the extraction of sodium chloride and potassium chloride. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Office

of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Minerals and Materials Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-138859; paper copy price code A03.

OFR 182–82. Burial of Potentially Toxic Surface Mine Spoil, by L. B. Phelps, L. W. Saperstein, W. B. Wells, and D. Yeung. October 1981. 343 pp. 134 figs. A method is presented for the burial of potentially toxic spoil in high-density zones or packages within spoil piles. Such burial could reduce the outflow of pollutants and thus minimize contamination of ground water flows. Laboratory model studies using ammonium bromide tracer were performed to quantify the expected outflow mixing that could be achieved through package construction in spoils. Field drilling and geophysical density logging of spoils was carried out at three sites in Pennsylvania and Ohio to obtain a range of field spoil bulk-density measurements and spoil samples. These data are analyzed to determine the relationships between spoil density and the controlling factors of lithology, depth, age, particle size distribution, and mining method. A separate series of spoil permeability tests were performed in the laboratory to investigate the relationship between permeability and its related parameters. Research results are applied to the toxic package method to suggest guidelines for package size, shape, density, and placement for future field prototype development. Research done under contract J0188136 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-136051; paper copy price code A15.

OFR 183–82. Development of Systematic Waste Disposal Plans for Metal and Nonmetal Mines, by G. W. Center, R. M. Wood, L. C. Richardson, D. W. Evans, D. J. Shosky, W. R. Killiam, E. W. Finke, and J. P. Schmid. June 1982. 643 pp. 121 figs. This manual is intended to assist Federal, State, and local regulatory and planning agencies, the mining industry, and consulting engineers in determining the regulatory, environmental, technical, and economic constraints influencing the site selection, planning, construction-operation, and reclamation phases of a waste disposal facility. The information presented shows that factors affecting an individual site may be simple or very complex. The manual discusses methods for making future land use decisions; determining regulatory requirements; evaluating physical, chemical, and structural properties of the disposed waste; and selecting appropriate waste disposal methods and control techniques. Procedures and guides in the manual will assist in assessing the complexities of waste disposal on a site-specific basis. The major types of waste disposal systems are discussed and evaluated in terms of advantages and disadvantages and applicability to varying site conditions and waste characteristics. Appropriate references following each chapter provide more detailed data on material presented in the text. Research done under contract J0208033 by Goodson & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn, Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-138065; paper copy price code A99.

OFR 184–82. The Effects of Moisture on Radon Emanation, Including the Effects on Diffusion, by Burton J. Thamer, Kirk K. Nielson, and Karen Felthauser. November 1981. 213 pp. 47 figs. Radon emanation coefficients of 0.02 to 0.55 were measured at moisture contents ranging from dry to saturation in 18 different ores. The emanation coefficients rose from a minimum when dry to a plateau usually starting at 5 to 20 percent of saturation. A model, using measured pore-size distributions, suggested that the radium mineralization may be confined to annular layers about 0.02 micrometer thick around pores. Radon's diffusion coefficient was determined as a function of moisture. The techniques involved comparing a disk's exhalation as a function of time whether or not the disk had a distributed source. The model was free of approximations and included the effects of porosity and adsorption. An increase of diffusion coefficient with moisture for one or two ores was explained in terms of a model's equation for the diffusion coefficient in terms of both volume and surface diffusion. Radon's adsorption coefficient was determined on a uranium ore. Research done under contract H0292024 by Ford, Bacon & Davis Utah, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-136358; paper copy price code A10.

OFR 185–82. Biological Oxidation of Iron (II) by T. Ferrooxidans in a Sequencing Batch Reactor, by T. L. Theis, L. H. Ketchum, Jr., and R. L. Irvine. August 1982. 141 pp. 38 figs. The use of a suspended growth system of *T. ferrooxidans* attached in a film to individual particles of bentonite and operated as a sequencing batch reactor has proved to be a practical way of oxidizing ferrous iron in acid mine drainage. This component, followed by limestone neutralization, is both a technically and economically feasible approach to the treatment of these wastewaters in comparison with existing and proposed methods. The advantages, in addition to less expense, are greater safety, acceptable treatment at a lower pH, lower solids buildup, less danger of overtreatment, and greater flexibility in operational characteristics. In this report, data on the continuous bench-scale operation of the system under a variety of conditions show sustained levels of oxidation in excess of 95 pct. Research done under contract J0100079 by the University of Notre Dame. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Morgantown, W. Va.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National

Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-137810; paper copy price code A07.

OFR 186-82. Establishment of Associative Nitrogen Fixing Grasses on Metal Mine Tailings, by L. H. Wullstein. June 1982. 42 pp. 4 figs. The purposes of this study were (1) to evaluate selected grasses for nitrogen fixation attributable to microorganisms inhabiting their roots and (2) to establish nitrogen-fixing bacteria on the roots of selected metal-tolerant grasses by inoculation trials. Nitrogenase activity (C_2H_2 reduction) was found to be associated with *Agropyron dasystachyum, Agropyron smithii, Aristida purpurea, Oryzopsis hymenoides,* and *Stipa comata.* Uptake of fixed nitrogen was also demonstrated for these grasses. Two unidentified nitrogen-fixing bacteria were isolated, one from *Stipa comata* and the other from *Aristida purpurea. Cynodon dactylon* and *Agropyron cristatum* were successfully inoculated with the unknown isolate obtained from *Stipa comata.* The inoculated plants exhibited nitrogenase activity whereas uninoculated controls gave negative results. Research done under contract J0205054 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Minerals and Materials Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-137596; paper copy price code A03.

OFR 187-82. Phase Equilibrium Studies of Refractory Oxide Systems. Part I: SrO-ZrO_2-MgO and SrO-MgO-Dolomite, by Charles E. Semler. March 1982. 99 pp. 40 figs. The possible utility of selected compositions in the systems SrO-ZrO_2-MgO and SrO-ZrO_2-dolomite for commercial refractory products was confirmed in this study. Specifically, the compositions of interest are located in the subsystems $SrZrO_3$-ZrO_2-MgO and $SrZrO_3$-ZrO_2-dolomite. Both subsystems have regions that are not affected by hydration, but the subsystem $SrZrO_3$-ZrO_2-MgO has a larger candidate compositional region. Solid-state phase relations were determined for the subject systems over the temperature range 1,600° to 1,300° C, with compatibility diagrams presented for each. The systems appear to show good refractory character with no apparent low melting compositions. Because the compositions of commercial interest lie mostly in the higher ZrO_2 portion of each system, information is presented regarding the firing treatment required to develop stabilized cubic ZrO_2. A list of suggestions for further study of these systems, to further delineate the characteristics required for possible commercial utilization, is presented. Research done under contract J0100045 by Ohio State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-134874; paper copy price code A05.

OFR 188-82. Haulroad Berm and Guardrail Design Study and Demonstration. Volume I, by Gary L. Stecklein and John Labra. June 1981. 186 pp. 57 figs. This report presents the findings of the test programs, simulations, and analyses performed to determine the requirements for the effective application of berms and guardrails as truck restraint systems for elevated mine roadways. Included are criteria for effective vehicle restraints for guardrail applications and recommendations for berm applications based on scale model tests and computer simulations. Full-scale haulage vehicle-berm interaction field tests were performed to correlate the results of these model tests and computer simulations. Recommendations for the construction of berms were made on the basis of tests of berm-bearing strength, response of the vehicle to different berms, and predictions based on the obtained correlation. Research done under contract H0282028 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-137091; paper copy price code A09.

OFR 189-82. Haulroad Sign Design Study and Demonstration. Volume II, by King K. Mak. June 1981. 131 pp. 44 figs. A literature search was conducted to detemine the state of the art for signing applicable to surface mine haulage roads, along with a survey of existing Mine Safety and Health Administration (MSHA) regulations and a review of MSHA accident records. Nine mines were visited to gather information on current signing practices. Preliminary signing guidelines were then developed based on the data. Field demonstrations of the preliminary signing guidelines were conducted in which signing programs were implemented in two mines. Signing requirements were first assessed at each of the two participating mines, and the necessary signs were designed, purchased, and installed. Evaluation of the signing program as to its adequacy, appropriateness, and effectiveness was solicited from mine management and operations personnel. Experiences gained from field evaluations were then incorporated into the final signing guidelines and are presented in this report. Research done under contract H0282028 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-137109; paper copy price code A06.

OFR 190-82. Dynamic Study of the Impact of Government Regulations on Small Surface Coal Operator, by Anil B. Jambekar and Patrick A. Kinek. December 1981. 205 pp. 83 figs. A system dynamic model was constructed as a framework to study the long-term consequences of Government regulations, and the delays inherent in these regulations, on the functional areas of small surface coal operators. The system structure is composed of four interacting sectors: a small coal operator sector, a Government sector, a market sector, and a financial-banking sector. The small coal operator is further subdivided into five interacting subsystems; land management, production management, capacity planning, finance

and accounting control, and a pricing mechanism. Several policies to alleviate the financial burdens of small coal operators are tested. Research done under grant G5105031 by the Michigan Technological University. Available for reference at the Office of the Assistant Director, Mining Research and Mineral Data Analysis, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Denver, Colo., and Twin Cities, Minn.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 191–82. Inventory and Hazards Monitoring of Mined Lands Using Automated Processing of Satellite Imagery and Collateral Data, by Charles E. Glass, Robert A. Schowengerdt, and James R. Carr. December 1980. 156 pp. 70 figs. The purpose of this report is to demonstrate the flexibility of remote sensing techniques to provide data that will implement mined-lands reclamation in an efficient and cost-effective manner. An operation program is presented to use satellite remote sensing data, collateral data, and automated image analysis. The program will provide (1) an inventory of coal and copper mines and mine waste in Arizona, (2) techniques to periodically monitor mining areas using multitemporal classification and image prediction techniques, and (3) the delineation of high-priority areas for future reclamation and current land-use planning of Arizona mining areas based on environmental hazards indices computed using classified scenes and collateral data. Research done under grant G5195005 by the University of Arizona. Available for reference at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 192–82. An Analysis of the Productivity Trends in the Strategic and Critical Minerals Industries: The Case of Copper, by James J. Doyle. October 1982. 335 pp. 1 fig. The objectives of this study are (1) to determine which productivity measures would serve as the best indicators of the financial health and efficiency of the strategic and critical minerals industries, and (2) to develop and estimate a model that identifies the major determinants of productivity, using copper as a test case. Based on an analysis of conceptual and empirical strengths and weaknesses and on a multivariate correlation model of productivity and financial measures, seven productivity measures were selected for subsequent analysis: output per production worker hour (QPM), QPM in copper smelting, QPM in copper refining, output per unit of capital (QPK), QPK in smelting and refining, multifactor productivity in mining, and total factor productivity in copper smelting and refining. An econometric model was developed and estimated that identifies the major determinants in each of the following categories: resource base and institutional characteristics, general economic factors, and technological factors. A long (1911–79) and a short (1948–79) version of the model was attempted. The results are as follows: (1) In general, the various productivity measures are affected by ore grade, capital-labor ratios, real gross national product (GNP), cost of energy, Government regulations, strikes, injury rates, and technology. (2) Technology appears to have played a more important role for labor and capital productivity in mining than any of the other productivity measures. (3) Labor productivity appears to be procyclical; that is, positively associated with the GNP while other productivity measures tend to behave countercyclically. (4) The negative impact of Government-mandated pollution control expenditures on labor productivity in copper refining is four times as great as the impact on the mining segment and three times as great as the smelting segment. Research done under contract J0113084 by JACA Corp. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 193–82. Resource Evaluation of Lower Pennsylvanian (Pottsville) Depositional Systems of the Western Warrior Coal Field, Alabama and Mississippi, by Arthur W. Cleaves III. November 1981. 125 pp. 43 figs. This report presents a coal exploration and resource evaluation for the western two-thirds of the Warrior Coalfield of northwest Alabama and extreme northeastern Mississippi. The report evaluates the stratigraphy, facies characteristics, and depositional history of post "Millerella" carboniferous rock units within an 18-county area on the northern rim of the Black Warrior Basin. Generation of data for coal exploration, such as the geographic distribution, thickness, and stratigraphic position of economically exploitable coal seams, represents an important aspect of this research. The principal goals of the study involve (1) formulation of a coal exploration model based on facies analysis that will aid in the search for undiscovered coal reserves, (2) construction of a workable surface and subsurface stratigraphic framework in which to map the terrigenous clastic and coal facies elements, and (3) estimation of the total shallow subsurface and deep basin coal reserves within the study area. Research done under grant G5195024 by the University of Mississippi. Available for reference at the Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 194–82. The Use of a Baffled Rotating Drum Mixer in the Flocculation Dewatering of Florida Phosphatic Clay Wastes, by James L. Hendrix. October 1982. 24 pp. 6 figs. The applicability of a rotating drum with an attached trommel as a flocculation dewatering device of Florida phosphatic clay wastes was studied. Several experiments were conducted to determine the important fabrication and operating parameters. Results from the experiments indicated that the dosage of polyethylene oxide required to form a satisfactory product cake could be reduced by using the rotary drum, which introduces less shear stress into the fluid than a constant stirred tank mixer. Research done under contract J0113008 by the University of Nevada, Reno. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director of Mining Research, U.S. Bureau of Mines, Washington, D.C. Copies of this report will not be available for purchase.

OFR 195–82. The Microbiological Flocculation of Phosphate and Potash Slimes, by Corale L. Brierley

and Guy R. Lanza. February 1982. 131 pp. 24 figs. Beneficiation of phosphate in the Southeastern United States generates a slurry of finely divided clay wastes that are impounded to allow the particulates to settle. The aggregation of phosphatic clay slime wastes and slimes produced from potash beneficiation by microbial processes was studied using several bacterial species known to produce polymeric substances. Experiments included flocculation activity of whole cells in the presence of phosphatic clays, observation of clay flocculation rates by polymers derived from these organisms, and clarity of polymer-flocculated clay suspensions. The polymer-producing organisms exhibited little capacity for flocculating phosphate and potash clay slimes. Fungal spores of *Cladosporium cladosporioides* (isolated from a phosphate clay waste impoundment), when agitated with clay slime for several days, caused the clay to form pellets. Separation of the clay-fungal pellets from the process water might be possible using a screening technique. Studies with *C. cladosporioides* included the determination of suitable energy substrates and supplements for growth, absorption studies of a pigment produced by the organism, determination of the time required for bioflocculant production by the organism, and an elucidation of the conditions required for the pelletization of clay slimes by the fungus. Research done under contract J0199150 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Office of Surface Mining Library and National Library of National Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Minerals and Materials Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-137315; paper copy price code A07.

OFR 196(1)–82. Procedures for Hoist and Shaft Inspection & Maintenance. Volume I. Systems Description, by J. Cseff, W. J. Forbes, A. W. Mills III, L. Albert, and F. A. Penning. October 1981. 310 pp. 190 figs. There is a variety of shaft and hoist equipment in the United States. Nearly all of the hoist systems are electrically driven. Machine elements that comprise the hoists and ancillary equipment include bearings, shafting, drums, gear reducers, couplings, brakes, clutches, sheaves, and electrical motors. This report describes the various components encountered in most mine hoist and shaft installations along with brief descriptions of the functions and construction; hoist and balance ropes are specifically excluded. Associated with the hoisting systems are the headgear, shaft and equipment, loading-dumping facilities, and the actual conveyances and their rope attachments. Research done under contract J0100035 by V. B. Cook Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-148049; paper copy price code A14.

OFR 196(2)–82. Procedures for Hoist and Shaft Inspection & Maintenance. Volume II. Inspection & Maintenance Procedures, by J. Cseff, W. J. Forbes, A. W. Mills III, L. Albert, and F. A. Penning. October 1981. 140 pp. 25 figs. This report discusses in general terms scheduled inspection and preventative maintenance of the hoists and ancillary equipment described in volume I. Preventative scheduled inspection and maintenance procedures assist in the smooth operation of mine hoisting systems by the prevention of unscheduled or catastrophic equipment failure and its attendant downtime. Schedules and overall maintenance planning are required at the management level. Inspection, maintenance, and unusual operations or incidents must be recorded in records and equipment logs. A cross reference between MSHA regulations and various equipment components is included as part of the report. A discussion of the various nondestructive testing methods that may be applied to hoisting equipment is also included. Research done under contract J0100035 by V. B. Cook, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-148056; paper copy price code A07.

OFR 197–82. Assessment of Critical Metals in Waste Catalysts, by Francis J. Hennion and Josef Farkas. September 1982. 170 pp. 37 figs. A survey was conducted of the U.S. catalyst industry for the purpose of defining critical metals usage and disposition. This report encompasses the petroleum, chemical, and environmental (industrial and automotive emission control) industries. Metals used for catalysts in these industries include nickel, cobalt, molybdenum, vanadium, tungsten, chromium, iron, copper, zinc, and precious metals—platinum, palladium, rhodium, rhenium, silver, and gold. In recent years, about 27 million pounds of non-noble metals have been consumed for catalysts annually. Over half of this, primarily metals of lower value or concentration, is currently not recycled. However, the more valuable nickel, cobalt, molybdenum, and tungsten are extensively recycled. About 1 million troy ounces of platinum-group metals are consumed annually for catalyst applications. The automotive industry uses over 60 percent of these metals, and only a negligible amount is currently being recycled, although the technology for recovery has been demonstrated. Of the precious metal catalysts consumed by the chemical and petroleum industries, about 15 percent is lost. The balance is recycled, primarily by toll refining. Research done under contract J0215042 by Inco Research & Development Center, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Minerals and Materials Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-144832; paper copy price code A08.

OFR 198–82. In-Mine Measurement of Reactive Diesel Exhaust Contaminants, by K. T. Menzies, K. J.

Beltis, P. L. Levins, L. H. Sadowski, and B. A. Workman. Sept. 3, 1980. 151 pp. 23 figs. This report documents laboratory and in-mine analyses of diesel exhaust pollutants carried out to assess the fate of potentially reactive species in a mine environment. Specifically, the concentration of stable compounds including carbon monoxide and carbon dioxide, and potentially reactive compounds including nitric oxide, nitrogen dioxide, sulfur dioxide, aldehydes, formaldehyde, acrolein, formic acid, odorants, particulates, soluble sulfates, and polynuclear aromatic hydrocarbons was determined. The concentration and mass emission rates of these compounds were measured in the laboratory under three engine speed and load conditions and with three exhaust control conditions; that is, none, catalyst, and water conditioner. Once calibrated, the engine was installed in the Bureau of Mines Safety Research Coal Mine, and the concentration of exhaust pollutants was measured at several distances downstream inby the engine. Laboratory results confirm the relatively small effect of exhaust control devices on most pollutants under engine conditions of low speed and load. At higher engine speed and load, the catalyst is more effective in controlling many pollutants. The in-mine data indicate that during residence times, which are typical for miner-exhaust contact, most diesel exhaust pollutants do not decrease in concentration. The obvious exceptions are nitrogen dioxide, sulfur dioxide, and formaldehyde. The concentration of these pollutants is reduced up to 75 percent in 5 minutes. The lack of increase in levels of obvious reaction products indicates that surface loss may be a major sink for these pollutants.. Research done under contract J0188061 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities at Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-146241; paper copy price code A08.

OFR 199-82. Interactive Computer Programs for Manipulating Detailed Leontief Type Input-Output Models, by Everard M. Lofting and A. David Johnson. May 1982. 89 pp. A series of interactive FORTRAN computer programs for manipulating Leontief-type input-output models are presented with documentation and a descriptive users manual. Sample program outputs are annotated and described. Research done under contract J0113107 by Engineering-Economics Associates, Inc. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-149526; paper copy price code E05.

OFR 200-82. Impact of Proposed Lignite Mining in West Tennessee, by Richard G. Stearns, John M. Wilson, and Arthur L. Reesman. October 1981. 217 pp. 68 figs. Extensive thick lignite apparently lies within 250 feet of the land surface in Dyer, Lake, Lauderdale, Obion, and Tipton Counties, Tenn. Information on geology, land use, soils, ground water, and instability is compiled along with a bibliography. A test and monitoring site was investigated at Fort Pillow Prison in Lauderdale County. Analyses were made of lignite, overburden, associated water, and leachate. A year or more of data are presented on rainfull, water levels, and chemistry of surface water, ground water, leachate, and water from test pits. The main potential environmental problems are quality of surface water and possibly shallow ground water. The main aquifer of the region will likely be unaffected by mining. Low transmissibility of shallow aquifers will minimize lowering water levels of wells. Soil reclamation and conservation should be readily accomplished. Dangerous earthquakes have a low probability and mines are not significantly more hazardous than steep bluffs. Research done under contract J0100024 by Vanderbilt University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-146274; paper copy price code A10.

OFR 201-82. Stronger Mine Ventilation Tubing, by T. A. Raczek. Mar. 7, 1980. 70 pp. 22 figs. Materials for stronger ventilation tubing for underground use in hardrock mines were developed. The new material composites were evaluated in characteristics and compared with presently used materials on tear, tensile, puncture, and flammability properties. Based on cost versus performance data, a polyester film bonded to a polyester fabric was selected for field testing. Ventilation tubing fabricated from the selected material was field tested in two underground uranium mines for 4-month periods. The tests indicated that the new composite showed an increase in useful life in the majority of applications. However, the cost performance ratio was not sufficiently improved to warrant commercialization of the product. When connected directly to some blowers, the material in close proximity to the blower deteriorated. However, material that was punctured or torn by mechanical means did not have propagation of the tear. The high tear strength of the material prevented further damage. Improved methods of repairing inflated ventilation tubing were investigated and developed. All repair kit methods had to be portable and self-contained. Repair kits based on adhesives, pressure-sensitive tapes, and mechanical means were evaluated. Plier staplers and patch systems based on pressure-sensitive adhesive proved to be functional. Research done under contract H0188048 by Sheldahl, Inc. Available for reference at Bureau of Mines facilities at Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy, Pittsburgh, Pa.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-145060; paper copy price code A04.

OFR 202-82. Soil-Depth Requirements To Reclaim Surface-Mined Areas in the Northern Great Plains, by Richard C. Barth and Brooks K. Martin. April 1982. 191 pp. 24 figs. The objective of this research was to (1) determine existing reclamation practices and measure reclamation success for surface coal mines in the Northern Great Plains, (2) determine the optimum soil-depth requirements for

grass production following surface mining, and (3) determine plant uptake of nutrients and trace elements in reclamation situations. Fourteen field plots were established at active coal mines. A wedge was cut into spoil and back-filled with soil; soil depth ranged from zero to 152 cm over a linear distance of 15 m. Perennial grasses were planted in each plot and production was measured from 1978 to 1981. Based on spoil traits and biomass response patterns, plots were grouped into four types. Spoil for type I was near neutral, slightly saline, nonsodic, and clay loam in texture. Perennial grasses reached maximum production with approximately 50 cm of soil depth. Spoil for type II plots was characterized as sodic and fine textured; soil-depth requirements averaged 83 cm for maximum production. Spoil for type III plots was characterized as strongly acid, and production increased throughout the range tested. Spoil for type IV plots was similar to soil in chemical and physical traits; there was no production response to soil depth. Soil-depth requirements were also dependent upon precipitation and species. In general, soil-depth requirements decreased in dry years and with use of introduced species. An appendix contains data evaluations on an individual plot basis. Research done under contract J0265025 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Like City, Utah, and Spokane, Wash.; and the Office of Surface Mining Library and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-148221; paper copy price code A09.

OFR 203–82. An Application of the Dedicated Wire Technique To Improve Coal Mine Trolley Carrier Phone Communications, by Robert L. Lagace and Richard H. Spencer. December 1981. 78 pp. 25 figs. A whole-mine experiment to assess the practical feasibility and utility of the dedicated-wire technique to overcome poor trolley carrier phone system performance at a large underground coal mine was designed, performed, and evaluated. The technique involves the use of a single, low-loss, properly terminated, and branched auxiliary wire placed in the rail haulageway. This auxiliary dedicated wire allows signals to electromagnetically couple to the trolley wire-rail transmission line and thereby significantly decreases the overall signal attenuation rate on the trolley wire-rail line. The in-mine dedicated-wire demonstration program and its results, conclusions, and recommendations are described. Research done under contract J0308036 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mine Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 83-149070; paper copy price code A05.

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OFR 1(1)–83. Mine Rescue Team's Protective Ensemble. Volume 1, by Victor Himel and Ernest V. Hansberry. May 1982. 30 pp. 24 figs. This report documents a systematic approach toward implementing an improved ensemble for the mine rescue team system that will protect against the hazards of mine rescue and recovery and will also afford improved performance through increased comfort and maneuverability, lighter burdens, and improved human engineering designs. Volume 1 is a detailed discussion of the approach to, and results of, three tasks. In the first task, the mine rescue team's protective needs were defined along with the test methods required to evaluate whether a particular piece of gear met these needs. The second task assessed existing gear against performance criteria and standards developed in the first task. The third task consisted of the conceptual design and construction phases of the mine rescue team's protective ensemble. Special consideration was given to advanced concepts, materials, and equipment. Research done under contract H0318048 by Grumman Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-162826; paper copy price code A03.

OFR 1(2)–83. Mine Rescue Team's Protective Ensemble. Volume 2, by Victor Himel and Ernest V. Hansberry. May 1982. 65 pp. 2 figs. This report documents a systematic approach toward implementing an improved ensemble for the mine rescue team system that will protect against the hazards of mine rescue and recovery and will also afford improved performance through increased comfort and maneuverability, lighter burdens, and improved human engineering designs. Volume 2 presents the performance goals needed for the development of a mine rescue team's protective ensemble. Consisting of five integrated systems, the protective ensemble provides body protection, breathing gas, illumination, and communications capability. In defining the performance requirements and the associated test methods for their evaluation, the standards provide the foundation for the development of each of the systems comprising the protective ensemble. Research done under contract H0318048 by Grumman Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-162818; paper copy price code A04.

OFR 2–83. Continuous Working Level Detector System, by T. R. Strombotne and A. L. Beggs.

May 1982. 27 pp. 8 figs Studies show that the exposure of radon daughter products to miners in underground mines causes a fivefold increase in the incidence of lung cancer. To aid the uranium mining industry in complying with the standards enforced to limit exposure to these daughter products, the Bureau of Mines and the Mine Safety and Health Administration have been conducting studies on personal dosimeters to determine the most accurate measurement of working level exposure. This report documents a contract undertaken to develop a commercially available source of a continuous working level detector developed by the Bureau of Mines. The report contains a system and a circuit description of the continuous working level detector. Research done under contract H0212005 by TSA Systems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-165787; paper copy price code A03.

OFR 3-83. Off-Highway Haulage Truck Overload Detection, by J. A. Bartol. January 1982. 85 pp. 28 figs. A survey was made of accident data and operating practices related to overloading and uneven load distribution on haulage trucks in noncoal open pit mines. Safety and economic aspects were analyzed. A bibliography of the literature was prepared. Review was made of available or projected systems for weighing or load indicating that might be applied to haulage trucks. A model specification system was prepared for an overload detection system. Several promising systems for overload detection were identified. One was installed and tested briefly in a 170-ton rear dump truck in a copper surface mine. Research done under contract J0188070 by Applied Engineering Resources, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-163881; paper copy price code A05.

OFR 4-83. The Quenching Behavior of Coal Dust-Air Mixtures, by Frank T. Greene and J. Eugene O'Donnell. August 1981. 88 pp. 36 figs. The quenching behavior of coal dust-air flames was investigated. The literature relevant to coal dust-air flames was reviewed, including information on the agglomeration, sedimentation, and dispersal of dust clouds. The simple equations relating the various concentrations involved in dust flame propagation are given, and their implications are elaborated. It is shown that the concentrations seen by a moving flame in a sedimenting dust cloud can differ significantly from the concentration commonly measured in such experiments. The known dust cloud phenomena that appeared significant in flame propagation studies were experimentally evaluated, and quenching diameters, flame speeds, and lean propagation limits for several tube diameters were measured. For Pittsburgh seam coal, the minimum quenching diameter (MQD) for dust between 10 and 20 μm was found to be between 0.7 and 0.8 cm, and the lean propagation for 3.2-cm tubes was found to be approximately 200 mg/L. Similar MQD data were also obtained for Pocahontas and Sewell coals, Beulah lignite, and a 50-gal/ton oil shale. The effects of temperature, coal particle size, and propagation tube material were also investigated. Research done under contract J0166076 by the Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-164665; paper copy price code A05.

OFR 5-83. Study of Mine Haulage Roadway Surface Safety Hazards, by E. Ohlsson, W. Watson, P. Cosby, and M. B. Elliott. Apr. 15, 1981. 161 pp. 9 figs. This study is divided into two sections. The first contains a summary of previous research projects on surface mine haulage systems and a bibliography of current information on design and maintenance. The second section discusses the relationship between design maintenance and associated hazards, presents a conceptual model that illustrates the interaction of the haulage system's components, and ranks common hazards according to the potential impact on mine safety. The ranking system was developed using the conceptual haulage system model and is based on interviews and questionnaires involving mine personnel throughout the United States. Research done under contract J0100028 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168088; paper copy price code A08.

OFR 6-83. Surface Oil Mining. A Technical and Environmental Assessment, by Michael Richings, Larry Lansing, and Leigh Readdy. October 1981. 266 pp. 41 figs. This report describes the work performed and the results obtained for a study to determine the environmental problems that would be encountered in the surface mining of the P.R. Spring tar sand deposit in Utah and the Kern River heavy oil sand deposit in California. The report includes a discussion of the criteria for selecting the two deposits; the existing site conditions for each deposit including geologic, hydrologic, and environmental; development plans for the mining and processing of the tar and heavy oil sands along with an economic evaluation of the deposits; and the environmental impacts resulting from the development of the two deposits and the mitigating procedures recommended to minimize these impacts. Research done under contract J0295027 by Golder Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Minerals Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Wash-

ington, DC. Order ONLY from NTIS: PB 83–168567; paper copy price code A12.

OFR 7–83. Face Ventilation Monitoring and Data Acquisition System, by George Quackenbos and Gary Tiani. April 1982. 78 pp. 22 figs. The objective of this program is the design, fabrication, and testing of an environmental system for operation in underground mines to assess the effect of various mining systems on the contaminant levels near the mine face and within return airways. To determine the effect on airborne contamination in mines resulting from the development of new mining techniques, equipment, and control systems, a comprehensive monitoring system was developed to assess such contamination levels at critical and strategic locations and to relate this information with ventilation parameters. The three variables to be sensed on a continuous basis are airborne dust concentration, methane concentration, and ventilation air velocity. Each monitoring station consists of a self-contained unit containing a power source and sensors to monitor the above-mentioned parameters. Ruggedness, reliability, ease of operation, and intrinsic safety are important design objectives. Data gathered by each monitoring station are fed to a central data acquisition system by a portable transfer unit. Research done under contract J0100032 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–170522; paper copy price code A05.

OFR 8–83. Selective Flocculation of Collophane, by Maurice C. Fuerstenau. May 1981. 67 pp. 40 figs. The adsorption of selected modifying agents (namely, starch, sodium, silicate, fluosilicic and oleic acids on collophane, calcite, and dolomite) was studied as a function of concentration and pH. Fluosilicate, silicate, and oleate anions chemisorb on collophane and dolomite, while high-molecular-weight starches hydrogen bond to these surfaces. Electrostatic adsorption of starch on calcite was also noted to occur. Selective flocculation of collophane from quartz and the carbonate minerals from three natural ores was achieved utilizing sodium silicate, sodium hexametaphosphate, and potato starch at pH 10.5. Additionally, small additions of polyelectrolyte were made to increase the settling velocity of the collophane floccules. With ores from Idaho and Florida, concentrates containing 32% to 33% P_2O_5 were satisfactorily recovered. However, several processing steps are required that result in large reagent consumption. Techniques are suggested to reduce the number of stages of concentrate cleaning. Research done under grant G0264028 by South Dakota School of Mines and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–168609; paper copy price code A04.

OFR 9–83. An Environmental Evaluation of Dust Suppressants: Calcium Chloride and Ligninsulfonates, by Rexford D. Singer, Jeffrey B. Stevens, Janine R. Gleason, David A. Baker, Thomas M. Baker, and Alan V. McEmber. June 1982. 35 pp. The purpose of this study was to evaluate the current literature on the use of calcium chloride and ligninsulfonates as dust suppressants with respect to potential adverse effects on health or the environment. Calcium chloride poses little internal hazard to humans and animals, but toxicity to vegetation in and around the area of application should be expected. The effects, however, should be considerably less than those observed from using calcium chloride as a road deicer. Except for trout, ligninsulfonates seem to pose little direct systemic toxicity problems in acquatic organisms, animals, and humans or any problems with local vegetation. Because of a greater volume of information on its use and effects, calcium chloride is recommended over ligninsulfonates. Research done under contract H0212027 by the School of Public Health, University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171967; paper copy price code A03.

OFR 10–83. A Study To Determine the Comparability of Pupillographic and Electrooculographic Measures in Determining Fatigue Effects in Truck Drivers, by John A. Stern and Larry C. Walrath. Jan. 4, 1982. 65 pp. 4 figs. Subjects were required to perform four vigilance tasks each lasting 32 minutes. The tasks involved temporal discrimination with a simple motor response required for the shorter duration signal. The ratio of short to long duration signal was 1:2. The short duration signal persisted for 200 ms; the long duration signal, for 400 ms. Two modes of stimulus presentation were used—auditory and visual—as well as two schedules of presentation —fixed interstimulus interval (2 s) and variable interstimulus interval ($\bar{X}$ – 2 s). Electrooculographic and behavioral data were obtained. The results are summarized. Evaluation of the eyeblink alertness detector identified a number of problems with the device, which are summarized in the report. Re search done under contract J0205064 by Washington University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resorces, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 11–83. Portable Trailing Cables, Splices, and Couplers Design and Installation Considerations, by L. A. Morley, J. N. Tomlinson, G. Moore, and D. E. Kline. Feb. 1, 1982. 96 pp. 61 figs. The principal concerns of this investigation were splice installations and considerations for the possible use of conductive-rubber shielding in low-voltage trailing cables and coupler installations in high-voltage cables. Flammability measurements on cable com-

ponents and general testing facilities for mine electrical equipment were secondary tasks. Theoretical and empirical data indicate that conductive rubber with high resistivity values is an unsatisfactory shield design for current-sensing fault detection. It was found that the elimination of partial discharge in coupler installations requires meticulous care. A summary and recommendations for future work are included in the report. Research done under contract J0199106 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170852; paper copy price code A05.

OFR 12-83. Assessment of Ground and Surface Water Effects Around Coal and Mineral Storage Areas, by Donald H. Koch, John R. Stetson, and Benjamin R. Genes. July 1982. 308 pp. 89 figs. Ten coal and mineral stockpile sites (5 coal and 5 mineral—phosphate, lead, copper, iron, and uranium) across the country were visited to determine the impact of the stockpiles on water quality. A series of leaching experiments was conducted in which drainage from the 10 coals and minerals was controlled and monitored to survey the extent to which storage piles release toxic ions to ground and surface waters. Pollution abatement techniques were reviewed in three generic treatment examples applied to lead-zinc ore, eastern coal, and uranium ore stockpile leachate. The study resulted in the following major conclusions: (1) Water quality impacts are site specific, (2) there is a high correlation between the sulfide content of a material and its solution potential, and (3) the selection of the best treatment alternative for a specific coal or mineral storage area must be based on site-specific criteria, pilot studies on representative leachate samples, and sound engineering design. Research done under contract J0199076 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168575; paper copy price code A14.

OFR 13-83. Beneficial Use of Sulfur in Highway Pavements. Characterization and Analysis of Plasticized Sulfur Concrete, by D. Saylak, D. N. Little, and S. W. Bigley. July 1982. 71 pp. 22 figs. This program was directed toward (1) establishing a familiarity with basic mix and sample preparation techniques, (2) material characterization, and (3) structural analysis of sulfur concrete mixtures using binders plasticized at 5, 10, 20, 30, and 40 percent. Suitable concrete specimens were prepared using the five binders. For mix design operations, the Marshall or Hveem procedures for asphaltic mixtures were found to be acceptable. For tests requiring larger size specimens such as unconfined compression and repeated-load creep, the California DOT Test Method 304 is preferred. Sulfur concrete mixtures were subjected to a characterization testing program designed to provide input to a linear viscoelastic pavement design system. A comparison of pavement performance characteristics such as rutting, roughness, cracking, and serviceability of sulfur concrete materials and asphaltic concretes indicated the former could be expected to behave as well as, or superior to, conventional pavement systems. The potential of an in situ characterization device called the Duomorph was investigated for monitoring property changes in the five modified-sulfur binders. An apparatus and testing procedure is described for measuring moduli of these binders over a range of test temperatures and loading rates. Research done under contract J0100100 by the Texas Transportation Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170670; paper copy price code A04.

OFR 14-83. Laboratory Experiments To Determine the Roof Behavior of Auger Mining With Aerostatic Support, by Madan M. Singh and Mark S. Ma. June 1982. 51 pp. 25 figs. The Bureau of Mines recently devised a method of mining that involves auger mining underground using aerostatic supports; that is, pressurized bladders inserted in the auger holes. Apart from other advantages that the method has to offer for underground productivity and safety, it permits controlled subsidence at the surface. Thus, large differential movements of the surface, which induce damage in structures, are prevented. This report describes model experiments in the laboratory that were conducted to obtain preliminary data for the design of field investigations. The results demonstrated the feasibility of the method and indicated that support pressures of 10 to 18 psi would be adequate for depths up to 1,000 ft and 70 pct recovery. The abutment loads do not exceed those generally encountered in longwall mining. Research done under contract J0295060 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 15-83. Design of a Load Haul Dump Tree Transplant Attachment, by J. P. Workman, K. E. Carlson, J. L. Smith, and K. A. Crofts. December 1980. 79 pp. 32 figs. Extensive transplanting of mature plants offers many advantages in mined land reclamation. Transplanted vegetation provides growing plants immediately to the barren reclaimed area. The front-end loader has been used on a limited basis for transplanting in the Western United States. However, these buckets are not suitable for transplanting because of their size and shape. Thus, a transplanting attachment, with straight back to prevent bending and damage to

taller plants, was fabricated to facilitate moving the maximum surface area of soil and plants consistent with the capacity of the loader. One hundred and forty clumps of vegetation were transplanted using the transplant attachment. The survival, wildlife use, and invasion of surrounding area were inventoried. These data are included in the report. In addition, a preliminary functional evaluation was made of a transport machine. The machine was self-powered and had the capability to load, transport, and unload pads of vegetation. Research done under contract H0292001 by the Colorado State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170621; paper copy price code A05.

OFR 16-83. Safe Organic Insulations and Fluids for Permissible Enclosures, by K. L. Paciorek, R. H. Kratzer, F. F. C. Lee, and J. H. Nakahara. June 1980. 168 pp. 66 figs. Explosion-proof electrical enclosures contain a variety of organic insulating materials of differing nature and chemical composition. When subjected to thermal and/or electric stress, organic insulators may be potentially hazardous owing to moist tracking and thermal oxidative degradation. Organic materials utilized as cable jacketing, cable insulation, standoffs, insulating boards, and potting compositions were identified and a literature survey performed to obtain the required thermal oxidative and moist tracking data. Thirty representative compositions were procured and subjected to thermal and moist tracking evaluations. Tracking was found to invariably result in ignition or glow of the test specimen. Influence of parameters such as electrolyte strength and composition, temperature, conductor spacing, and electrode material were investigated. Volatiles produced by selected insulators on thermal oxidative and electrical stress were identified, quantitated, and their potential impairment action upon a current interrupter assessed. Research done under contract J0377075 by Ultrasystems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170712; paper copy price code A08.

OFR 17-83. A Ventilation Study With Pressure Cycling in a Kerr-McGee Mine at Ambrosia Lake, New Mexico, by J. E. Cleveland, J. D. Shreve, and Frank Moreno. July 1982. 62 pp. 13 figs The major health concern for uranium miners is the release of radon gas and the resultant ingrowth of the short-lived daughters in the mine atmosphere. Present methods of control are the utilization of mine ventilation systems for dilution and control of ingrowth time to maintain working levels below those set by regulations. This study examines pressure cycling effects on the radon emanation. The mechanical ventilation systems were altered to allow pressure changes throughout the mine to increase radon influx during the off shifts and thus deplete the sources of radon gas. Continuous radon working level and environmental monitors, developed by the Bureau of Mines, were employed to monitor radiation and physical parameters in the mine workings. The mine ventilation system was then varied to induce radon flows during off shifts, thus depleting the radon sources during normal production shifts. Electrostatic precipitators were also tested to determine radon daughter collection efficiencies. Both radon and radon daughter concentrations were monitored and evaluated. Major problems were found in the simple mechanical operation of cleaning these units. Research done under contract J0265058 by Kerr-McGee Nuclear Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 18-83. The International Stainless Steel Market: An Analysis of Supply, Demand, Prices and Trade Flows, by Per Baverstam, Thomas B. King, and Joel P. Clark. January 1982. 310 pp. 41 figs. A mathematical model was developed to simulate the international market for stainless steel in the market economy countries. The model was constructed by analyzing stainless steel markets in four regions: the United States, Japan, Sweden, and the European Community. Regional interrelationships between stainless steel supply, demand, prices, and trade are taken into account. Analysis is based on historical data collected for each market covering the 1970-79 period. The data are used to illustrate changes in production technology, capacity, and costs over time and to show consumption of raw materials, energy, and stainless steel products. Demand for stainless steel is calculated for each region annually through 1990. Using forecasts from several macroeconomic services available through 1981, simulation of the international market through 1990 indicates regional annual growth rates of stainless steel demand ranging from 5 percent in the United States to 7.9 percent in Japan, and growth rates of exports ranging from 5.3 percent annually for Sweden to 10.7 percent for Japan. Research done under contract J0199152 by the Massachusetts Institute of Technology. Available for reference at the National Library of Natural Resources, U.S. Department of the Interior, and Office of Assistant Director—Minerals Information, U.S. Bureau of Mines, Washington, DC. Order ONLY from NTIS: PB 83-170902; paper copy price code A14.

OFR 19-83. Contamination of Ground and Surface Waters by Uranium Mining and Milling. Volume II. Field Sampling and Empirical Modeling, by Gergely Markos and Kathryn J. Bush. December 1981. 127 pp. 17 figs. Uranium mill tailings represent a potential threat to the human habitat by containing large amounts of radioactive and chemically toxic substances in high concentrations. The main objective of this investigation was to evaluate the actual movement and model the potential movement of contaminants by seepage of water from the tailings into the subtailings soil. This report presents various models of the movement of contaminants using both theoretical approaches and empirical evaluation of data available from other investiga-

tions. The data consist of field measurements and laboratory determinations of major and trace cations, the dominant anions, pH, Eh, and specific conductance of solids and waters from the tailings and surroundings. Evaluation and interpretation of data were accomplished by using Eh-pH diagrams, various statistical methods, and the WATEQFC computer program. Data analysis shows that the critical area of investigating movements is the interfaces between tailings and the external environment. The chemical differences at interfaces seem to result in a sink system for contaminants. The tailings-soil-water system shows extreme complexities because of chemical and physical heterogeneity of the system preventing the use of a single comprehensive model to represent real conditions. The validity of the simplifying assumption used has been shown and increasing complexity has been built into the models. Analogs of these models can be used for evaluation of similar systems. Research done under contract J0295033 by the University of Colorado, Denver, and GEC Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–170688; paper copy price code A07.

OFR 20–83. Resilient Screen Test Program, by William R. Wessels. January 1982. 55 pp. 24 figs. This report describes a field survey and laboratory investigation into the causes of resiliently clad screen decks applied to coal preparation plants. Blinding of screen deck perforations and delaminations of the resilient cladding are studied and mechanisms responsible for these failure modes are hypothesized. A laboratory test program to simulate the mechanisms was begun and abandoned when it became apparent that meaningful test results would require a substantially redirected effort. No meaningful test data were obtained from the laboratory simulation. Research done under contract J0100042 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171983; paper copy price code A04.

OFR 21–83. Explosion Proof High and Medium Voltage Connector, by M. S. Cetiner. March 1982. 70 pp. 32 figs. This report describes the prototype development of a medium to high voltage coupler, suitable for underground coal mining operations. The coupler has such unique features as automatic dust covers and continuous phase pin shielding. The coupler is rated at 7,500 V and 250 A continuous operation. Research done under contract H0188155 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 22–83. Rheology of Viscoelastic Fluids for Oil Recovery, by G. B. Thurston and G. A. Pope. December 1982. 23 pp. 12 figs. The objective of this research was to characterize the viscoelastic behavior of the fluids used in enhanced oil recovery by chemical flooding methods. By a better understanding of the rheological properties controlling porous media flow, more reliable and efficient design can be achieved and more economical oil recovery can be attained. Two polymers, a xanthan gum having a molecular weight near 2×10^6 Daltons and a hydrolyzed polyacrylamide, were selected for application to a variety of rheological evaluations and porous media flow tests. The most conspicuous difference was that the hydrolyzed polyacrylamide showed pronounced dilatancy in porous media flow while the xanthan gum did not. Cross linking in situ was evaluated for the polyacrylamide. Research done under grant G1115481 by the University of Texas at Austin. Available for reference at National Library of Natural Resorces, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 23–83. Processing of Mineral Fines by Column Flotation, by K. V. S. Sastry. November 1982. 35 pp. 14 figs. A complete understanding of the flotation process in columns is necessary for establishing their design and operational basis and for demonstrating the potential of separation improvements that can be achieved A research program directed toward an experimental and theoretical investigation of the processing of mineral fines by column flotation is currently underway. Specific aspects of the research program include (1) establishing the range of particle sizes over which column flotation would be most effective, (2) determining the influence of operating variables and their relation to the mineral properties on the overall efficiency of flotation columns, and (3) identifying necessary improvements in flotation column design and investigating the effectiveness of the new design. Experiments were performed using glass beads in various size ranges, and the behavior of the column was evaluated in terms of air and water holdup profiles, particle concentration profile, and flotation recovery. Research done under grant G5105014 by the University of California. Available for reference at Bureau of Mines facilities in Avondale, MD, and Twin Cities, MN; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 24–83. Fracture Mechanics and Structural Response Investigations Associated With Energy Resource Recovery, by S. H. Advani, V. H. Kenner, and T. G. Richard. Dec. 15, 1982. 97 pp. 45 figs. Experimental and theoretical investigations pertinent to fracture mechanics and structural modeling associated with energy resource recovery are reported. The experimental studies include the mixed mode as well as crack opening mode fracture toughness characterization of Pennsylvanian age shales as a function of moisture content. The analytical studies include (1) the stress and subsidence analysis of mine systems, (2) coal hydraulic fracture studies with bi-material response evaluation, (3) tailored

pulse loading studies, and (4) constitutive modeling. Research done under grant G1115393 by Ohio State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, D.C. Copies of this report will not be available for purchase.

OFR 25(1)–83. Monitoring and Modeling of Shallow Ground Water Systems in the Powder River Basin. Volume I, by Donald Koch, Charles D. Ringrose, Richard C. Moore, and David L. Brooks. July 1982. 358 pp. 85 figs. The project investigated regional impacts of mining on the ground water system of the Powder River Basin by (1) establishment of a regional ground water monitoring network and (2) development of a set of digital computer models to simulate ground water flow and quality, ground water contributions to surface water flow and quality (i.e., baseflow), and watershed runoff and recharge. Over 100 wells were monitored for physical and chemical parameters. Data were used as input to the models and for the development of a comprehensive data base. The basin was modeled on a regional and a subregional scale. Two watershed models were evaluated for their ability to provide runoff and recharge inputs to the basic ground water model. Application of the regional and subregional models using conservative mining scenarios showed that drawdowns may extend west from the mines as far as 10 miles but that impacts would be insignificant on a regional scale. The watershed model could be effectively applied to small watersheds only. Volume I describes in detail the work performed and the results obtained. Research done under contract J0265050 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 25(2)–83. Monitoring and Modeling of Shallow Ground Water Systems in the Powder River Basin. Volume II. Appendices, by Donald Koch, Charles D. Ringrose, Richard C. Moore, and David L. Brooks. July 1982. 698 pp. 109 figs. The project investigated regional impacts of mining on the ground water system of the Powder River Basin by (1) establishment of a regional ground water monitoring network and (2) development of a set of digital computer models to simulate ground water flow and quality, ground water contributions to surface water flow and quality (i.e., baseflow), and watershed runoff and recharge. Over 100 wells were monitored for physical and chemical parameters. Data were used as input to the models and for the development of a comprehensive data base. The basin was modeled on a regional and subregional scale. Two watershed models were evaluated for their ability to provide runoff and recharge inputs to the basic ground water model. Application of the regional and subregional models using conservative mining scenarios showed that drawdown may extend west from the mines as far as 10 miles but that impacts would be insignificant on a regional scale. The watershed model could be effectively applied to small watersheds only. Volume II contains the data collected during the course of the project, as well as the source codes for the models developed. Research done under contract J0265050 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 26(1)–83. Data Collection and Mathematical Modeling for Predicting Underground Mine Water Inflow. Volume I, by R. Williams, G. Bloomsburg, G. Winter, and D. Ralston. August 1982. 330 pp. 114 figs. The objective of this study is to evaluate the hydrologic variables associated with surface and ground water systems that affect the inflow of ground water into an underground mine. Data collection techniques are reviewed for their applicability for quantifying these hydrologic variables. Innovative techniques are also investigated. Existing analytical and numerical procedures for predicting underground mine water inflow are reviewed and evaluated. Research done under contract J0100013 by Williams-Robinette and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171108; paper copy price code A15.

OFR 26(2)–83. Inflow to Horizontal Drains in Tailings Embankments, by R. Williams, G. Bloomsburg, and G. Winter. August 1982. 53 pp. 19 figs. A technique was developed to determine the length and spacing between horizontal drain pipes to be installed in a tailings embankment through the use of the finite element model UNSAT2. The analysis is based on the combined output of a vertical planar mesh and a horizontal planar mesh. The slot opening in the drain pipe and the length of the perforated section are determined from an analogy to water well design. The pipe diameter and gradient can be determined from Manning's equation. Research done under contract J0100013 by Williams-Robinette and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of

the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178749; paper copy price code A04.

OFR 27-83. Further Studies on Optimum Combined Fire Retardant/Preservative Treatments and Stench Warning Systems for Wood Mine Timber, by Mark Davis, William Holley, and W. Robert Diehl. May 1982. 82 pp. 11 figs. As a follow-on to previous investigations, reduced treatment levels for the optimum fire retardant-preservative system were evaluated. An impregnation of 3.5 lb/ft^3 of Fyreprufe followed by 3.5 mils of Albi 107A plus an Albi 144 top coat provides adequate flammability and flame spread protection. However, there is a significant loss in compressive strength at this retention level, particularly parallel to the grain. A pilot-size pressure impregnation cell was installed for use in treating larger quantities of wood. Based on the optimum fire retardant-preservative treatment system, a model treatment process was developed capable of handling 3 million board feet per year. Associated annual costs per thousand board feet for treating 12- by 12-in timber were calculated. A literature search was conducted to identify materials and techniques suitable for a localized stench warning system for heated mine timbers. Based on this review, several stench warning concepts were developed. Those based on surface coating were given a preliminary laboratory evaluation. Research done under contract J0166068 by Springborn Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171975; paper copy price code A05.

OFR 28-83. Development of Improved Seatbelt Systems for Surface Mining Equipment, by L. E. Carlson and A. G. Hoffman. Oct. 30, 1981. 127 pp. 4 figs. Tasks required in the development of improved seatbelt systems included a literature and information search, development and test of a prototype seatbelt system, production of field test systems, field tests, and evaluation of the field test results. The systems were a retractable sheath design with both automatic and manual locking features. Results indicate mining equipment operator acceptance of seatbelts were enhanced by the design features of the improved systems. Research done under contract H0202005 by the Mobility System and Equipment Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171991; paper copy price code A07.

OFR 29(1)-83. High Angle Conveyor Study. Volume I, by E. A. Mevissen, A. C. Siminerio, and J. A. Dos Santos. December 1981. 294 pp. 93 figs. With the ever-increasing consumption of mineral commodities, the vital question is not whether sufficient mineral quantities will be available, but rather can the known existing low-grade resources be mined economically. Conventional conveyor systems are being used in some open pit mines to decrease haulage costs. This report presents cost analyses that were performed on hypothetical copper, taconite, and phosphate mines. Available high-angle conveying equipment is identified, and the haulage and crushing costs associated with a conventional truck and shovel mining operation and a high-angle conveyor operation are examined. Information was gathered from a series of high-angle conveying equipment and open pit mining operations in the United States. Volume I includes a detailed review of the state of the art in high-angle conveying concepts, the hypothetical mine development, and the cost analyses. Research done under contract J0295002 by the Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175042; paper copy price code A13.

OFR 29(2)-83. High Angle Conveyor Study. Volume II, by E. A. Mevissen, A. C. Siminerio, and J. A. Dos Santos. December 1981. 279 pp. 2 figs. This report presents the cost analyses on hypothetical copper, taconite, and phosphate mines. Information was gathered from a series of high-angle conveying equipment and open pit mining operations in the United States. Volume II includes the appendices. Research done under contract J0295002 by the Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175059; paper copy price code A13.

OFR 30-83. Phone Line Signal Propagation in Coal Mines, by Terry S. Cory. August 1981. 178 pp. 114 figs. This report describes the results of a measurement program to determine the broad spectral characteristics of both differential and common mode noise on phone lines in three coal mines and signal attenuation spectral characteristics on the same broad basis over phone line strings with taps and/or branches. The frequency range used was a baseband of 1,000 kHz for resolution bandwidth ranging from 100 Hz near baseband to 30 kHz near 1 MHz. The signal attenuation measurements were performed on all three "legs" of taps where possible and applicable. Results were obtained comparing shielded and unshielded phone lines in one mine. The results include an improved electromagnetic noise chart for coal mines showing variations with types of mines, topology, and

location of noise sources. Fundamental high-frequency limit on untreated phone lines in coal mines is identified. Research done under contract J0308095. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171637; paper copy price code A09.

OFR 31(1)-83. Floodplain Disposal of Mill Tailings. Volume I—Text, by K. E. Robinson, B. E. McKee, and M. M. Eivemark. October 1981. 67 pp. 15 figs. Volume I of this two-volume report provides an initial indication that mill tailings produced in the Coeur d'Alene mining district of Idaho can be placed on floodplain areas in a technically acceptable manner without artificial liners and without seriously contaminating the surrounding area. Tests have shown that landfills on these unused areas can result in returning the areas to productive use. Among the environmental considerations in using tailings for landfill construction are acid and other contaminations produced by tailings and wind erosion of exposed tailings surfaces. The results indicate that adverse impacts are not as severe as previously thought and that mitigative measures are feasible. Based on the preliminary data, and in accord with Federal and State waste management regulations, a conceptual design was developed for 23 potential landfill sites in the district that could reclaim 750 acres of floodplain. A cost analysis of landfill construction with mill tailings indicates that the method would be an economically viable means for increasing the valley-wide tailings storage capacity, provided construction with slurried tailings is feasible. Research done under contract J0188146 by Robinson Dames & Moore and Greater Shoshone County Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170779; paper copy price code A04.

OFR 31(2)-83. Floodplain Disposal of Mill Tailings. Volume II—Appendices A-F, by K. E. Robinson, B. E. McKee, and M. M. Eivemark. October 1981. 242 pp. 152 figs. This study provides an initial indication that mill tailings produced in the Coeur d'Alene mining district of Idaho can be placed on floodplain areas in a technically acceptable manner without artificial liners and without seriously contaminating the surrounding area. Volume II of this two-volume report contains appendices A through F. The report includes (1) the results of a study that evaluates the feasibility of disposing of mill tailings by landfill construction, (2) a description of a field and laboratory testing program that assesses the effectiveness of a soil liner as a means of seepage control, (3) a summary of a thesis on the analysis of acid production potential and the results of geotechnical testing of mill tailings, (4) a description of potential landfill sites and their development to meet the present needs of the mining industry and the future requirements of the community, (5) a description of the legislation impacting on tailings disposal, and (6) a discussion of the environmental and socioeconomic factors that should be considered. Research done under contract J0188146 by Robinson Dames & Moore and Greater Shoshone County Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170787; paper copy price code A12.

OFR 32(1)-83. Safety Analysis of the Blind Shaft Borer. Volume 1. Summary Report, by C. A. Geffen-Fowler. July 1981. 77 pp. 7 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. A comparison of the BSB system with conventional shaft sinking was made on the basis of relative risk levels, which includes both the frequency and the potential consequence of accidents. A safety evaluation of the component operations of the two BSB systems was performed using a failure modes and effects analysis methodology. The results of this analysis show generally that both BSB systems are safer than conventional shaft sinking. The potential risk of conventional shaft sinking operations could be reduced by over 30% with the use of the original BSB system, and by about 10% with the modified BSB system. Design change recommendations to further improve the safety of these systems include a better fire suppression system, improved worker haulage systems, and more compact hydraulics. An operational safety manual was also developed for the modified BSB system. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174284; paper copy price code A05.

OFR 32(2)-83. Safety Analysis of the Blind Shaft Borer. Volume 2. Supplementary Reports A-E, by C. A. Geffen-Fowler. July 1981. 443 pp. 24 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 2 comprises supplementary reports A

through E. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–174292; paper copy price code A19.

OFR 32(3)–83. Safety Analysis of the Blind Shaft Borer. Volume 3. Supplementary Reports F-J, by C. A. Geffen-Fowler. July 1981. 434 pp. 10 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 3 comprises supplementary reports F through J. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, Co, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174300; paper copy price code A19.

OFR 32(4)–83. Safety Analysis of the Blind Shaft Borer. Volume 4. Safety Manual, by C. A. Geffen-Fowler. July 1981. 105 pp. 5 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 4 contains the safety manual. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174318; paper copy price code A06.

OFR 33–83. Fluid Cavitation as a Rock Crushing and Rock Fragmentation Tool, by David A. Summers and Marian M. Mazurkiewicz. December 1982. 94 pp. 36 figs. The use of high-pressure fluid cavitation is investigated as a means of breaking an ore into its constituent grains. This cavitational rock disaggregation (CRD) is found to be possible and effective in breaking down galena ore, both in sandstone and dolomite host material. The technique did not work as well in comminuting and cleaning oil shale because the cavitation drove the oil into emulsion with the water. The presence of dominant bedding in the rock also caused preferential breakage to these lines rather than to the individual grain boundaries. This problem was also encountered in tests on igneous ore where weakness planes of the overall ore proved weaker than the boundaries of the individual grains. The prevailing expression of cavitation erosion dependence on pressure was not found to be absolutely valid. In contrast, CRD was found to be much more sensitive to jet flow diameter, and when this was recognized, it was found possible to erode with compressive strength of up to 350 MPa with operating jet pressures of 40 MPa. Research done under grant G1115291 by University of Missouri—Rolla. Available for reference at the Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Spokane, WA, and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 34–83. Determination of the Washability and Flotation Characteristics of Missouri Coal Seams, by M. Hayri Erten. Sept. 30, 1982. 158 pp. 44 figs. The objectives of this research were (1) to draw the washability curves of Missouri coal seams to determine their washability characteristics, (2) to investigate the possibility of ash and sulfur removal by gravity methods, and (3) to determine the flotation behavior of the seams. During a 2-year period 47 channel and 29 drill-hole samples were received and tested. The samples showed that Missouri coal seams contain high ash and sulfur in the as-received condition. The ash contents of 76 samples tested ranged from 8.30 to 39 percent, whereas the sulfur contents ranged from 0.95 to 14.55 percent. However, the washability tests conducted on —1.00- to —0.25-in channel samples and —0.25-in core samples indicated that 1.40 and 1.50 specific gravity separations, clean coals containing fairly low ash and a total sulfur percentage ranging between 1.02 and 4.69 can be obtained. Research done under grant G1115293 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Rolla, MO, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 35–83. Pilot Study for the Development of Precision Electronic Blasting Delay Detonators Utilizing Self-Contained Integrated Timing Circuits, by Paul Worsey. Nov. 29, 1982. 67 pp. 7 figs. Apart from being inaccurate, electric blasting caps (detonators) are known to be inherently dangerous with respect to potential accidental initiation. This may be caused by different electric and electromagnetic phenomena such as static electricity, overhead powerlines, ground currents, radio waves, stray currents, and electric storms. However, apart from the risk of accidental initiation, commercial detonators are susceptible to misfire from grounding, short circuit, etc., due to the presence of moisture. Because of the latter two problems, certain manufacturers have begun to change production from electrically initiated detonators to encapsulated explosive tube initiated detonators. Although this new form of nonelectrical detonator has none of the quoted potential

risks of accidental initiation or misfire, it contains the same type of chemical delay element that is the major cause of inaccuracy in electric delay series blasting caps. The purpose of this work is to combine the old and new technologies and develop a new integrated electronic delay blasting cap that utilizes an electronic microchip as a delay element. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Avondale, MD, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 36–83. Improvement of the Performance of Copper Electrowinning in Fluidized Bed Cells, by J. W. Evans, M. Dubrovsky, and D. Ziegler. Sept. 30, 1982. 11 pp. 7 figs. Research was done on anodes for use with fluidized bed cathodes for electrowinning copper. Suitable anodes must have low power consumption (less than 3 kilowatt hours per kilogram of copper) while operating at high current densities (several thousand amperes per square meter). The anodes must also be free of operating problems and suitable for scale-up. The research resulted in a cell with energy consumption rates less than in conventional cells up to a current density about 10 times greater than in a conventional cell. The anode was tested on both a small, 50-ampere cell and on a larger, 1,000-ampere scale. Auxiliary experiments were carried out on the fluidized bed electrowinning of copper from dilute solutions, from dilute solutions containing cobalt and nickel, and from dilute chloride solutions. Research done under grants G1115061, G1105060, and G1195006 by the University of California at Berkeley. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Reno, NV, and Salt Lake City, UT; at the National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mineral and Materials Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 37–83. Autoclaved Lime-Aluminosilicate Materials for Alumina Extraction and Construction, by Charles A. Sorrell. Sept. 30, 1982. 25 pp. The initial purpose of this project was to investigate reactions between lime and aluminosilicate materials to (1) obtain compounds more susceptible to acid leaching for removal of alumina, titania, or other commercially valuable components, and (2) to develop a cementitious bond strong enough to warrant use of waste materials or inexpensive rock materials for construction materials. It was found that the first objective need not be pursued because it was unnecessary to react many materials prior to acid leaching and that the second objective was not worth pursuing because nothing was found to equal presently available sandlime bricks in terms of strength, durability, or cost. Research done under grant G1115292 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 38–83. Characterization of Ohio Limestone To Determine Potential Use in Control of Coal Emissions, by Roger J. Bain. December 1982. 43 pp. 4 figs. Over 200 carbonate rock samples were collected from 33 quarries in Ohio. Quarries were studied and described in detail in order to characterize the nature of the quarry operation, the type of stone being produced, variability in carbonate materials, and the ability to produce a lithologically consistent product. The 200 samples were analyzed by petrographic thin section analysis, scanning electron microscopy, neutron activation, cathode luminescence, X-ray diffraction, sulfur reactivity, chemical analysis, porosimetry, and pore casts. Variations in rock were tested to determine which lithologic features affected reactivity. It was determined that crystallinity, crystal size, porosity, and chemical composition are the major controlling factors. The best sorbent will possess euhedral crystals in the 0.05- to 0.2-mm size range, intercrystalline porosity, and a high calcium content. Dolomites, in general, possess the best texture and several units in Ohio are suitable for use as sorbents. Research done under grants G5105080, G1105080, G1115392, and G5195033 by the University of Akron. Available for reference at the Bureau of Mines Salt Lake City (UT) Research Center; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 39–83. Nursery Techniques for Production of Tree Seedlings Infected With Specific Mycorrhizal Fungi for Surface Mine Reclamation, by James W. Hendrix. Dec. 30, 1982. 45 pp. 2 figs. A survey of endomycorrhizal fungi occurring on orphan coal mine lands in western and eastern Kentucky revealed a great diversity of species present. Thus, a large number of fungi are available for isolation and evaluation for enhancing revegetation of mined lands. Endomycorrhizal fungi isolated from orphan mines stimulated growth of sweetgum seedlings on mine soil at low fertilization but inhibited growth at high fertilization; this growth inhibition at high fertilizaton did not occur with plants growing on peat-perlite. Banding of endomycorrhizal inoculum was not advantageous, compared with incorporation of inoculum throughout the growth medium, for production of mycorrhizal sweetgum seedlings. Newly reclaimed mine spoils were nearly nonmycorrhizal, compared with land reclaimed 4 or 8 years earlier. A procedure for isolation of single-spore cultures of endomycorrhizal fungi was developed; this is necessary for ecotypic variability. A practical procedure using container-grown *Pisolithus tinctorius*-infected shortleaf pine seedlings for production of large numbers of bareroot pine seedlings infected with *P. tinctorius* for mined land reclamation was demonstrated. Research done under grants G1105004, G1115003, and G1115212 by the University of Kentucky. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 40-83. Wireless Communications for Trackless Haulage Vehicles, by Terry S. Cory. July 1979. 164 pp. 51 figs. This report describes a complete system design methodology for medium frequency

(MF) wireless radio systems for use in coal mines. The emphasis is on ac mines where no trolley wire exists and for which conventional trolley phone communications cannot be used. The report constitutes an MF system design handbook and includes a compendium of all previous MF technology elements as well as a reference index with abstracts of all pertinent literature. Research done under contract J0395072. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171744; paper copy price code A08.

OFR 41-83. Laboratory Evaluation of Janelid Method of Dead Heading Ventilation, by A. Erickson and K. Heller. August 1981. 56 pp. 17 figs. The effectiveness of a loader-mounted fan on diesel vehicles combined with natural convection for ventilation of a dead heading ventilation system was investigated. The results were obtained using CO_2 as a tracer gas in a ¼-scale model heading. Buoyant forces were scaled to establish similarity with full scale. For a loader moving in a typical load-haul-dump cycle, the loader-mounted fan reduced the tracer gas concentration by 26 percent compared with a reduction of 32 percent for a jet fan of four times the flow capacity. Research done under contact J0395016 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171959; paper copy price code A04.

OFR 42-83. In Situ Shear Strength of Rock in Open Pit Benches (Development of Equipment and Field Procedures), by M. K. McCarter and L. R. Partington. August 1982. 173 pp. 54 figs. This project involves the construction and field testing of a large borehole jack designed to operate within a conventional 12 ¼-inch rotary blasthole common to open pit mining. The system is capable of exerting approximately 800,000 pounds on curved platen measuring about 4 by 24 inches. Field tests indicate that the system will operate in a mining environment, and preliminary results suggest the possibility of using the force-displacement data generated by the jack to rank the competency of material within a mine bench. Research done under grant G1195048 by the University of Utah. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171736; paper copy price code A08.

OFR 43-83. Reclamation of Mined Peatlands, by R. S. Farnham. March 1982. 20 pp. 3 figs. Peat is partially decomposed plant material that has accumulated in a saturated environment. Peatlands are located in depressional areas, large sloping lake plains, or any area in which the topography, climate, and hydrology produce an oxygen-deficient environment limited to microbial decomposition. The mining of this material for horticultural peat and energy production has taken place for the past several decades in several European countries and information gathered from past reclamation research on these lands is cited in this report. This project addresses the problems associated with the agricultural reclamation of these mined lands. Peatland drainage, fertility, and field preparation as well as crop selection for these areas is discussed. Laboratory, greenhouse, and field evaluations of representative Minnesota peats are included in the report. Data derived from these investigations suggests that the low natural fertility and short growing season of peatland areas are the major limitations to reclamation. Relatively large amounts of potassium and phosphorus fertilizers and some micronutrient additions are required on peatlands to obtain proper plant growth. It was found that the cole crops (broccoli, cauliflower, cabbage) and short season agronomic crops are suitable on Minnesota peatlands. Research done under contract J0205044 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-172007; paper copy price code A02.

OFR 44-83. Propose and Evaluate Methods of Controlling Mercury Vapor Emissions in a Processing Mill Furnace Room, by Paul T. Bartlett and Terry L. Muldoon. July 1982. 115 pp. 29 figs. The objective of this program was to develop cost-effective methods of controlling mercury vapor in a processing mill furnace room with particular emphasis on the McDermitt mercury mill in Nevada. Process, environmental, and operating data were collected at McDermitt and a preliminary evaluation of control systems was performed. Efforts were focused on the furnace, which is the primary mercury emission source, and furnace positive pressure or "blowback," which is the cause of the greatest furnace emissions. Cost-effective conceptual design alternatives were prepared that addressed the identified emissions problems, particularly furnace blowback. Two designs were selected and detailed design drawings and cost estimates were prepared. The first design agglomerates the filter cake upstream of a belt conveyor, which replaces the existing screw conveyor. The second design dries the filter cake to 5 percent moisture before conveyance on the belt conveyor. Both designs are expected to reduce mercury vapor concentrations by more than 500 $\mu g/m^3$ in the furnace building and approximately 160 $\mu g/m^3$ in the concentrator building during furnace operations. Research done under contract J0318024 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of

the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171751; paper copy price code A06.

OFR 45-83. Evaluating the Impact of Prospective Changes in Materials Use: An Input-Output Approach, by Wassily Leontief, Michael Bever, James C. M. Koo, and Ira Sohn. December 1982. 83 pp. The purpose of this study was to investigate the economic impact of prospective changes in materials use in the U.S. motor vehicle, household furniture and appliances, beverage packaging, and highway and street construction industries under alternative scenarios. The impact of increased imports of automobiles and a changing recycling rate of nickel was also examined. Under assumed economic growth rates and structural changes in the U.S. economy, projections of output and consumption levels of selected industries and level of nonfuel minerals to 2000 were computed. Chapter I of the report addresses the applicability of input-output techniques followed by a detailed description of the structure of the model in Chapter II. Chapter III discusses the economic growth assumptions of the United States to 2000 as well as data and assumptions used in designing each of the eight scenarios included in the study. Results, analyses, and conclusions of each scenario are presented. Research done under contract J0188147 by the Institute of Economic Analysis, New York University. Available for reference at Bureau of Mines facilities in Juneau, AK, Denver, CO, Pittsburgh, PA, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170845; paper copy price code A05.

OFR 46-83. Improved Fire Protection System for AN-FO Haulers and Loaders, by Bruce Christensen, Steven Hunter, and Lyle McDonald. June 30, 1980. 215 pp. 59 figs. The objectives of this investigation are to (1) conduct a fire hazards analysis of all AN-FO haulers and loaders and (2) to develop and demonstrate an automatic fire sensing and suppression system for this class of surface mining machinery. The research included (1) data acquisition through visits to nine mine sites, two AN-FO hauling contractors, two equipment manufacturers, and a literature search. (2) Analysis of accumulated data providing specific design inputs for an AN-FO hauler representing the greatest overall fire hazard, operating conditions, previous fire experiences and performance, cost, and maintenance factors affecting potential purchases of automatic fire control systems for AN-FO haulers and loaders. (3) Development of a recommended design concept for a low-cost and reliable fire protection system. A specific system design was developed based on the data analysis and system specifications were determined. Factory testing of the fire protection system components included a full-scale fire test of the system on an AN-FO vehicle mock-up. Installation of the prototype system on an AN-FO vehicle at a surface coal mine and a demonstration of performance by fire tests were performed. Research done under contract H0282015 by The Ansul Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170704; paper copy price code A10.

OFR 47(1)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 1. Executive Summary, by Mohan K. Wali.. June 1982. 35 pp. This report, the first in a series of 13, provides a summary of 11 major topics on which individual reports have been prepared. The topics include (1) nature of coal mine spoils, topsoils, and unmined soils; (2) influence of macro- and microclimate on biomass; (3) plant production on spoils and topsoils; (4) prediction of aboveground biomass from plant cover; (5) mineral composition of plants; (6) controlled environment studies on plant growth response; (7) microbial communities; (8) water chemistry and organism diversity of catchbasins; (9) vegetation and soil development on abandoned sites; (10) vegetation and soil development on topsoiled sites; and (11) viability and diversity of seed banks. Based on these investigations, general conclusions and some recommendations are presented. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171322; paper copy price code A03.

OFR 47(2)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 2. Physical and Chemical Properties of Overburden and Topsoils as Affected by Time and Amendments, by Nirander M. Safaya, Richard H. Bares, Nunna Malakondaiah, and Stuart A. Nicholson. June 1982. 180 pp. 88 figs. Field experiments were conducted at six coal mine sites in Oliver and Mercer Counties, ND, to determine the subsequent effects of a single application of selected amendments on spoil and topsoils over the 5-year period, 1974-78. Considerable variations in the physical and chemical properties were found in mine spoils from site to site. The texture of spoils ranged from sandy clay loams to loamy sands. The pH of the sites ranged from 6.5 to 8.2. In many cases, the pH values of mine spoils were not significantly different from the topsoils. The electrical conductivity did not exceed 6 mmhos cm^{-1} at the test sites even though in other studies much higher values were recorded in the vicinity. The spoils can be classed as moderately saline to nonsaline. The sodium adsorption ratios (SAR) ranged from less than 1 to 32, with the lowest SAR values in the topsoiled sites. Some of the spoils were highly calcareous. The spoils that were the least calcareous showed the calcium carbonate equivalent three times higher than that of the topsoil. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171330; paper copy price code A09.

OFR 47(3)–83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 3. Soil and Vegetation Development of Abandoned Mines, by Mohan K. Wali and Richard H. Pemble. June 1982. 99 pp. Soil and vegetation development were studied on abandoned mine sites in Ward County, ND. The sites studied were 1, 7, 17, 30, and 45 years old since abandonment; unmined sites were also studied to provide measures of comparison. Species diversity was the highest at unmined sites and lowest at the 1-year-old site; sites 7, 17, 30, and 45 years old had 37, 52, 43, and 68 species, respectively. Stand ordination revealed that site ages were the most important in influencing species diversity and composition. Stand-environmental complex ordinations encompassing 53 variables showed topographic variables to be the most important followed by site ages. Species distributional diagrams are provided to show habitat preferences that may be helpful in formulating species prescriptions for revegetation. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171348; paper copy price code A05.

OFR 47(4)–83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 4. Soil and Vegetation Development on Topsoiled Areas, by Louis R. Iverson and Mohan K. Wali. June 1982. 68 pp. 12 figs. Four North Dakota reclaimed mined sites 1 to 4 years old were studied for patterns of species colonization, biochemical interaction among species, competitive phenomena, and management applications. *Kochia scoparia*, a colonizer, was the dominant species for the first 2 years, but was completely eliminated by the fourth year; the planted *Agropyron* grasses concomitantly increased during the 4-year period. Chemical analysis of the soils over the same period showed decreases in several soluble elements due to leaching and a slight buildup of nitrogen and organic matter. Competition experiments between *Kochia* and *Agropyron* revealed that *Kochia* initially acted as a "nurse" crop for *Agropyron* establishment, but later in the first season began to shade excessively, reducing *Agropyron* tillering. Studies on the plant population biology of *Kochia* showed that it conformed well to several established laws governing yield versus density relationships. Field and growth chamber experiments revealed that decaying *Kochia* leaves and roots were toxic to *Kochia* growth and were partially responsible for the rapid demise of the species. Chemical analysis of the soils and plant tissues indicated nutritional imbalances may be responsible for the autotoxicity. Another bioassay experiment implicated allelochemics to be important in several other colonizing species. Mowing the first year colonizing species just prior to seed set proved to be effective in reducing weed populations and improving planted *Agropyron* populations in the second year. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171355; paper copy price code A04.

OFR 47(5)–83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 5. Plant Production on Spoils and Topsoils as Affected by Time and Amendments, by Richard H. Bares. June 1982. 67 pp. 14 figs. Field study sites were established on recontoured mined areas during the early 1970's in which several amendments were tested for their ability to improve spoil-topsoil conditions and, hence, increase plant production. A number of grass and legume species combinations were studied. The general effects of one-time, single-rate application of leonardite and/or slack coal to spoils and topsoils was the reduction of grass dry matter yields and the promotion of legume establishment and yield. Production of weedy species was remarkably lower on topsoil treated with leonardite than that without leonardite. The general effect of commercial fertilizer applied one time prior to seeding was to increase plant production during the first 2 to 3 years after which the effect disappeared; the effect was much more pronounced on spoils. Weedy species accounted for most of the biomass production during the first growing season. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171363; paper copy price code A04.

OFR 47(6)–83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 6. Relationship Between Cover and Aboveground Biomass, by Diana K. Schimmelpfennig. June 1982. 52 pp. 5 figs. A study was done to evaluate the predictability of aboveground biomass production on revegetated mined sites and adjacent native prairies using plant cover estimates made with the point frame method. The predictability of biomass production by cover estimates bears on the need for measurements of both plant cover and aboveground biomass in assessing revegetation success. A positive, statistically significant correlation was demonstrated between plant cover (estimated by the point frame method) and aboveground biomass (estimated by the harvest method) regardless of community type (mined or native), species composition, diversity, or level of biomass production. However, the latter did have their effects on the relationship and must be accounted for in any predictive equations; that is, the predictive equations must be considered site specific. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–171371; paper copy price code A04.

OFR 47(7)–83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in

North Dakota. 7. Mineral Analysis of Plants Grown on Spoils and Topsoils, by Nunna Malakondaiah. June 1982. 46 pp. Plant samples collected from mined and test sites in surface coal mined areas of North Dakota were analyzed for nutrient concentrations. The vegetation from the mined areas generally showed lower concentrations of Na, P, and Cu and failed to meet the nutritional requirements for beef cattle as defined by the National Research Council. Some plants showed generally higher concentrations than others, and lower concentrations of P were reported in most of the plants on some unmined sites. Amending the spoil with slack at one test site decreased the concentrations of Zn, Cu, and P in wheatgrasses grown on spoil from 0- to 2-, 5- to 10-, and 20- to 25-foot depths, respectively. Leonardite amendment at one test site decreased P concentration in grasses compared with control, whereas fertilizer increased the same. The concentrations of Ca, Mg, Na, Fe, Cu, and N in grasses were significantly higher on topsoil than at slack-amended spoil at one test site. The data presented in this report act only as an indication of between-treatment and between-species differences in tissue composition of plants harvested in midsummer season. Since none of the nutrients analyzed were found toxic, the cattle can safely feed on the mined land vegetation. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171389; paper copy price code A03.

OFR 47(8)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 8. Soil Algae, by Thomas L. Starks and L. Elliot Shubert. June 1982. 75 pp. 11 figs. Surface soil and topsoil samples from experimental test sites in western North Dakota were aseptically collected during August 1975 and from May through September during 1976-77. Selected samples were cultured in a defined inorganic medium and after 6 weeks the algae were identified. Chlorophyll *a* content of the soil and spoil was used as a measure of the algal abundance. Soil physical-chemical properties, species variety, and abundance were statistically analyzed. All test sites revealed distinct soil algal communities and demonstrated a successional trend as evidenced by significant increases in species variety and biomass over time. Some soil factors (Ca, Cu, and P) affected species variety and abundance at more than one site. Others were important at specific sites (Si and Al at one site; Mn, Na, and Zn at another site; and B, Cd, and Mg at another site). Topsoiled areas had higher species varieties and abundances when compared with control areas, as did plots treated with amendments such as leonardite and fertilizer. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171397; paper copy price code A04.

OFR 47(9)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 9. Viability and Diversity of the Seed Bank, by Louis R. Iverson and Laura Brophy. June 1982. 43 pp. 7 figs. Analysis of seed numbers present in topsoils indicated that seeds of the most prevalent colonizers were not present in the topsoil in a grazed area, an ungrazed area, and two stockpiles upon respreading but rather reappeared by immigration from the surrounding areas. The grazed site had a seed density of over 7,700 seeds per m^2 and the ungrazed site had 3,900 seeds per m^2; the stockpiled topsoils had very low seed densities (225 and 520 seeds per m^2). Seed densities and diversity decreased with depth on both the grazed and ungrazed sites; this was especially true on the grazed site where 94% of the seeds were found in the surface 7.5 cm. Several species were present in the seed bank that were also found on the 3- and 4-year-old mined sites in the aboveground vegetation survey. Seeds from these species may germinate after several years of dormancy, thereby starting populations on mined sites and enhancing plant diversity. Seed bank analysis was also undertaken on mined sites ranging from 2 to 6 years old and on an unmined site. Mined site seed densities ranged from 1,630 to 3,980 seeds per m^2; the 4-year-old site had the greatest density and the unmined site and stockpiled topsoil sample had lower seed densities. A significant positive correlation between total viable seed content and soil-water saturation percentage indicated that soil texture may influence seed viability-dormancy; there was poor correlation between the aboveground flora and the belowground seed composition. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171405; paper copy price code A03.

OFR 47(10)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 10. Elements of Macro- and Microclimate, by Richard H. Bares. June 1982. 61 pp. 13 figs. The general or macroclimate of the study site in western North Dakota is characterized by rapid and sometimes extreme daily and day-to-day temperature fluctuations, rainfall patterns that are erratic in spatial and temporal distribution and intensity, generally low relative humidity, plentiful sunshine, nearly continuous air movement, and a relatively short frost-free period. Of particular relevance to plant growth and productivity is the mosaic of microclimates that are affected by landform; exposure; slope angle, length, and aspect; and soil color, texture, and surface and vegetation cover. The most critical plant growth-governing factor is available water. It is determined principally by water input (precipitation) and water loss (evapotranspiration), which is increased by high temperatures, wind, and poor surface and vegetation cover. While spring and fall precipitation is generally gentle and soil-soaking, summer rains frequently come in the form of intensive, soil-washing, localized convective thunderstorms of short duration. Due to the convective nature of these storms, summer rainfall is particularly affected by regional topography; southwest slopes and crests often receive more rainfall since the storms usually

move in a northeasterly direction. The water loss due to runoff and consequent soil erosion are major problems resulting from such "cloudbursts." Previous fall precipitation in September and October, when added to the current seasonal precipitation from March through August, was found to be significantly correlated with plant production. Generally clear skies over the region facilitate receipt of abundant sunshine at the earth's surface. While good for early season soil warming and plant photosynthesis, this abundant sunshine coupled with long days and nearly continuous wind is responsible for evapotranspiration exceeding precipitation by an average of 6 inches between June and September. On a local scale, the water deficit is most severe on the southern exposures, which receive the most direct solar radiation and therefore are warmer than other exposures. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171413; paper copy price code A04.

OFR 47(11)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 11. Effect of Amendments on Soil-Plant-Nutrient Relations Under Controlled Conditions, by Nunna Malakondaiah and Nirander M. Safaya. June 1982. 64 pp. 2 figs. Several growth chamber and laboratory experiments were conducted to study the germination behavior of plant species on mine spoils and plant growth responses to nutrients on spoils and topsoils. Experiments were conducted to study the germination potential of some native and introduced species under various conditions. The seeds of green needlegrass, side oats grama, thickspike wheatgrass, crested wheatgrass, birdsfoot trefoil, and emerald crownvetch were less tolerant, whereas those of alkali sacaton, durar hard fescue, slender wheatgrass, yellow sweetclover, and alfalfa were most tolerant to the sodic mine spoil conditions. Addition of leonardite improved the germination potential of some of the poor germinators. Slender wheatgrass and yellow sweetclover were used as test plants to study the fertility status and productivity potential of stockpiled topsoils and spoils collected. The topsoils were neither saline nor sodic but low in N and P; the spoils were neutral to alkaline. Application of N and P together to the topsoils increased the yield of wheatgrass and sweetclover by 88% to 70% of their respective maximum yields, whereas near maximum yields were obtained for both species by the same treatments to the spoils. The average yields on topsoils were higher than the yields on spoils. The concentrations of major nutrients were higher in plants grown on topsoil, whereas the opposite was true with concentrations of Mn, Zn, and Cu. Growth chamber experiments were conducted to study the growth responses of alfalfa, oats, and slender wheatgrass by the application of Mn and Zn to a sodic coal mine spoil tht was previously used for pot culture experiments. Significant growth responses to Mn and Zn were observed in alfalfa but not in oats or slender wheatgrass. Fertilizing the spoil with Mn along with NPK increased the yield of alfalfa to 85% and with Mn plus Zn to 99%. Growth responses and plant composition results of this study confirm that the application of major nutrients to spoils can accentuate Zn and Mn deficiencies in some plants. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171421; paper copy price code A04.

OFR 47(12)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 12. Screening Plants for Phosphorus Requirements, by Nirander M. Safaya and Nunna Malakondaiah. June 1982. 49 pp. 2 figs. Several plant species were screened using continuous-flow and spoil culture methods for their P uptake efficiency. In flow cultures, P was maintained at 0.25, 2.5, and 25 μmoles; while in spoil cultures P was added at 0, 25, and 75 μg/g spoil to a P-deficient spoil. Alfalfa, birdsfoot trefoil, and emerald crownvetch showed P deficiency symptoms, while burning bush and Russian thistle showed no such deficiency symptoms; their dry matter yields in the 0.25-μm P treatment was 24% and 36%, respectively, of their maximum yields obtained with 25 μM P. The root dry weight ratio in the legumes increased from an average 0.22 to 0.43 with the increase in solution P, while in the weeds the increase was 0.14 to 0.30. The low susceptibility of Russian thistle to P deficiency was also demonstrated in the spoil culture experiment. Higher P concentrations were observed in weeds than in legumes or grasses. In general, increases in P supply increased P concentrations and decreased Zn concentrations. The influence of P fertilization on the tissue concentrations of Mn and Zn was similar in both flow culture and spoil culture methods. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171439; paper copy price code A03.

OFR 47(13)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 13. Statistical Analysis, by Richard H. Bares. June 1982. 18 pp. This paper describes the purpose and application of 17 statistical and mathematical procedures used in this 13-volume report. The objective of the report is to help readers to better understand the purpose and utility of statistical techniques applied to data from the various subprojects reported in this series. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171447; paper copy price code A02.

OFR 48-83. System To Prevent Clogging of Gas Sampling Tubes, by Kyle W. Charlton and Lloyd

D. Bowman. Dec. 18, 1981. 91 pp. 39 figs. The Bureau of Mines utilizes special testing methods for the analysis of underground mine atmospheres for use during or after mine disasters and fires. These methods depend upon drawing sample gas to the surface through multiple tube bundles with the subsequent analysis of grab samples or the automatic analysis by often remotely located instruments on a continuous, 24-hour basis. During cold weather, low ambient temperature causes condensation and freezing of condensable vapors in the sample, which can result in delayed response times or complete blockage of the sample line. This report covers research and resulting development conducted by the Bureau to produce a reliable method to selectively remove condensable vapors and particulate in the sample gas stream under worst-case field conditions. The effort resulted in two prototype systems that have greater field utility than originally anticipated. Research done under contract H0308042 by Charlton Technology Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration facilities in Aliquippa and Pittsburgh, PA, and Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178806; paper copy price code A05.

OFR 49–83. State-of-the-Art Environmental Assessment of Onshore Disposal of Manganese Nodule Rejects, by F. A. Kennedy, E. O. Porter, J. L. Deis, F. C. Brown, and R. E. Versaw. July 30, 1982. 238 pp. 43 figs. As part of a cooperative research program with the National Oceanic Atmospheric Administration, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service, the Bureau of Mines contracted for an environmental assessment on onshore waste disposal that is expected to occur with the development of commercial deep seabed mining. The assessment was conducted in order that testing and refinement of nodule waste disposal techniques can be completed prior to 1988, when commercial seabed mining can begin under U.S. legislation. Three classes of process and four classes of waste disposal techniques were identified, and five sites were selected as representative of first-generation nodule operations. Each site-process-disposal technique combination was compared against potential effects to determine important characteristics of the rejects and the sites. Regulatory requirements were also considered at each site to identify important issues and their effect on the permitting process. The principal conclusions are (1) uncertainties in the regulatory regimes for hydrometallurgical process tailings, primarily regarding classification as hazardous wastes; (2) slags from nodule processing that are expected to be inert and relatively easy to dispose of at all sites; and (3) additional physical and chemical information on properties of rejects from all processes that will be necessary to predict environmental effects. Research done under contract J0100085 by Rogers, Golder & Halpern, EIC Laboratories, and Golder Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175380; paper copy price code A12.

OFR 50–83. Demonstration of Noise Control Techniques for the Crushing and Screening of Nonmetallic Minerals, by Robert J. Pokora and Terry L. Muldoon. December 1981. 187 pp. 64 figs. The objectives of this program were to identify the prevalent sources of crushing and screening noise in portable and stationary plants, design retrofit noise control treatments for those sources, and field test control treatments under actual operating conditions. A survey was made to assess the variety of noise sources, to determine the worker exposure to those sources, and to identify possible constraints that should be considered in designing and installing retrofit controls. Retrofit noise control treatments designed included a primary crusher operator control booth; screen decks made of resilient cloth; screen feedbox impact pads; and rubber feed plates and chute lines, and noise attenuating curtains for a secondary crusher. A new primary crusher control booth was installed at one plant and the noise levels were reduced from 97 dBA to 78 dBA. Screen noise at two secondary crushing plants was reduced by 3 dBA, and crusher noise at one of these plants was reduced by 5 dBA. Noise levels at normal outside operator and cleanup locations were not significantly reduced in the second plant because of rapid wear of installed materials, but at the other plant the retrofit noise control materials displayed excellent wear characteristics. Research done under contract J0100038 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-173039; paper copy price code A09.

OFR 51–83. Telephone Communication System for a Deep-Vein Metal Mine, by Terry S. Cory. March 1982. 108 pp. 17 figs. This report describes the results of a program to design, procure, install, and evaluate a multichannel underground telephone system of modern design in the Sunshine Silver Mine near Wallace, ID. The report contains a cost benefit analysis for such a system using estimates of operational data for the Sunshine Mine. The results show a centrally switched telephone system of conventional design with ruggedized phone enclosures and special environmentally sealed dial pads to be the most economical. Research done under contract J0100093. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-173021; paper copy price code A06.

OFR 52–83. Microseismic Applications for Mining—A Practical Guide, by Wilson Blake. July 12, 1982. 208 pp. 82 figs. Microseismic activity and properties of microseismic events are treated so that these parameters can be taken into account when develop-

ing monitoring equipment. Microseismic equipment is discussed to provide familiarization with the components of monitoring systems. Factors to be considered and procedures for developing a microseismic monitoring system are presented. Both physical and electrical considerations for the installation of a monitoring system are discussed in detail. The operation of a microseismic system including data analysis procedures is presented. Field examples to illustrate use of microseismic data in evaluating ground control problems in a number of case histories are also included. Research done under contract J0215002. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Denver, CO, and Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director —Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-180877; paper copy price code A10.

OFR 53–83. Investigation of Extinguishing Agents for Coal Dust Explosion, by Marcel Vanpee and Reginald W. Tyler. November 1982. 83 pp. 35 figs. Eight extinguishing powders were tested in five types of diffusion flames. The effect of flame temperature on the inhibition efficiency was investigated by varying the oxygen index of the flame-supporting atmosphere. In addition, a spectrographic investigation of powder-flame dissociation products was carried out on the methane-air-ABC ($NH_4H_2PO_4$) flame. Dissociation products for this flame included PO, PH, NH, and Na. It was concluded that the main factor to be considered in the efficiency of the powder is the flame temperature. Purple K ($KHCO_3$) was typically inefficient in low-temperature flames and very efficient in high-temperature flames. On the other hand, ABC ($NH_4H_2PO_4$) was found to lose its efficiency at high temperatures but to be quite efficient in the low-temperature flames. The effect of temperature is offered as an explanation of the poor efficiency of $KHCO_3$ against coal dust explosions in contrast to the high efficiency of the phosphate salts against coal dust explosions. Research done under contract J0395097 by the University of Massachusetts. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-180885; paper copy price code A05.

OFR 54(1)–83. Constitutive Relations of Coal and Coal Measure Rocks. Volume I. Interrelationship of Mechanical, Index and Geologic Properties of Coal Measure Rocks, by T. G. Barbour, R. H. Atkinson, and Hon-Yim Ko. March 1980. 111 pp. 9 figs. Cores of coal measure rocks from five mines across the United States were tested for mechanical, index, and mineralogic properties. About 600 samples were tested to determine 15 mechanical property parameters, 7 index parameters, and 30 geologic parameters. The results were analyzed for their statistical distributions, and bivariate and multivariate, linear and nonlinear correlations were attempted for these groups. Significant correlations were found for some of the parameters. On the basis of these statistics, predictive models are postulated for the mechanical properties on the basis of index and geologic parameters. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178244; paper copy price code A06.

OFR 54(2)–83. Constitutive Relations of Coal and Coal Measure Rocks. Volume II. A Study of the Orthotropy of Coal and Other Rock Materials, by D. J. Hawk and Hon-Yim Ko. March 1980. 129 pp. 13 figs. The mechanical properties of coal are often represented by the orthotropic material model, which consists of nine elastic constants. The material symmetries involved are found in coal primarily because of the natural process by which the coal was formed. In this report, the material properties of five U.S. coals, as obtained from cubical testing, are examined using the assumption of the orthotropic material model as a basis for comparison. An analysis is performed on each set of coal material data in order to examine its conformability to other, less complex material models—the transversely isotropic model consisting of five elastic constants and the isotropic model consisting of two elastic constants. In addition, the material properties of the two U.S. shales are analyzed, based on the assumption that they comply with the transversely isotropic model. An analysis similar to that performed on the coal material is applied to the shale to determine the conformity of its material properties to the isotropic model. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178251; paper copy price code A07.

OFR 54(3)–83. Constitutive Relations of Coal and Coal Measure Rocks. Volume III. Drying Shrinkage and Creep Behavior of Coal, by R. J. Tocher and Hon-Yim Ko. March 1980. 114 pp. 35 figs. Uniaxial testing was performed on coal specimens to determine the time-dependent response. The testing was carried out on coal from six mine sites throughout the Western United States and Pennsylvania. Testing configurations were varied to allow analysis of moisture dependency, stress level, and specimen orientation. Several theories were presented for the behavior of coal due to moisture diffusion. Experimental results showed the correlation between the theories and the actual material response. Coal

deformation was found to be highly dependent on the moisture level of the testing environment. Moisture migration causes drying and shrinkage which lead to progressive degradation of the material. The coal tested experienced a rebound if saturated after a period of drying. This type of time-dependent behavior overshadows a noticeable creep behavior. Analysis of one series of creep test results was performed. A relationship was developed on the basis of a simplified rheological model to describe the coal response to uniaxial stress. Previous empirical formulations in the form of power laws were compared and their deficiencies pointed out. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178269; paper copy price code A06.

OFR 55–83. Automated Blast Hole Logging and Design, by D. E. Scheck, L. H. Mitchell, and G. W. Mack. December 1982. 126 pp. 29 figs. A blast hole drill was instrumented and equipped with a digital recorder to monitor quantitative drilling parameters such as down pressure and rotational speed of the bit. This information was captured on nonvolatile memory and transmitted to a mainframe computer for analysis. The variation in the energy required to turn the bit was found to be correlated with the geological structure of the overburden. This information was used to design explosive loads with hole size, pattern, and powder factor held constant. The decked shots designed from the drilling parameters produced better fragmentation than the mine's standard undecked design. The monitor system on board the blast hole drill was modified to perform the data analysis, identify the hard to fragment zones, and print the recommended blast designs. The final task was to design and build a hardened version of the system. This equipment is now used routinely and is available for further research and testing. Research done under grants G1105006 and G1115006 by Ohio University. Available for reference at the Office of the Assistant Director—Mining Research, Bureau of Mines, Washington, DC; Bureau of Mines, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 56–83. An Investigation of the Effects of Explosive Primer Location on Rock Fragmentation and Ground Vibrations, by Norman S. Smith. 1982. 10 pp. 5 figs. The degree of fragmentation and the magnitude of ground vibration from rock blasting are affected by numerous factors. Previous investigations have studied many of these factors; however, the influence of the blasthole primer location in a bench blast on the resulting degree of fragmentation or peak particle velocity of ground vibrations has not been investigated. This investigation used a series of three-hole, reduced-scale bench blasts in a dolomite rock mass to examine and compare effects of collar and bottom priming, the two most commonly used primer locations, on fragmentation and near-field ground vibrations. It was found that collar priming produced trends of a lower degree of fragmentation and of greater peak particle velocities than did bottom priming. There was no significant variance in toe formation or overbreak due to primer location. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at the Office of the Assistant Director—Mining Research, Bureau of Mines, Washington, DC; Bureau of Mines facilities in Avondale, MD, and Pittsburgh, PA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 57–83. Evaluation of Effectiveness of Fly Ash in Fixing Metals Within and Controlling Leachate Contamination From Tailings Ponds, by John L. Sonderegger and Joseph J. Donovan. December 1982. 42 pp. 15 figs. Western, calcium-rich fly ash was used as a tailings amendment in laboratory studies with pyrite, galena, and tailings from a complex sulfide deposit. The base buffering capacity of the fly ash reduced dissolved heavy metal content up to three orders of magnitude. When used in this manner, with a 10 wt-pct fly ash amendment per unit weight of pyrite in the tailings, at least a three order of magnitude reduction in quantity of heavy metals leached through the tailings and into local ground and surface water systems can be expected. Research done under grants G1105005 and G1115005 by the Montana College of Mineral Science and Technology. Available for reference at the Office of the Assistant Director—Mining Research and the Office of Minerals and Materials Research, Bureau of Mines, Washington, DC; Bureau of Mines facilities in Avondale, MD, and Salt Lake City, UT; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 58(1)–83. Development of Selective Submicrometer Particulate Fire Detectors for Underground Metal Mines. Volume I, by G. F. Skala and F. W. VanLuik, Jr. December 1979. 129 pp. 43 figs. The development of two prototype instruments for the discrete detection of submicrometer particles in metal and nonmetal mines is described. The detectors are designed to utilize properties of submicrometer particles to distinguish between those produced by fires from mine ambient particles primarily resulting from diesel engine exhaust. One detector is based on the electrical tagging of the diesel exhaust particles with subsequent detection of uncharged fire particles utilizing an ion chamber as the primary sensor preceded by an electrostatic precipitator. The other detector is based on the ability to pyrolyze fire-produced particles, but not diesel exhaust-produced particles, into a high concentration of smaller particles. This concentration was compared with the concentration of unpyrolyzed fire particles and caused an alarm on a preset value. The primary sensors used were two matched cloud chamber devices. Each detector demonstrated good ability to discriminate between fire and ambient diesel-produced particles. The report contains a literature survey, experimental charging and pyrolysis data, detector design descriptions, and test results. Research done under contract H0387025 by Environment/One Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spo-

kane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178947; paper copy price code A07.

OFR 58(2)-83. Development of Selective Submicrometer Particulate Fire Detectors for Underground Metal Mines—In-Mine Evaluation. Volume II, by G. F. Skala. January 1982. 36 pp. 10 figs. Testing of two prototype instruments for the discrete detection of submicrometer particles in metal and nonmetal underground mines is described. The detectors are designed to utilize properties of submicrometer particles to distinguish between those produced by fires from mine ambient particles primarily resulting from diesel engine exhaust. One detector is based on the ability to pyrolyze fire-produced particles, but not diesel exhaust particles. An alarm is produced when the ratio of pyrolyzed to unpyrolyzed particles exceeds a present value. The other detector utilizes a continuous-flow ion chamber preceded by a denuder to remove charged particles. Discrimination against diesel-produced submicrometer particles results because the diesel particles are naturally more highly charged than fire-produced particles. In-mine testing was conducted over a period of several months. Both detectors exhibited an ability to discriminate against diesel exhaust. However, problems with the recording equipment, and with the detectors themselves due to large ambient dust particles, prevented enough data from being obtained to choose between the two methods. Research done under contract H0387025 by Environment/One Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178954; paper copy price code A03.

OFR 59-83. Reconnaissance of Tin and Tungsten in Heavy Mineral Panned Concentrates Along the Trans-Alaska Pipeline Corridor, North of Livengood, Interior Alaska, by James C. Barker. 1983. 24 pp. 3 figs. In 1978 through 1980, the Bureau of Mines collected a series of 514 panned concentrates from selected granitic regions along a section of the Trans-Alaska pipeline corridor, bounded on the south by Livengood and on the north by the Koyukuk River. The methods of sample collection and analytical procedures are described. Sample analyses for tin, as well as for tungsten and eight other common pathfinder elements, are presented. The data indicate both tin and tungsten anomalies in the vicinity of the northern Ray Mountains to the Sithylemenkat Lake area, near the Fort Hamlin Hills, and west of Caribou Mountain. Only tungsten anomalies occur on upper Bonanza Creek. Research done by the Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, AK; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 60-83. Improved Ground Control Safety in the Stone, Sand and Gravel Industries, by Tuncel M. Yegulalp and S. H. Boshkov. June 10, 1981. 299 pp. 8 figs. The objective of this study was to categorize mining operations in the stone and sand and gravel industries into areas of similar ground control functions and define initial factors affecting operational safety in each area by utilizing publicly available data, telephone interviews, and onsite observations. The findings and recommendations presented in this report are based on information collected during the two phases of the project. The report also contains, in part, the collective qualitative opinion of the operators with respect to Government rules and regulations on ground control safety and the implementation of these rules and regulations by Government inspectors. Research done under contract J0100027 by H. H. Aerospace Design Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-183111; paper copy price code A13.

OFR 61-83. Design, Construction & Development of In Situ Mining Wells, by David L. Shuck and James N. Brooke. November 1982. 135 pp. 35 figs. This report describes the current methods of design, construction, and development of wells for in situ leaching of uranium. The discussion includes the alternatives for well design drilling equipment and fluids, grout formulation and emplacement, well integrity testing and repair, and well development and stimulation. Current practice in these areas was determined through interviews and discussions with eight operators of commercial-scale in situ facilities. Based on this information and previous experience, recommendations are made regarding well design, construction, and development for in situ leaching. Research done under contract J0218018 by High Life Helicopters, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-183418; paper copy price code A07.

OFR 62-83. Utilization of Nickel Refining By-Products on Agricultural Lands, by V. V. Volk, E. H. Gardner, P. J. Sheets, and R. J. Gulack. Mar. 1, 1982. 89 pp. 6 figs. Laboratory, greenhouse, and field experiments were conducted to determine the effects of a tailings material and a magnesium ammonium phosphate (MgAP), produced from a Ni refining operation, on plant growth and soil properties. The tailings contain high levels of soluble salts (9.7 mmhos/cm), NH_4-N (0.1%), total Ni (2,470 μg/g), Cr (3,825 μg/g), and Co (313 μg/g), and low levels of Ca (1.3 meq/100 g) and extractable P (1.0 μg/g). Tall fescue (*Festuca arundinaceae S.*) was grown on soils amended with tailings and plant yield and elemental composition was determined. The MgAP was compared with $MgNH_4PO_4$ (MgKAP) and traditional fertilizer as sources of N and P for tall fescue and white clover. Tall fescue established slowly on soils amended with the

highest rate of tailings while other plants grew well. Concentrations of Mn, Ni, Cr, and Co in tall fescue grown on the treated soils were within normal ranges. The tailings should be leached further to reduce the $(NH_4)_2SO_4$ content to allow better stand establishment at high tailing application rates. All fertilizer materials provided similar levels of N and P, as evidenced by plant yield and elemental content. Research done under contract J0295058 by the Oregon Agricultural Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mining Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–183129; paper copy price code A05.

OFR 63–83. Mesabi Range Water and Iron Ore Industry, by Anching Line. October 1981. 269 pp. 17 figs. The purpose of this study was to provide an evaluation of the current state-of-the-art information concerning the availability, need, use, and degradation of the water systems associated with Mesabi Range iron ore mining. The study was carried out in three phases: (1) characterization of the Minnesota iron ore industry and associated water systems on a regional basis, (2) detailed individual case analysis of present and future iron ore developments and the associated watershed systems, and (3) impacts of potential copper-nickel development on the watershed requirements of the iron ore industry. The conclusions are presented in a summary preceding the three phases of the report. Research done under contract J0208023 by the Uintex Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 64–83. Alumina Miniplant Operations—Removal of Iron From Aluminum Nitrate Pregnant Liquor by Solvent Extraction, by Roy T. Sorensen. 1982. 19 pp. 5 figs. The Bureau of Mines investigated the recovery of aluminum by nitric acid leaching of calcined kaolinitic clay. Most iron impurities were leached from the calcined kaolin during the extraction of aluminum and must be removed before or during the crystallization of aluminum nitrate nonahydrate in order that the subsequent thermal decomposition step will yield an alumina product of acceptable iron analysis. Solvent extraction miniplant studies using di(2-ethylhexyl) phosphoric acid in kerosine diluent have demonstrated that iron content in aluminum nitrate pregnant liquors can be decreased to levels of less than 0.0007 pct (7 ppm), expressed as Fe_2O_3. A number of the miniplant tests were interrupted or terminated because of an increase in the viscosity of the solvent extraction circuit flowstreams. Under these conditions circuit control was difficult, high alumina loss occurred, and iron impurities increased in the recycled solvent. An addition of less than 0.5 mol of nitric acid per liter increased the free acid content of the pregnant liquor and eliminated the viscosity problem in solvent extraction. Bench-scale research was not confirmed because most miniplant testing was not at best operating parameters. Research done by the Boulder City Engineering Laboratory. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Boulder City and Reno, NV, Albany, OR, Pittsburgh, PA, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 65(1)–83. Reduction of Land Recontouring Costs. Volume I—Texas Lignite Field, by J. W. Howland and Lee Wray Russell. September 1981. 39 pp. 8 figs. To determine their effectiveness in different climate and soil conditions, a demonstration of dozer blades specifically designed for recontouring mine spoil was conducted at an east Texas surface coal mine. The specialized equipment included a 48-ft angle blade, a modified 24-ft "U" blade, a 13-ft-deep "U" blade, and a 24-ft grading bar. Both the 48- and 24-ft "U" blades were mounted in a two-tractor, single-operator configuration. To meet flotation problems common in this mining region, a 22-ft lightweight blade was developed and demonstrated for use on a 400- to 430-hp tractor. The demonstration involved 1,185 acres and showed a 50% reduction in reclamation costs and a 47% reduction in fuel requirements over conventional equipment. Research done under contract H0282035 by Russell & Sons Construction Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS. PB 83–191569; paper copy price code A03.

OFR 65(2)–83. Reduction of Land Recontouring Costs. Volume II—Bituminous Coal Field, Northeast Arizona, by J. W. Howland and Lee Wray Russell. June 1982. 48 pp. 9 figs. A demonstration of dozer blades was conducted at a northeast Arizona surface coal mine to determine their effectiveness in different climate and soil conditions. The specialized tools were a 48-ft angle blade on a side-by-side tractor, a 24-ft grading bar, a modified 24-ft "U" blade on a side-by-side tractor, and a 13-ft-deep "U" blade. Interest in the increased dirt-filling capacity of a previously built 22-ft blade resulted in the design of a new center-flow blade of good versatility able to maintain increased flow in otherwise difficult-to-move spoil. The demonstration involved 263 acres and showed a reduction of 50% in reclamation costs and 20% in fuel requirements over conventional equipment. Research done under contract H0282035 by Russell & Sons Construction Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–191577; paper copy price code A03.

OFR 66–83. Frictional Ignition Suppression by the Use of Cutter-Drum Mounted Sprays, by R. O. Ag-

bede, K. L. Whitehead, R. L. Mundell, and R. D. Saltsman. January 1982. 135 pp. 46 figs. The objective of this investigation was to conduct tests with a full-scale longwall shearer drum in a simulated mine environment to determine the effectiveness of drum-mounted water sprays in controlling frictional ignitions. The tests were conducted with a drum equipped with a single bit that cuts a sandstone block enclosed in a chamber filled with a combustible methane-air mixture. Without the sprays operating, no ignition occurred when only the carbide tip was impacting the stone. The likelihood of ignition increased with degree of bit wear and exposed steel contact area. Backflushing sprays, properly applied, were effective in controlling ignitions, but pickflushing and bit-cooling sprays were ineffective. Decreasing drum speed did not reduce the likelihood of ignitions until a bit peripheral speed of 200 fpm, 14 rpm for a 54-in drum, was reached. Research done under contract J0395040 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191593; paper copy price code A07.

OFR 67–83. Coal Dust Combustion in a Stirred Reactor: Evaluation of Combustion and Extinction Mechanics in Coal Dust Explosion Flames, by R. H. Essenhigh. October 1981. 78 pp. 20 figs. The relative effects of seven additives (N_2, He, CO_2, fly ash, $KHCO_3$, NaCl, and $NH_4H_2PO_4$) on extinction limits of coal dust flames have been studied in a 200-cm^3 jet-stirred reactor. Conditions in the reactor are known to be comparable to those at the head of a coal dust explosion flame. $KHCO_3$, NaCl, and $NH_4H_2PO_4$ are commercial fire retardants and are presumed to be chemically active, but test results support the presumption only for NaCl and $NH_4H_2PO_4$. Curves of weight-of-additive to suppress the flame and temperature at extinction were obtained as a function of stoichiometry. For all but the NaCl and $NH_4H_2PO_4$, 20% to 30% additive in the mixture of coal plus air plus additive is required for extinction of maximum combustibility. With NaCl and $NH_4H_2PO_4$, the figures were 13% and 4%, respectively. The extinction mechanism is presumed to be chain termination of volatiles combustion. Extinction temperatures were found to be substantially independent of kind of additive, with essentially constant values in the fuel-rich region, and declining as fuel concentration decreased. Research done under contract J0199018 by the Ohio State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191585; paper copy price code A04.

OFR 68–83. Preliminary Predictive Model of Subsidence Process Over Room and Pillar Workings. Phase I: Definition of Factors, by S. K. Mathur and M. R. Mikkilineni. April 1982. 113 pp. 38 figs. The report identifies all the possible activities, variables, and factors that contribute to the surface subsidence process over room-and-pillar workings. These factors are responsible for mine instability and collapse that ultimately transforms into surface subsidence. Such a failure mechanism is initiated by the failure of the mine floor bed and/or the failure of the pillars or the failure of the roof after second mining, which eventually brings down the roof. The individual responses of the pillar, floor, and roof rocks to the mining-induced stresses and the complex interaction between these components cannot be attributable to any single factor. Also, no attempt has been made to quantify the significance of each of these factors and relate to the ground subsidence due to the lack of field data. The discussion here is centered primarily on the first mining, although second mining is mentioned very briefly. Research done under contract J0100073 by MRM Engineers. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191759; paper copy price code A06.

OFR 69–83. Geophysical Hazard Detection From the Working Face, by Sidney A. Suhler, Thomas E. Owen, Bob M. Duff, and Ron J. Spiegel. Jan. 15, 1981. 234 pp. 80 figs. The objective of this project was to define and demonstrate the feasibility of remotely sensing abandoned mine workings from underground. Geophysical probing techniques based upon electrical, seismic, and electromagnetic methods were evaluated; the seismic method was determined to be the most favorable. Guided seismic wave propagation in coal seams offered the potential of detecting inundation hazards 200 ft or more ahead of mining. Controlled waveform seismic source transducers and specialized receiving transducers were developed with emphasis on concept demonstration and experimental guided wave propagation studies. Two major field tests were undertaken in Kentucky and Virginia. Guided wave propagation phenomena were observed in 54- and 70-in coal seams. Normal mode Love waves and Rayleigh-type guided waves were generated by the controlled-source transducers and by hammer blows on a steel anvil attached to the coal. Numerical evaluations of theoretical velocity dispersion characteristics of both Love and Rayleigh-type waves were confirmed in the experimental test results. Analyses of the test results and recommendations for additional future research efforts are presented in detail. Research done under contract H0272027 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191742; paper copy price code A12.

OFR 70–83. Video Image Sensor Systems Applied to Pit Slope Displacement Monitoring, by Robert J.

Dompe, James L. Eirls, Rodney D. Smith, William G. McKinley, and Gordon B. Hall. December 1982. 274 pp. 92 figs. The objective of this program was to develop a cost-effective microprocessor-based electronic image sensor for monitoring pit slope displacement to detect and/or predict impending slope failure in surface mines. A background study and data analysis yielded a performance specification for candidate video slope monitoring systems. A design concept was developed based on using a pair of solid-state video cameras located on precision pointing assemblies. The digital images from the cameras are compared and, using electronic triangulation, slope topology is calculated. The current and past locations of operator-selected features are compared to determine pit slope displacement. A proof-of-concept test was performed using a laboratory model of a pit slope. Based on the successful results of that test, it is recommended that an in-mine evaluation be performed using a full-scale prototype video slope monitoring system. Research done under contract J0295040 by Tracor MBA and Science Applications. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191734; paper copy price code A13.

OFR 71–83. Zinc Retorting Without Pollution, by George W. Healy. Nov. 30, 1982. 53 pp. 16 figs. The direct retorting of zinc sulfide concentrates in the presence of lime and carbon was examined on a laboratory scale in an apparatus that permitted the volatilized zinc to be condensed and weighed while the reaction gases were analyzed periodically with a gas chromatograph. The zinc vapor was calibrated on prepared gas mixtures of CO and COS and of CO_2 and SO_2 in nitrogen. Neither of these sulfur gases were detected. Increasing the proportion of lime and carbon enhanced zinc recovery, as did higher temperature; going from 90% to 110% of theoretical reagents and from 1,100° to 1,200° C increased recovery of zinc from 75% to 93%. The reaction rate for direct retorting was compared with that for reduction of oxide with carbon using theoretical amounts of reagents. It was found that above 600° C, where carbon gases were first detected, reaction proceeded almost twice as fast for oxide plus carbon as for sulfide plus lime and carbon. Since CaS might react with the atmosphere to give off sulfur gases, it was attempted to stabilize it by oxidizing to $CaSO_4$. Because a residue of ZnS remained in the material from incomplete retorting, SO_2 was evolved while the CaS oxidized. Oxidation was 20% complete at 800° C, rising to 90% at 1,200° C. It was concluded that while the retorting step is nonpolluting, if stabilization of CaS is included in the process, the pollution is a problem. Research done under contract J0295069 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191726; paper copy price code A04.

OFR 72–83. Monitoring of Gases From Explosives Detonated in an Underground Mine, by Meliton M. Garcia, Edward P. Jucevic, and W. Cary Kittrell. June 30, 1982. 81 pp. 18 figs. The concentration of six different gases produced by the detonation of four explosives was measured in a dry underground metal mine during actual mining operations. The four explosives included one semigelatin dynamite, one gelatin dynamite, and two water gel explosives. A standard drill pattern was used to detonate the explosives as a full-face round in the drift. The gases released by the explosion were trapped in the drift. The concentration of the gases in the test chamber were measured by direct readout instruments. The average volume of each gas per pound of explosives detonated in the following ranges, in cubic feet per pound: NO, 0.04 to 0.14; NO_2, 0.03 to 0.10; CO, 0.08 to 0.45; SO_2, 0.001 to 0.006; NH_3, 0.003 to 0.027; and CO_2, 1.82 to 7.02. Research done under contract H0395098 by the University of Arizona. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Rolla, MO, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191718; paper copy price code A05.

OFR 73–83. Earth Resistivity Investigations in Reclaimed Surface Lignite Mine Spoils, by A. E. Kehew and G. H. Groenewold. November 1982. 98 pp. 65 figs. Earth resistivity surveys using the Wenner electrode configuration were made in unmined areas and reclaimed spoils at three surface lignite mines in western North Dakota. Automatic interpretation of the curves was accomplished with the method of Zohdy and Bisdorf. Overburden materials become more homogeneous with respect to resistivity during the mining and reclamation process. The spoils curves show localized heterogeneities probably related to discontinuous moisture content variations in the spoils. Consistent resistivity differences in spoils occur between mines with overburdens of different mineralogic compositions. Ground water chemical compositions in terms of total dissolved solids (TDS) is inversely correlated with apparent resistivity at the 80-ft spacing from a survey centered at a piezometer screened near the base of the spoils. Better inverse correlation is probably prevented by high variability in TDS within the spoils ground water. A useful predictive relationship may be the plot of mean apparent resistivity at the 80-ft spacing for an entire mine against mean TDS for all wells in spoils at that mine. Research done under contract J0275010 by the North Dakota Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 74–83. Downhole Rock Borehole Shear Tester, by R. L. Handy, Bruce Roorda, and Steve Futrell. May 30, 1982. 22 pp. 10 figs. The goal of this research was to adapt the rock borehole shear test for use in deep, small-diameter boreholes. Operating somewhat on the principle of a rock bolt, the borehole shear test measures both the expansion pressure

and pulling force to give discrete measures of rock shearing strength as a function of the applied normal pressure. A new instrument was designed and built to fit into a 2-3/8-in-diam hole. Complications attributed to constraints of the small hole, the added requirements of an in-hole anchor to push against, and a rotating shear plate cleaner for repeated tests downhole made the design unreliable. One reason for the complexity could be the length, which is over 10 feet. The instrument also employs concentric cylinders and one hydraulic cylinder bored into the piston of another, or it would be even longer. Since advanced drilling technology has greatly reduced costs of drilling 5- or 6-in-diam holes, the downhole tester should be redesigned and simplified for use in a larger diameter drill hole. Research done under grant G0284002 by the Iowa State University, Ames. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 75–83. A Study of Stability Problems and Hazard Evaluation of the Kansas Portion of the Tri-State Mining Area, by J. R. McCauley, L. L. Brady, and F. W. Wilson. January 1983. 193 pp. 46 figs. The Kansas portion of the tristate (southwestern Missouri, southeastern Kansas, and northeastern Oklahoma) lead and zinc district was studied in order to compile maps and report on the location and extent of past mining activities and the resulting hazardous surface effects of mining. Information was acquired from old mine maps, reports, personal interviews, aerial photo interpretation, and fieldwork. Three maps have been prepared that show (1) extent of underground workings and mine shafts, (2) hazardous mine openings including open mine shafts and mine collapses and (3) waste piles and tailings ponds. In addition, tabulations are included for all mine hazards as well as large waste piles and hazardous tailings ponds. Research done under contract J0100131 by the Kansas Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 76–83. A Study of Stability Problems and Hazard Evaluation of the Oklahoma Portion of the Tri-State Mining Area, by Kenneth V. Luza. February 1983. 147 pp. 20 figs. Approximately 2,240 acres are underlain by underground lead and zinc mines in northeastern Oklahoma and approximately 2,900 acres are overlain by mine and mill waste materials. The principal objectives of this investigation are to (1) compile on a series of maps the location and extent of past mining activities and the resulting surface effects, (2) identify hazardous areas with potential for future damage to persons or property, and (3) consider methods for providing public protection from existing and potentially hazardous conditions. Research done under contract J0100133 by the Oklahoma Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 77–83. Fire Hazard Evaluations of Mine Materials in a Small-Scale Combustibility Apparatus, by A. Tewarson. June 1982. 79 pp. 8 figs. Fourteen commonly used mine materials were evaluated for combustibility in a small-scale apparatus. The data obtained and predictions of these data from large-scale fires were successfully validated for conveyor belting, brattice cloth, and treated and untreated wood. All the wood treatments except Fireguard were found to be effective for reducing the fire hazard. Five parameters proposed for rating mine materials are (1) ignition and flame spread, (2) generation of combustible vapors, (3) generation of heat, (4) generation of toxic and corrosive products, and (5) light obscuration by smoke particulates. Research done under contract J0395125 by Factory Mutual Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196204; paper copy price code A05.

OFR 78–83. Study of Automated Continuous Explosive Excavation Systems, by E. Concha and J. A Bartol. January 1982. 95 pp. 27 figs. The concept of an automated continuous explosive excavation system (ACEE) for the underground mining applications of development drifting and room-and-pillar mining has been evaluated in comparison with conventional drill, blast, and muck operations. The role and possible extent of application of this method was examined in a defined mine environment. Step-by-step procedures were developed to quantify the evaluation process where this appeared feasible. One conclusion was that a system approach to ACEE design is not only feasible but attainable within the state of the art. Several preliminary design concepts were formulated and examined in order to determine what further research or development might be needed to realize them. Research done under contract J0100082 by Applied Engineering Resources, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196212; paper copy price code A05.

OFR 79–83. Remote Monitoring of a Coal Waste Impoundment in West Virginia, by Gordon E. Green and David A. Roberts. February 1982. 175 pp. 70 figs. This report addresses remote monitoring of coal waste impoundments for stability. Existing automated geotechnical monitoring systems are described and reviewed along with details of instruments suitable for such systems. An impoundment in West Virginia, which was in the construction stage, was instrumented and monitored between July 1979 and May 1981. Sensors that measure sur-

face and subsurface parameters including settlement, horizontal deflection, surface tilt, pore water pressure, seepage, pond level, and meteorological parameters were installed. Data from 37 sensors were collected by on-site logger and transmitted by telephone to a central processing station in Seattle for recording and interpretation. Difficulties were encountered with telephone and powerline outages and malfunction of electronic units. Detailed descriptions of the design and performance of the system are provided along with evaluation and comparison with other systems. Recommendations for improving and expanding the capabilities of the monitoring system are given. Research done under contract H0282041 by Shannon & Wilson, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196584; paper copy price code A08.

OFR 80–83. Geological Sampling and Magnetic Surveys of a Tungsten Occurrence, Bonanza Creek Area, Hodzana Highlands, Alaska, by Karen H. Clautice. Mar. 29, 1983. 80 pp. 23 figs. The tungsten occurrence at the margin of the Kanuti batholith in the Bonanza Creek area was investigated by the Bureau of Mines for the Bureau of Land Management as part of an inventory of mineral deposits within and bordering the trans-Alaska oil pipeline corridor. Fieldwork was conducted over a period of 6 weeks during the summer of 1979. Analyses and sample location maps were compiled from stream sediment, panned concentrate, soil, and rock samples. Analytical methods included atomic absorption, X-ray fluorescence, emission spectrography, and neutron activation. Tungsten and molybdenum, occurring in the minerals scheelite and molybdenite, were found in trace amounts throughout the 30-mi² project area. The highest grade tungsten mineralization was found in a pyrrhotite-rich chalcopyrite-bearing tactite adjacent to a biotite quartz monzonite contact. The tactite occurs in pods up to 10 ft wide. Scheelite was most commonly found in a relatively sulfide-free calc-silicate schist that was of lower grade than the tactite. Traces of molybdenite occur in quartz veins, pegmatite, and aplite dikes. No well-developed quartz stockworks were observed. Magnetic surveys show calc-silicate country rock to be more magnetically susceptible than granitic rocks. One magnetic anomaly of 1,700 gammas within calc-silicate schist coincided with a group of anomalous soil samples high in W, Mo, Pb, Cu, and Zn. Research done by the Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, AK; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 81–83. Hydrologic and Erosional Characteristics of Regraded Surface Coal Mined Land in Colorado, by W. D. Striffler and R. Allan Rhodes. Dec. 31, 1981. 119 pp. 15 figs. Land disturbed by surface mining in Colorado and other Western States has increased substantially over the past several years and is likely to increase even more in the future. This study was initiated to provide basic information on hydrologic and erosional characteristics of regraded coal spoils in Colorado as an aid for planning future reclamation activities. Of 21 surface mines licensed in Colorado, 11 were sampled during the summers of 1980-81. Mines not sampled included those that had not progressed to the point that reclamation had begun and mines where operators denied permission to sample. All coal regions were sampled except the San Juan Coalfield. Physical and hydrologic characteristics of regraded coal spoils in Colorado were determined using standard field and laboratory procedures. Field sampling included characterization of sites (slope, vegetation density, proportion of surface rock, bare soil, etc.) and infiltration measurements using a 1-m² drop former raining on a 1/2-m² rectangular plot frame. Core samples were analyzed for saturated hydraulic conductivity, bulk density, organic matter, moisture retention, and texture. The erosion potential of each site was determined using the Universal Soil Loss Equation. Results of the sampling indicate that infiltration rates vary widely both within and between sites. Research done under grants G5105062 and G5195010 by the Colorado State University. Available for reference at Bureau of Mines facilities in Denver, CO, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 82–83. Hydrogeologic Aspects of Flyash Disposal Sites in Missouri, by Allen W. Hatheway. Mar. 28, 1983. 54 pp. 36 figs. Coal-fired utility generation stations in Missouri and the near environs of Kansas and Illinois have a production capacity of more than 12,546 megawatts of electricity. Annual consumption of coal for these plants is believed to be in excess of 23 million metric tons; most of which is midwestern and of a relatively high sulfur content. The stations produce unique forms of waste that are classified as "special" wastes by the Environmental Protection Agency. Their mineralogical character is probably the most important aspect of the fly ashes, bottom ashes and slags, and flue-gas desulfurization wastes. Most of the wastes are produced in the extreme heat of the powerplant furnaces or in the stream of hot stack gases. Most of the concern for accessory pollutants comes from elements that are carried as surface coatings on these generally fine particles. The main objective of the current research is to provide a single source assessment of the hydrologic status of utility waste disposal sites in the Missouri coal-fired electric generation region. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, and Rolla, MO; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 83–83. Radionuclide and Heavy Metal Distribution in Recent Sediments of Major Streams in the Grants Mineral Belt, N.M., by Carl J. Popp, John W. Hawley, and David W. Love. March 1983. 214 pp. 102 figs. The major objective of this research was to determine the extent to which active uranium mining and milling operations in the Grants mineral belt of west-central New Mexico contribute excess trace metals and radionuclides to Rio Puerco and Rio San Jose sediments. Subsidiary objectives include the determination of the modes of sediment move-

ments in the Rio Puerco-Rio San Jose drainage systems and determination of the age of deposits along and adjacent to the modern drainage channels. Procedures used to make these determinations include (1) geomorphic evaluation of the fluvial transport and depositional system and evaluation of loci of sediment deposition along the drainages, (2) historical documentation of loci of deposition to aid in determining the age of sediments, (3) field sampling and sediment characterization, (4) laboratory characterization of grain size and mineralogy of sediment samples, (5) laboratory determination of trace metals and radionuclide concentrations in sediments, and (6) laboratory determination of ages of sediments using radioactive cesium-137 and lead-210. Research done under grants G1115352 and G5105041 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Reno, NV; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 84–83. Extraction of Radionuclides From Low-Grade Ores and Mill Tailings, by Arpad E. Torma. Mar. 31, 1983. 85 pp. 19 figs. The present study demonstrates the possibility of development of efficient leaching processes for the extraction of uranium from a low-grade ore and for the removal of long half-life radionuclides, especially radium-226, from the leach residues in order to produce environmentally safe and radiochemically innocuous tailings. The report provides kinetic information, not previously available, for low-grade uranium ore leaching by sulfuric and hydrochloric acids and by sodium carbonate and bicarbonate leachants. Based upon a statistical experimental design, a generalized mathematical form was developed for the initial rate of uranium extraction as a function of the leaching parameters using a linear regression computation technique. A specific ion exchanger for the removal of radium-226 from leach solutions and actual neutralized tailings effluents was developed. This solid ion exchanger can be obtained through a simple treatment of commercially available organic resins. Research done under grants G1115353, G5105078, and G5195031 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 85–83. Design Procedures for Coal Mine Tunnels, by Z. T. Bieniawski. Mar. 31, 1983. 49 pp. 14 figs. Although coal mine tunnels such as the main haulageways or roadways are the lifelines of coal mines, little attention has been paid to them in the United States in terms of preconstruction planning and design. This report summarizes the results of a 3-year research project aimed at improving the design procedures for coal mine tunnels. A new design approach was developed for this purpose and roof-support design charts were prepared for mine tunnels and their intersections. Analytical studies, "base friction" model experiments, and in situ rock stress measurements were performed during this research. Research done under grants G1115425, G5105083, and G5195042. Available for reference at Bureau of Mines facilities in Denver, CO, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-197624; paper copy price code A03.

OFR 86–83. Characterization and Processing of Coal Fired Copper Reverberatory Flue Dusts, by Srinivasan Raghavan and Aniedi Ette. January 1983. 56 pp. 23 figs. A detailed study of the physical and chemical characteristics of a flue dust sample from a coal-fired copper reverberatory furnace was carried out. The studies revealed that the majority of the copper in the flue dust is strongly associated with iron in the form of a cuprous ferrite, $CuFeO_2$ (delafossite). The flue dust has an extremely fine size distribution with 70% of the particles below 37 μm in size. The recovery of copper from the flue dust was investigated using an ammoniacal carbonate solution. The results indicate that a reductive roast prior to leaching is necessary to obtain high extractions. In order to better understand the leaching characteristics of the flue dust, attempts were made to synthesize and study the leaching of the main copper-bearing constituent, $CuFeO_2$. The dissolution of the $CuFeO_2$ was found to depend on the extent of reduction, particle size, and stirring speed. A film diffusion model was proposed to describe the kinetics of leaching of $CuFeO_2$. Research done under grants G5105012 and G5115042 by the University of Arizona. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-197707; paper copy price code A04.

OFR 87–83. Beneficiation of Low Grade Appalachian Iron Ores To Recover Enriched Iron Concentrates, by H. S. Hanna and I. J. Anazia. Dec. 20, 1982. 126 pp. 49 figs. The feasibility of applying fine grinding and fine particle processing technology, as practiced in the Lake Superior region, to the low-grade, high-phosphorus red iron ores of the southeastern Appalachian region to recover iron ore products of a quality suitable for smelting competitively with imported materials is discussed. The application of new or improved processing technology or approaches embracing extremely fine grinding to achieve maximum liberation of the iron oxides and gangue constituents also is discussed. The research involved two principal lines. One emphasized the development of fundamental data relating to the fine grinding, sizing, and liberation characteristics of the ores to gain a better understanding of the most effective beneficiation approaches for separating the iron oxide and gangue minerals. The second focused on determining the merits of various beneficiation methods or combined techniques that would yield maximum recoveries of plus 60% iron products. Among the techniques applied were flotation, selective flocculation, reductive roasting and magnetic separation, magnetic flocculation, and hydrocyclone concentration. Research done under grants G1105056, G5105056, and G5195002 by the University of Alabama. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, and Twin Cities, MN; Office of Assistant Director—Minerals and Materials Research, Bu-

reau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 88–83. Workshop—Cyanide From Mineral Processing, ed. by Jerry L. Huiatt, James E. Kerrigan, Ferron A. Olson, and Gary L. Potter. February 1983. 112 pp. 8 figs. A workshop on cyanide use in the minerals industry, sponsored by the Bureau of Mines, the National Science Foundation, the minerals industry, and supporting industries, was held on February 2–3, 1982, at the Bureau's Salt Lake City (Utah) Research Center. The workshop focused on use of cyanide as it relates to the gold and silver mining industry and the froth flotation processes employed by mineral mining companies. The intent was to discuss state-of-the-art technology and provide information pertinent to cyanide use in the minerals industry. No attempt was made to advocate regulatory limits or set policy governing the use of cyanide. The principal topics of discussion included (1) chemistry and use of cyanides, (2) control and treatment of cyanide mining wastes, (3) toxicity of mining wastes, (4) fate of cyanide in the environment, and (5) the analytical chemistry of cyanide. The problems associated with cyanide use in the mining industry and areas where technical information is insufficient were identified. The types of research required to understand and resolve potential adverse environmental problems were also identified. The problems and research needs are mentioned in a special summary to this document. Research done under contract J0113087 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research and Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 89–83. Fly Ash Pelletization, by Douglas W. Fuerstenau and Vikram P. Mehrotra. June 1982. 76 pp. 27 figs. The use of pulverized coal for power generation results in the production of vast amounts of fly ash in the United States. This research is concerned with the role of the physicochemical characteristics of fly ash in governing its pelletization and the strength of the product pellets in relation to their potential use as lightweight aggregate. The potential impact of the research is extremely great in that a severe environmental problem may be alleviated by converting a huge mineral waste into a resource. Although results on batch and locked-cycle pelletization tests have indicated that it is possible to produce pellets of adequate strength from fly ash, appropriate and precise control of operation conditions is vital. Particle packing characteristics and the pozzolanic nature of ash have been identified as the important factors controlling the pelletization moisture and pellet growth. Pellet strength properties were found to be related to the amount of active silica and lime in the ash, the curing conditions, and the final products of hydration reactions. A thorough understanding of the control of continuous pelletization circuits must be developed if products of uniform quality are to be produced. Research done under grant G5105059 by the University of California. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, and Albany, OR; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–201889; paper copy price code A05.

OFR 90–83. Investigation of Microbially Induced Permeability Loss During In-Situ Leaching, by Corale L. Brierley and James A. Brierley. Apr. 16, 1982. 71 pp. 10 figs. Accumulations of microorganisms in the in situ leaching environment are believed responsible for plugging of the ore body and thus decreasing uranium extraction. To assess the contribution of microbial growth to this problem, packed columns of ore and core specimens were leached in the laboratory. Samples collected at four in situ uranium mining operations revealed pseudomonads, Xanthomonads, *Bacillus* sp. and *Micrococcus* sp. These microorganisms, inoculated into simulated leaching conditions, decreased permeability in two uranium ores by one order of magnitude in 20 days. Hydrogen peroxide alleviated microbial plugging in the laboratory. Periodic injection of hydrogen peroxide through the production well into the ore body may reduce microbial plugging problems in the field. Research done under contract S0211032 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–205534; paper copy price code A04.

OFR 91–83. Development of Improved Scrubbers for Coal Mine Applications, by D. Grigal, G. Ufken, J. Sandstedt, M. Blom, and D. Johnson. July 1982. 124 pp. 63 figs. The objective of this four-task program was to develop smaller, less expensive scrubbers while maintaining or improving scrubber efficiency and reliability. The development included (1) building a scrubber test facility suitable for testing contract-developed and future scrubber systems, (2) develop and test four fibrous-bed panels and two water droplet eliminators to reduce scrubber size and clogging, (3) fabricate and test two fibrous bed panels for use with the Bureau of Mines rotating, flooded-bed scrubber system, and (4) develop and test water-powered scrubber and recycle water systems for use at low water pressures. Tests revealed that the standard water droplet eliminator and the 20 double-layer fibrous-bed panels were the best choices for scrubber improvement. Based on clogging and pressure drop tests, it was recommended using 16 double layers of knitted wire mesh in the rotating scrubber. Research done under contract H0199055 by the Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–205385; paper copy price code A06.

OFR 92–83. Preparation and Evaluation of Self-Regenerative Carbon Monoxide Detection Gels, by John G. Palmer, Michelle Cecil, Gerhard N. Schrauzer, and Kurt E. Shuler. September 1982. 51 pp. 7 figs. Continued development of an especially impregnated silica gel capable of reversible chemical detection of carbon monoxide was reported. The effects of changes in mine-related ambient conditions on the detection catalyst's response were explored. Temperature, humidity, and several interfering gases were found to affect the detection catalyst. The interferents include hydrogen sulfide, nitrogen dioxide, acetylene (and methylacetylene), and ammonia. High humidity decreased the detection catalyst's sensitivity to carbon monoxide for some formulations. Increasing temperature generally decreased the reaction time of the detection catalyst with carbon monoxide. A limited physical, chemical, and mechanistic characterization of the detection catalyst and the materials used to prepare it has been carried out. Metal component ratio studies, spectral, analytical, pH, and rate measurements were done. Research done under contract J0188159 by the University of California—San Diego. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205179; paper copy price code A04.

OFR 93–83. Cable Fault Locator Research, by C. A. Cole, S. K. Honey, J. P. Petro, and A. C. Phillips. July 1982. 128 pp. 45 figs. This work consists of research in cable fault location and the construction of four field test units based on the research. Swept-frequency sounding of mine cables with radio frequency (RF) signals has been the technique most thoroughly investigated. The swept-frequency technique is supplemented with a form of moving target indication to provide a method for locating the position of a technician along a cable and relative to a suspected fault. Separate, more limited investigations involved high-voltage time domain reflectometry and acoustical probing of mine cables. Particular areas of research included microprocessor-based control of the swept-frequency system, a microprocessor-based fast Fourier transform for spectral analysis, RF synthesizers, transmit-receive switches, RF receivers, cable dispersion-compensation techniques, low-voltage multielement display systems, and techniques for injecting or recovering RF energy through cable walls in support of clamp-on fault locators. Research done under contract H0166082 by SRI International. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205393; paper copy price code A07.

OFR 94–83. A Hydrogen Engine Induction Technique for Backfire-Free Operation, by Ned Baker and Frank Lynch. May 30, 1982. 46 pp. 24 figs. Details are given of a fuel-induction system for a hydrogen-fueled engine. The induction system was designed to preclude backfire otherwise common in hydrogen-fueled engines. System features and test data are presented and discussed in the context of the requirements peculiar to use in an underground mine environment. The fuel-induction system, when tested in conjunction with a modified Caterpillar 3304 engine, provided backfire-free engine operation and satisfactory engine performance. Research done under contract H0202034 by EIMCO Mining Machinery International. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205443; paper copy price code A03.

OFR 95–83. Personal Dust Monitor—Light Scattering, by Pedro Lilienfeld and Roger Stern. November 1982. 40 pp. 13 figs. The objective of this program was the development, design, and fabrication of six personal-sized, completely self-contained dust monitors capable of real time as well as time-averaged monitoring of the concentration of respirable particles in coal mines in the range of 0.1 to 100 mg/m^3. The operation of these monitors is based on light scattering and passive air sampling. The design stressed overall miniaturization, ruggedness, simplicity, and versatility. These instruments incorporate a single-chip CMOS microprocessor to perform all signal processing, data display and storage, and timing functions. The overall dimensions of these devices are approximately 10 by 10 by 5 cm. Research done under contract H0308132 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205435; paper copy price code A03.

OFR 96–83. A Study of Explosion-Proof Enclosures, by P. A. Cox, O. H. Burnside, E. D. Esparza, F. D. Lin, and R. E. White. December 1982. 426 pp. 204 figs. The purpose of the initial research performed under this contract was to determine the margins of safety in explosion-proof (XP) enclosures that were designed and certified according to Schedule 2G. Results from this work provide baseline data on the current schedule, from which a new schedule can be formulated to give equal or greater levels of safety. Results and discoveries in the initial work led to an expansion of the contract to cover, additionally, weld quality in enclosure fabrication, reliability of enclosures with windows and lenses, and performance tests for enclosure qualification. Finite element calculations and hydrostatic tests revealed wide variations in the margins of safety in the enclosures studied; however, only one enclosure had a safety factor of less than one. Results from a weld quality survey led to the recommendation of AWS Welding Standard D14.4 for the fabrication of XP enclosures. Based on other work, accelerated aging tests were recommended for qualifying plastics and adhesives that are used in some enclosures, and a structural performance test was developed to test enclosure strength for a minimum static pressure of 150 psig. Research done

under contract H0377052 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205450; paper copy price code A19.

OFR 97-83. Study of Stability Problems and Hazard Evaluation in the Missouri Portion of the Tri-State Mining Area, by Michael C. McFarland and James C. Brown, Jr. Apr. 30, 1983. 141 pp. 39 figs. A 2-year investigation disclosed 469 hazardous sites resulting from past zinc-lead mining in the vicinity of Joplin, MO. Aerial-photo analysis, fieldwork, library research, and personal interviews were conducted to locate and describe the abandoned mining areas and their associated hazards. Open shafts, subsidence pits, and other mine-related dangers exist in areas easily accessible to the public. Accidents involving humans and livestock have been reported. Some recent damage to buildings and roads can be attributed to the collapse of underground mine workings. A few landowners have employed successful methods of safeguarding dangerous sites. In addition, some surface reclamation has been effected by gradual removal and use of mine and mill waste-rock, with subsequent leveling and reuse of the land. Other than backfilling shafts, nothing has been done to stabilize undermined areas. A continuing problem is indicated. Under present laws, most government reclamation funds are designated for coal-mined lands. A comprehensive program of hazard control and monitoring for the entire study area is warranted. Research done under contract J0100132 by the Missouri Department of Natural Resources, Division of Geology and Land Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 98-83. Evaluation of Charged Water Sprays for Dust Control, by J. McCoy, J. Melcher, J. Valentine, D. Monaghan, T. Muldoon, and J. Kelly. January 1983. 151 pp. 38 figs. Charged sprays and fog were evaluated for reducing respirable dust concentrations. Charged spray technology was reviewed for effectiveness, equipment, and theoretical considerations. A mathematical model was developed for predicting dust reduction effects. Laboratory tests were made showing charged spray is considerably more effective at reducing dust on a unit water basis than hydraulic spray. Positive and negative sprays are equally effective. Combined polarity sprays are considerably less effective than either polarity alone. Little difference in effectiveness by dust type was observed. The charged cloud can present a spark hazard in explosive atmospheres; therefore, this technique must not be used in gassy mines. Predictions were made for field test conditions but confirmation was impossible because of particles resulting from dissolved solids in the spray water. Dissolved or suspended solids in atomizing sprays can result in an increase of the respirable dust burden. Charged sprays are an available dust control technique best suited to applications where water usage must be limited and long contact time between spray and dust is possible. Research done under contract H0212012 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210476; paper copy price code A08.

OFR 99-83. An Observational Study of Classroom Health and Safety Training in Coal Mining, by R. Michael Digman and John T. Grasso. April 1982. 65 pp. 3 figs. This study was concerned with the quality and effectiveness of existing classroom coal mine health and safety training programs. The study involved field data collection through pre- and posttesting of trainees, audiotaping class sessions, and administering short feedback forms with trainers and trainees at 14 sites in West Virginia, Maryland, Kentucky, and Pennsylvania. Results indicate that goals, methods, materials, and outcomes of existing training programs vary widely among trainers and sites. The report provides less by way of solution to problems than it highlights the breadth of issues that relate to the question of training effectiveness and quality. The report concludes that additional work by industry, labor, government, and academia is necessary to improve health and safety programs. Recommended steps are (1) to develop performance standards and measurable criteria in each of the types of mandated training, (2) to develop better training of trainers, (3) to develop expanded training support services, and (4) to undertake further research and development in health and safety training in the mining industry. Research done under contract J0188069 by the West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210518; paper copy price code A04.

OFR 100(1)-83. Evaluation of Proximity Warning Devices. (Phase III, Volume 1), by J. H. Nixon, J. E. Hipp, T. C. Green, G. H. Munsch, and J. P. Cater. Dec. 31, 1982. 91 pp. 46 figs. A three-phase program evaluated commercial proximity warning devices, developed and designed a microprocessor-based electrostatic field measurement instrument, and utilized the instrument to investigate the electrostatic fields about powerlines. Phase I consisted of test evaluations of these commercially available proximity devices. Phase II resulted in the design and development of a microprocessor-based distributed sensor ac electrometer that measures the electrostatic field at 17 discrete locations along a crane boom. Under the phase III program, electrostatic fields around a crane boom were measured by the instrument at 17 high-voltage powerlines of various voltages and geometries. The data were processed and plotted versus boom distance from the powerlines. Analysis of the data indicate that the distances at which a single sensor alarm will activate vary by a factor of 3 to 1, due primarily to

variations in boom orientation. The results also indicate that in the case of multiple powerlines, a single electrostatic field sensor cannot reliably be used to determine the distance from a powerline. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210260; paper copy price code A05.

OFR 100(2)-83. Evaluation of Proximity Warning Devices. (Phase III, Volume 2), by J. H. Nixon, J. E. Hipp, T. C. Green, G. H. Munsch, and J. P. Cater. Dec. 31, 1982. 311 pp. 277 figs. Phase I of this three-phase program consisted of test evaluations of commercially available proximity warning devices. Phase II resulted in the design and development of a microprocessor-based distributed sensor ac electrometer that measures the electrostatic field at locations along a crane boom. In volume 1 of phase III the electrostatic fields around a crane boom were measured by the instrument at high-voltage powerlines of various voltages and geometries. Volume 2 of phase III contains the appendixes. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210278; paper copy price code A14.

OFR 101-83. Catalysis of Chlorination Reactions, by Y. K. Rao. May 5, 1982. 24 pp. 11 figs. The objective of this research was to determine the feasibility of catalyzing the chlorination of alumina using inexpensive catalytic substances. The chlorination kinetics of alumina in the presence of carbon were investigated for different forms of carbon and two different alumina particle sizes. The influence of catalysts such as ternary, NaF, and cryolite were studied for different carbon materials. The following observations were noted: (1) sodium fluoride appears to be the most stable catalyst, (2) ternary catalyst is quite powerful initially but its catalytic activity diminishes gradually possibly because of progressive deactivation, and (3) cryolite is an intermediate catalyst that may be more desirable than NaF in industrial applications. Research done under grant G1105054 by the University of Washington. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 102-83. Computer Simulation of Mining Subsidence Using the Zone Area Method, by M. Karmis and C. Haycocks. March 1983. 95 pp. 43 figs. The objective of this research was to develop a computer model of subsidence prediction based on the zone area method. This technique was chosen because of its potential to investigate a mining plan of any shape, thus facilitating subsidence prediction over longwall as well as room-and-pillar coal mining systems. A comprehensive subsidence data bank was established that included published as well as unpublished information on subsidence measurements. Based on these studies, some fundamental characteristics of longwall subsidence were established, and this information was utilized to develop an empirical prediction method. The established relationships were also used for the formulation and subsequent testing of the modeling procedures. The results and comparisons of the study demonstrated that the zone area method has considerable potential for accurate, rational, and flexible subsidence predictions. Research done under grants G1105051 and G1115512 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 103-83. Probabilistic Modeling of Soil Loss From Surface Mined Areas, by K. B. Rojiani, K. A. Tarbell, V. O. Shanholtz, and F. E. Woeste. Apr. 28, 1983. 77 pp. 24 figs. The goal of this study was to provide a rational basis for selecting a sediment control system for surface mine regions that would minimize the chance of exceeding effluent standards set by regulatory agencies for total sediment yield. A probabilistic model to predict storm sediment yield and sediment yield over the lifetime of the mining operation was developed. This model can be used to predict sediment yield for a given period of occurrence that can subsequently be used as a basis for the design of sediment control structures. Probability distributions of sediment yield were determined by coupling probabilistic models of rainfall amount, duration, and time between storms with a deterministic event-based model of the sediment yield process. A modified universal soil loss equation formed the basis for the deterministic sediment yield model. Runoff volume and peak flow were computed using the Soil Conservation Service runoff curve number method. Using probabilistic analysis procedures and a simulation approach sediment yield probability, distributions were determined for individual storm events and for the lifetime of the mining operation. Research done under grant G1115514 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 104-83. A Low-Cost Landsat Digital Technology Training Package, by John A. Harrington, Jr. May 1983. 49 pp. 17 figs. The purpose of this report is to document a computer-assisted instruction package developed to facilitate instruction of computer-based, interactive, image processing of remote sensor data. The computer software was designed for a low-cost Apple II+ microcomputer and four-channel Landsat digital data. Utilization of this educational package should extend the availability of college-level instruction concerning multispectral digital image analysis in remote sensing,

especially since this technology is now coming into research and commercial application in the mining and mineral industries. Research done under grant G1195039 by the University of Oklahoma. Available for reference at the Bureau of Mines facility in Avondale, MD, and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 105–83. The Competitive Position of the United States Copper Industry: 1980–2000, by Patricia T. Foley and Joel P. Clark. Oct. 29, 1982. 306 pp. 9 figs. An engineering-economic model was used to determine the effects that U.S. State tax actions can have on U.S. copper mines operating in a world market. The copper model used in this report is based on site- and input-specific data for 65 copper operations in the United States and site-specific data for 348 copper operations in the rest of the world. These data are used to develop world shortrun and longrun supply functions that are equated with an econometric estimate of world demand and solved for price and production under various tax scenarios. The shortrun analysis included currently producing mines; deposits for which the development decision has been made and for which the financing has been arranged are included in the longrun analysis. Research done under grants G5105029 and G5115253 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Salt Lake City, UT; Office of Assistant Director—Minerals Data Analysis, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 106(1)–83. The Effects of Increasing Energy Costs on the Future Relation Between Open Pit and Underground Mining. Volume I: Chapters 1–10, by Dan S. Nilsson. December 1982. 253 pp. 67 figs. The objective of this study was to evaluate the energy consumption in some open pit and underground mines and to show the optimal proportion between open pit and underground mining for different types of commodities. The results show (1) the future relation between open pit and underground mining of different types of deposits, (2) the future competitiveness between large-scale mining of low-grade ore and small-scale mining of high-grade ore, (3) actual power consumption figures for different mining activities, and (4) guidelines for a more energy-efficient mining industry. The study provides a base for forecasting mine production of different commodities and for decisions about how to spend research money and organize education in the field of mining engineering. Volume I contains chapters 1 through 10. Research done under grant G5105032 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Denver, CO, and Avondale, MD; Office of Assistant Director—Minerals Data Analysis and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216515, paper copy price code A12.

OFR 106(2)–83. The Effects of Increasing Energy Costs on the Future Relation Between Open Pit and Underground Mining. Volume II: Chapters 11–17, by Dan S. Nilsson. December 1982. 216 pp. 43 figs. The objective of this study was to evaluate the energy consumption in some open pit and underground mines and to show the optimal proportion between open pit and underground mining for different types of commodities. The results show (1) the future relation between open pit and underground mining of different types of deposits, (2) the future competitiveness between large-scale mining of low-grade ore and small-scale mining of high-grade ore, (3) actual power consumption figures for different mining activities, and (4) guidelines for a more energy-efficient mining industry. The study provides a base for forecasting mine production of different commodities and for decisions about how to spend research money and organize education in the field of mining engineering. Volume II contains chapters 11 through 17. Research done under grant G5105032 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Denver, CO, and Avondale, MD; Office of Assistant Director—Minerals Data Analysis and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216523; paper copy price code A10.

OFR 107–83. Control of Blackwater in Coal Preparation Plant Recycle and Discharge, by P. A. Rey, R. Hogg, and F. F. Aplan. Apr. 29, 1983. 38 pp. 6 figs. Water recycle is an important part of the coal preparation process. This study was directed toward (1) a survey of current practice and an evaluation of both the solid and liquid components of blackwater, (2) an experimental study of blackwater flocculation, and (3) a fundamental analysis of the flocculation process. The solids contained in the blackwater discharge to the fine refuse thickener of a coal preparation plant were found to contain, on average, 56% coal and 44% mineral matter. The mineral matter was largely illitic clay, while the water phase contained relatively large amounts of SO_4 and Ca^{++}. Detailed studies were made of both natural and synthetic flocculants and the influence of polymer type and pH on the settling rate, turbidity of the supernatant liquid, and sludge volume of the settled solids. More fundamental studies were made that clearly indicate the need for controlled mixing of polymer into the suspension to be flocculated and the need to evaluate more closely the structure of the flocs formed during the process. Research done under grants G1115424, G5105082, and G5195041 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216481; paper copy price code A03.

OFR 108–83. Flotation Properties and Selective Flotation of the Slightly Soluble Minerals, by F. F. Aplan and M. Castillo. March 1983. 27 pp. 7 figs. Separation of the slightly soluble minerals, $K_{sp} \approx 10^{-10}$, is one of the more difficult tasks confronting flotation engineers. This study focused on means of separating such prominent members of this class as scheelite, fluorite, and calcite from one another. Some experimental work was also done on magnesite, dolomite, and apatite. Four techniques were evaluated for separation of the minerals: (1) control of potential determining ions, (2) use of stereo-

specific collectors, (3) use of flotation rate differences, and (4) use of selective activating and depressing compounds. Each of these techniques was found to be a possible method of achieving selectivity between scheelite, fluorite, and calcite. The use of stereospecific fatty acid or sulfonate collector appears to be a particularly promising method of achieving selectivity between minerals of the slightly soluble class. Research done under contract J0199162 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–218412; paper copy price code A03.

OFR 109–83. Incorporation of Fire Extinguishing Agents in High Expansion Foam, by S. S. Gross. July 1982. 34 pp. 9 figs. A program was conducted to determine whether sufficient quantities of the flame retardant, ammonium phosphate, could be incorporated in a water-based foam solution to prevent or delay reignition (burnback) without significant degradation of foam properties. Up to 20% of monoammonium and diammonium phosphate was added to a high-expansion foam solution. This mixture was applied to burning wood and coal samples. The effect of the mixture on burnback was laboratory tested by placing the wood or coal sample in front of a radiant panel. It was found that diammonium phosphate levels of 20 wt-pct prevented reignition without degrading foam properties. A field test was then conducted using a 20% diammonium phosphate mixture and a control with no phosphate on a wood crib fire. The experimental foam did extinguish the crib fire faster than the control as evidenced by the smoke from the crib; however, neither crib reignited. Research done under contract H0308064 by MSA Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–218859; paper copy price code A03.

OFR 110–83. Personal Equipment for Low Seam Coal Miners: VIII. Improved Traction Rubber Boot Soles, by Mark S. Sanders and Jacqueline V. Downing. October 1982. 26 pp. 3 figs. Based on laboratory and preliminary field tests of off-the-shelf steel-toed rubber boots, a molded sole design was developed to provide increased traction over conventional calendared sole miners' boots. The pattern provided sharp edges perpendicular to both lateral and fore-aft slip vectors. The sole was designed to reduce mud caking. An instep lace-up capability was added to better secure the foot inside the boot. A 5-month field evaluation compared the prototype boots to the boots the participants usually wear. Although objective slip and fall data showed no significant advantage for the prototype, subjective evaluations made by the participants indicated increased traction for the prototype boots. Approximately 75 percent preferred the prototype to their own boots. Approximately one-third used the lace-up capability. It was concluded that molded soles provide better traction than calendared soles for the underground mining environment. Research done under contract J0387213 by the Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218594; paper copy price code A03.

OFR 111–83. Development of a Prototype Retrofit Noise Control Treatment for Jumbo Drills, by Nicholas R. Dixon and Matthew N. Rubin. July 1982. 106 pp. 70 figs. The noise and vibration levels of four jumbo drills were characterized and a survey of percussive rock drill usage is reported. A Gardner-Denver DH 123 drill was chosen as a demonstration drill, and extensive noise diagnostic studies were performed. Noise control treatments were designed, developed, and evaluated in a reverberant drill test facility. The treatments consisted of an integral enclosure-muffler for the drifter, vibration isolation of the drifter from the enclosure and feed, and a drill steel sheath. A 19-dbA reduction in overall sound power level was achieved with no loss in drilling rate. The prototype retrofit treatments were field tested in an aboveground mine and in a production section of an underground zinc mine. Long-term durability and operator acceptance of the enclosure-muffler treatment were excellent. Preliminary evaluation of the drill steel sheath was encouraging, although additional testing is required. Research done under contract H0387006 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218800; paper copy price code A06.

OFR 112–83. Dust Control on Active Tailings Ponds, by Russel R. Bohn and Jeffrey D. Johnson. February 1983. 124 pp. 42 figs. The objectives of this study were to (1) determine the state of the art for the control effectiveness of various chemical dust suppressants, (2) field test the effectiveness of the dust suppressants, and (3) develop technical guidelines for selecting and implementing cost-effective tailings pond dust control programs. Chemical stabilizers evaluated under field conditions were Coherex, calcium lignosulfonate, Nalco 656 and 655, and magnesium chloride. Testing in the field utilized a portable field in situ wind tunnel. The wind tunnel was placed on the tailings surface, and simulated wind speeds up to 80 mph were used to determine wind erosion threshold velocities. Emission rate testing was performed with the wind tunnel through the use of a real-time cascade impactor. A control cost-effectiveness evaluation was performed to determine how efficient the chemical stabilizers were on a dollars expended per acre basis. Research done under contract J0218024 by Environmental Services & Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT,

and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216382; paper copy price code A06.

OFR 113-83. Improving Check Curtains, Line Curtains and Extensible Face Ventilation Systems, by T. Muldoon, P. Bartlett, and W. Schroeder. November 1982. 112 pp. 56 figs. A fieldworthy 10-ft extensible brattice to maintain a 10-ft setback was found in use in two mines on continuous miner faces. The technique was evaluated in the laboratory for leakage and methane control at the face. Significant results include the following: (1) Air leakage through a gap in the extensible curtain depends upon the ratio of the cross-sectional areas between entry and return as well as gap area, (2) gap shape has no significant effect on methane concentrations at the face—increasing gap area diminishes ventilation effectiveness, and (3) substantial reductions of CH_4 concentrations at the face were accomplished by brattice extensions with gaps up to 5 ft^2 in area. An inby hook, inserted in the roof automatically to make possible the deployment of a longer brattice extension in the context of a remotely controlled miner, was tested in various roof types. Insertion of this design succeeded only in coal. Research done under contract J0100075 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interor, Washngton, DC. Order ONLY from NTIS: PB 83-216242; paper copy price code A10.

OFR 114-83. Development of a Slurry Filling System for Modified In Situ Oil Shale Mining, by E. A. Ziemba, G. H. Watson, P. H. Bissery, D. L. Namy, P. Pfister, and R. L. Griffis. March 1982. 190 pp. 74 figs. The modified in situ process is one of the methods being considered for extracting oil from oil shale. One of the questions to be answered for this approach is the environmental consequence of underground retort abandonment. This report outlines a study that addresses the question in terms of a grouting solution. The report covers the development of a spent shale-ash-based grout that will fulfill the environmental requirements in terms of strength, stability, and impermeability. In addition, the grout will allow the reinjection of up to 50 percent of material mined and surface retorted as part of the process. Research done under contract J0295046 by Rio Blanco Oil Shale Co. and Soletanche & Rodio, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216374; paper copy price code A09.

OFR 115(1)-83. Development of an Improved Man Transit Vehicle. Volume 1. Prototype Demonstration Vehicle, by Bruce Pinkston and William F. Hahn. January 1981. 81 pp. 17 figs. This report presents a description of a prototype demonstration vehicle that was constructed to assess the feasibility of a set of equipment-related guidelines. State-of-the-art improvements were embodied in such areas as collision survivability, occupant comfort, and multiple-mode operation. The electric battery-powered vehicle carries a 12-person section crew at speeds up to 12 mph. The description of the demonstration vehicle is presented in volume 1. Research done under contract J0366003 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218156; paper copy price code A05.

OFR 115(2)-83. Development of an Improved Man Transit Vehicle. Volume 2. Safety Guidelines, by Bruce Pinkston and William F. Hahn. January 1981. 124 pp. This report presents a description of a prototype demonstration vehicle that was constructed to assess the feasibility of a set of equipment-related guidelines. State-of-the-art improvements are embodied in such areas as collision survivability, occupant comfort, and multiple-mode operation. The electric battery-powered vehicle carries a 12-person section crew at speeds up to 12 mph. Safety guidelines are presented in volume 2. Research done under contract J0366003 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218164; paper copy price code A06.

OFR 116-83. Management and Supervisory Training: Review and Annotated Bibliography, by Joseph A. Olmstead and Devah R. Galloway. June 1980. 83 pp. Literature concerned with management and supervisory training was reviewed and analyzed from the perspective of relative effectiveness of various training methods for improving knowledge and awareness, changing attitudes, improving problem-solving skills, improving interpersonal skills, and improving on-the-job performance. Conclusions were drawn relative to each method and the current state of the field of management and leadership training. A 168-item annotated bibliography is presented. Research done under contract J0188053 by the Human Resources Research Organization. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: AD-A102589; paper copy price code A05.

OFR 117–83. Portable Dynamic Brake Testing Apparatus for Mobile Underground Mine Equipment, by Martin Smirlock and Mark Tanquary. December 1981. 166 pp. 40 figs. A novel instrumentation system was developed that enables simple, quick, and accurate measurement of vehicular dynamics within low-speed ranges. The system, consisting of a microwave transceiver and microprocessor data acquisition and reduction system, measures the deceleration dynamics of low-speed mining and construction equipment. It makes the basic measurement; calculates key parameters such as average deceleration, initial velocity, stopping distance, and brake system delay time; and produces autoscaled graphs of velocity, acceleration, and displacement versus time. Research done under contract H0308033 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218511; paper copy price code A08.

OFR 118–83. Automated Cableless Face Haulage Vehicle, by T. M. Heinrich. Aug. 27, 1979. 108 pp. 34 figs. An automated haulage system is described that utilizes existing battery-powered face haulage vehicles modified such that they follow a guidepath defined by an electrically excited wire fixed to the mine roof. Rerouting of the haulage paths is accomplished by simply reconnecting the guidewires. The development of the system was carried out through a design phase, and the impact on safety, productivity, and cost effectiveness was studied. Research done under contract H0155103 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220988; paper copy price code A06.

OFR 119–83. Driver Alertness Monitoring System for Large Haulage Vehicles, by Slade F. Hulbert, Robert J. Dompe, and James L. Eirls. November 1982. 120 pp. 11 figs. A driving simulator for large haulage vehicles (100+ tons capacity) was designed and assembled to conduct experiments leading to the definition of prototype driver alertness monitoring and driver warning systems for installation on-board operating vehicles for in-mine tests and evaluation. The truck-mounted system would monitor driver performance and physical condition-behavior to determine onset of unalertness that could lead to an accident. The report describes the large truck simulator, tests using the simulator on driver subjects, and the specifications for on-board driver alertness monitoring and driver warning system for in-mine testing. Research done under contract H0282006 by Tracor MBA. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220640; paper copy price code A06.

OFR 120–83. Mine Hoist Operator Training and Information Processing Workload, by Richard Rosenblatt, Paul Loustaunau, and Devah Galloway. August 1982. 97 pp. 2 figs. This report describes a training program for mine hoist operators and a human factors study on the possibility of an information processing overload in mine hoist operators. The first effort addresses formalizing and accelerating the process of hoist operator training. This was achieved through the collection of task data, development of training objectives, specifications of controlled training exercises, and development of requisite training materials. Validation results are presented. The second effort, addressing hoist operator overload, investigated the potential overload of the hoist operator's abilities to process information and control the hoist. Data were gathered in the field during periods when the probability of operator overload was greatest. The data were analyzed and the conclusions drawn therefrom are presented. Research done under contract H0387003 by the Human Resources Research Organization. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220434; paper copy price code A05.

OFR 121–83. Alumina Extraction From Anthracite Culm With Energy Recovery, by Robert P. Apa, Earl S. Grimmett, F. Ralph Keller, and John N. McFee. Sept. 21, 1982. 86 pp. 14 figs. The objective of this program was to develop a process to recover alumina and energy from northeastern Pennsylvania anthracite culm. The program located culm banks of sufficient size and quality to support a commercial plant. The method of using a fluidized bed to process the ore for alumina and energy recovery was demonstrated to be technically feasible. The fluidized bed can tolerate large fluctuations in both carbon and ash contents without affecting alumina recoverability. Based on the tests, a conceptual design was prepared and is included in this report. Based upon 1982 values for alumina and electricity, a facility of this magnitude has a marginal economic return. Increases in either the market value of alumina or the sale price of electricity may provide economic justification for the construction of such a facility in the near future. Research done under contract J0215022 by Energy Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Reno, NV, Rolla, MO, Albany, OR, and Salt Lake City, UT; U.S. Department of Energy, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220897; paper copy price code A05.

OFR 122–83. Novel Cab Design Concepts To Improve Large Haulage Vehicle Safety, by Glenn E. Adkins, John L. Dahle, and Lawrence Owens. November 1982. 152 pp. 47 figs. The objective of this work

is to improve the safety potential associated with off-highway haulage truck operations. The report describes the development and evaluation of seven novel cab location concepts for large off-highway haulage trucks. A preliminary design of a completely novel truck configuration is also described. An analysis of 1978–79 haulage truck accidents as well as the fundamental parameters of haulage truck design, operation, and selection are presented. Research done under contract J0295013 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA; Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-221085; paper copy price code A08.

OFR 123–83. Design of an Extended Bumper for Mine Haulage Trucks, by John L. Dahle, Lawrence Owens, and Glenn E. Adkins. May 15, 1981. 88 pp. 40 figs. This report presents extended bumper designs for 170-ton rear-dump haulage trucks used in the mining industry. The extended bumper designs are to provide operator protection in the event of rear-end collisions between two trucks. The bumper designs are a result of studying critical truck characteristics important in rear-end collisions and haulage truck accident data, as well as the dynamics of a collision. In addition, existing extended bumper designs were analyzed and evaluated. Research done under contract J0215003 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-221515; paper copy price code A05.

OFR 124–83. Fatalities in Small Underground Coal Mines, by National Academy of Sciences. May 1983. 20 pp. 2 figs. The National Academy of Sciences, in a prior report "Toward Safer Underground Coal Mines," identified a strong correlation between mine size and fatality rate. That work showed that the fatality rate in mines with fewer than 50 employees was nearly three times that of large mines (those who employ over 250 employees). The current report determines why small mines have a higher fatality rate. The high rate is contributed to several factors that include (1) the intermittent mode of small mine operation, (2) insufficient financial resources, and (3) inadequacies in the training of workers and managers. It was also determined that 85 pct of all small mines are concentrated in Virginia, West Virginia, and Kentucky. It is recommended that the governments of these three States should provide assistance to small mine operators in the form of advice on safety. Research done under contract J0100145. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 125(1)–83. Technological Innovation in the Copper Industry. Volume I. Methodology, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 58 pp. 7 figs. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume I describes the methodology procedures used to survey the opinions of experts, analyze the findings, and prepare the report. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227066; paper copy price code A04.

OFR 125(2)–83. Technological Innovation in the Copper Industry. Volume II. Technology Forecast, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 137 pp. 29 figs. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume II presents the consensus technology forecast of the experts surveyed in the study. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227074; paper copy price code A07.

OFR 125(3)–83. Technological Innovation in the Copper Industry. Volume III. Cost/Benefit Analysis, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 91 pp. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume III provides estimates of the net present value cost effectiveness of each technology assessed under both optimistic and pessimistic scenarios. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227082; paper copy price code A05.

OFR 126–83. Propagation of EM Signals in Underground Metal/Non-Metal Mines, by Terry S. Cory and Richard J. Mahany. Aug. 20, 1981. 266 pp. 142 figs. This report describes the results of a measurement and analysis program to characterize wireless radio transmission in metal-nonmetal mines over a wide frequency range from 0.2 to 1,000 MHz and over a variety of mine environments. Six

mines were chosen based on the relative economic significance of their product to the U.S. economy. Mine types include oil shale, uranium, potash, lead-zinc, copper, and silver. Particular mines were chosen to embody the most important mining techniques of the group. The results show that transmission at medium frequencies are optimum for wireless mine communications, agree with extensive testing previously performed in coal mines, and that minewide wireless systems are feasible with a minimum requirement for new dedicated wiring. Research done under contract J0308012 by Terry S. Cory. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234666; paper copy price code A12.

OFR 127–83. Evaluation and Acceptance Criteria for Innovations in Explosionproof Electrical Enclosures, by R. J. Gunderman. March 1982. 141 pp. 25 figs. A conventional trailing cable connection box on a continuous mining machine was modified by the addition of two innovative devices: A pressure vent to preclude buildup of high pressure caused by an explosion inside the enclosure and a grommet-type cable entry to simplify and speedup cable entering procedures. The devices were evaluated for 8½ months in a working section of an underground coal mine. Laboratory tests before and after the in-mine exposure show no measurable change in the devices. Following the favorable in-mine evaluation, technical performance criteria were defined to serve as the basis of approval for the use of the devices. Additional tests to measure comparable gripping of the cable by asbestos rope, substitution rope materials, and by the urethane grommet-type entry were included. Also, literature covering the last 80 years was searched. Comments are provided as to how the devices comply with 30 CFR Part 18. Research done under contract H0357107 by Jeffrey Mining Machinery Div., Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-233379; paper copy price code A07.

OFR 128–83. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mine Drainage, by Fraser M. Walsh. July 1982. 69 pp. 3 figs. The objective of this program was to determine by laboratory experiments the kinetics and mechanics of the reactions that produce acid in coal mine drainage. The program was divided into three phases: In phase I, five coal mines, representative of Appalachian coal mines, were chosen for sampling and an experimental design was identified suited to accomplish the program objectives. In phase II, the five mines were sampled and test protocols applied. The results showed most pyrite weathering to be based on oxidation in the presence of water. Iron bacteria, especially *Thiobacillus ferrooxidans*, catalyzed the rate of pyrite weathering by a factor of three. An increase in initial iron concentration in a system that modeled the mine environment acted to inhibit bacterial catalysis of weathering. In phase III, five tailings piles were sampled and the material obtained was used to evaluate this method of bacterial catalysis inhibition. The evaluation verified method effectiveness; inhibition over 80% of the release of weathering was observed. Research done under contract J0387215 by ECO, Div. of KOR, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-233387; paper copy price code A04.

OFR 129–83. Assessment of a 40-Kilowatt Stirling Engine for Underground Mining Applications, by James E. Cairelli, Gary G. Kelm, and Jack G. Slaby. June 1982. 75 pp. 54 figs. The National Aeronautics and Space Administration (NASA) Lewis Research Center performed an assessment of alternative power sources for the Bureau of Mines. As part of this assessment, NASA tested a 40-kW Stirling research engine to evaluate its performance and emission characteristics when operated with helium working gas and diesel fuel. This report describes the engine, the test facility, and the test procedures. Performance and emission data for the engine operating with helium working gas and diesel fuel are reported and compared with data obtained with hydrogen working gas and unleaded gasoline fuel. Helium-diesel test results are compared with the characteristics of current diesel engines and other Stirling engines. External surface temperature data are also presented. Emission and temperature results are compared with Federal requirements for diesel underground mine engines. The durability potential of Stirling engines is discussed on the basis of the experience gained during the engine tests. Research done under contract J0100026 by NASA Lewis Research Center. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: N82-30714; paper copy price code A04.

OFR 130–83. Effects of Engineering Parameters on the Control of Respirable Dust, by R. L. Rankin, S. J. Rodgers, and E. V. Polite. November 1982. 49 pp. 4 figs. Field studies were conducted on eight continuous miner sections and two longwall sections operating in five different coal seams. Data and information on dust concentrations and engineering dust controls were acquired for normal operations. Dust concentrations at the mine operator and longwall face locations were evaluated using gravimetric samplers and instantaneous dust monitors. Engineering dust controls that were evaluated included airflow rates and/or velocities, waterflow rates and/or pressures, brattice distances, and face cutting times or rates. An analysis of the data acquired during the field studies was performed using multiple regression methods. Several relationships describing the influence of dust control parameters upon dust levels of mining equipment operators are

presented. The effects of engineering dust controls upon miner operator dust concentration may be expected to be different from mine to mine and sometimes from section to section. A consistent relationship between the dust concentration variations and dust control variations was not observed. Research done under contract J0387226 by MSA Research Corp. Div., Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-232207; paper copy price code A04.

OFR 131–83. Safety and Health in Underground Mine Waste Disposal, by J. P. Schmid, M. R. Schmidt, G. J. Colaizzi, and R. H. Whaite. December 1982. 221 pp. 23 figs. Results of a comprehensive investigation of the impact of underground mine waste disposal on the health and safety of miners are presented. Information was gathered through an extensive search of U.S. and foreign literature and personal communication with professionals in private industry and government. All conceivable health and safety hazards directly or indirectly related to underground mine waste disposal are analyzed, categorized, and ranked on an industry-wide basis. Positive health and safety effects are analyzed and ranked in a similar way. Both potential and known hazards and positive impacts are included. Recommendations on abatement techniques for the various hazards are presented. Case histories of a fill-related accident in a metal mine and a health hazard associated with coal waste backfilling are included and causes and possible abatement procedures are discussed. The role of management in the promotion of health and safety in backfilling operations is discussed. Research done under contract H0218021 by Goodson & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-232140; paper copy price code A10.

OFR 132–83. Direct Smelting of Lead Sulfide, by Y. K. Rao. June 1983. 94 pp. 53 figs. The extraction of lead from lead sulfide by a direct-smelting process that is free of sulfur oxide emissions was investigated. The process involved reducing lead sulfide with carbon in the presence of limestone. Under the conditions employed, limestone dissociates readily into lime and carbon dioxide. The limestone is the active desulfurizing agent that fixes the sulfur in the charge by forming CaS residue. The investigation focused on the measurement of reduction kinetics in the temperature range of 768° to 1,026° C. The reduction of PbS in the presence of lime using CO-CO_2-N_2 gas reductant was also studied. The kinetics of both the catalyzed and uncatalyzed reduction processes were investigated. The catalyst used is an equimolar ternary eutectic $(K,Na,Li)_2CO_3$ that has a relatively low melting point of 397° C. Research done under contract J0205011 by the University of Washington. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities. MN. Rolla. MO. Reno. NV. Albanv. OR. Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 133–83. Development of Environmentally Attractive Leachants. Volume I, A Minitest for In Situ Uranium Leaching, by Robert S. Schechter, Larry W. Lake, and Muhammad I. Kabir. Jan. 31, 1983. 314 pp. 80 figs. This report describes a minitest consisting of a central injection production well surrounded by at least two observation wells designed to detect the arrival of injected fluid, leached minerals, and nonideal flow. The goals of the test are to determine the susceptability of the host formation for uranium leaching, to establish important kinetic parameters so that the results of the minitest can be used to correctly scale the process, and to identify those factors that may render site restoration difficult. The report considers nonidealities such as reservoir permeability heterogeneities, nonuniform mineral distribution, and minerals other than uranium that may react with the leach solution. To circumvent these difficulties, methods of interpretation were proposed and tested by analysis of realistic data generated by a computer simulator. Clear-cut methods of interpretation were not found in the more complex cases, but in every case the design of an optimum test was considered and recommendations made. Research done under contract H0282016 by the University of Texas at Austin. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234497; paper copy price code A14.

OFR 134–83. Mine Waste Location by Satellite Imagery, by Michael A. Anuta and Om P. Bahethi. December 1982. 100 pp. 19 figs. This report describes the potential for utilization of satellite observations for remote sensing of mine waste disposal areas. Four study sites consisting of metal and nonmetal mining areas in different climatic and physiographic regions of the contiguous United States were used in the investigation. The mine waste disposal sites consisted of mining of phosphates in Florida, copper in Arizona, silver in Idaho, and coal in West Virginia. Landsat satellite multispectral scanner observations were used together with aerial photographs, ground surveys, U.S. Geological Survey maps, and other ancillary information. Landsat digital data were categorized using automated supervised classification algorithms and an image analysis system. Detailed descriptions of automated classification techniques employed and the accuracy attained are provided together with the results of manual interpretations. The inventory of areas disturbed for phosphate mining and a change detection investigation for Polk County, FL, were also undertaken during the study. Research done under contract J0208030 by Science Systems and Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin

Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238519; paper copy price code A05.

OFR 135-83. Critical Parameters for Tailings Embankments, by Gregory B. Baecher, W. Allen Marr, J. S. Lin, and John A. Consla. January 1983. 282 pp. 186 figs. Geotechnical data on copper, uranium, and phosphate tailings from 41 mines were collected and analyzed to empirically establish the variability in strength properties for tailing embankments. These data were analyzed both from geotechnical and statistical perspectives to infer typical strength parameters for slope stability analysis. The results indicate large variability of strength properties both within and among tailings embankments. However, this variability in most cases appears statistically regular and tends toward normal distributions when spatial trends are removed. The implication is that probabilistic techniques can be used to assess the importance of strength property variability for embankment stability and that the assumption of common distributional forms for input to such modeling is appropriate. Research done under contract J0215028 by Baecher, Marr and Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238394; paper copy price code A13.

OFR 136-83. Technique for Determining Efficiency of Sorbents in Diffusion-Type Samplers, by E. D. Palmes. March 1983. 28 pp. 2 figs. Phase I of this study demonstrated the feasibility of measuring the efficiency and capacity of sorbents in tube samplers for contaminant gases. This was accomplished by measuring concentration at various points along the length of the diffusion path during sampling by removing small aliquots with gas-tight syringes and injecting them into a gas chromatograph. With hexane as the gas and activated charcoal as the sorbent, the procedure was successful. Phase II involved application of the principle to gases of importance in diesel exhaust using a variety of sorbents. High concentrations of the test gas clearly demonstrated the differences in both efficiency and capacity of the sorbent for each of several gases. The chief drawbacks of the system were that efforts to determine more toxic gases at realistic occupational exposure levels or to determine formaldehyde at any level using the flame ionization detector were unsuccessful. It was concluded that, although the method is feasible, oresensitive methods of measuring concentrations of gas in the tube must be developed to make the procedure applicable to regions of chief industrial hygiene interest. Research done under contract J0308072 by the New York University Medical Center. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-236190; paper copy price code A03.

OFR 137-83. A Simulation Model for Predicting the Performance of Vibrating Screens, by Kevin Hennings and Doug Grant. December 1982. 120 pp. 44 figs. Screening efficiency models developed to date rely almost exclusively on empirical formulas based upon large amounts of acquired operating data. A screening model was developed using a combination of empirical coefficients and explicit mathematical expressions that quantify screening phenomena. A series of screening tests was run to supply data for purposes of correlation and empirical coefficient evaluation. The model was implemented as a digital computer program. The validity of the modeling procedure was established by laboratory testing. The results were used to compile an applications handbook that can be used to predict screening performance instead of using the computer program. Research done under contract J0395138 by Allis-Chalmers Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238386; paper copy price code A06.

OFR 138-83. Removal of Pyrite From Coal by Heap Leaching, by L. M. Cathles and K. J. Breen. June 1983. 287 pp. 34 figs. The feasibility of leaching pyrite from coal heaps is analyzed by adapting a model of the heap-leaching process developed in the copper industry. Parameters in the model are first determined through literature review and direct measurement. The model is then used to predict how coal fragments will leach in reaction kettles containing ferric sulfate solution, in columns through which air is circulated, and in actual heaps. Model parameters are verified and refined by kettle and column experiments. The model is then used to determine the optimum heap size and operating procedures. Eight-foot heaps of ¼-inch coal fragments leach best. The average rate of application of flush solutions should be less than 0.01 gal/ft^2-hr. It should be possible to leach more than 90% of the finely disseminated pyrite from the coal in 9 months, providing the flush solutions are recirculated. Removal of pyrite from coal utilizing such a process is economically attractive. A heap-leaching operation capable of depyritizing 1 million tons of coal per year has a positive net present value at discount rates up to 16% (base case) to 33% (best case). Research done under grants G1115427, G5105007, and G5115007 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Pittsburgh, PA, and Salt Lake City, UT; Office of Assistant Director—Mining Research, and Office of Assistant Director—Mineral Data Analysis, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238758; paper copy price code A13.

OFR 139-83. Leaching of Bornite With Oxygen and Ferric Chloride as Oxidants, by Ferron A. Olson.

June 11, 1982. 183 pp. 98 figs. Natural bornite (Cu_5FeS_4) leached in ferric chloride or in sulfuric or hydrochloric acid solutions with oxygen showed several differences. In ferric chloride 80% of the copper was leached in two stages. The first was controlled by liquid ferric ion diffusion and chemical surface reaction and required 1 minute for a 30% copper removal. The second was controlled by formation of a surface sulfur layer and then diffusion through the sulfur. With oxygen in sulfuric acid, reaction was slow and only the first stage was studied. Copper removal had an induction period. The bornite structure disappeared at 12% copper removal (also found with ferric chloride) and covellite formed on the surface with a species inside the particles with an X-ray structure similar to $CuFeS_2$ but with Cu_5FeS_4 composition and ferric chloride. Copper removal was controlled by iron dissolution. Surface iron vacancies filled with Cu^+ to give CuS while interior copper dissolution produced Cu_5FeS_4. Preliminary results with oxygen and hydrochloric acid showed 80% copper removal and sulfur as end products. Research done under grant G0284001 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, and Albany, OR; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234997; paper copy price code A09.

OFR 140(1)-83. Development and Fabrication of a Continuous Miner Training System. Volume 1, by C. W. Morris, E. H. Conklin, and F. J. Bick. August 1982. 64 pp. 6 figs. This report describes the major technical activities that were accomplished to produce a comprehensive continuous miner training system (CMTS) for coal industry utilization. The primary product of this program was a continuous miner part-task trainer. It is composed of an interactive computer graphics system combined with the operating controls of a continuous mining machine mounted in a simulated cab. The cab contains an audio system for reproducing continuous miner operational sounds. The trainer is supplemented with a complete set of cognitive materials that provide instruction in the operation, safety, and health of continuous miner operations. A complete summary of the field test and evaluation of the CMTS is provided along with recommendations for further training program refinements, expansions, and utilization. Research done under contract H0377025 by McDonnell Douglas Electronics Co. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 140(2)-83. Development and Fabrication of a Continuous Miner Training System. Volume 2, by C. W. Morris and E. Conklin. August 1982. 79 pp. 18 figs. The continuous miner training system provides classroom materials, training aids, and a continuous miner simulator to provide a short, intensive instruction and skills development program for training or retraining continuous miner operators. The project included refinement of training objectives, revision of training aids, improvements to the simulator, and evaluation of the entire system. This report describes the revised materials and the validation of the training system. Research done under contract H0377025 by McDonnell Douglas Electronics Co. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 141-83. Particle Dispersion in Fine Mineral Flotation, by Maurice C. Fuerstenau. July 1982. 58 pp. 29 figs. Studies on the composition of aluminum hydroxy silicate polymer were undertaken using gel filtration chromatography. Preliminary analysis indicates that 14 to 17 silicon atoms to 1 aluminum atom are contained in the polymer. Optimal pH for formation is between 5.5 and 6.5. Electrokinetic and microflotation studies on pure minerals were undertaken to establish mechanisms of aluminum hydroxy silicate adsorption and to determine the effect that this dispersant exhibits on flotation response. The polymer chemisorbs on chrysocolla, chalcopyrite, and chalcocite but does not interfere with flotation even with relatively large additions. Dispersion of finely divided particles with aluminum hydroxy silicate sol results in improved recovery in copper flotation systems. Copper recovery is increased by 4.9 pct from an oxide ore and 2.1 pct from a sulfide ore in the presence of low additions of aluminum hydroxy silicate sol. Research done under contract J0295077 by the South Dakota School of Mines and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238360; paper copy price code A04.

OFR 142-83. The Impact of Surface Lignite Mining on Surface- and Ground-Water Quality in Texas, by C. C. Mathewson, K. W. Brown, L. E. Deuel, and D. G. Kersey. August 1982. 84 pp. 28 figs. The impact of surface mining of Texas lignites on surface and ground water systems was investigated. Surface water and/or hydrogeologic analysis were conducted at two active and three proposed mines in the Texas lignite belt. Field and laboratory studies measured the infiltration characteristics of surface mined land, determined the quality of surface water runoff, and analyzed the hydrogeologic impacts of surface mining on ground water quality and quantity in resaturated mine spoil. Adverse impacts of surface mining were found to be minimal in deltaic and coastal lagoon lignite deposits, which have shale-rich overburden; disturbances to the hydrologic balance were negligible. Mining of fluvial lignites associated with thick aquifer sands may result in degraded ground water quality and quantity, but long-term impacts are projected to be minimal. Runoff from mined land is similar to that from unmined native soils; both have high suspended loads. Research done under contract J0295016 by Texas A&M University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238378; paper copy price code A05.

OFR 143-83. Demonstrating the Noise Control of a Coal Preparation Plant. Volume II: Long Term Treatment Evaluation, by Matthew N. Rubin. June 1982.

91 pp. 56 figs. The purpose of this work was to obtain operational data on retrofit noise control treatments suitable for use in coal preparation plants. These data were obtained by evaluating the performance of four categories of noise control treatments (resilient screen decks, resilient impact pads, chute liners, and curtains) that were installed in a commercial coal preparation plant. The selection, installation, and initial evaluation of the treatments were presented in volume I of the report. Volume II, the present work, summarizes the results of the long-term evaluation of the original treatments, as well as some additional tests that were conducted on elastomer-clad (resilient) screen decks. The project demonstrated the feasibility of a number of retrofit noise control treatments, some of which also proved to be quite durable over the long term. Research done under contract H0155155 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-237354; paper copy price code A05.

OFR 144–83. Scaling in Geothermal Systems: Investigations of Geothermal Brines of the Salton Sea Area, by H. L. Barnes, J. D. Rimstidt, D. O. Hayba, and J. B. Murowchick. December 1978. 223 pp. 55 figs. The objective of this research was to develop an understanding of the fundamental processes involved in the formation of geothermal scales. One step toward this understanding involves compiling available data on brine composition and temperatures. Also, chemical and mineralogical analyses of scales that have precipitated from these brines under known and controlled conditions are necessary. To obtain especially documented samples, field tests were developed and performed to simulate the scale-forming processes. Laboratory studies of the thermodynamic and kinetic characteristics of silica-water reactions were carried out. Silica was emphasized because it is the most common, pervasive, and bothersome scale component. The resulting insights into the physical chemistry of the scale-forming processes are presented here together with some of their implications for scale prevention. Research done under grant G0155140 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Avondale, MD, and Reno, NV; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 145–83. Point Defects in Hydrometallurgical Processes, by G. Simkovich and K. Osseo-Asare. June 1983. 16 pp. 9 figs. This project investigated the effect of point defects on hydrometallurgical processes of mineral dissolution. Samples of NiO, ZnO, α Fe_2O_3, and CuO that were doped with lower and higher valent dopant cations showed significant changes in dissolution rate when compared with that of the pure compound. Doping and stoichiometry control in ZnS, however, have a lesser effect when compared with the specific interaction from copper ions. Research done under grants G1115426, G5105084 and G5195040 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 146–83. Applications of Image Processing to the Comminution of Fine-Grained Complex Sulfide Ores, by J. R. Craig, R. M. Haralick, and R. H. Yoon. June 1983. 244 pp. 59 figs. This investigation was directed toward a detailed study of the comminution of complex sulfide ores from the Eastern United States. The first part deals with laboratory batch grinding experiments in which several different ore samples are characterized in terms of rate of breakage and breakage distribution functions. Using these parameters, the batch grinding experiments are simulated by the ESTIMILL program. In the second part, both pulverized and uncrushed ore samples are examined using an optical microscope, with the images processed by a computer. A software package named the General Image Processing System (GIPSY) was adapted and expanded to process the optical images and to characterize the ore samples and mill products. Finally, the image analysis data are compiled to determine the degree of liberation of the various minerals present in the complex sulfide ores. Research done under grants G1105052 and G1115513 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 147–83. Development of Chromium-Free Grades of Constructional Alloy Steels, by Carl J. Keith and V. K. Sharma. May 15, 1983. 60 pp. 26 figs. The objective of this research was to develop a new series of cost-effective chromium-free steels. The new steels are intended to be capable of adoption by a broad range of industry as a substitute for the chromium-containing 8600 and 4100 standard grades of heat-treated constructional alloy steels. Based upon several socioeconomic scenarios and their projected impacts on alloying element cost and availability in 1985, a computerized metallurgical design system was used to design two substitute steels for each of the standard grades. Both steels, a manganese-molybdenum substitute and a manganese-nickel-molybdenum substitute, are expected to provide heat-treat response and mechanical properties equivalent to the 8600 and 4100 steels. Small, experimental heats of the chromium-free replacement steels were prepared and their hardenability response and mechanical properties were evaluated and compared with the base-line 8620 steel. Research done under contract J0113104 by the International Harvester Co. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Albany, OR, and Pittsburgh, PA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-243873; paper copy price code A04.

OFR 148–83. Evaluation of Novel Coal Cutting Concepts for Reduced Dust Generation, by Robert W. Decker. July 1981. 147 pp. 38 figs. This report presents a survey of published novel cutting (mining) concepts along with a brief discussion of each.

A preliminary evaluation follows that identifies promising concepts, emphasizing reduced dust generation and economic production potentials. The promising concepts are then studied more deeply and evaluated in more detail with recommendations given for further development action. Research done under contract J0199065 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-243717; paper copy price code A07.

OFR 149–83. Copper Sulfide Flotation in an Air-Sparged Hydrocyclone, by David J. Kinneberg and Jan D. Miller. May 1983. 85 pp. 25 figs. The concentration of a low-grade porphyry ore by froth flotation in a 4.7-cm-diam air-sparged hydrocyclone was investigated. The effects of important design and operating variables on the separation efficiency were examined. The variables included slurry feed rate, airflow rate, pulp density, cell length, wall porosity, and kerosine additions. Several modifications to the basic design of the air-sparged hydrocyclone were also studied. A comparison of performance of the air-sparged hydrocyclone with conventional flotation for this particular ore showed that remarkably short retention times were required to achieve satisfactory separations. Moreover, preliminary data indicated that the recovery of molybdenum and gold with the air-sparged hydrocyclone was comparable with that obtained in a conventional cell. It was concluded that the air-sparged hydrocyclone has the potential to significantly alter conventional copper rougher or scavenger circuits, although additional research will be required before this potential can be realized. Research done under grants G1105049 and G1115492 by the University of Utah. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-253526; paper copy price code A05.

OFR 150–83. Ground Control in Multi-Level Room and Pillar Mines, by William G. Pariseau. June 1983. 122 pp. 36 figs. This research is concerned with ground control in multiseam mining and relates mainly to the analysis of stress about multiseam room-and-pillar mines. The two variables of most concern are distance between seams and alignment of the pillars between seams. The first efforts of the investigation apply to the development phase of mining when the extraction is typically less than 50%. The second efforts are concentrated on retreat mining and barrier-pillar safety when the extraction is typically greater than 50%. The procedures in both cases are readily applicable to more than two seams. Although two-seam mines are the most frequent type of multiseam operations, because of the potential for three-seam operations in the Western United States, a number of three-seam development analyses are also presented. Research done under grants 1105048 and G1115491 by the University of Utah. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-252965; paper copy price code A06.

OFR 151(1)–83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Final Report, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 116 pp. 18 figs. Productive and beneficial use of reclaimed surface-mined land is a concern of industry, Government, and the general public. An investigation was conducted on current mined-land practices to aid in the development of a procedure to evaluate postmining land use potential that considers both industry and public approaches. A detailed review of the impact of regulations, factors that determine land use, and current site planning methods employed by the mining industry is included. The investigation included three in-depth case studies of surface mines in the Eastern, Central, and Western United States. A site planning process was developed and applied to the studies to evaluate the economic, environmental, and social impacts of postmining land use alternatives. In addition, guidelines were proposed to enhance the cooperation between local land use planners and surface-mine planners, as well as to improve comprehensive planning with regard to mineral resources at the local and regional levels. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-253401; paper copy price code A06.

OFR 151(2)–83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Appendix I: Eastern U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 89 pp. 30 figs. The potential usefulness of reclaimed surface-mined land has received much attention in recent times. This is partially because of the establishment of Federal environmental reclamation standards, but concern for achieving better land uses has also been shown by interested members of the mining industry. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, a 430-acre surface mine in Clearfield County, PA, was studied. Established site planning principles were applied to the study site including formation of a data base, development of alternate land use plans, and evaluation of the economic, environmental, and social impacts of the land use alternatives. Key factors affecting site realization were identified along with positive suggestions for applying land use planning processes to mined-land planning. Research done

under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-264325; paper copy price code A05.

OFR 151(3)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Appendix II: Central U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 137 pp. 38 figs. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, the Chinook Mine-West Field, located in western Indiana, was studied. The Chinook Mine is presently operated by AMAX Coal Co. and has been in continuous operation since 1928 under various ownerships. The status of current reclamation and land use planning was reviewed. In addition, site planning principles were applied to the active mine area that include the formation of a data base and development of postmining land use plan alternatives. Key factors affecting site potential realization for Midwestern area mines were identified along with suggestions for applying land use planning processes to mined-land planning. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-264333; paper copy price code A07.

OFR 151(4)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Appendix III: Western U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 108 pp. 31 figs. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, the Indian Head Mine, which is located in Mercer County, ND, was studied. The Indian Head Mine is presently operated by American Coal Corp., Western Div., and has been in operation since 1917 under various ownerships. The status of current reclamation and postmining land use planning was reviewed. In addition, the relationship between mine planning and public planning in an area impacted by energy development was investigated. Finally, key factors affecting site potential realization for Western surface mines were identified. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-264341; paper copy price code A06.

OFR 152(1)-83. Noise Attenuating Properties of Earmuffs Worn by Miners. Volume 1: Comparison of Earmuff Attenuation as Measured by Psychophysical and Physical Methods, by Kenneth C. Stewart and Ernest J. Burgi. January 1980. 46 pp. 22 figs. This contract was directed toward a study of the attenuating properties of earmuffs as worn by miners. Two attenuation measurement procedures were utilized. Human subjects were tested in a diffuse sound field according to threshold shift procedures recommended by the American National Standards Institute and a physical measurement procedure was accomplished in the same diffuse field on the same subjects with microphones placed simultaneously on the inside and outside of the muffs. All measurements were obtained on 1/3 octave of random noise. The results indicated that physical and psychophysical attenuation measurements are in essential agreement at frequencies from 125 Hz to 2 kHz. Above 2 kHz the psychophysical measurement demonstrates larger amounts of attenuation than the physical measurement. The difference in attenuation ranged from approximately 7.0 to 9.0 dB at frequencies of 4 kHz and above. A possible explanation for the differences in attenuation is presented. Research done under contract J0188018 by the University of Pittsburgh. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257063; paper copy price code A03.

OFR 152(2)-83. Noise Attenuating Properties of Earmuffs Worn by Miners. Volume 2: Development of a Laboratory Procedure for the Physical Measurement of Earmuff Attenuation, by Kenneth C. Stewart and Ernest J. Burgi. June 1980. 37 pp. 17 figs. The purpose of this study was to develop and evaluate, in the laboratory, instrumentation and procedures that might allow for the use of physical measurements of earmuff attenuation that would yield results equivalent to those obtained from psychophysical measures of attenuation. The ultimate goal was to evaluate techniques that might subsequently prove feasible for physical measurement of earmuff attenuation in the field. Instruments currently in use were modified to have a response similar to differences observed in earmuff attenuation as observed in volume 1 of this report. Mining noise spectra were selected and presented to a single subject seated in a diffuse noise field wearing one of the muffs evaluated in the earlier study and fitted with two physical sound measurement systems. A linear system measured the outside noise level and a linear system plus correction filter measured the inside noise level. The measurement indicated that under the procedures presented in this report, a laboratory method for measuring earmuff attenuation is feasible and yields results comparable with an extensive psychophysical procedure. Research done under contract J0188018 by the University of

Pittsburgh. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257071; paper copy price code A03.

OFR 153-83. System Study of Mine Rescue Through Electromagnetic Means, by Robert L. Lagace, James M. Dobbie, Gordon Raisbeck, Richard H. Spencer, Mark A. Degatano, Francis J. Lambiase, and N. Albert Moussa. October 1982. 181 pp. 1 fig. This report describes the results of a system study of factors influencing mine rescue attempts based on the use of electromagnetic VF (voice frequency) rescue transmitters by trapped miners and helicopter-borne search receivers by mine rescue personnel. The report covers four areas: (1) mine emergency and disaster considerations that concentrate on characterizing the events and key parameters of mine fires and explosions related to trapped miner location and rescue activities, (2) hardware considerations that concentrate on characterizing the relevant properties of VF rescue transmitters and search receivers; oxygen-type self-rescuers; and helicopter performance, signal detectability, and sensor sweepwidths, (3) a search theory probabilistic model that develops a method to identify the most important regions to be searched and to allocate helicopter-based search efforts to maximize the number of miners detected in time to be rescued, and (4) sensitivity analyses and application of the search model on representative mine emergency and disaster scenarios to assess the impact and effectiveness of helicopter-based searches. Conclusions and recommendations are presented, together with a set of search planning guidelines. Research done under contract J0113043 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-253393; paper copy price code A09.

OFR 154-83. Validation and Extension of Visibility Requirements Analysis for Underground Mining Equipment, by Mark S. Sanders and Gregory S. Krohn. January 1983. 65 pp. 25 figs. Six underground coal mine shuttle cars were used to assess visibility using visual attention locations (VAL) and an improved human eye reference measurement instrument (HERMI Mark II). Each machine was assessed in the inby and outby directions of travel without a canopy and with a canopy in its highest and lowest positions, enabling the illumination level at each VAL to be determined. The results showed that operator eye position was the most important variable determining visibility. When this variable is controlled, the addition of a canopy has no effect on visibility. Further, with the eye position controlled, there is no difference between high and low seam machines. The assessments showed blind spots on the opposite side of the car from the operator and ahead of the machine. The report includes suggestions to reduce the blind spots and a procedures manual for using HERMI Mark II and the system of VAL to assess visibility from underground mining equipment. Research done under contract J0318072 by the Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-252957; paper copy price code A04.

OFR 155-83. Evaluation of the Black River Mine Telecommunication System, by Dana T. Updyke and Howard C. Turnage. February 1983. 104 pp. 7 figs. An evaluation was made of one of several improved underground communication systems sponsored by the U.S. Bureau of Mines. The system was installed in a typical metal-nonmetal, room-and-pillar mine and utilized ultrahigh frequency repeaters connected to a unique distributed antenna and passive reflector system that provided minewide communications. A microprocessor-controlled data collection system was assembled and installed for the evaluation. Data consisting principally of times and durations of messages and identities of the originating transceivers were collected over a 6-month period. Analyses of these data show that the principal benefits are reduction in time required for unscheduled maintenance and repair, enhancement of safety, and better coordination of production activities. A cost benefit analysis shows a net benefit over cost, although it is also concluded that the capacity of the system is greater than can be justified by current activity in the mine. Research done under contract J0318074 by the Atlantic Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257097; paper copy price code A06.

OFR 156-83. Diesel Engines in Underground Mining: A Bibliography With Abstracts, compiled by Robert W. Waytulonis and Wanda J. West. April 1983. 443 pp. 1 fig. This publication contains 1,000 citations of technical and semitechnical literature treating diesel-powered equipment usage underground both generally and specifically. The citations were gathered by Bureau of Mines personnel during 1978-83. The citations concern diesel engines as powerplants for underground mining use; their design, emission characteristics and control, maintenance, and usage; and health and safety aspects. All of the citations have been abstracted and arranged in a subject classification system with extensive cross-referencing. Work done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO,

Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258608; paper copy price code A19.

OFR 157–83. Use of Surfactants To Improve Oil Recovery, by W. Fred Ramirez. June 1983. 93 pp. 25 figs. The theory of optimal control of distributed parameter systems is presented for determining the best possible injection policies for enhanced oil recovery processes. The optimization criterion is to maximize the amount of oil recovered while minimizing injection costs. Necessary conditions for optimality are obtained through application of the calculus of variations and Pontryagin's Weak Minimum Principle. A gradient method is proposed for the computation of optimal injection policies. Research done under grant G1115081 by the University of Colorado. Available for reference at Bureau of Mines, Avondale, MD; U.S. Department of Energy, Bartlesville, OK; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 158–83. Develop Data for Review of Metal and Nonmetal Mine Methane Hazard Classification, by Alastair M. Lumsden and Richard Talbot. January 1983. 519 pp. 15 figs. A study was initiated to examine the ways in which a number of foreign countries classify and regulate metal and nonmetal mines that experience problems caused by naturally occurring flammable gases. Twenty countries were selected for study and useful information was obtained from 16. Nine countries were visited to hold meetings with representatives of government mine regulatory agencies and mine operators and to visit mines encountering methane, carbon dioxide, nitrogen, etc. Seven gassy metal and nonmetal mines in the United States were visited to provide a basis for comparison, and hence the evaluation of both U.S. and foreign gassy mine regulations. In addition to obtaining copies of the mining laws and regulatons of a number of foreign countries, nine foreign and seven U.S. gassy mines were documented in as much detail as possible. Research done under contract J0100060 by Golder Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258624; paper copy price code A22.

OFR 159–83. Heat-Pulse Anemometer for Measuring Air Velocities in the Range 0.4 to 7 Ft/Sec. Part I: Development. Part II: Microprocessor-Based Instrument, by G. T. Skinner, M. G. Dunn, and R. J. Hiemenz. May 1982. 110 pp. 39 figs. This report describes the development of a portable low-speed heat-pulse anemometer for underground mine airflow measurements. Part I describes the development of the instrument. Various physical and electrical parameters such as wire diameter, spacing of the probe wires, operating temperature of the pulsed wire, signal processing and system control, ambient thermal properties, and flow alignment were varied in a successful effort to find a method of operating a heat-pulse anemometer over the range of air velocities from 24 to 390 ft/min. Part II describes the implementation of these findings in a personal, self-contained microprocessor-based instrument measuring 6 by 7 by 2½ in, with a sectioned 2-ft wand. Mechanical, aerodynamic, and electronic design details are given, and the software is documented. Research done under contract H0377029 by Calspan Corp. Advanced Technology Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256917; paper copy price code A06.

OFR 160–83. Coal Fines Recovery and Utilization, by Juh W. Chen, Albert C. Kent, and Charles B. Muchmore. May 1983. 134 pp. 33 figs. A process to recover energy from waste coal fines, developed through laboratory, bench, and pilot plant experiments, was investigated. The process consisted of mechanical cleaning followed by high-temperature oil agglomeration and pelletization. The process can produce a quality product under an economically and environmentally acceptable condition. Waste coal fines with ash less than 35% and high-heat value (HHV) greater than 6,000 British thermal units per pound (Btu/lb) were upgraded to a product with less than 15% ash and HHV greater than 11,500 Btu/lb. A computer model was developed to optimize the processing costs and to perform economic evaluation of specific sites. Ultimately, the model can be utilized to establish a priority listing for a region in assisting the determination of reclamation strategy. Research done under grants G1105064, G1115172, and G1195016 by Southern Illinois University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 161–83. A Study of Superconducting Separators for Weakly-Magnetic Ores, by M. K. Abdelsalam, R. W. Boom, and R. R. Hughes. June 1, 1983. 200 pp. 100 figs. A high field helical flow slurry separator was constructed to concentrate weakly magnetic ores with a magnetic moment about the value of hematite. The process is to flow the slurry helically around a current-carrying conductor in a cylindrical annulus. The magnetic field gradient forces magnetic particles inwards while nonmagnetic particles are deflected outwards by centrifugal force. Separation occurs at the exit end of the channel by a divider that separates inboard from outboard slurry. The separator performance was studied both theoretically and ex-

perimentally. A universal theoretical model was developed based on turbulent diffusion in cyclones. The model is in good agreement with experimental data. Research done under grant G0177066 by the University of Wisconsin—Madison. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 162(1)–83. Mining in Low Coal. Volume I: Biomechanics and Work Physiology, by M. M. Ayoub, N. J. Bethea, M. Bobo, C. L. Burford, D. K. Caddel, K. Intaranont, S. Morrissey, and J. L. Selan. November 1981. 175 pp. 69 figs. The objectives of this research were (1) to evaluate the job demands associated with low coal mining; (2) to survey the anthropometry, strength, and aerobic capacity of low coal miners to determine if they differ from the U.S. population; and (3) to recommend, on the basis of available information, optimal job and work station design for low coal mining. The male and female anthropometry, except for weight and circumferential dimensions, was quite similar to the comparison populations. Back strength for male and female miners was significantly lower than the industrial worker population. This can be one of the contributing factors of low back problems in mining. Shoveling, timbering, and helpers tasks were physiologically demanding activities. However, because of the frequent stoppage of work, adequate rest was usually available. If work stoppage is corrected, then better work and rest schedules are essential. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–258160; paper copy price code A08.

OFR 162(2)–83. Mining in Low Coal. Volume II: Anthropometry, by M. M. Ayoub, N. J. Bethea, M. Bobo, C. L. Burford, D. K. Caddel, K. Intaranont, S. Morrissey, and J. L. Selan. Jan. 15, 1982. 123 pp. 54 figs. This report covers the anthropometric study of low coal miners. The male and female anthropometry, except for weight and circumferential dimensions, was quite similar to the comparison populations. The miners tended to be heavier and have greater circumferences. The measurements made in this study were used to develop 5th, 50th, and 95th percentile, quarter- and half-scale, male and female mannequins. The mannequins can be used in workplace and equipment design and redesign. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–258178; paper copy price code A06.

OFR 162(3)–83. Mining in Low Coal. Volume III: Clothing Design Study, by D. K. Caddel, J. L. Selan, J. L. Smith, and M. M. Ayoub. Jan. 15, 1982. 75 pp. 48 figs. Several problems exist with the present design of coveralls used by low coal miners. The back of the coveralls often tears when roof bolts or rough areas in the roof are hit. Movement in the shoulder area is restricted. Female low coal miners find it difficult to purchase coveralls that fit properly and must remove both their hard hat and safety belt to urinate and defecate. The objective of this research was to design coveralls that would alleviate these problems. The following features were incorporated into the coveralls: padding in the back, an action pleat in the shoulders, an inseam zipper to more easily allow miners to perform their bodily functions, and reflective tape to increase visibility of the miner. A heavy denim fabric was used to increase warmth and durability. The coveralls were assessed for comfort, safety, worker productivity, and fabric suitability using both an infield assessment by miners and simulation studies. The experimental coveralls proved superior to standard coveralls along all four parameters. Work clothing sizes for female miners were developed. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–258186; paper copy price code A05.

OFR 163–83. Proceedings of the Sixth WVU Conference on Coal Mine Electrotechnology, ed. by Wils L. Cooley. July 1982. 428 pp. 170 figs. This report is a compilation of papers presented at the 6th West Virginia University Conference on Coal Mine Electrotechnology in Morgantown, WV, on July 28–30, 1982. The papers cover areas of power systems, communications, safety systems, automation and control, safety devices and instrumentation, and monitoring systems. Report prepared under contract J0123017 by West Virginia University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–255984; paper copy price code A19.

OFR 164–83. Evaluation of Bulkheads for Radon Control, by Clifford H. Summers, Donald B. Lindsay, Richard S. Lindstrom, and Kenneth L. Alder. July 1982. 88 pp. 19 figs. The objective of this task was to investigate the availability and suitability of some novel materials and methods of

construction for air-restraining bulkheads for use in confining radon-rich air in unused sections of underground uranium mines. Two preferred systems of bulkhead construction were proposed, based on a search of commercially available materials, and were successfully tested in an operating commercial mine in LaSal, UT. Both systems were found to be generally satisfactory under the conditions of the 5-month-long test. As an auxiliary aid to prevent leakage of radon-polluted air from the bulkhead area, a servocontrolled exhaust system was designed to maintain a favorable atmospheric-pressure gradient relative to the rest of the mine. A radon-scavenging system, based on adsorption on activated charcoal, was also designed and successfully tested for use in connection with the pressure-balancing exhaust unit. Research done under contract H0212003 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256503; paper copy price code A05.

OFR 165-83. Development of a Nondestructive Test Device for Friction Rock Supports, by R. Lusignea, J. Felleman, and K. Kirby. February 1983. 135 pp. 58 figs. A device was developed for nondestructive testing of the holding power of split-tube friction rock supports. The device operates by measuring the amount of decrease in internal volume when the support is forced into the drilled hole. The pullout force, or slip load, is a function of the decrease in volume. The device gives readouts of the average internal diameter and predicted pullout force for the support. Laboratory and field tests showed excellent repeatability and good correlation between predicted and actual pullout force. The device is hand-operated, lightweight, and can be used on any friction support. Research done under contract H0202030 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257519; paper copy price code A07.

OFR 166-83. Assessment of Alternative Power Sources for Mobile Mining Machinery, by James E. Cairelli, William A. Tomazic, David G. Evans, and John L. Klann. December 1981. 109 pp. 60 figs. The National Aeronautics and Space Administration Lewis Research Center, under an agreement with the Bureau of Mines, performed an assessment of alternative power sources for mining applications, primarily mobile underground equipment. Each alternative power source was assessed in terms of (1) ability to achieve the duty cycle, (2) ability to meet Government regulations, (3) production readiness, (4) market availability, and (5) packaging capability, which were established as a first step in the assessment. An initial screening reduced possible alternative power sources, that were evaluated in more detail, to (1) improved diesel, (2) Stirling, (3) gas turbine, (4) Rankine, (5) advanced electric, (6) mechanical energy storage, and (7) use of hydrogen evolved from metal hydrides. The alternative power sources were divided into two categories, heat engines and energy storage systems, because heat engines are basically limited by emissions and energy storage systems are limited by energy storage density. Each alternative power source is described briefly, including its current development status, specific problem areas, and possible future improvements. Each is then evaluated against the requirements initially established. Research and development efforts for each alternative power source are discussed and evaluated in terms of potential. Research done under contract J0100026. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: N83-14691; paper copy price code A06.

OFR 167-83. Field Demonstration of Deep-Penetrating Geophysical Techniques, by S. A. Suhler and T. E. Owen. January 1983. 68 pp. 27 figs. Field tests were conducted to demonstrate the performance of an advanced development model borehole directional radar probe in coal measure rocks. Preliminary test site evaluations at five candidate coal mines were performed to determine the electromagnetic propagation parameters of the coal seams and to inspect available geologic mine hazards such as paleochannel sand cutouts, faults, and weak roof conditions as potential radar test targets. The York Canyon Mine near Raton, NM, was selected as the demonstration site. Surface-operated tests in vertical boreholes as well as in-mine tests in horizontal boreholes were conducted using the radar probe, resulting in the detection of a near-vertical seam displacing fault. Other electromagnetic tests using separate source and receiving probes in vertical boreholes as well as in through-transmission tests in underground coal pillars provided useful data on the electromagnetic parameters of the coal and large-scale geologic structures. One series of transmission tests was successful in coupling across the fault-displaced coal seam. All of the tests utilized pulsed electromagnetic signals in the 30- to 300-frequency range. Research done under contract H0212018 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256222; paper copy price code A04.

OFR 168-83. Recommended Acceptance Criteria for Potting Materials Used in Explosion Proof Enclosures in Coal Mines, by W. R. Herrera, R. E. White,

L. M. Adams, and H. S. Silvus. March 1982. 100 pp. 17 figs. Research was conducted to develop methodology for evaluating candidate potting materials intended for use in explosion-proof enclosures. The primary purpose was to develop acceptance guidelines based on arc decomposition products. Acceptance criteria can be based on (1) inherent thermochemophysical, mechanical, and electrical properties; (2) arc decomposition products (nature of volatile products produced; e.g., flammability, explosivity, synergistic effects on existing environment in the enclosure, and toxicity; and quantity produced as a function of arc power and duration); and (3) acceleration aging tests to evaluate breakdown under electrical stress. Research done under contract J0100041 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-254722; paper copy price code A05.

OFR 169-83. Low Glare Luminaire for Thin Seam Mining, by John R. Parker and William F. Hahn. October 1982. 102 pp. 42 figs. Work places of an underground coal mine are required (30 CFR 1719) to be illuminated while self-propelled equipment is used. Permissible machine-mounted systems have been developed and applied satisfactorily to many mining operations. However, some low- and thin-seam equipment has been difficult to illuminate because reliable, direct current (dc) systems and compact, low output, low-glare luminaires were not available. This program resulted in the design and prototype construction of compact, low-glare luminaires and alternate current (ac) power systems, particularly suited to resolving illumination problems on low- and thin-seam mining equipment. Design objectives were based on enhancing the prospects for thin-seam illumination solutions through definition of a product that could challenge markets enjoyed by higher glare luminaires and through reduction of technical risks associated with any new product development as well as the MSHA certification process. Research done under contract J0188077 by Booz, Allen & Hamilton, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257246; paper copy price code A06.

OFR 170-83. Cost-Effectiveness of Increasing Airflow at Any Location in Underground Coal Mines (Volume I), by Sandip K. Mukherjee, Anthony W. Laurito, M. O. Rahim, and Madan M. Singh. February 1983. 113 pp. 16 figs. This report presents the results of the economic analyses of several applicable alternatives to increase airflow in four underground coal mines. Pressure and quantity surveys were conducted underground, and measurements were made at the main mine fans. The existing ventilation networks were modeled using a modified ventilation simulator, and the applicable alternatives were simulated. Performance data obtained from the simulation runs were utilized to conduct the cost-effectiveness analyses. The costs for each of the alternatives included capital, operating, and maintenance. These costs were expressed as annual ventilation costs per active section in terms of dollars per cubic foot per minute, taking into account the economic life associated with each of the alternatives. The benefits were expressed as increased airflow quantity in the critical sections. A section of the report also deals with comparison of simulator-predicted air quantity values against air quantity values measured underground. Research done under contract J0100066 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257105; paper copy price code A06.

OFR 171-83. Noise Reduction of Chain Conveyors. Volume II, by A. Galaitsis, R. Madden, and D. Andersen. February 1983. 63 pp. 26 figs. This report briefly reviews the aboveground tests performed on a Jeffrey 120M conveyor that were documented in volume I of this study, and describes the performance of treatments implemented on underground equipment. The noise level at the operator's position in the aboveground test facility was reduced from 101.5 to 91 dBA using treatments with satisfactory aboveground durability. Extensive underground evaluation was performed only on the constrained layer damping, which has reduced the conveyor noise by 2 to 6 dBA, depending upon the operating conditions, and was shown to be sufficiently durable. Other promising candidates for exploratory evaluation include resilient layers for the top and bottom decks and smoother discontinuities between adjacent conveyor sections. Research done under contract H0155113 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262634; paper copy price code A04.

OFR 172-83. Theoretical Study, Design and Analysis of an Improved Shuttle Car Cable Reel, by P. W. Meisel and G. J. Hundman. August 1983. 70 pp. 42 figs. A hydraulic-powered reel system to minimize peak tension transients in shuttle car trailing cables was theoretically designed and analyzed using

a computer. A single, spring-loaded takeup sheave stores or gives up cable to maintain tension within specified limits. Controls were incorporated to shut down the vehicle before all cable is removed from the reel and to deenergize the cable in the event of a reel-cable jam. Full-scale hardware configuration drawings sufficient for manufacture of a test system were completed. Research done under contract J0318086 by Jeffrey Mining Machinery Div., Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262352; paper copy price code A04.

OFR 173-83. Instruments and Techniques for Dynamic Particle Size Measurement of Coal Dust, by Virgil A. Marple and Kenneth L. Rubow. January 1981. 242 pp. 122 figs. The purpose of this study was to conduct research in several areas of instrumentation used to determine the quantity of respirable dust in a mining atmosphere. The study was divided into eight tasks including (1) the feasibility of using a dichotomous impactor in conjunction with two photometers for a machine-mounted dust monitor, (2) development of a laser diode optical particle counter, (3) development of an instrument evaluation chamber, (4) instrument evaluations and calibrations, (5) development of a new personal respirable dust sampler, (6) development of a uniform deposit cascade impactor, (7) inertial impactor calibrations and theoretical investigations, and (8) descriptions of field studies. Research done under contract H0177026 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262360; paper copy price code A15.

OFR 174-83. Safety Evaluation of Conveyor Belt Cleaning Systems, by William Kleysteuber. Jan. 14, 1983. 118 pp. 88 figs. The focus of this study was to determine the effectiveness of practical conveyor belt cleaning devices in removing the material that carries back past the normal discharge point from the return strand belt so that it can not fall off. The material that falls off becomes part of the spillage that requires manual cleanup and increases miner exposure to hazards. The belt-cleaning problem was found to be much more complex than simply the removal of this material. The material becomes spillage by an interaction of the belt with the return roller that is governed by the characteristics of the carry-back material and is dependent upon moisture content and particle size distribution. The results of laboratory tests show that practically any type of blade held in intimate contact with the belting will reduce the amount of material carried back. Effective cleaning, however, requires high pressure on a blade material compatible with the carried back material in that it is not cut and grooved by the particles. Selection of cleaning methods is largely controlled by site-specific conditions at the installations and the end use of the product. This report defines engineering criteria that will increase the effectiveness of belt cleaning devices and methods and suggests a method to predict the costs of cleaning. Research done under contract J0215015 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262592; paper copy price code A06.

OFR 175-83. Fire Hazard Criteria for Noise Control Products in Underground Coal Mines, by Mark R. Pettitt, R. E. Giuntini, and William R. Wessels. May 1983. 211 pp. 61 figs. The development of fire hazard criteria for noise control products in underground coal mines are presented. Qualifying requisites of the criteria include maintaining miners' safety, allowing for maximum use of noise control products, and economic feasibility. The burning process is analyzed for its relationship to fire hazard criteria developed by the National Aeronautics and Space Administration and the Federal Aviation Administration, and the mine environment is analyzed in conjunction with the end-use applications of noise control products. Also, the interim fire hazard specification developed by the Mine Safety and Health Administration is appraised as it applies to end-use applications of noise control products. From these analyses and a literature survey, fire hazard criteria are developed that include an initial screening procedure that evaluates the level of flammability testing required. Research done under contract J0395100 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262584; paper copy price code A10.

OFR 176-83. Design and Demonstration for Area Walkway Lighting on Electric-Powered, Mobile, Surface Mining Equipment, by Martin H. Wahl. Nov. 1, 1982. 119 pp. 46 figs. The January 13, 1977, Federal Register (v. 42, No. 9, sec. 77.027, par. d) proposed new regulations specifically applicable to aboveground operations directly related to illumination of areas in, on, and around draglines, shovels, and wheel excavators. This report details the design, installation, and demonstration of lighting systems of large draglines and shovels for areas 20 ft in all directions from the main frame, exterior walkways on board the mining machines, and the area beneath the boom 20 ft from the main frame to the farthest point the equipment is capable of excavat-

ing or discharging materials. Research done under contract H0387024 by the Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83–262600; paper copy price code A06.

OFR 177(1)–83. Electrical-Shock Prevention. Volume I—Protection of Maintenance Personnel, by L. A. Morley, T. Novak, and F. C. Trutt. Dec. 8, 1982. 127 pp. 61 figs. The objective of this four-volume report was to investigate the application, economic, and safety considerations of electrical-shock prevention techniques applied to surface and underground mines This report is primarily concerned with the protection of maintenance personnel. The scope of the work is specified, electrical shock is defined, and needed ground-fault relay characteristics to prevent ventricular fibrillation are established. This is followed by an analysis of ac systems, a comparison of these systems with respect to body currents, the advantages and disadvantages of the various ground-fault protection techniques, and an analysis of dc systems for off-track vehicles. Summaries and synopses of each of the three remaining volumes are included. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–102946; paper copy price code A07.

OFR 177(2)–83. Electrical-Shock Prevention. Volume II—Ground-Fault Interrupting Devices, by L. A. Morley, F. C. Trutt, and D. J. Rufft. Dec. 8, 1982. 110 pp. 60 figs. This report is primarily concerned with the application of sensitive ground-fault interrupters (GFI's) to ac utilization circuits in U.S. mines. The main concepts examined are shock prevention and methods to reduce nuisance tripping. The research involved a literature search, input from previous Bureau of Mines contracts, and contacts with electrical manufacturers and mining personnel. Several devices that showed promise were tested and the results indicate the existence of GFI's that may be modified to perform adequately on U.S. mining systems. A set of guidelines covering design, construction specifications, and performance tests is included. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–102953; paper copy price code A06.

OFR 177(3)–83. Electrical-Shock Prevention. Volume III—Fault Protection for Motion-Drive Equipment, by L. A. Morley, F. C. Trutt, and G. M. Buchan. Dec. 8, 1982. 65 pp. 17 figs. This report examines the indication versus interruption procedures used on motion-drive power equipment with emphasis on surface excavators. A review of the electromechanical ac-dc conversion used with the control system is presented. Protection for the drive-system components are discussed. Fault sources and calculations for both the ac supply source and dc power loop are introduced to assist in discussing indication and interruption procedures. The dynamic process of the machine is examined and the effects of fault current and position of the machine to allow for an orderly shutdown is determined. Possible indication and interruption procedures are given for the four-quadrant duty cycle of excavators. The report is concluded by introducing other mining operations that utilize similar motion-drive systems and static (solid-state) drives and recommends further research in these areas, as well as a more detailed examination of the dynamic fault analysis for excavators. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–102961; paper copy price code A04.

OFR 177(4)–83. Electrical-Shock Prevention. Volume IV—Overhead-Line Contact Fatalities, by L. A. Morley, F. C. Trutt, and G. T. Homce. Dec. 8, 1982. 116 pp. 35 figs. This report examines the problem of indirect contact of overhead high-voltage powerlines by mining personnel. This refers to the contact of energized lines by workers through an intermediate conductor such as a metallic tool or a piece of high-reaching mobile equipment. The shock hazard by such contact has been a major cause of electrical fatalities associated with mining operations. The report is divided into three areas. The first gives a general background of overhead lines, basic characteristics, and associated hazards and describes presently used techniques and devices that attempt to alleviate the contact problem. The second area presents a detailed analysis of 39 overhead-line contact accidents in mining since 1970. The third section used the information in the first two areas to formulate recommendations to prevent these accidents and subsequent electrocutions at mining installations. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director — Mining Research, Bureau of Mines, and the Natural Resources Library,

U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102979; paper copy price code A06.

OFR 178-83. Compressed Oxygen One-Hour Self-Rescuer, by Michael A. Borrello. January 1983. 49 pp. 18 figs. A 60-min-duration, compressed-oxygen self-rescuer for emergency escape from coal mines was developed. The design, a closed-circuit pendulum-type rebreather, contains special techniques in packaging, cooling, gas flow, and human engineering factors. Test results on the performance of the apparatus are presented and recommendations are made for further improvement of the design. Research done under contract J0100074 by U.S.D. Corp., Survivair Div. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-105337; paper copy price code A03.

OFR 179-83. Analysis of Electrical Accident Prevention Countermeasures, by W. L. Cooley, W. Collins, Z. Elrazar, R. Kumar, R. McConnell, and M. Jerabek. Dec. 31, 1982. 359 pp. 84 figs. This report provides a detailed analysis of 23 electrical accident countermeasures contemplated for use in the metal-nonmetal mining industry. The costs and potential benefits of implementing groups of countermeasures are estimated, and methods are outlined by which countermeasures can be selected in an effective manner. The analysis is based largely on an extensive electrical accident event tree that is developed in detail. For those countermeasures that are not currently technically feasible, several prototype devices were developed to help speed development. Research done under contract J0113064 by the West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102987; paper copy price code A16.

OFR 180-83. Modeling of Solution Mining Systems for Deep Mineral Resources Recovery, by Milton E. Wadsworth and H. Y. Sohn. May 1983. 110 pp. 32 figs. Laboratory studies were carried out to identify and quantify the important processes operative in solution mining of minerals. Specifically, the kinetics of leaching copper from chalcopyrite-bearing ore particles were determined under various oxygen partial pressures and temperatures. The effect of particle size on the rate of leaching was also investigated. Computer simulation models to predict the copper recovery from an underground rubblized ore body were developed. One model describes the process in which oxygen-saturated leach solution is used with no bubbles in the bed. The other model is applicable when leach solution containing oxygen bubbles is used for leaching. Research done under grants G1105088, G1115494, and G1195047 by the University of Utah. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-103837; paper copy price code A06.

OFR 181-83. Simplex Gasification Demonstration in the Wellman-Galusha Gasifier, by the Mining and Industrial Fuel Gas Group, the U.S. Bureau of Mines, and Dynecology, Inc. June 30, 1982. 110 pp. 40 figs. The objectives of this project were to produce at least 200 tons of simplex briquets and to evaluate their performance as a fixed-bed, dry-bottom gasifier feedstock. To accomplish this, 240 tons of caking coal and shredded municipal refuse were compacted into simplex briquets and gasified in a Wellman-Galusha producer at the Bureau of Mines in Minneapolis, MN. It was concluded that the briquets have good potential as a gasifier feedstock and that the briquets do not swell or cake even though they contain 67 wt pct of a highly caking eastern bituminous coal. Research done under contract J0205070. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Reno, NV, Albany, OR, and Salt Lake City, UT; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-103324; paper copy price code A06.

OFR 182-83. Leaching of Uranium and Fluorine From Quenched Slag, by C. M. Wai and K. A. Prisbrey. Jan. 15, 1982. 28 pp. 17 figs. Waste slag from the Phosphoria Phosphate Formation in Utah, Idaho, and Montana contains one of the Nation's largest reserves of uranium. Large quantities of phosphate slag was premised in pretreatments and fluorite from before solidifying. By appropriate pretreatment, it was anticipated to stimulate selective leaching of valuable constituents at low acid consumption. In this project, the mechanisms of leaching were identified by analysis of leaching kinetics. The change in mechanisms associated with slag pretreatments were identified and quantified in terms of mass transfer, solid-state diffusion, and chemical reaction rates. A kinetic leaching model was used to predict treatments that were potentially economical. Although this research did not show that the economics of dilute acid leaching are favorable, it does point toward some innovations. Research done under grant G5105020 by the University of Idaho. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Reno, NV, Albany, OR, and Salt Lake City, UT; and Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 183-83. Combined Stability-Deformation Analysis for Rock Slopes in Open Pit and Strip Mines, by John Kafritsas, Herbert H. Einstein, and Gregory B. Baecher. September 1983. 115 pp. 23 figs. This report presents a computer analysis that couples the deformation of a rock mass and the flow of water in its joints. Two-dimensional prob-

lems involving a rock mass transversed by relatively closely spaced joint sets that divide it into distinct blocks can be treated. Deformations are modeled using the rigid block method, which assumes that the rock mass is composed of rigid rocks with the deformable contact points. The analysis proceeds in time steps, evaluating at a series of successive instants the forces acting on each block. The forces are used to find the acceleration of each block, which is then integrated to find the displacement increment of each block during the time step under consideration. There are considerably different force-deformation laws, time-dependent behavior, or expansive properties of joint fillers. Flow is modeled by recognizing its discontinuous features as occurring in a system of interconnected conduits formed by the joints. Both laminar and nonlaminar flow can be modeled, as can problems involving free-surface flow. Full account is taken of the coupling between flow and deformation. Water forces are continuously updated to account for changing joint and apertures caused by block displacements, and vice versa, and block displacements between time steps take into account the changing water-pressure field. Research done under grants G1105027 and G1115251 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 184–83. Solids Flow in a Recirculating Fluidized Bed, by Takafumi Matsuzaki and John F. Elliott. June 1983. 115 pp. 59 figs. The objective of this study was to evaluate the general nature of solids flow in a 30-cm-ID recirculating fluidized bed using silica sand. A bubbling or turbulent bed with a density of $\frac{1}{2}\rho_b$ was observed in the lower part of the reaction and a pneumatic transport phase with a density of $\frac{1}{100}\rho_b$ was observed in the upper part. The solids feed rate was regulated by a nonmechanical valve called an "L-valve." The maximum solids feed rate through the L-valve is limited by the head of solids in the downcomer. The saturated solids carryover rate was found to be proportional to the fourth power of the gas velocity. Recommendations for further studies and modifications to the system are presented. Research done under grant G1115252 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Albany, OR; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 185–83. Iowa Coal Project Demonstration Mine, Oskaloosa, Iowa, by Iowa State University. May 1981. 35 pp. 5 figs. This 37-acre tract was leased by Iowa State University in 1975 and is located 8½ miles southwest of Oskaloosa. Reclamation was completed in November 1977, after 108,000 tons of coal was mined at the site. The present research deals with the post-restoration management of reconstructed soil and the environmental quality of reclaimed land. Research done under grant G1105024. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 186(1)–83. Development of a Continuous Shaft Lining System, Volume I, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 224 pp. 72 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining (CSL) system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume I describes the basic CSL concept, the design and operation of a prototype unit, and estimates of cost. Research done under contract J0333915 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS; PB 84-113216; paper copy price code A10.

OFR 186(2)–83. Development of a Continuous Shaft Lining System. Volume II, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 120 pp. 42 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume II summarizes the results of the laboratory- and full-scale tests conducted during the program. Research done under contract J0333915 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113224; paper copy price code A06.

OFR 186(3)–83. Development of a Continuous Shaft Lining System. Volume III, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 510 pp. 79 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume III, the appendix, contains related information on the laboratory tests and test facilities. Research done under contract J0333915 by Foster-Miller, Inc. Available for reference at Bureau of Mines facili-

ties in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113232; paper copy price code A22.

OFR 187-83. The Impact of Longwall Mining on the Hydrologic Balance; Premining Data Collection, by Ginger S. Evans, Tsegaye Hailu, Helen M. Weagraff, James W. Warner, and G. Steve Lowry. May 31, 1983. 141 pp. 34 figs. This report documents a preliminary hydrologic investigation of an area where longwall mining methods are to be used. The scope of work includes determination of physical and chemical characteristics of major soil types in the area; determination of physical and chemical properties of surface water bodies; collection of geologic characteristics, including stratigraphy, structure, and detailed aquifer descriptions; a 10-year collection of meteorological data and installation of a weather station; and a detailed ground water investigation that includes completion of observation wells, aquifer testing, water quality sampling, and analysis using a 3-D computer model. The Trescott model developed by the U.S. Geological Survey was used to simulate steady-state aquifer conditions. Input data from eight multiple-completion monitor wells were used to model an area of approximately 10 square miles. Two confined layers, coal and overburden, were simulated. Model results showed good agreement with known piezometric data, desaturated areas, and flow from springs. Research done under contract J0218025 by J. F. Sato and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113174; paper copy price code A07.

OFR 188-83. Survey of Blasting Effects on Ground Water Supplies in Appalachia. Part II, by Philip R. Berger, D. T. Froedge, James A. Gould, and Lorraine F. Kreps. August 1982. 114 pp. 25 figs. This report covers an 18-month study of the performance of a 300-ft-deep test water well located at the Ayrshire Mine of the AMAX Coal Co. near Evansville, IN. Well performance, as characterized by 10-hr drawdown tests, was monitored as the strip mining operation approached the well site from distances of 2,000 to 15 ft (overburden removal). Blast-induced ground motion was measured at the surface next to the test well, and peak particle velocities in excess of 4 in/s were obtained. No evidence of changes in water quantity or quality could be directly attributed to the blasts. However, some lowering of the static water level in the observation well, and a simultaneous increase in the adjusted specific capacity of the test well, suggest that overburden removal caused lateral stress relief with consequent opening of vertical fractures. Research done under contract J0285029 by Philip R. Berger and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113182; paper copy price code A06.

OFR 189-83. Stable Isotope Variations in Coals and Associated Mineral Matter, by Thomas F. Anderson. August 1983. 79 pp. 18 figs. Measurements of stable isotopic variations (sulfur, carbon, and oxygen), supplemented by chemical, mineralogical, and petrographic analyses, were used to investigate the processes responsible for the incorporation of sulfur in coal and the development of permineralized peat zones (coal balls). Sulfur isotopic results indicate that there are two principal sources in Pennsylvania coals from the Illinois Basin: (1) primary sulfur assimilated by plants (low-sulfur coal), and (2) secondary sulfur produced by reactions involving H_2S that was produced by the anaerobic reduction of sulfate in seawater that permeated the peat during postdepositional marine transgressions (the dominant source of sulfur in high-sulfur coals). Sulfur isotopic compositions of low-sulfur coals in several Tertiary basins of Wyoming are consistent with a plant sulfur source. However, the inverse correlation between content and isotopic composition of sulfur observed in coals from the Powder River Basin suggest some secondary additions to these low-sulfur coals. Several Quaternary freshwater peats that were submerged by sea level rises during deglaciation have sulfur contents and isotopic compositions similar to high-sulfur coals. Carbon and oxygen isotopic compositions of calcareous coal balls from North America and Europe suggest that the carbonate was derived from variable proportions of oxidized plant matter and inorganic carbonate, and the carbonate minerals were precipitated from fresh-to-brackish waters. Local geochemical and hydrological conditions were apparently more important than regional depositional environments in controlling the source of carbonate and the development of coal balls. Research done under grant G1115171 by the Southern Illinois University at Carbondale. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 190-83. Iowa Coal Project Demonstration Mine, Oskaloosa, Iowa. Annual Progress Report—1982, by Stan Henning, R. B. Hall, G. A. Miller, M. L. Thompson, C. R. Klein, R. C. Schultz, and H. M. Van Es. May 1983. 50 pp. 12 figs. This 37-acre tract was leased by Iowa State University in 1975 and is located 8½ miles southwest of Oskaloosa. After 108,000 tons of coal were mined at the site, reclamation was completed in November 1977. The present research deals with the postrestoration management of reconstructed soil and the environmental quality of reclaimed land. Research done under grants G1105024 and G1115191 by the Iowa State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 191–83. Mining Resources and Potential Problems Associated With Mining of Cenozoic Rocks of the Williston and Powder River Basins, Northern Great Plains, by Richard D. LeFever and Edward C. Murphy. September 1983. 174 pp. 73 figs. The objective of this study was the compilation and assessment of existing data on mining resources and potential problems associated with mining of Cenozoic rocks in the Williston and Powder River Basins in the Northern Great Plains. The report presents an interpretation of the three-dimensional stratigraphic framework and depositional setting of the Cenozic sedimentary section, and the construction of a data base accessible to scientists and other users. The bibliography consists of about 800 references on sedimentology, stratigraphy, coal and uranium reserves, coal chemistry, ground water and rock geochemistry, and rock mineralogy. The references are cross-indexed by subject matter and geographic location. The computer data base contains data from 8,508 locations and has about 12,500 entries in the various individual data sets. Research done under grants G1105042 and G1115381 by the University of North Dakota. Available for reference at the Bureau of Mines Avondale (MD) Research Center; Office of Assistant Director—Mineral Data Analysis and Office of Technical Information, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 192–83. Characterization of Subsidence Over Longwall Mining Panels—Eastern Coal Province, by Peter J. Conroy and Julianne H. Gyarmaty. May 1983. 120 pp. 53 figs. The objective of this study was to describe the physical response of overlying strata to longwall mining of panels and observe changes in surface and ground water flows caused by subsidence from underground mining. The study was performed at Quarto Mining Co.'s No. 4 mine in the eastern coal province. The work included monitoring both surface and underground instrumentation and characterizes surface subsidence and strain, determines the potential effects of subsidence on cultural features including structures and water supplies, and develops criteria to assist in predicting subsidence for mines with similar mining and geologic conditions. Research done under contract J0133920 by Dames & Moore. Available for reference at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 193–83. Testing and Demonstration of Roof Bolter Instrumentation for Detecting Hazardous Roof, by Richard Lusignea and John Felleman. April 1983. 165 pp. 34 figs. A single-boom roof bolting machine was outfitted with measurement and recording systems to detect changes in machine parameters while drilling. The purpose of the instrumented bolter was to detect changes in roof conditions from the machine parameters of penetration rate, thrust, rotation rate, torque, reflected light from rock cuttings, and vibration of the roof during drilling. The system was demonstrated underground in coal mine conditions and showed correlation between rock type and drilling parameters. Research done under contract H0202008 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 194–83. Dry Dust Collector, by Gary R. Gillingham and Jon P. Sandstedt. March 1982. 121 pp. 57 figs. The objective of this investigation was to design, fabricate, and demonstrate a small, safe, simple, and rugged dry dust collector suitable for face (including machine mounting), belt transfer, and other mining applications. The report traces the development of the dry dust collector from the original design concept and component testing performed during phase I to the fabrication, laboratory testing, and field evaluation of two mine-worthy dry dust collector prototypes during phase II. Successful field evaluations took place at a belt transfer point in a trona mine and a bagging station at a silica sand plant. Future modifications suggested by the field evaluations as well as production cost estimates are included in the report. Research done under contract H0395039 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127356; paper copy price code A06.

OFR 195(1)–83. Evaluation of Safety Assessment Methods for the Mining Industry. Volume I, by P. M. Daling and C. A. Geffen. May 1983. 123 pp. 19 figs. The objectives of this study were to examine a representative cross section of formal safety analysis techniques developed for the nuclear and aerospace industries, to recommend those methods that would be suitable for application to the mining industry, and to include those methods in a user's manual. Volume I of this two-volume report presents the results of the examination of available safety assessment methods. The major safety concerns and needs of mine operators were identified through telephone contacts and a visit to a minesite. Safety assessment methods recommended for use by the mining industry were also investigated for potential adaptability to a user-interactive computer system. Several methods were determined to be immediately transferrable to the mining industry and are described in Volume II. Research done under contract J0225005 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126440; paper copy price code A06.

OFR 195(2)–83. Evaluation of Safety Assessment Methods for the Mining Industry. Volume II. User's Manual of Safety Assessment Methods for Mine Safety Officials, by P. M. Daling and C. A. Geffen. May 1983. 96 pp. 15 figs. The objectives of this study were to examine a representative cross section of formal safety analysis techniques developed for the nuclear and aerospace industries, to recommend those methods that would be suitable for application to the mining industry, and to include those methods in a user's manual. The user's manual, this report, describes several methods that were determined to be immediately transferrable to the mining industry. The manual gives detailed instructions on appropriate application and utilization of the methods. Research done under contract J0225005 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–126457; paper copy price code A05.

OFR 196–83. Shearer Mounted Dust Collector. Laboratory Testing, by J. Kelly, T. Muldoon, and W. Schroeder. October 1982. 168 pp. 69 figs. Effective control of respirable dust is one of the most serious problems associated with longwall mining in the United States. This report describes the development and laboratory testing of dust collectors for use on double-drum shearers. The systems tested included a high-capacity flooded-bed scrubber and water-powered extraction cowls, extraction drums, and spot scrubbers. The systems were tested using tracer gas in a full-scale model of a longwall shearer face. A detailed description of the test facility, test methods, and system test results is provided. Research done under contract J0387222 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–126614; paper copy price code A09.

OFR 197–83. In-Situ Shear Strength Tester for Coal, by Richard L. Handy, Lawrence E. Engle, and John M. Pitt. May 10, 1976. 125 pp. 42 figs. The objective of this research was to develop a lightweight, portable device for rapid in situ measurement of rock shearing strength and to compare the results with those obtained by other test methods. The rock borehole shear test (RBST) operates by expansion of two opposed steel plates against rock in the periphery of a 76-mm (13-in) diameter borehole, followed by axial movement of the plates. Small teeth on the contact plates cause shearing to occur with the rock itself. Several tests were conducted at different applied expansion pressures to generate a failure envelope of shearing strength versus applied normal stress. The envelope is plotted while the test is being conducted; a complete envelope may be generated by four tests in about 45 min. The slope of the envelope is the angle of internal friction, and the extrapolated shearing strength at zero normal stress is the cohesion. Analogous data are obtained for the residual shear strength, or strength along the induced fractures. The device also indicates whether dilatancy, or rock volume expansion, occurs during shearing. Comparative RBST versus triaxial and other tests indicate close agreement of friction angles but somewhat lower cohesions caused by disturbance by the shear plate teeth. Research done under grant G0144021 by Iowa State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–126481; paper copy price code A06.

OFR 198–83. Foreign Literature on Environmental and Personal Factors Affecting the Safety and Productivity of Miners: A Topical Listing and Annotated Bibliography of Recent Research, by Robert H. Peters. Jan. 4, 1983. 91 pp. 4 figs. This report is a review of foreign literature concerning human factors issues in the mining industry and updates Bureau of Mines OFR 27–72. About 500 references were located using computerized literature research systems. The references were sorted by topic into six major categories including accident and safety, individual miner, health and medicine, technical and engineering, environment, and ergonomics. Some of the major issues include effects of environmental stress on health and productivity, accident prevention, protective clothing and equipment, miner-machine relationship, training programs, and psychological principles applied to mine problems. Summaries are included for publications that describe the results of empirical investigations of factors affecting miner safety or productivity. It is concluded that foreign countries are improving the safety and productivity of mining operations through (1) improvements in technologies associated with mining processes; (2) improvements in equipment design; (3) improved understanding of miner physiological, anatomical, and psychological limitations; and (4) implementation of more sophisticated technical devices to monitor and control the underground environment. Research done by the Bureau of Mines Industrial Safety and Training Systems. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–127687; paper copy price code A05.

OFR 199–83. Determination of Velocity Measurement Correction Factors and Guidelines, by J. L. Kohler and L. M. English. June 1983. 216 pp. 97 figs. The objective of this study was to establish a set

of guidelines to select locations for and applying correction factors to vane anemometer, smoke, and tracer gas velocity measurements. A literature search and analysis was performed, in-mine experiments were conducted, and a quantitative analysis of the data was used to develop correction factor tables and site selection guidelines. The report also presents guidelines to select velocity measurement locations and discusses how to improve cross-section measurements. Research done under contract J0308027 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127851; paper copy price code A10.

OFR 200-83. Floodplain Landfill With Mill Tailings, by K. E. Robinson and H. M. Eivemark. July 1983. 206 pp. 99 figs. This study develops a valley-wide mill tailings disposal plan to utilize 20 potential landfill sites on floodplain areas in the Coeur d'Alene mining district in Idaho, and presents measures to reclaim the sites for subsequent productive use. Field and laboratory testing on one test section and two abandoned impoundments support the use of hydraulically deposited tailings for landfill construction. Hydrological testing showed that controlled discharge from tailings impoundments results in contaminant levels in the discharge below regulated standards. Additional testing indicated that compacted soil liners and pond management provide adequate contaminant abatement where acid-generating tailings are encountered. Mechanical compaction, including surcharge loading, upgrades foundation support capacity so that construction on the surface of tailings deposits is feasible. Details concerning potential landfill sites were refined. At recent production rates, the 20 sites would result in 680 acres of reclaimed land while providing a minimum of 40 years of tailings storage capacity. Research done under contract J0113047 by Greater Shoshone County Inc. and Robinson Dames & Moore. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-125707; paper copy price code A10.

OFR 201-83. Evaluation of Longwall Dust Sources, by Jonathan Ludlow and Eric Marshall. April 1983. 260 pp. 72 figs. To define the relative contributions of various sources of respirable airborne dust on longwall faces, continuous dust level data were recorded on five longwalls for an average of five shifts each. Analyses of these data with records of face activity showed that it was possible to determine the overall contribution of each major element. Average levels were determined for roof support generated dust, conveyor and intake dust, and for dust levels during various shearer activities. When average levels were compared between mines, a significant degree of consistency was noted. To differentiate the various dust sources associated with the shearer, fly cuts ranging from 6 to 30 in were closely monitored as were dust levels at operator positions over the various segments of the longwall cycle. These data indicate that the clearance ring of the shearer drum is a disproportionately heavy contributor to shearer dust make. A statistical analysis of the effect of shearer haulage speed on dust make revealed that high haulage speeds are associated with low specific dust make. Research done under contract H0202016 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127018; paper copy price code A12.

OFR 202-83. Geological and Geochemical Controls on the Chemical Evolution of Subsurface Water in Undisturbed and Surface-Mined Landscapes in Western North Dakota, by G. H. Groenewold, R. D. Koob, G. J. McCarthy, B. W. Rehm, and W. M. Peterson. May 1983. 292 pp. 39 figs. Studies of several surface coal mining sites in western North Dakota resulted in the development of a hydrogeochemical model that accounts for the observed chemical characteristics of subsurface water in undisturbed settings. The near-surface several meters of the landscape is constantly subjected to alternate wetting-drying, a key mechanism in hydrogeochemical evolution. The purposes of this study were to refine the model, with particular emphasis on the sulfur cycle, and to determine the applicability of the model to post-mining landscapes (spoils). Field activities included detailed ground water instrumentation of undisturbed and spoils areas at two sites. Refinement of the model included detailed analyses of the texture, bulk and clay mineralogy, sulfide abundance, and sulfur concentrations in overburden core samples. Laboratory experiments were designed to determine the source and mechanisms of sulfate salt production from overburden samples. It was concluded that the hydrogeochemical model is equally applicable to undisturbed and spoils landscapes and that the major species of concern in this region are sodium and sulfate. It was also concluded that the major source of sulfate is sulfides in the overburden and that the solubility of sulfate in ground water in these settings is largely controlled by the sodium-calcium ratio. Research done under contract J0275010 by the North Dakota Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126952; paper copy price code A13.

OFR 203-83. Coupled-Transport Membranes for Metal Separations—Phase V, by W. C. Babcock, M. B. Chidlaw, D. J. Kelly, and E. D. LaChapelle. August 1983. 52 pp. 24 figs. This report covers phase V of a continuing program to apply a new

liquid membrane process called coupled transport to the recovery of metals from hydrometallurgical leach solutions. During this phase, a membrane system of moderate scale was constructed and field-tested at the Exxon Highlands Mine and Mill Co. site near Douglas, WY. The test unit contained four hollow-fiber membrane modules, each with 100 ft^2 of membrane area. In the field tests, about 1,000 gallons per day of leach solution was processed. The unit was operated on the leach solution for about 50 days. Leach solution entering the unit contained 100 ppm uranium. This concentration was reduced to about 5 ppm by coupled-transport treatment, and the uranium was concentrated to about 2 wt % as a uranyl carbonate product. Under these conditions, a transmembrane uranium flux of about 2.5 lb/ft^2 per year was obtained. An economic analysis showed that the cost of recovering uranium from this leach solution via coupled transport is about $1.20 per pound. At higher concentrations the cost is reduced; for example, at 1,000 ppm the cost of uranium recovery is about $0.30 per pound. Research done under contract J0205061 by Bend Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127034; paper copy price code A04.

OFR 204–83. Continuous Respirable Dust Monitoring System (CRDMS), by Pedro Lilienfeld, Roger Stern, and Gary Tiani. May 1983. 101 pp. 28 figs. The objective of this program was the development, design, fabrication, and laboratory testing of a mine-worthy continuous respirable dust monitoring system (CRDMS). The operation of the sensor unit of the system is based on the light scattering intensity of the respirable fraction of the airborne dust. The CRDMS is compatible with the typical environmental rigors that characterize coal mines, and, in particular, the shock, vibration, impact, moisture, and dust conditions prevailing at active mining machines. The sampled area must be within the breathing zone of the mining machine operator whose dust exposure is to be monitored. Instantaneous, as well as shift-averaged dust concentrations, are displayed and recorded for later retrieval. Alarm indications and other diagnostic information are provided. Research done under contract H0100110 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126473; paper copy price code A06.

OFR 205–83. Environmental Assessment of Stream Pollution by Mine Drainage as a Function of Geologic Type and Reclamation Success, by H. S. Boyne, J. B. Ingwersen, J. V. Ward, Lawrence J. Gray, James Harvey, and S. L. Ponce. March 1982. 69 pp. 34 figs. The purpose of this study was to examine effects of acid mine drainage (AMD) originating from volcanic, igneous, and sedimentary watersheds in the Colorado mineral belt on stream chemistry and macroinvertebrates. Specific objectives were to (1) quantify water quality derived from mine drainage in relationship to macroinvertebrate community structure, (2) assess the natural downstream recovery rates of stream water quality and aquatic biota, and (3) compare inorganic water quality and macroinvertebrate community structure as related to the degree of reclamation success for mines located in volcanic, igneous, and sedimentary rock types. Criteria for the selection of study watersheds were a well-defined point source of AMD, presence of suitable control site, and accessibility. The selected watersheds were Kerber Creek near Villa Grove in the San Luis Valley, Peru Creek near Dillon in central Colorado, and Coal Creek near Crested Butte. The report presents results of monthly sampling conducted from July-September 1980 through May-July 1981. Kerber and Peru Creeks received AMD throughout the study period. In June 1981, a treatment plant began operations that significantly improved water quality in Coal Creek, thus allowing an assessment of reclamation success. Research done under grants G1105001 and G1115001 by the Colorado School of Mines. Available for reference at the Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 206–83. Oxidation of Pyrite to Maghemite, by W. M. Roggenthen. October 1983. 143 pp. 54 figs. Investigation of the alteration processes of pyrite revealed that several magnetic chemical species are formed, depending upon oxygen and sulfur fugacities, temperature, and pH. Oxidation in both a dry and aqueous environment was studied. The primary purpose of the work included attempts to understand the processes wherein magnetic substances can be created from pyrite with the ultimate goal of aiding in the magnetic separation of pyrite, and hence sulfur from coal. This report presents a detailed description of the investigation. Research done under grants G1105047 and G1115461 by the South Dakota School of Mines and Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Albany, OR, and Salt Lake City, UT; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 207(1)–83. Metal Organic and Inorganic Affinities in Strippable Fort Union Formation Coal. Volume 1, by F. E. Diebold and Douglas Drew. September 1983. 52 pp. 35 figs. The methodology for describing the geochemistry of elements in a coal seam was developed and has been applied to the Rosebud Coal Seam, an economically important member of the subbituminous coals of the Fort Union Formation in eastern Montana. The method development involved a detailed study of two popular techniques for determining the metal geochemistry of coal, namely, whole coal analyses and coal physical fractionation. The mathematically contrived element associations and the element concentration trends in the float and sink fractions are considered to lead to only qualitative conclusions

concerning the chemical associations of the elements in coals. Additionally, the processes taking place with the coal during low-temperature ashing in an oxygen plasma were experimentally investigated and shown to be of sufficient extent that the use of such low-temperature ash for deciphering element geochemistry is questionable. Volume 1 of this two-volume report presents a description of the study. Research done under grants G1105074 and G1195027 by the Montana College of Mineral Science and Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 207(2)–83. Metal Organic and Inorganic Affinities in Strippable Fort Union Formation Coal. Volume 2, by F. E. Diebold and Douglas Drew. September 1983. 139 pp. 35 figs. The methodology for describing the geochemistry of elements in a coal seam was developed and has been applied to the Rosebud Coal Seam, an economically important member of the subbituminous coals of the Fort Union Formation in eastern Montana. The method development involved a detailed study of two popular techniques for determining the metal geochemistry of coal, namely, whole coal analyses and coal physical fractionation. Volume 2 of this two-volume report contains maps and tables associated with the study. Research done under grants G1105074 and G1195027 by the Montana College of Mineral Science and Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 208–83. Derivation and Use of the Critical-Path-Method Diagram To Streamline Metallic Mining Premine Stage Requirements, by Joseph M. Pugliese and James P. Ludwig. 1983. 28 pp. 3 figs. The Bureau of Mines, through its contract research program, recently analyzed the mining and environmental requirements in the premining stage for copper mining in the northern highland of Wisconsin using the critical-path-method (CPM). However, a step-by-step derivation of the CPM diagram was beyond the scope of the effort. The Bureau's objective now is to show, step by step, how the original hand-computed CPM diagram was constructed. The streamlining (restructuring) of the diagram from the original effort is also summarized. The critical path time (longest time) through the original CPM diagram was 25.12 yr, excluding public liaison effort. The diagram showed the involvement of the regulatory agency, mining applicant, and public in the premining stage. Analysis of the diagram produced a streamlined version that reduced the critical path time by nearly 7 yr. The CPM construction methodology may be applied to mine planning for any mining operation. Research done by the Twin Cities (MN) Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 209–83. Reverse Performance Characteristics of Main Mine Fans, by M. F. Dunn, S. Bhattacharya, and V. Rajaram. August 1983. 65 pp. 25 figs. During a mine fire or other emergency, it may be desirable to reverse the airflow in order to provide an escapeway or to isolate a fire. Also, in colder areas, the airflow may be reversed to prevent ice buildup. When reversing main mine fans, the mine operator usually does not know what operating characteristics of flow and pressure to expect. Laboratory and field tests of vane-axial main mine fans in the 7- to 9-ft-diam size range were conducted to establish forward and reverse performance characteristics under controlled conditions and at typical mine installations. The data obtained suggest that reverse performance characteristics are dependent upon the blade angle and the hub-to-tip ratio. There is also evidence that reverse performance can be predicted for a family of bland angles and a given hub-to-tip ratio. Generally, quantity of air is 30% to 65% less in reverse than when operating in the normal forward mode. Research done under contract J0308044 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–143726; paper copy price code A04.

OFR 210–83. Achieving Uniform-High-Tensions in Mechanical-Anchor Bolts, by Anil Mahyera and A. H. Jones. November 1982. 122 pp. 158 figs. Toward the goal of achieving uniform high tensions in roofbolts to provide superior roof support for extended periods, mechanical anchor bolts were installed in a mine in eight different ways—under torque thrust control with and without hardened washers, belleville washers, and tension equalization; and in a conventional manner with and without hardened washers. The various bolt groups were analyzed in terms of tension uniformity and mean tension levels. Installing the bolts accurately with hardened washers under the bolthead, and with proper torque control, resulted in the most uniformly tensioned bolts—a coefficient variation of only 14%, an improvement three times over conventional installations. Also, these bolts maintained a high tension level—80% of the installation tension compared with 50% achieved conventionally. Research done under contract H0202006 by Terra Tek, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–143718; paper copy price code A06.

OFR 211–83. Recommendations for Human Factors Research and Development Projects in Surface Mining. by Ernest J. Conway and Mark S. Sanders. May 1982. 86 pp. 10 figs. To facilitate the planning of future research within the Bureau of Mines, 74 human factors research and development projects were identified for possible Bureau funding. The projects were based on (1) literature surveys, (2) reviews of accident statistics and reports, (3) interviews with equipment manufacturers, Mine Safety and Health Administration (MSHA) and Bureau personnel, and (4) site visits to 26 mines. The projects were divided into categories related to (1) mobile equipment, (2) maintenance shops and areas, (3) plans and mills, (4) organizational factors, (5) safety programs data, and (6) training. The projects were placed into three categories of priority and were rated by industry and MSHA people in terms of benefit to the industry. The highest priority contained 25 projects with 26 in category 2. and 23 projects in the lowest category. Research done under contract J0395080 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–143650; paper copy price code A05.

OFR 212–83. CMI Inert Gas Mine Firefighting System, by M. Paczkowski, G. A. Tracey, and A. Wojtyczka. February 1982. 58 pp. 23 figs. The use of inert gas systems to extinguish mine fires has been the subject of research for some time in the United States. In some European countries it is an established practice. Tests were conducted with the Central Mining Institute (CMI) Inert Gas System, which is being used by the Polish mining industry. This system utilizes a modified jet aircraft engine and afterburner as a compact source of combustion products with a very low oxygen content. Water injected into the combustion products stream provides evaporative cooling and forms a mist with a high cooling capacity. The CMI system was used under controlled conditions to extinguish coal pile fires at the Bureau of Mines Experimental Mine in Bruceton, PA. The tests results show that the CMI system can be used conveniently to extinguish fires quickly and to maintain an inert atmosphere in the fire zone to prevent reignition. Research done under contract J0318080 by CSE Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–142678; paper copy price code A04.

OFR 213–83. Slack and Overload Rope Protection System, by Holt L. Farley, Roger B. Fish, Robert L. Jeffcoat, and David L. Hoadley. January 1983. 327 pp. 71 figs. This report describes the development of an electronic system that detects unsafe slack and overload conditions in underground mine hoist ropes. The slack and overload rope protection system (SORPS) includes a fail-safe load cell inserted between the rope and the conveyance and an accelerometer mounted on the conveyance. Signals from these transducers are telemetered via a radio link to the hoist control room where they are combined with drum speed and chair status in a microprocessor-based decision and display unit. Abnormally high external force levels are detected as discrepancies between rope and tension and cage acceleration; conveyance weight is inferred continuously. Hazardous conditions and general hoist status are displayed to the hoist operator. The system has been tested in a working mine for approximately 2 years. The report contains specifications, design data, and field test experience generated under the SORPS program. Information on dynamic modeling, vibration environment, status of existing slack detection systems, and applicable control strategies are included. Research done under contract J0199008 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–143460; paper copy price code A15.

OFR 214–83. Reclamation of Tailing Basins Resulting From Copper-Nickel Milling, by John P. Borovsky, David F. Grigal, and Ricki L. Strassman. August 1983. 149 pp. 34 figs. A 3-year study was conducted to evaluate the problems and benefits of using vegetation to stabilize tailing from a potential Minnesota copper-nickel milling operation with the major objective of developing a feasible method for revegetation. Secondary objectives were to (1) describe the physical and chemical characteristics of copper tailing and determine the potential influence of those characteristics on plant growth, (2) identify alternative plant species and soil management techniques useful in the revegetation of copper-nickel tailing, (3) evaluate the effects of vegetation establishment on the liberation of potentially toxic metals in tailing drainage water, and (4) assess the accumulation of potentially toxic metals in vegetation grown in copper-nickel tailing. Research done under contract J0205050 by Barr Engineering Co. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84–142587; paper copy price code A07.

OFR 215(1)–83. Basic Research on Coal Fragmentation and Dust Entrainment. Volume I—Technical Information, by Gary L. Stecklein, Ronald Branstetter, Roy Arrowood, David Davidson, James Lankford, Robert Lyle, and Carter Nulton. June 1982. 123 pp. 66 figs. This report summarizes the results of research into the areas of the fragmentation and entrainment of airborne respirable dust (ARD). The objectives of the program were fourfold: First, to review the present state of knowledge regarding ARD; second, to expand this state of knowledge through the identification of hypothetical microscopic mechanisms by which the coal is fragmented and the dust becomes entrained; third, to specify the informational requirements to verify or nullify

these hypotheses; and fourth, to relate experimental techniques that will produce that required information. Additionally, insights are provided regarding potential methods of extraction and/or treatment that may reduce the concentration of ARD. Volume I presents the technical information on the investigation. Research done under contract J0215009 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143445; paper copy price code A06.

OFR 215(2)-83. Basic Research on Coal Fragmentation and Dust Entrainment. Volume II—Appendix Information, by Gary L. Stecklein, Ronald Branstetter, Roy Arrowood, David Davidson, James Lankford, Robert Lyle, and Carter Nulton. June 1982. 168 pp. 33 figs. This report summarizes the results into the areas of the fragmentation and entrainment of airborne respirable dust (ARD). The objectives of this program were fourfold: First, to review the present state of knowledge regarding ARD; second, to expand this state of knowledge through the identification of hypothetical microscopic mechanisms by which the coal is fragmented and the dust becomes entrained; third, to specify the informational requirements to verify or nullify these hypotheses; and fourth, to relate experimental techniques that will produce that required information. Additionally, insights are provided regarding potential methods of extraction and/or treatment that may reduce the concentration of ARD. Volume II contains the appendix. Research done under contract J0215009 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143452; paper copy price code A08.

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AD/MDA	Assistant Director—Mineral Data Analysis, USBM, Washington, DC.
AD/MI	Assistant Director—Mineral Information, USBM, Washington, DC.
AD/MMR	Assistant Director—Minerals and Materials Research, USBM, Washington, DC.
AD/MR	Assistant Director—Mining Research, USBM, Washington, DC.
AFOC/A	Alaska Field Operations Center, USBM, Anchorage, AK.
AFOC/F	Alaska Field Operations Center, USBM, Fairbanks, AK.
AFOC/J	Alaska Field Operations Center, USBM, Juneau, AK.
ALRC	Albany Research Center, USBM, Albany, OR.
AVRC	Avondale Research Center, USBM, Avondale, MD.
BLM	Bureau of Land Management, DOI, Washington, DC.
DMA	Minerals Availability Field Office, USBM, Denver, CO.
DOE/B	U.S. Department of Energy, Bartlesville, OK.
DOE/M	U.S. Department of Energy, Morgantown, WV.
DOI	U.S. Department of the Interior.
DRC	Denver Research Center, USBM, Denver, CO.
IFOC	Intermountain Field Operations Center, USBM, Denver, CO.
LIB	Natural Resources Library, DOI, Washington, DC.
MSHA	Mine Safety and Health Administration, Washington, DC.
MSHA/P	Mine Safety and Health Administration, Pittsburgh, PA.
NMH&SA	National Mine Health and Safety Academy, Beckley, WV.
OSM	Office of Surface Mining Library, DOI, Washington, DC.
PRC/B	Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.
RERC	Reno Research Center, USBM, Reno, NV.
RORC	Rolla Research Center, USBM, Rolla, MO.
SLRC	Salt Lake City Research Center, USBM, Salt Lake City, UT.
SRC	Spokane Research Center, USBM, Spokane, WA.
TCRC	Twin Cities Research Center, USBM, Twin Cities, MN.
TURC	Tuscaloosa Research Center, USBM, Tuscaloosa, AL.
USBM	U.S. Bureau of Mines.
WFOC	Western Field Operations Center, USBM, Spokane, WA.

OFR 1-84. Elucidation of the Fundamental Chemistry and Recovery of Gold From Carbonaceous Ore Bodies, by James L. Hendrix, Frank G. Baglin, and John H. Nelson. Sept. 1983. 66 pp. 34 figs. Low-grade carbonaceous gold ore from eastern Nevada was characterized by a variety of analytical and spectroscopic techniques with emphasis on vibrational spectroscopy. It was found that no detectable amounts of humic acid materials or organic hydrocarbons were present in the samples. Different hydrometallurgical techniques were used in an attempt to extract gold values from the carbonaceous ores. The techniques included the use of thiourea, diethylamine, and ammonium thiosulfate. None of these achieved the extraction levels gained by the standard hydrometallurgical practice of oxidation pretreatment followed by cyanidation. This report contains published papers covering most of the results of the study. Research done under grants G1105039 and G1115322 by the University of Nevada—Reno. Available for reference at the following facilities: AD/MR, ALRC, AVRC, LIB, RERC, and SLRC. Copies of this report will not be available for purchase.

OFR 2–84. In Situ Mining of Bituminous Coal With Fluorinated Solvents, by Arnulf P. Hagen. June 1983. 58 pp. This project was designed to explore the suitability of using fluorinated inorganic materials as solvents for in situ mining of thin seamed, heavily overburdened coal; to build a data base for the selection of an inorganic solvent for use in coal cleaning; and to determine if fluorinated solvents will reduce the organic and inorganic sulfur contents of coal as well as to lower the ash content. The coal samples were combined with pure solvent and with aqueous solutions at atmospheric pressure and at increased pressure. The increased pressure experiments are important because they duplicate the conditions anticipated for an in situ cleaning and mining operation. Trifluoroacetic, difluorophosphoric (phosphorodifluoridic), and trifluoromethanesulfonic acids were found to be effective for cleaning high-sulfur, high-ash coal at 300° C and at atmospheric pressure. At pressures up to 20,000 psi the effectiveness of these reagents is not decreased. Research done under grants G1105043 and G1115401 by the University of Oklahoma. Available for reference at the following facilities: AD/MR, AVRC, DRC, LIB, OSM, PRC, RERC, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 3–84. Characterization of Subsidence Over Longwall Mining Panels—Rocky Mountain Coal Province, by John E. O'Rourke, Pamela H. Rey, and Kevin O'Connor. Sept. 19, 1982. 192 pp. 59 figs. This report documents the process of site selection, instrument installation, data acquisition, and preliminary data analysis followed to characterize the physical response of overlying strata to longwall mining. A system of surface, subsurface, and mine level instrumentation was installed at the Allen Mine in Weston, CO, where the overburden ranged from 600 to 900 ft thick. Survey monuments, automatic-recording strainmeters, multipoint rod extensometers, inclinometer-extensometers, stressmeters, and tap extensometer convergence stations were installed to monitor displacements and stress changes. A preliminary analysis of the data acquired up until project termination showed the system to be operative and strata response to be similar to that reported for other subsidence monitoring case histories. Recommendations for continued monitoring of the instrumentation systems are presented. Research done under contract J0333953 by Woodward-Clyde Consultants. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–142918; paper copy price code A09.

OFR 4–84. Blasthole Depth and Stemming Height Systems, by Calvin J. Konya and Duane R. Skidmore. Sept. 12, 1981. 75 pp. 15 figs. Overloaded blastholes and insufficient stemming are major factors in flyrock accidents at surface metal and nonmetal mines. Accurate measurement of blasthole depth, stemming height, and water depth would reduce the overload and the probability of blowout, flyrock, excessive ground vibration, and airblast. Problems result because current measuring systems are inaccurate and often difficult to use. A literature survey determined measurement techniques and blasting parameters prior to 1970. Similar data were gathered for current practices in 11 iron mines, 30 copper mines, and 92 quarries. Most operations used a cloth tape to measure borehole depth and stemming height; approximately 10 of the operations had dry blastholes. Alternate measurement techniques were evaluated and discussed. Candidate measuring techniques with best potential for improvement over the present weighted tape method are disposable tapes or string chains, automated readout tapes, modified sludge level indicators, and acoustic reasonance methods. Research done under contract J0208022 by Intercontinental Development Corp. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–142694; paper copy price code A05.

OFR 5–84. Design, Development and Validation of a Training System for Roof Bolt Equipment Operators, by William M. Hinton, Jr., George W. Menzer, Raymond E. Reilly, and Robert M. Baker. Apr. 10, 1982. 127 pp. 6 figs. The objective of this program was to design and produce a training sequence that would prepare roof bolter trainees for job performance. Data were collected and analyzed using the general procedures in Instructional Systems Development (ISD). Input data came from a previous roof bolter training analysis program. These data were expanded and structured through a series of ISD steps—objective hierarchies, media selection, syllabus, lesson specifications, and training materials development. The resulting program consisted of an ordered sequence of 15 lessons. The media mix for the lessons included lectures, slide-tape lessons, and hands-on instruction using operational roof bolters. Contents of all lessons were reviewed and approved by the Bureau of Mines. Research done under contract H0188039 by Allen Corp. of America. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–141886; paper copy price code A07.

OFR 6–84. Development of a Training Program for Shaft and Slope Construction Personnel, by Bryan R. Carmenati, Robert H. Trent, and Karen L. Sackett. July 1982. 128 pp. This report documents the need for formal health and safety and equipment operations training in the mine construction industry. The outlines, objectives, and training texts were developed based on the recommendation of needs of mine construction personnel and two contractors. The training materials contained herein, and under other contracts, are designed to improve the safety and production of those in mine construction. Research done under contract J0318020 by Mine Training Systems, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–143767; paper copy price code A07.

OFR 7–84. Ground Control Mechanisms in Multi-Seam Mining, by C. Haycocks, M. Karmis, Eddie Barko, John Carman, Brian Ehgartner, Steve Hudock, and Steve Webster. Oct. 1983. 328 pp. 156 figs. The objective of this research was to improve the design of underground mines to avoid or minimize the problems caused by the interaction of overlying coal seams. To evaluate past interaction effects and provide guidelines for future mine design, interactive ground control problems were categorized into four areas—pillar load transfer, massive inter-

seam shearing, subsidence, and pressure arching effects. The research was carried out using a two-pronged approach: (1) Modeling using finite elements, body-loaded low-modulus photoelastic and brittle models and (2) using results of field studies and detailed analyses of field observations. It became obvious early in the project that the geologic environment played a major role in interaction and interpretation of field data. Therefore, a review was made of the central Appalachian coalfields and geologic environment. The results of this review are presented in appendix 1. Research done under grants G1105050 and G1115511 by the Virginia Polytechnic Institute and State University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 8–84. Control of Airblast and Excessive Ground Vibration From Blasting by Use of Efficient Stemming, by Calvin J. Konya, Duane Skidmore, and Francis Otuonye. June 1981. 199 pp. 62 figs. The objective of this study was to determine the relationships between borehole diameter and efficacious stemming type and length for a range of explosive pressures. A preferred material type and size was obtained after a detailed analysis of the data on minimum stemming lengths for retention acquired for limestone aggregate, crushed gravel aggregate, and Ottawa and river sands. Variables including the size, shape, and cohesive properties between the stemming particles and between stemming material and borehole walls were evaluated along with the strength of the rock. The study suggests that proper selection of stemming rock type and size distribution can reduce necessary stemming length, airblast levels, and ground vibration levels. Consequently, breakage can be improved and reductions realized for airblast, flyrock, and ground vibration. Research done under grant G5195034 by the Ohio State University. Available for reference at the following facilities: AD/MR, AVRC, LIB, OSM, and PRC/B. Copies of this report will not be available for purchase.

OFR 9(1)–84. Development of Models for Simulating Stormwater Runoff From Surface Coal Mined Lands. Volume I. Unit Hydrograph Models, by Michael E. Meadows, Kevin M. Howard, and Allen L. Chestnut. Nov. 1983. 173 pp. 39 figs. This study was designed to test the regional application of four popular synthetic unit hydrograph models. The performance of each model was evaluated with experimental watershed data from 38 watersheds in 14 States, 9 physiographic provinces, and 6 major coal-producing regions. The results provide insights to the regional application of each model and can be used to plan future hydrograph model development and calibration studies once an adequate surface mined land hydrologic data base is available. Research done under grants G1105070, G1115213, and G1195019 by the University of Kentucky and the University of South Carolina. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 9(2)–84. Development of Models for Simulating Stormwater Runoff From Surface Coal Mined Lands. Volume II. Finite Element Simulation of Overland Flow, by George E. Blandford, N. Peters II, and Michael E. Meadows. June 1983. 161 pp. 37 figs. Both Federal and State regulations require mining companies to develop specific plans for protecting the hydrological balance of a watershed, controlling sediment production, and diverting surface flows. Plan preparation requires predicting runoff volume, peak rate, and total hydrograph for design rainfall events. There is currently a very limited scientific basis for simulating the hydrological impact of surface mining activities. The purpose of this report is to present a scientifically (physically) based deterministic model to assess the hydrological impact of surface mined watersheds. Research done under grants G1105070, G1115213, and G1195019 by the University of Kentucky. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 10–84. Concurrent Establishment of Ground Cover and Hardwood Trees on Reclaimed Mineland and Unmined Reference Sites, by W. R. Byrnes, W. R. Chaney, and P. E. Pope. Dec. 1983. 13 pp. This research was conducted to assess reforestation success and ultimate productivity for areas reclaimed under the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). The objectives were to (1) compare establishment success and productivity of ground cover and commercial hardwood trees planted concurrently and maintained under the same level of management on reclaimed mineland and unmined reference sites; (2) evaluate survival and growth of bareroot, containerized, and mycorrhizal inoculated hardwood seedlings; and (3) evaluate chemical plant control as a technique for concurrent establishment of hardwood tree species and low ground cover vegetation. Research done under grants G1105023 and G1115182 by Purdue University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 11–84. Streamflow Estimation and Water Use Planning for Surface Mining in Northern Alaska, by S. Bandopadhyay, P. M. Fox, and R. F. Carlson. June 30, 1983. 72 pp. 16 figs. The primary objectives of this project were to improve methods to determine summer streamflow and stream response to surface mining activities in remote northern regions. A secondary objective was to provide a handbook describing techniques to estimate streamflow regimes and their accuracy for use by small-scale surface mining operators in the North. The project focused on developing standardized streamflow estimation procedures for different levels of surface mining activity versus differing availability of streamflow and climatic data. Decisions trees or flow diagrams based on data availability and size of mining operation were developed that will lead to a particular procedure to estimate streamflow for a particular mining operation. The flow diagrams were developed for each region because different stream regimes are anticipated within each region. The flow diagrams will provide standardized procedures to estimate streamflows (given a certain amount of data and the size of the mining operation), but also includes estimates of the risk inherent in the procedure used to estimate each parameter. All flow charts are based on the knowledge needed to successfully design and operate a long-term mine plan. Research done under grants G1105009 and G1115021 by the University of Alaska—Fairbanks. Available for reference at the following facilities: AD/MR, AVRC, DRC, LIB, PRC/B, SRC, and

TCRC. Copies of this report will not be available for purchase.

OFR 12-84. Survey of Ground, Surface Conditions Affecting Structural Response to Subsidence, by R. W. Bruhn, R. C. Speck, W. S. McCann, and O. S. Cecil. June 1983. 602 pp. 214 figs. The objective of this study was to examine the apparent influence of soil and near surface rock strata on the severity of damage experienced by surface structures subjected to mine subsidence. The report discusses (1) modes of ground movement that might complicate or be confused with mine subsidence, (2) prevailing concepts concerning mine subsidence in the Northern Appalachian Coalfield and Illinois Basin, (3) apparent influences of soil and near surface rock strata on the character of subsidence-related ground movements, (4) classifications and criteria for characterizing damage due to ground movements, and (5) types of subsidence damage experienced by homes above active mines in western Pennsylvania. A damage classification system that incorporates a severity index to characterize damage to homes with basements above active mines is presented. Also, a series of case histories illustrate subsidence damage to structures above active and abandoned mines. Research done under contract J0295014 by GAI Consultants, Inc. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-155860; paper copy price code A99.

OFR 13-84. Potash and Phosphate Demand, and Agricultural Supply Submodel, by Prospective Decision Models, Inc. Oct. 31, 1983. 149 pp. 3 figs. Potash and phosphate supply and demand computer submodels were developed and incorporated into the global macrodynamic simulation model, GloMaDyn, which represents 14 regions of the world. Each region is represented by submodels for demographics, economics, agriculture, energy, minerals, investment goods, aid, and trade. The objective of adding potash and phosphate representations to GloMaDyn was to analyze the interactions between the production of and agricultural demand for these minerals as productive inputs within an integrated, dynamic global framework. The enhanced model permits analysis of price changes, impacts of shortfalls in supplies, and other long-range events or policies that could affect the supply-demand balance. Research done under contract J0123067. Available for reference at LIB. Order ONLY from NTIS: PB 84-155878; paper copy price code A07.

OFR 14-84. Improved Crowd Limit Switches and Greenhorn for Electric Shovels, by Gary Choate, Fred O'Neil, Rudy Wachtler, and Cosmo Fazio. Sept. 30, 1983. 120 pp. 38 figs. The objective of this research was to develop and demonstrate appropriate system hardware for electric mining shovels that will prevent damage and downtime resulting from the shovel operator overextending the dipper handles when digging. The program began with a literature search and manufacturers product review to gather material as a basis for concept generation. Visits to three open pit mines provided information from operation and maintenance managers that was useful in preparing design concepts. These concepts were evaluated through laboratory tests and engineering analyses to select a final design concept. The improved greenhorn is designed to absorb the maximum energy generated by the greenhorn impacting the shipper shaft at maximum velocity with a loaded dipper. It consists of three shock-absorbing pads mounted on each side of the two dipper handles in a housing that bolts to the end of the dipper handle. The crowd limit control system is a nonmechanical device that senses the location of the dipper by counting the teeth of the pinion gear that drives the dipper handle and makes appropriate commands to the crowd motor to prevent greenhorn and shipper shaft collision. Research done under contract H0212019 by the Bendix Corp. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 15-84. In-Mine Long Term Testing of Improved Truck Ladders, by J. L. Dahle, G. R. Gavan, and D. Strassel. Feb. 1983. 170 pp. 140 figs. This report describes in-mine tests that were conducted at eight mines in the United States to evaluate the novel pretensioned spring ladder design on haulage trucks. The design was initially developed by Woodward Associates, Inc., under a previously completed Bureau of Mines sponsored contract, Bureau of Mines OFR 87-81. The design is intended to improve ingress-egress for haulage truck operators as well as reduce maintenance of lower steps. Research done under contract J0295017 by Woodward Associates, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-158831; paper copy price code A08.

OFR 16-84. Human Factors Analysis of Underground Metal and Nonmetal Mines, by Martin G. Helander and Gregory S. Krohn. Feb. 1983. 99 pp. 13 figs. The objective of this program was to research, develop, and validate a training program that will instruct miners in the proper preshift inspection, operating, and shutdown procedures for various types of major machines and equipment used in underground noncoal mines in order to reduce accidents and injuries. To identify human factors problems, unstructured interviews were performed with mine management, safety personnel, and mine workers. About 100 persons were interviewed at 9 mine locations, and work activities in each mine were inspected. Seventy-seven human factors problems were identified. A questionnaire was used to assign priorities to the research issues. The questionnaire was evaluated by human factors mining experts, MSHA inspectors, mine management personnel, and mine safety personnel. Of the 77 problems that were uncovered, 18 were selected for research and are described. Research done under contract H0308067 by Canyon Research Group, Inc. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-158732; paper copy price code A05.

OFR 17-84. Evaluation of Geophysical Surface Methods for Measuring Hydrological Variables in Fractured Rock Units, by Robert W. Taylor. Nov. 1982. 146 pp. 73 figs. A simplified theoretical model for the use of electrical resistivity measurements to determine joint orientation and intensity was developed. A field procedure based on the theoretical model was applied to a physical model under laboratory conditions and at two field sites. The two field sites

were identical geologically but differed in that one site was intensely mined while the other was unmined. In all three cases, joint strike was determined within approximately 5° and the relative indications of joint intensity were correct. In addition to the electrical measurements, the anisotrophy associated with seismic velocity and attenuation was measured at each field site. The seismic measurements, in comparison with the electrical measurements, were much less informative and more difficult to interpret. A computer-automated system for the continuous monitoring of resistivity depth soundings was deployed at one of the sites. Continuous 48-h monitoring following a rainfall suggested that the downward movement of water could be detected. Research done under contract H0318044 by the University of Wisconsin—Milwaukee. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–158021; paper copy price code A07.

OFR 18–84. Fabrication and Test of an Articulated Remote Manual Roof Bolter, by R. E. Leyner and L. Brummert. Sept. 30, 1983. 34 pp. 14 figs. The objective of this investigation was to fabricate, laboratory test, and perform an underground test and evaluate a prototype articulating remote manual bolter for greater-than-seam-height bolting. The machine operator is located under supported roof approximately 5 ft from the bolt being installed. The results demonstrate that roof bolting with the articulating chassis and the operator approximately 5 ft from the bolting operation is feasible. Research done under contract H0202036 by the Bendix Corp. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–157866; paper copy price code A03.

OFR 19–84. A Study of Precalculation of Effect of Fires on Ventilation System of Mines, by Rudolf E. Greuer. Mar. 15, 1983. 293 pp. 25 figs. Two computer program sections to determine the fume or other contaminant exposures of underground miners were developed. One section deals with exposure at fixed points of the ventilation system, the other deals with the exposure of miners traveling along specified escapeways. The feasibility of combining the latter section with an existing mine evacuation program was investigated. Modifications were devised and the evacuation plan and contaminant exposure of 10 miners is presented. Based on the assumption that a nonsteady-state process can be approximated by a sequence of short-duration, steady-state processes, a new program for the nonsteady-state simulation of ventilation systems under the influence of mine fires was developed. Research done under contract J0285002 by the Michigan Technological University. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–159979; paper copy price code A13.

OFR 20–84. Feasibility Study of In-Mine Coal Preparation Facilities, by Dames & Moore and Roberts & Schaefer. 1982. 114 pp. 7 figs. This work examined the feasibility of in-mine coal preparation. The work included a survey of previous investigations and a preliminary analyses of the economic and technical feasibility on a selection of representative sites and degrees of cleaning. The preliminary analysis determined that in-mine preparation systems can be applied using currently available technology. The most likely mines for application will have shaft or slope access and be deeper than 500 ft. The refuse disposal systems technically feasible are (1) pneumatic placement of coarse refuse in room-and-pillar panels or longwall faces, (2) mechanical placement of coarse and fine fractions in room-and-pillar panels, and (3) hydraulic placement of fine fractions in room-and-pillar panels. The economic feasibility is much more dependent on the refuse disposal system than on the preparation system. It is estimated that the capital cost of an in-mine preparation and disposal system would be $6.00 per clean ton and the operating cost would be $1.24 per clean ton for a 1-million-clean-ton-per-year mine. Research done under contract J0333939. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–171347; paper copy price code A06.

OFR 21-84. Copper, Gold, Platinum, and Palladium Sample Results From the Klukwan Mafic/Ultramafic Complex, Southeast Alaska, by Jan C. Still. June 1983. 53 pp. 6 figs. The Klukwan mafic-ultramafic complex, located near Haines in southeast Alaska, was examined by Bureau of Mines personnel in 1981-82 to determine its potential for platinum-group metals, gold, and copper. The ultramafic portion of the complex and the alluvial fan below have long been recognized as a significant iron deposit. During this examination, over 400 rock, panned concentrate, and stream sediment samples were collected from an area 9 miles long by about 3 miles wide. Analyses of the samples indicate interesting values in platinum, palladium, gold, and copper at a number of locations throughout the area. Some of these values are located on Bureau of Land Management land open to claim staking and the remainder are located on patented mining claims. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, and LIB. Copies of this report will not be available for purchase.

OFR 22–84. Economic Potential for Chromium, Platinum, and Palladium in the Mount Hurst Ultramafics, West-Central Area, Alaska, by William S. Roberts. Dec. 1983. 52 pp. 15 figs. Platinum, palladium, and chromite potential of the ultramafic rocks of Mt. Hurst, Ophir Quadrangle, west-central Alaska, was investigated in 1981 by the Bureau of Mines as part of a critical and strategic minerals program. Analyses of rock, stream sediment, soil, and panned concentrate samples indicate a low potential for lode and placer deposits of platinum, palladium, and chromite. The potential for paleoplacers is unknown. The ultramafic rocks consist of peridotites and pyroxenites of ophilitic origin. Comparison of these ultramafic rocks to other known occurrences provides a general framework for predicting size and quality of deposits. The upper limit for lode chromite ore is about 1 million tons; a greater probability exists for deposits containing less than 1,000 tons. The discontinuous character of the ultramafic rocks and the chemical variability of the chromite suggest the unlikelihood of economically significant platinum and palladium or chromite lode

deposits. Placer potential for these metals is limited because of the relative absence of alluvial deposits in the first order drainages. Placer potential in larger adjacent drainages is unknown except for the apparent negative results of historical prospecting. The detection of platinum and palladium in selected chromite and panned concentrate samples suggest a source for the nearby Boob Creek placer platinum occurrence reported by previous investigators. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, and LIB. Copies of this report will not be available for purchase.

OFR 23–84. Cost-Effectiveness of Increasing Airflow at Any Location in Underground Coal Mines (Volume II—Appendices), by Sandip K. Mukherjee, Anthony W. Laurito, Muhammed O. Rahim, and Madan M. Singh. Feb. 1983. 122 pp. This report presents the results of the economic analyses of several applicable alternatives to increase airflow in four underground coal mines. Pressure and quantity surveys were conducted underground, and measurements were made at the main mine fans. The existing ventilation networks were modeled using a modified ventilation simulator, and the applicable alternatives were simulated. Performance data obtained from the simulation runs were utilized to conduct the cost-effectiveness analyses. Volume II, this report, contains the output of the computer simulation runs. Research done under contract J0100066 by Engineers International, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(1)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colorado. Volume 1. Geotechnical Information, by Staff, Multi Mineral Corp. Aug. 1983. 249 pp. 77 figs. Horse Draw Mine, a facility owned by the U.S. Bureau of Mines, provides subsurface access to the nahcolite, dawsonite, and saline oil shale deposits in the Parachute Creek Member of the Green River Formation. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the facility to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. An extensive research program of core drilling, geology, rock mechanics, ventilation, and drilling and blasting tests was conducted. Processing studies included crushing, photosorting, heavy media separation, and flotation. The work is reported in detail in this seven-volume report. Volume 1 comprises geotechnical information. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(2)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colorado, Volume 2. Mine Operations Engineering, by Staff, Multi Mineral Corp. Aug. 1983. 338 pp. 63 figs. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume comprises information on the current ventilation system and scheduled mine development and production for the program. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(3)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colorado. Appendix Volume A–1. Raw Data, by Staff, Multi Mineral Corp. Aug. 1983. 274 pp. 57 figs. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume comprises rock mechanics test information and assay data. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(4)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colorado. Appendix Volume A–2. Core Hole 1840-UG-3 Data, by Staff, Multi Mineral Corp. Aug. 1983. 265 pp. 1 fig. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume comprises test data on core hole 1840-UG-3. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(5)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colorado, Appendix Volume A–3. Drawing Index, by Staff, Multi Mineral Corp. Aug. 1983. 11 pp. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume is an index of the drawings that are included in the report. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(6)–84. Mining and Rock Mechanics Research in Oil Shale and Nahcolite, Horse Draw Shaft, Colo-

rado. Appendix Volume A–4. Surface Testing, by Staff, Multi Mineral Corp. Aug. 1983. 316 pp. 22 figs. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume comprises data pertaining to the surface testing that was performed. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 24(7)–84. Mining and Rock Mechanics Research In Oil Shale and Nahcolite, Horse Draw Shaft, Colorado. Appendix Volume A–5. Sample Log, by Staff, Multi Mineral Corp. Aug. 1983. 230 pp. 35 figs. The Bureau of Mines and the Bureau of Land Management entered into an agreement with the Multi Mineral Corp. (MMC) for a research program to be conducted by MMC at the Horse Draw Mine in the Green River Formation to obtain mining, environmental, and geotechnical test data and bulk samples of the nahcolite, dawsonite, and oil shale. This volume comprises the sample log. Research done under memorandum of agreement MOA14-09-0070-799. Available for reference at the following facilities: AD/MR, BLM, DRC, IFOC, LIB, MSHA, PRC/B, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 25–84. A Summary of Data From the Sunnyside Single Entry Study—1971–80, by Elaine T. Bowers and Laurin N. Henton. May 12, 1983. 541 pp. 538 figs. The Sunnyside single-entry project pioneered the use of single entries for longwall development in this country. During the 10-year course of the project, an immense amount of information was gathered. Over 3 miles of entries were observed primarily through instrument groupings placed in strategically located areas or "rooms." Nearly 1,200 instruments were monitored to gain information on the behavior of coal entries during development stages and through the mining of two longwall panels. This was one of the most extensively documented projects undertaken by the Bureau of Mines. The data gathered has a great potential for scientific research, especially in the area of longwall mining. This report presents the ground control data gathered, in the form of computerized plots. Roof-to-floor deformation and load on cribs and roof bolts make up the bulk of the data, which is presented as load or deformation versus time. The plots are organized, generally, by the three main entries involved and, specifically, by the individual areas or rooms in those entries. No major attempt will be made in this paper to analyze data other than to identify the source and history. Research done by the Spokane (WA) Research Center. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 26–84. Preparation of Asbestos Substitute Multi-Strand Glass Fibers, by R. G. Simhan. Sept. 30, 1983. 20 pp. 2 figs. Several slate-slime glass fiber formulations were suggested as substitutes for asbestos in alkali environments. Different coatings were applied to determine their contribution to the alkali resistance of the system. The short fiberizing temperature range of the compositions precluded their fiberization with a 100-hole bushing. A single-hole bushing was used to obtain gram quantities for evaluation. This short fiberization range would preclude commercial-scale manufacture without further development. Research done under contract J0123050 by Manville Service Corp. Available for reference at the following facilities: ALRC, AVRC, LIB, MSHA, NMH&SA, PRC/B, and TCRC. Copies of this report will not be available for purchase.

OFR 27–84. Evaluation of Ceramic and Refractory Grade Raw Materials in Alabama: Gibbsite in Saprolites of East-Central Alabama. Phase II: Detailed Evaluation, by Mirza A. Beg. Sept. 30, 1983. 70 pp. 14 figs. Gibbsite occurs in soils and saprolites derived from feldspathic biotite and hornblend gneiss and layered amphibolite in Chambers County, AL. This region lies in a humid, subtropical climatic zone in the Piedmont physiographic province of east-central Alabama. Three target areas (I, II, and III) were selected on the basis of reconnaissance sampling carried out during the first phase of the study. Soil and saprolite samples were collected at 5-ft (1.52-m) intervals from shallow auger drill holes in the target areas. Gibbsite content of samples, as measured by differential scanning calorimeter (DSC), range from zero to 72 pct. Areas containing more than the average 10 pct gibbsite (DSC) are outlined for each target area and estimates of gibbsite tonnages were made for each. The gibbsite-rich saprolite blanket is usually within the first 20 ft (6.1 m) of the surface in the B and upper part of the C soil horizons. Gibbsite concentrations are richer where the depth of weathering is not more than 25 ft (7.62 m) because unweathered bedrock is conducive to internal drainage depending upon the mineralogy and orientation of rock structure. Estimated tonnage of 10 pct (DSC) or more gibbsite for target area I is 554,880 metric tons, target area II is 50,616 metric tons, and target area III is 309,729 tons. Research done under contract J0123066 by the Geological Survey of Alabama. Available for reference at the following facilities: ALRC, LIB, and TURC. Copies of this report will not be available for purchase.

OFR 28–84. Minerals Availability Manganese Deposit Abstracts, by Joseph S. Coffman, Catherine C. Kilgore, and Cesar M. Palencia. Dec. 1983. 118 pp. This report on manganese is one of a series of minerals availability commodity deposit abstracts. Nonconfidential information from the Minerals Availability Program data base covering domestic and foreign manganese properties and deposits has been abstracted for use in the report. Abstracts include applicable data on location, published reserves and resources, geology, mine beneficiation systems, and operational information. Research done by the Bureau of Mines Minerals Availability Field Office. Available for reference at the following facilities: AFOC/J, DMA, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 84–166164; paper copy price code A09.

OFR 29–84. Electrical Installations in Oil Shale Mines, by Bobby B. Gillenwater, Richard J. Kline, and Norbert Paas. Aug. 1983. 165 pp. 23 figs. This report presents recommended guidelines and regulatory changes applicable to electrical installations in underground oil shale mines. The recom-

mendations are based on information gathered from oil shale operators, government agencies, and other knowledgeable sources familiar with existing plans for mining systems and electrical installations, and on present understanding of the problems and hazards associated with oil shale mining. Additional discussions of specific electrical problems related to oil shale mining include ground fault current levels, permissible electrical wheel motors, permissible batteries and electrical starting systems, intrinsically safe instrumentation, and applicability of existing test standards. Research done under contract J0113061 by Foster-Miller, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-165794; paper copy price code A08.

OFR 30-84. Influence of Rock Discontinuities on Coal Mine Subsidence, by Kevin M. O'Connor, John E. O'Rourke, and James Carr. Sept. 10, 1983. 129 pp. 37 figs. This report documents the process of literature review, site selection, instrument installation, data acquisition, and preliminary data reduction performed to evaluate the influence of rock mass discontinuities on coal mine subsidence. A system of surface, subsurface, and mine level instrumentation ranged from 630 to 1,040 ft thick. Survey monuments, borehole pressure cells, full-profile borehole inclinometer-extensometers, mine level extensometers, stressmeters, and tap extensometer convergence stations were installed to monitor displacements and stress changes. Final design of the instrumentation system was based on (1) review of available information, (2) field mapping and analysis of areal photography, (3) drilling, and (4) borehole geophysics. The report contains the complete graphed data of stress and displacements accompanying the longwall mining of a 4,800-ft-long by 480-ft-wide coal panel. Research done under contract J0100087 by Woodward-Clyde Consultants. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-166370; paper copy price code A07.

OFR 31-84. Ultrasonic Stress Transfer: A Direct Test of Rock Bolt Integrity, by G. R. Moulder, P. L. Howard, J. C. Hesler, and W. B. Tarpley, Jr. Aug. 1983. 84 pp. 15 figs. A device was developed that measures dynamic stress (ultrasonic energy) transfer through installed rock bolts, a measure that is directly proportional to the degree of grout bonding of the bolt to the mine roof structure and thus the ability of the bolt to bear static stress. The rock bolt bond tester (RBBT) is a handheld portable device that shows three ranges of bolt bond condition; i.e., one-third (bad bond), two-thirds (marginal), or fully bonded. These are shown respectively by a red, yellow, or green light that displays for 4 s. RBBT performance was verified with 2½- to 8-ft bolts installed in various types of mine roof structures (sandstone, shale, and boney coal-mud), and is now being tested by the Bureau of Mines in mines across the United States. The unit is about the size of a five-battery flashlight and contains the transducer, electronics, and battery pack. The RBBT is designed for extreme ease of operation, requiring only manual contact with the bolt and signal readout. The batteries are rechargeable and the package is designed for durability in a mine environment. Research done under contract J0295037 by the Energy & Minerals Research Co. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, SRC, and TCRC. Order ONLY from NTIS: PB 84-165802; paper copy price code A05.

OFR 32-84. Application of Draft Power Sensor (DPS) Concepts to Pan Scrapers, by H. S. Benson. Aug. 1983. 102 pp. 50 figs. This report describes the pan scraper wheel slip monitor (WSM), the function of which is to instantly warn the operator of wheel slip and thus allows for immediate corrective action. Knowledgeable pan scraper people recognize that the preponderance of scraper time damage and wear occurs during useless wheel slip when the operator attempts to increase machine draft beyond what traction will allow. The resultant shortened tire life has become very expensive. The WSM reported here provides the means for relieving the operator of attempting to judge wheel slip on tires out of view. Direct and intuitively understandable audible and flashing light warnings tell the operator which wheel is slipping and indicates the relative magnitude of the slip. Besides the WSM's patent utility as a real time operator aid, it has unique potential for application to extended term wheel slip history acquisition under field conditions. Research done under contract H0292016 by the Southwest Research Institute. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-166610; paper copy price code A06.

OFR 33-84. Appraisal of Deeper Soil Loosening Equipment for Use in Reclaiming Illinois Prime Farmland After Surface Coal Mining, by Yoginder P. Chugh and K. V. K. Prasad. Oct. 1983. 112 pp. 29 figs. This study appraises available deeper soil loosening equipment in the 1- to 4-ft-depth range, in the United States and abroad, that has potential for Illinois prime farmland reclamation. The appraisal was based on written and/or oral contacts with equipment manufacturers, reclamation experts, and visits with selected equipment manufacturers. The results indicate that several manufacturers in the United States, the Federal Republic of Germany, and England market static and vibratory deeper soil loosening equipment that may have potential for application in Illinois. Pertinent information concerning equipment with potential is presented in this report. Research done under contract J0225015 by Southern Illinois University—Carbondale. Available for reference at the following facilities: AD/MR, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-166644; paper copy price code A06.

OFR 34-84. Evaluation of Branch and Horizontal Boreholes for In Situ Leach Mining, by D. W. Dareing, E. T. Wood, and D. H. Davidson. July 1980. 151 pp. 39 figs. Multiple-branch wellbores and horizontal holes, when applied to deep lying ore bodies, have the potential of significantly reducing total footage drilled per acre of well pattern. In addition, horizontal holes may increase sweep efficiency. Several drilling and completion concepts are given and evaluated in this report. The evaluation shows that there is economic incentive to further develop these concepts for field application to ore bodies 1,500 ft deep. Research done under contract J0199113 by Maurer Engineering Inc. Available for reference at the following facilities: ALRC, AVRC, DOE/M,

DRC, LIB, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-165869; paper copy price code A08.

OFR 35-84. Evaluation of Roof Trusses, Phase II. Use of Frequency of Vibration To Determine Chord Tension, by Clark P. Mangelsdorf. Jan. 1983. 58 pp. 27 figs. This report deals with efforts to develop a portable device suitable for underground use for the purpose of measuring the frequency of vibration of the horizontal chords of Birmingham roof trusses. Four devices were investigated and evaluated. An approximate empirical expression developed from a mathematical analysis provides a means of converting the frequency into tension. The method appears to be effective in mines with shale roof but requires some modification for other roofs. Research done under contract J0100070 by the University of Pittsburgh. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-166479; paper copy price code A04.

OFR 36-84. Development and Evaluation of Noise Control Techniques for Taconite Processing Equipment, by N. R. Dixon, A. R. Thompson, M. N. Rubin, and R. Madden . Feb. 1983. 160 pp. 97 figs. The objectives of this research were to assess worker noise exposure to taconite processing plants; identify major noise-generating equipment; and develop, install, and evaluate noise control treatments for those sources. Extensive noise and vibration meaurements were made on grinding mills in which the process parameters affecting mill noise were identified and the level of shell impact noise around the mill was defined. A multiplexing telemetry system was used to obtain shell vibration measurements from a rotating mill. Mill noise control methods were investigated and a partial mill barrier was built and tested on a semiautogeneous mill. A noise reduction of approximately 3 to 6 dBA was achieved on the falling side of the mill. The use of rubber mill liners on autogeneous mills was evaluated. Noise sources on fine screens were quantified and noise control measurements were developed. Noise reductions of 11 to 13 dBA were achieved at positions around the fine screen and some in-service testing was done. Noise measurements of crusher screens were obtained and noise control through resilient screen decks appears to hold the most promise. Additional benefits might be lower life-cycle cost because the service life of resilient decks is claimed to be longer than that of steel. Research done under contract H0377014 by Bolt Beranek and Newman Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-166198; paper copy price code A08.

OFR 37-84. Monitoring of a Phosphate Mining Area in Central Florida Using Landsat Satellite Data, by Michael Inglis and Thomas K. Budge. Mar. 1983. 67 pp. 34 figs. This report presents an investigation on the applicability of Landsat multispectral scanner satellite and simulated thematic mapper data to the phosphate mining area of central Flordia. An evaluation was made of the sensors as mine monitoring tools. The report describes the computer software and hardware used in the digital analysis of the scanner data, the theory of unsupervised classification, the methodology of image processing, and documents the classifications of selected mining and wetland areas. Conclusions are discussed and recommendations are made for future investigations. Research done under contract J0113099 by the University of New Mexico. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-165752; paper copy price code A04.

OFR 38-84. Handbook for State and Local Taxation of Solid Minerals, by George H. K. Schenck. Sept. 1983. 181 pp. 8 figs. This report provides a discussion of the appropriate procedures for conducting an economic analysis of proposed new taxes or changes in taxes on owners and operators of solid mineral deposits. Price elasticity of demand and supply are emphasized as key factors in determining the incidence of a mineral tax and the degree to which a mineral tax can be passed on by mine operators within a State to citizens of other States. Income, property, and severance taxes are the focus of the report; however, it is emphasized that the interrelationships between these taxes, their use at the several taxing levels (Federal, State, and local), and with other government-mandated charges should be incorporated as part of an analysis of tax changes. Constitutional provisions set important constraints on tax alternatives available to State and local governments. Principles guiding good tax practice are provided, and the relative advantages-disadvantages of the major taxes are discussed. Three analytical methods are described and several case studies are discussed. The cases, along with their detailed solutions, provide easily followed concepts. Research done under grants G1115423 and G5105046 by the Pennsylvania State University. Available for reference at the following facilities: AD/MDA, AD/MI, AVRC, LIB, OSM, and PRC/B. Order ONLY from NTIS: PB 84-166602; paper copy price code A09.

OFR 39-84. Postmining Results in Coshocton County, Ohio: Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining, by U.S. Department of Agriculture and Ohio State University. May 1983. 176 pp. 53 figs. Watershed CO6 in Coshocton County, OH, was instrumented in 1976 as one of three watersheds established for the purpose of investigating surface mining and reclamation effects on local hydrology, sediment discharge, and water quality. Each watershed occupied approximately 50 acres in a unique geologic setting within southeastern Ohio. Surface runoff and ground water levels were monitored. Samples were taken for sediment determination and chemical analysis prior to mining. Monitoring and sampling continued through the period of watershed disturbance caused by mining and reclamation activities, which began in November 1976. A postreclamation period that followed the cessation of worker-machine activity on the watershed began in October 1978 and continued to the end of January 1981. Research done under contracts J0166054 and J0166055. Available for reference at the following facilities: LIB, OSM, SRC, and TCRC. Order ONLY from NTIS: PB 84-165893; paper copy price code A09.

OFR 40-84. Theoretical Noise and Propagation Models for Through-the-Earth Communication, by D. A. Hill

and J. R. Wait. May 1982. 52 pp. 12 figs. A survey of the literature on extremely low-frequency and very low-frequency atmospheric noise was made. Most measurements have concentrated on vertical electric field and the horizontal magnetic field rather than the vertical magnetic field, which is of interest in transmission between horizontal loops. The limited vertical magnetic field data indicate that the vertical component is generally 10 to 20 dB below the horizontal component. Three laterally inhomogeneous earth models were analyzed for conversion of horizontal to vertical magnetic field. The rough surface model examines surface effects, the inhomogeneous thin sheet model treats volume effects, and the buried cylinder model treats localized manufactured effects. All three models predict the possibility of significant conversion from horizontal to vertical magnetic field. A thin sheet model was also used to examine transmission from a buried magnetic dipole source. It was found that the predicted fields more nearly model the measured data than does the homogeneous half-space model. Research done under contract J0113058 by the National Telecommunications and Information Administration. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–166628; paper copy price code A04.

OFR 41–84. Recommended Guidelines for Oxygen Self-Rescuers—Volume IV—Underground Non-Coal Mining, by Randolph Berry and Donald W. Mitchell. June 1983. 176 pp. 26 figs. The Bureau of Mines initiated a contract for the development of guidelines for the storage and use of self-contained self-rescuers (SCSR) in underground noncoal mines. An SCSR is a device capable of supplying, in an emergency, 1 h of self-contained oxygen (no breathing of mine air). The information and recommendations in this report were developed primarily from three sources: discussions with mine representatives (including management, labor, and government), site visits in underground mines, and a detailed analysis of every reported noncoal accident that produced hazardous atmosphere during the 5-yr period 1976-80, plus 10 other major incidents from prior years. Research done under contract J0199118 by Foster-Miller, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–166636; paper copy price code A09.

OFR 42–84. Noise Control Techniques for the Design of Coal Preparation Plants, by M. N. Rubin, A. R. Thompson, R. K. Cleworth, and R. F. Olson. Dec. 1982. 135 pp. 51 figs. The purpose of this work was to document currently available noise control techniques that can be incorporated into new coal preparation plants during the design stage. This was accomplished by reviewing previous experience, conducting an extensive literature search, visiting operating coal preparation plants, and contacting various equipment manufacturers. The treatments addressed include equipment substitution, changes in plant layout, and retrofit treatments for existing equipment. Research done under contract J0100018 by Roberts & Schaefer Co. and Bolt Beranek and Newman Inc. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84–166172; paper copy price code A07.

OFR 43–84. Noise Control of Rubber-Tired Front-End Loaders Used in Surface Mining, by N. R. Dixon and A. R. Thompson. June 1983. 52 pp. 28 figs. The objectives of this program were to assess and demonstrate retrofit noise control technology for front-end loaders. The treatments had to be practical, cost effective, and easily installed by mine personnel. The noise sources and acoustic paths that contribute to operator noise exposure were identified for two selected loaders. Retrofit noise control treatments were designed and installed on the loaders, and noise reduction of more than 10 dBA at the operator position were achieved on both machines. The retrofit packages are low cost and have been field tested in two mines for more than 2 yr. The results of the program were communicated to the mining industry through a series of workshops and a field manual. The workshops were given in 9 States across the United States, and more than 440 manuals were distributed. An audiovisual slide presentation was also developed that summarizes the program. Research done under contract J0395028 by Bolt Beranek and Newman Inc. Available for reference at the following facilities: DRC, LIB, MSHA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84–166180; paper copy price code A04.

OFR 44–84. Use of Hazard Pictorials/Symbols in the Minerals Industry, by Belinda Lowenhaupt Collins. Sept. 1983. 193 pp. 52 figs. This report documents a multiphase research effort on the evaluation of the effectiveness of safety symbols and hazard pictorials for use in mining and milling operations. The first phase reviews applicable codes and standards, and documentation of typical mining hazards to determine relevant safety messages. In the second phase, visits were made to eight minesites to document existing sign practice and common mining hazards. In the third phase, the effectiveness of two sets of symbols for 40 different safety messages was evaluated with 267 miners from 10 sites at disparate geographical locations. The evaluation included an assessment of the effectiveness of six different symbol surround shapes and colors. The most effective symbols depicted both the person and the hazard or protective gear; these were more representational rather than highly abstract. Based on this research, a set of 40 symbols are suggested for further graphic refinement, additional evaluation, and eventual use. Research done under contract J0113020 by the National Bureau of Standards. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–165877; paper copy price code A09.

OFR 45–84. Evaluation of Surface Storage Facilities for Explosives, Blasting Agents and Other Explosive Materials, by J. Roth. June 1, 1983. 78 pp. 3 figs. The purpose of this study was to increase the safety of explosive storage. This was accomplished by (1) review of histories of recent and past magazine explosions to define causes and trends; (2) observation of present-day explosive storage and practices at active mines; (3) examination of Federal regulations on explosive storage to determine whether they address all conceivable safety problems, whether they contain redundant or obsolete standards, and whether their intent is clearly stated; and (4) recommendations for safety improvements and for revision and clarification of governmental regula-

tions. A recent increase in magazine explosion frequency must be attributed to an increase in deliberate (criminal or malicious mischief) explosions. Fires of various origins account for the remaining explosions of the past decade. During 1884–1926, several lightning-generated explosions occurred in nonmetal magazines, but it appears that a well-constructed metal magazine is immune to direct lightning strikes, regardless of whether it is grounded or not grounded. Grounding a metal magazine cannot be harmful, but it may well be superfluous. Magazines were observed at 34 widely separated mines, and storage problems were discussed with personnel at those mines. In general, storage conditions and practices were found to be satisfactory. Usually, only small quantities of explosives are stored on mine property since most explosives are brought in by suppliers when needed. Mine Safety and Health Administration and Bureau of Alcohol, Tobacco and Firearms standards on explosive storage appear to cover safety aspects adequately; however, certain revisions are recommended to clarify. Research done under contract J0318071 by Management Science Associates. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–168392; paper copy price code A05.

OFR 46–84. Development of a Phase Difference of Arrival Technique for Location of Trapped Miners, by W. G. Hopkins III, R. H. Church, and W. E. Webb. Aug. 27, 1983. 35 pp. 12 figs. The development of systems for location of miners who have become entrapped following a mine disaster is one of the major research goals in the Bureau of Mines. Current technologies for locating trapped miners from the surface are either simple direction finders or time difference pulse systems that have accuracy limitations. Developing technologies using full-vector field measurements at several receiving points are currently being studied. The necessity of measuring field strength with great accuracy can be a drawback in these systems. However, a system that operates with continuous-wave radio signals, with phase differences that can be measured accurately even in weak signal conditions, would greatly improve the location accuracy. A microcomputer could be used in conjunction with the system to gather and manipulate the data to automatically pinpoint the location of trapped miners. Comparison of this system with existing technology indicates a favorable accuracy-complexity ratio for the phase difference of arrival technique. Research done by the Tuscaloosa Research Center. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 47–84. Noise Control of Large Track Dozers Used in Surface Mining, by R. Madden and M. Rubin. Apr. 1983. 58 pp. 35 figs. This report summarizes the development and demonstration of retrofit noise control treatments for large track dozers. Noise control treatments were installed on three demonstration dozers and field tested for more than 1 yr in surface mines. One dozer was equipped with a basic operator cab and the other two were equipped with rollover protective structures. The noise control treatments proved to be both effective and durable. As part of the project, a field manual describing the fabrication and installation of the treatments was also produced. The manual was distributed to mining industry representatives through a series of 1-day workshops across the United States. Forty-nine workshops were presented to over 800 people. As a result of the favorable reception of the workshops, an audiovisual slide presentation was also developed that summarizes the program. Research done under contract J0177049 by Bolt Beranek and Newman Inc. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84–172477; paper copy price code A04.

OFR 48–84. Evaluation of Proposed Human Subject Certification Tests for Self-Contained Breathing Apparatus, by J. Frederick Stampfer, Alan L. Hack, and Andres Trujillo. Mar. 1983. 56 pp. The Bureau of Mines proposed a new series of human subject certification tests for self-contained breathing apparatus (SCBA) in 1977. Eight SCBA's, one open-circuit and seven closed-circuit, were worn by test subjects while performing the tests. The functioning of the apparatus was monitored continuously during the majority of the tests. The major conclusions were: (1) The proposed tests are not too physically demanding. (2) There should be a minimum test subject weight. (3) The important apparatus variables to be measured are breathing resistance, temperature, and CO_2 and O_2 concentrations of the inhaled gas. (4) Continuous monitoring should be employed. (5) New pass-fail criteria based on realistic estimates of the physiological requirements of the user, tempered by present and future engineering limitations, are needed. (6) Breathing machines should be used for the majority of certification testing when available. (7) A more realistic ergonomics test than that presently proposed is needed. (8) System gas leak and facepiece leakage tests are also needed. Research done under contract J0100068 by the Los Alamos National Laboratory. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–172212; paper copy price code A04.

OFR 49–84. Recommended Guidelines for Oxygen Self-Rescuers—Volume III—Escapetime Studies in Underground Coal Mines, by D. Randolph Berry, Diane M. Doyle, Eliezer Kamon, and Donald W. Mitchell. June 1983. 49 pp. 6 figs. The objectives of this project were to (1) determine escape speed in different mine conditions, (2) evaluate the performance of chemical oxygen self-contained self-rescuers (SCSR) under actual escape conditions, and (3) measure the physiological cost of mine escape. A special escapeway was established so that escape speeds and the use of SCSR's could be analyzed over a wide range of conditions, including travelway heights of 30 in to 7 ft. The average escape speeds ranged from 96 ft/min crawling to 264 ft/min for head-bent walking. The average life of six SCSR's was 60.8 min; those traveling faster consumed their SCSR's faster, although the total distance traveled before exhaustion of the SCSR was independent of speed and travel. Physiological data were also recorded. The average respiration rate was 41 L/min and the average oxygen consumption was 1.38 L/min. Research done under contract J0199118 by Foster-Miller, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and

TURC. Order ONLY from NTIS: PB 84–179506; paper copy price code A03.

OFR 50–84. Stress Analysis of Wire Hoist Rope, by George A. Costello and James W. Phillips. Sept. 30, 1983. 103 pp. 25 figs. A theoretical analysis is presented for the static and dynamic response of wire rope in deep-shaft mining operations. Expressions for the stresses in the individual wires of complex wire ropes are derived, and specific results for simple strands are presented for the case of ropes subjected to a combination of axial loading and bending over a sheave. Consideration is also given to the dynamic overloading associated with certain mining operations, such as dumping ore into a suspended skip and accelerating a fully loaded skip upward. Experiments to determine the axial stiffness of wire rope are described. Factors affecting the service life of wire rope, such as residual and contact stresses and fatigue behavior, are discussed. Specific research areas in need of further investigation are identified. Research done under contract J0100011 by the University of Illinois—Urbana-Champaign. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–172618; paper copy price code A06.

OFR 51–84. Contamination of Ground and Surface Waters by Uranium Mining and Milling. Volume III: Experimental Studies & Analytical Procedures, by D. D. Runnells, C. N. Gerlitz, A. Davis, R. D. Lindberg, R. Meglen, G. Swanson, L. Taylor, R. Sistko, and R. McNelly. Sept. 15, 1983. 229 pp. 71 figs. The objective of this study was to measure the degree of retardation of the important chemical species in fluid from a uranium tailings pile as the fluid passed through cores taken from underlying rock. The measurements indicated that pH was the dominant control on the behavior of these species, and that the pH was affected primarily by the calcite cement in the rocks. The most appropriate species for monitoring were sulfate, chloride, and selenium. An appendix provides a description of the advantages and disadvantages of the various analytical procedures used on these high-ionic strength solutions. Research done under contract J0295033 by the University of Colorado. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–172204; paper copy price code A11.

OFR 52(1)–84. Surface Coal Mine Spoil Stability Study, Eastern Coal Province. Volume I, by Paul G. Swanson, J. Christopher Giese, and John S. Jones, Jr. Aug. 25, 1983. 168 pp. 32 figs. The objective of this project was to quantitatively assess the slope stability problems associated with coal surface mining in the eastern coal province and to recommend spoil placement techniques that provide for slope stability. Data were collected for 11 minesites in Alabama, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia. A site was selected in each of the six States on which a detailed investigation was conducted. The investigations included drilling through the slide into solid ground beneath, collecting samples at various depths for identification, and for laboratory tests. A topographic survey and field monitoring was conducted to determine field conditions at each slide. It was concluded that there are numerous factors related to the geologic and topographic conditions within the region that contribute substantially to the problems of spoil stability. The most significant factor appears to be the steep topography of the areas being mined. Research done under contract J0395011 by the Law Engineering Testing Co. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–178672; paper copy price code A08.

OFR 52(2)–84. Surface Coal Mine Spoil Stability Study, Eastern Coal Province. Volume II, by Paul G. Swanson, J. Christopher Giese, and John S. Jones, Jr. Aug. 25, 1983. 351 pp. 225 figs. The objective of this project was to quantitatively assess the slope stability problems associated with coal surface mining in the eastern coal province and to recommend spoil placement techniques that provide for slope stability. Data were collected from 11 minesites in Alabama, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia. Volume II contains the field data of each site collected during the study. The data are presented in a separate section for each site. Each section contains a site description, a review of the applicable regulations at the time the site was mined and reclaimed, and a review of the mining and reclamation method. A review of the site geology, a stratigraphic section, and a geologic structure map is provided for each site. Research done under contract J0395011 by the Law Engineering Testing Co. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–178680; paper copy price code A16.

OFR 52(3)–84. Surface Coal Mine Spoil Stability Study, Eastern Coal Province. Manual of Practice, by Paul G. Swanson, J. Christopher Giese, and John S. Jones, Jr. Aug. 25, 1983. 41 pp. 17 figs. This manual is to be used in combination with volumes I and II of the study on spoil stability in the eastern coal province. The manual applies the predictive matrices developed in the parent study for use in evaluating the stability of typical mine spoil slopes. The values of internal friction and pore pressure coefficient are derived for many varied slope conditions. The results can be used in conventional stability analysis equations to assist mine operators or regulatory personnel in evaluating spoil stability from very limited information. Research done under contract J0395011 by the Law Engineering Testing Co. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–178698; paper copy price code A03.

OFR 53–84. Application of Tailings Flow Analyses to Field Conditions, by Samuel Bryant, James M. Duncan, and H. Bolton Seed. Aug. 1983. 312 pp. 134 figs. The purpose of this study was to develop procedures to measure Bingham flow properties for mine tailings and to use these procedures to predict the possible consequences of a hypothetical tailings flow failure at the Tenmile Tailings Pond at Climax, CO. Values of τ_y (Bingham yield shear strength) and η_p (plastic viscosity) were measured for 10 materials using results obtained from vaned coaxial viscometer and triaxial tests. It was concluded that the consequences of such a failure were minimal and the failure itself was highly unlikely. Re-

search done under contract J0285039 by the University of California—Berkeley. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-174184; paper copy price code A14.

OFR 54-84. Statistical Analysis of Wire Rope, by Richard C. Rice and Richard L. Jentgen. Feb. 16, 1983. 198 pp. 62 figs. The objective of this investigation was to determine from existing wire rope test data the effect of different operating parameters on rope life and to develop an optimum statistical methodology for the analysis of that data. Laboratory and field data for wire ropes typical of constructions used in underground mine hoisting were obtained, screened, encoded, and analyzed statistically. The analysis of hoist ropes retired from service showed that rope remaining strength or strength loss can be predicted with good accuracy if several nondestructive measures of rope damage are assessed. The outer-wire corrosion rating, the electromagnetic nondestructive inspection technique used for predicting strength loss, and the rope diameter reduction was found to be most important. Signs of rope deterioration such as broken wires or damage were also important indicators of strength loss. Based on the results of the investigation, a number of recommendations are presented that promise to yield better rope inspection and retirement criteria that will lead to improved safety and efficiency in underground mine hoist systems. Research done under contract J0215012 by Battelle, Columbus Laboratories. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-175934; paper copy price code A10.

OFR 55-84. Energy Conservation in Mining Operations, by E. K. Stanek and N. V. Suryanarayana. Dec. 1982. 117 pp. 27 figs. This study, performed on a case study basis, can be divided into two parallel thrusts: electrical and thermal energy conservation. In the electrical portion, five areas were addressed: optimal dispatching of on-site generation, high-efficiency motors, conductor selection, power factor correction, and high-efficacy lighting. In the case study mine, which has a multiple-unit on-site generation system, optimally dispatching units can save significant energy. The other four methods are difficult to justify on a retrofit basis owing to capital costs. In the thermal portion of the study, a thermodynamic analysis was performed on the reverberatory smelting process. Possible areas of energy conservation were identified as radiation and convection heat losses from the furnace arch and the dumping of high energy content smelting slag. It was determined that materials currently available can provide the means of reducing heat loss from the reverberatory furnace. It was also determined that a significant amount of energy may be recovered from the slag. However, these are both subject to further study and validation. Research done under contract J0113078 by the Michigan Technological University. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-175942; paper copy price code A06.

OFR 56-84. Personal Dust Exposure Monitor Based on the Tapered Element Oscillating Microbalance, by Harvey Patashnick and Georg Rupprecht. Apr. 1983. 89 pp. 27 figs. Current state-of-the-art microweighing technology represented by the tapered element oscillating microbalance (TEOM) is utilized as the basis for a new generation of personal dust exposure monitors (PDEM). Two design configurations are presented. The first is an end-of-shift analysis system that uses small TEOM-PDEM cannisters to replace the filter cartridges in the current PDEM system. All other components carried by the miner (cyclone preseparator and pump) are the same. After the shift, the TEOM cannister is plugged into an interface box that enables a minicomputer to automatically identify the unit, determine the dust mass increase during the shift, compute the shift average dust mass concentration, and print out and/or store the data. The second design is a real-time TEOM-PDEM system that is capable of operation over a 10-h shift and, on demand, display real-time dust concentration level, time-weighted average, and shift average concentration. A prototype end-of-shift analysis system was fabricated and delivered to the Bureau of Mines. A description of the system consisting of six TEOM cannisters, interface electronics, and a minicomputer is given. The system represents a significant advance in the dust monitoring program in terms of accuracy and automation. Research done under contract H0308106 by Rupprecht & Patashnick Co., Inc. Available for reference at the following facilities: AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-173749; paper copy price code A05.

OFR 57(1)-84. Development of Guidelines for Rescue Chambers, Volume I, by John F. McCoy, D. Randolph Berry, and Donald W. Mitchell. Oct. 1983. 79 pp. 16 figs. The Bureau of Mines awarded a contract to develop guidelines for designing, constructing, stocking, and maintaining rescue chambers in underground mines. This report presents information and recommendations that could be used by a mine operator who desired to install a rescue chamber. Volume I covers atmospheric life support, configuration and construction, chamber location, power and lighting, equipment and supplies, communications, and psychological aspects and training. Research done under contract J0387210 by Foster-Miller, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-173723; paper copy price code A05.

OFR 57(2)-84. Development of Guidelines for Rescue Chambers, Volume II, Appendices, by John F. McCoy, D. Randolph Berry, and Donald W. Mitchell. Oct. 1983. 135 pp. 31 figs. The Bureau of Mines awarded a contract to develop guidelines for designing, constructing, stocking, and maintaining rescue chambers in underground mines. This report presents information and recommendations that could be used by a mine operator who desired to install a rescue chamber. Volume II, the appendices, covers the history of barricading, chamber pressurization considerations, diffusional infiltration of gas, compressed air storage, location examples, and psychological aspects. Research done under contract J0387210 by Foster-Miller, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B,

RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-173731; paper copy price code A07.

OFR 58-84. Development and Analysis of Slurry Transport Systems in Longwall Mining of Coal, by Tuncel M. Yegulalp, Robert C. Knight, and Nicholas Marchi. Sept. 30, 1982. 127 pp. 14 figs. A preliminary systems analysis of coarse-particle coal slurry pipelines as a haulage method was performed. Two literature surveys on state-of-the-art longwall mining and slurry transport technologies were prepared. Two representative longwall systems were designed, one with conventional haulage and one with slurry haulage. The two systems were then compared on the basis of cost, safety, and reliability. It was concluded that for the case of a two-face longwall mine, a coarse slurry transport system does not have a clear-cut cost advantage over a conventional system. However, indications were that a cost advantage could occur under different analytical conditions such as (1) a larger scale mine, (2) if intangible benefits were quantified, and (3) if new generation technology rather than currently available technology were applied. Research done under contract J0333905 by Columbia University. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-173756; paper copy price code A07.

OFR 59-84. SPASID: A Computer Program for Predicting Ground Movement Due to Underground Mining; User Manual, by Jaan Kiusalaas and Eric K. Albert. Aug. 1, 1983. 201 pp. 44 figs. This report is a self-contained user manual for a computer program called SPASID (Subsidence Prediction and System Identification). The program has two primary functions: (1) precalculation of ground movements due to underground mining operations using the influence function method and (2) computation of influence function and site parameters from measured displacements. SPASID is written in FORTRAN and consists of four modules: (1) a preprocessor module that prepares and maintains surface and mine data bases, (2) a subsidence computation module that predicts movements of the surface, (3) a system identification module that is used to calculate the optimal influence function parameters, and (4) a postprocessor module for generating graphic displays of subsidence data. The last module is somewhat machine dependent but has internal documentation to indicate potential changes. All of the modules may be run in either batch or interactive mode. The manual does not assume previous knowledge of the influence function method or programing competence. Research done under contract J0295031 by the Pennsylvania State University. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-175074; paper copy price code A10.

OFR 60-84. Performance Criteria Guideline for Three Explosion Protection Methods of Electrical Equipment Rated Up To 15,000 Volts AC, by Larry Joe Linley and Alton B. Luper. Dec. 1982. 63 pp. 7 figs. This performance criteria guideline is an evaluation of three explosion protection methods of machines electrically powered with voltages up to 15,000 V ac. A sufficient amount of basic research has been accomplished to verify that the explosion-proof and pressurized enclosure methods can provide adequate explosion protection with the present state of the art up to 15,000 V ac. The routine application of the potted enclosure as a stand-alone protection method requires further investigation or development in order to clarify performance criteria and verification-certification requirements. A literature search, a series of high-voltage tests, and a design evaluation of the three methods performed at the White Sands Test Facility indicate that the explosion-proof, pressurized, and potted enclosures can all be used to enclose up to 15,000 V ac, if the performance criteria and verification-certification requirements recommended in this guideline are implemented. Research done under contract J0318081 by the National Aeronautics and Space Administration. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-172303; paper copy price code A04.

OFR 61-84. Role of Rock-Fluid Reactions in the Enhanced Recovery of Petroleum, by W. H. Somerton and C. J. Radke. Feb. 1, 1984. 121 pp. 43 figs. The objectives of this project were to evaluate the effects rock-fluid reactions in typical oil-producing formations may have on the success or failure of enhanced oil recovery (EOR) operations. Core samples were collected from a number of oil-producing formations that are undergoing or are potential candidates for EOR operations. The mineralogical-petrographic characteristics of the cores were evaluated. The cores were then subjected to fluid-flow tests in which sequences of flowing fluids, which might be used in EOR operations, were used to evaluate effects on flow capacity. Stabilizing agents were studied to determine their effectiveness in minimizing loss of flow capacity. Cores from formations in which steam injection operations are planned or were in progress were steamed to evaluate effects on rock behavior. Chemical loss studies were undertaken to evaluate rock-fluid reactions in chemical EOR operations. Research done under grants G1105015 and G5115063 by the University of California—Berkeley. Available for reference at the following facilities: AD/MR, AVRC, DOE/B, LIB, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 62-84. Processing of Dolomites for Refractory Applications, by G. L. Messing and R. C. Bradt. Dec. 1983. 122 pp. 42 figs. This report presents specific research pertinent to various aspects of dolomite processing. The concept of reactive phase calsintering evolved from research on raw material effects. This process allows for the densification of dolomite in a single-step process in which the dolomite is first mixed with an oxide that will form a liquid at elevated temperatures and a compact formed by processing. The compact is then heated in a controlled manner to 1,100° C to effect the decomposition of the dolomite. The decomposed material is rapidly heated from 1,100° C to the sintering temperature, where the liquid phase forms. The calsintering process is then extended to the sintering of calcium carbonate. The result of adding a chloride salt was investigated and determined to be deleterious to the calsintering of dolomite. It is believed that this is primarily an effect of the chloride salt on the decomposition product. To more fully understand this process, both chloride and fluoride salts were systematically added to dolomite, calcite, and magnesite and their effects on the decomposition

were studied. Research done under grants G1105044 and G1115421 by the Pennsylvania State University. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, RORC, and TURC. Order ONLY from NTIS: PB 84–172345; paper copy price code A06.

OFR 63–84. Clay-Mineral Assemblages in Upper Cretaceous Shales in the Torreon Wash and Star Lake Coal Areas, Southeastern San Juan Basin, New Mexico, by Marc W. Bodine, Jr. Dec. 1983. 75 pp. 13 figs. This project was undertaken to characterize the mineralogy and chemical composition of clay-mineral assemblages in Upper Cretaceous shales in the southeastern part of the San Juan Basin in northwestern New Mexico and to determine their relations with episodes of coal deposition. The shales represent a range of depositional environments from marine, through near-shore mixed marine and continental, into fluvial and aeolean continental. Coal accumulation in the Torreon Wash and Star Lake areas occurs in both mixed marine and continental and fluvial continental facies. Research done under grants G1105077 and G1195030 by the New Mexico Institute of Mining and Technology. Available for reference at AVRC and LIB. Order ONLY from NTIS: PB 84–172352; paper copy price code A05.

OFR 64–84. Cobalt Behavior in Ammonia Leaching Systems, by K. Osseo-Asare and H. W. Pickering. Dec. 1983. 30 pp. 22 figs. The solution chemistry of the Fe- and Co-NH_3-H_2O-CO_3 systems was analyzed in terms of aqueous stability diagrams. Electrochemical techniques such as open-circuit potential and anodic polarization measurements were used to investigate the dissolution behavior of bulk and sintered Fe, Co, and Fe-Co alloys in ammoniacal ammonium carbonate solutions. The open-circuit and anodic polarization behaviors were studied in terms of alloy composition, heat treatment, solution composition, metal particle size, and sintering conditions. In addition, metallurgical characterization of the electrochemically treated solid surface was conducted by using various metallographic techniques, including X-ray diffraction and auger electron spectroscopy. The results indicate that the passivation behavior of Fe controls the dissolution behavior of Fe-Co alloys. Thus the electrochemical dissolution behavior of Fe-Co alloys may be, in part, responsible for the poor recovery of cobalt when the reductive-roast ammonia leach process is applied to ferruginous oxide ores. Research done under grants G1105045 and G1115422 by the Pennsylvania State University. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, RERC, RORC, and SLRC. Order ONLY from NTIS: PB 84–172295; paper copy price code A03.

OFR 65–84. Geochemical Properties and Toxicological Effects of Aquatic Life of Coal Wastes, by William R. Roy, Thomas M. Skelly, Ivan G. Krapac, Robert A. Griffin, Donald R. Dickerson, Rudolph M. Schuller, John J. Suloway, and Neil F. Shimp. Jan. 1984. 166 pp. 19 figs. This investigation is comprised of interrelated physical, chemical, and biological analyses for a broad-based evaluation of the impact of abandoned spoil banks and coal solid wastes on the aquatic environment. The analytical synthesis of the data from this investigation would aid in control technology, development of reclamation, and determine the potential degree of toxicity of these wastes as required by the Surface Mine Control and Reclamation Act of 1977, Public Law 95–87. Research done under grants G1105002 and G5115002 by the Southern Illinois University—Carbondale. Available for reference at the following facilities: AD/MMR, AVRC, DRC, LIB, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 66–84. Structural Location and Role of Hydrogen Ions in Kaolinite and Its Products in Aluminum Removal, by R. A. Young, P. R. Suitch, and W. E. Moody. Dec. 1983. 24 pp. 8 figs. The objectives of this program were to (1) determine the mechanistic details by which the structural locations and ordering of the hydrogen ions in kaolinite affects its crystallinity, solubility, viscosity, processing, and use characteristics; (2) determine the intracrystalline mechanisms involved in the extraction of aluminum; and (3) better determine and control the characteristics of the siliceous byproducts of aluminum extraction in order that useful products may be created from them. X-ray and neutron powder diffraction data and the Rietveld method were used to refine the crystal structure of kaolinite specimens. The positions of the nonhydrogen atoms in dickite were similarly re-refined from X-ray powder data. In kaolinite, the rotation in the tetrahedral sheet is 7(1)°. The two inner hydroxyl O-H bonds are differently oriented; one points into an octahedral vacancy and the other points away. All six of the inner surface hydrogen atoms appear to be nearly equally involved in the hydrogen bonding between kaolinite layers in kaolinite. The process of dehydroxylation of the kaolinite was followed in detail with X-ray diffraction techniques. Dehydroxylation began at about 325° to 350° C and was more than half completed at 465° C. It was found that "half completed" means that one-half of the initial sample was completely dehydroxylated while the other one-half was not, retaining all details of its kaolinite structure. Research done under grants G1105019 and G1115131 by the Georgia Institute of Technology. Available for reference at the following facilities: AD/MMR, AVRC, and LIB. Copies of this report will not be available for purchase.

OFR 67–84. Citrate Process Flue Gas Desulfurization Demonstration Plant, by John M. Cigan. Sept. 1, 1983. 154 pp. 15 figs. An SO_2 emission control program at the St. Joe Minerals Corp.'s zinc smelter powerplant evolved into a cooperative program with the Bureau of Mines for the installation and initial operation of a citrate process flue gas desulfurization demonstration plant. The plant was operated on an intermittent basis from November 1979 to September 1982. The citrate process proved capable of absorption of greater than 90% of the SO_2 from the flue gas with ultimate conversion to elemental sulfur. However, in order to overcome problems that severely restricted process ontime, plant modifications were made that resulted in lower SO_2 absorption—generally 50% to 70%. Analysis of the operation identified equipment areas where redesign was needed for achieving high SO_2 removal with reasonable levels of process equipment ontime. The additional investment could not be justified by anticipated smelter revenues. The recent availability of a bubble concept by the environmental regulatory agencies permitted an SO_2 emissions compliance program that could be implemented on a more timely basis and preclude St. Joe Corp.'s continued involvement in the citrate process flue gas desulfurization development. Research done under contract S0261008 by the St. Joe Minerals Corp. Available for reference at the following facilities: ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, and TURC. Order ONLY

from NTIS: PB 84-176007; paper copy price code A08.

OFR 68-84. Improvement of On-the-Job Training Procedures Through Utilization of Modeling, Imitative and Other Learning Techniques, by Paul E. Loustaunau, Catherine Wetherby, and Richard Rosenblatt. June 30, 1983. 36 pp. This report describes a project in which three structured underground coal mine equipment operator training programs were developed. The project was carried out in two parts. In the first part, a study was conducted to determine how on-the-job training is currently conducted in industry, determine the overall effectiveness of current on-the-job training, and the possible application of the principles of the social learning theory to on-the-job training. In the second part, three on-the-job training programs were developed for shuttle car, roof bolter, and continuous miner operations. These programs were structured to eliminate the shortcomings of current industrial on-the-job training identified in the study and incorporated the application of relevant principles of the social learning theory. The programs are prototypes that underground coal mine training personnel can use as models to develop their own customized equipment operator training programs. Research done under contract H0308028 by the Human Resources Research Organization. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH-&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-180199; paper copy price code A03.

OFR 69-84. Gases in Hydrous Alteration Minerals: An Exploration Tool for Ore Deposits, by David I. Norman. Mar. 1984. 118 pp. 20 figs. The possibility of gases trapped in hydrous minerals and fluid inclusions as geochemical guides to sulfide ore deposits was studied. Techniques for analyzing structurally bound gases in hydrous minerals were developed. A survey of phyllosilicate minerals indicated that those associated with ore deposits had up to 10 times the amount of CO_2 and H_2S as similar minerals from nonore locals. Analyses of gases in altered, phyllosilicate-bearing rock samples from the Bingham, UT, and Copper Flat, NM, porphyry copper deposits indicated that the gas consumptions are related to the specific types of alteration and mineralization. Samples were collected from the surface of the Copper Flat deposit before it was disturbed by mining. Gases in phyllosilicates outlined the deposit that did not crop out. Samples were collected on the exposed portions of the St. Cloud-U.S. Treasury vein that crops out for about 1.5 km. There are no trace element anomalies either in the vein or wall rock over the silver-rich ore shoots that are in production. Both Co_2 content of inclusion gases as well as N_2-CO_2 ratios indicated the location of ore shoots. Research done under grants G1105040 and G1115351 by the New Mexico Institute of Mining and Technology. Available for reference at the following facilities: AD/MMR, AVRC, LIB, PRC/B, RERC, and SLRC. Copies of this report will not be available for purchase.

OFR 70-84. Revegetating Disturbed Areas To Protect the Environment, by Edward F. Redente, Norman E. Hargis, and Mario Biondini. Jan. 23, 1984. 97 pp. 10 figs. The purpose of this research was to develop guidelines for the efficient management of soil resources and for the production of rangeland vegetation, winter wheat, and alfalfa on surface mined areas in northwestern Colorado. The experimental soil management practices were four soil replacement thicknesses and ripping, disking, and fertilizing the overburden. The simple effects of soil thickness and cultural practices and their interaction were evaluated. Research done under grants G1105017 and G1115082 by Colorado State University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 71-84. Flotation Recovery of Molybdenite From Porphyry Copper Ores, by Srinivasan Raghavan and Land L. Hsu. Dec. 1981. 47 pp. 25 figs. Investigations were conducted to characterize the surface chemical and flotation properties of molybdenite in aqueous environments typical of those that exist in the copper circuits of plants that process prophyry copper ores. The investigations showed that molybdenite and quartz particles are negatively charged at the pH commonly used for bulk sulfide flotation. While the adsorption of calcium ions reduces the magnitude of negative charge on molybdenite, the adsorption can reverse the surface charge on quartz particles when the calcium concentration in solution exceeds 1 by $10^{-3}M$. Heterocoagulation of molybdenite and quartz particles will thus be inevitable in solutions containing large amounts of lime and will impair the floatability of molybdenite. The deleterious effects of heterocoagulation can be somewhat overcome by an ultrasonic conditioning prior to flotation. Besides heterocoagulation, particle size is very critical for optimum molybdenite flotation. Coarse molybdenite particles float extremely rapidly and completely without being influenced by solution pH or heterocoagulation. The flotation of fine molybdenite particles is sensitive to the mean particle size and heterocoagulation. Results of tests conducted to assess the effects of overgrinding of molybdenite indicated that while there is no change in the crystal structure due to prolonged grinding, the floatability is significantly reduced due to the creation of rough surfaces. Research done under grant G5105011 by the University of Arizona. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, RERC, and SLRC. Copies of this report will not be available for purchase.

OFR 72-84. Application of a Portable Device for Measuring Dragline Roller Circle Track Deviations and Roller Loadings, by R. Pallini, J. Rumbarger, D. Powell, H. Urbanek, J. Yankanich, and J. Sague. July 1982. 54 pp. 28 figs. The objective of this work was to develop and demonstrate an instrumentation system for measuring roller circle distortions and roller loads, and to develop methods for using elastomeric materials to reduce the loading on thrust rollers in walking draglines. A practical and portable device was developed and demonstrated on a walking dragline at the Falkirk Mine, Underwood, ND. The device performed reliably and provided data on the vertical (out-of-flat) and angular twist or warp of each dragline roller track. This information can identify whether the upper rotating frame structure, the tub structure, or both are the source of distortions. The combined distortion data can be used to calculate realistic roller loads, predict track service life, and assist in evaluating the cost effectiveness of potential field repairs (elastomeric cushioning materials) versus costly track and tub replacement. Research done under contract J0233919 by the Franklin Institute. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and

TURC. Copies of this report will not be available for purchase.

OFR 73–84. Testing of a Fragmentation System for a Hard Rock Mining Machine, by Thomas Brunsing and Robert Morin. Nov. 1983. 78 pp. 38 figs. The purpose of this program was to develop deep-kerfing and core-breaking techniques to be incorporated into the design of a field prototype hard-rock mining machine. The machine is designed to mine nonabrasive bedded deposits up to 20,000 psi in uniaxial compressive strength. The mining technique involves cutting approximately 2-ft-deep parallel kerfs spaced 2 ft apart in either a horizontal or vertical direction and subsequently breaking out the cores as defined. The program was aimed at minimizing the required kerf width, obtaining reliable breaking within that kerf width, and determining cutter blade requirements necessary to achieve a mining rate of 20 ft^3/min. Full-scale breaking and half-scale kerfing experiments were employed to evaluate the system. High-strength concrete test specimens were used to simulate the rock being cut and broken. The results indicate that the kerf-break technique can achieve the desired mining rate by utilizing two 7-ft-diam blades to cut 2-in-wide by 24-in-deep kerfs. A lateral load applied to the base of the kerf was selected at the core-breaking technique to be employed by the full-scale machine. Research done under contract J0100081 by Foster-Miller, Inc. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–186394; paper copy price code A05.

OFR 74–84. Small Diameter Corrosion Resistant Pumps for In Situ Leaching, by Joe Puckett, John Murphy, and Kenneth Nixon. Dec. 1981. 70 pp. 18 figs. Reduced pump diameter allows use of smaller diameter wells and reduces drilling costs. This report describes pumping systems that can be used in smaller diameter wells at in situ leaching operations. Two 2-in monitor pumps were built and tested in 2-in wells, and two 3-in corrosion-resistant (production) pumps were built and tested in a 3.35-in well. The monitor pump was an 8-hp, 41-stage, centrifugal booster pump driving an injector located down in the well. The two pumps delivered 9.4 to 11.5 gpm, depending on the water level. The gasoline engines used 0.65 gph of gasoline. The performance of both pumps was unchanged after the test period. The production pump was a 40-hp, 12-stage, centrifugal booster pump driving an injector located down in the well. The two production pumps delivered 31 to 39 gpm against approximately 20 psi. The drive motors drew approximately 48 amp on a 420-V, 3-phase circuit. During the 40-h test run of each pump there was one shutdown that was caused by an overpressurization in the service line that caused the safety switch to cut out. The performance of both pumps was unchanged after the test period. Research done under contract H0292022 by the Kidde Co. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–186386; paper copy price code A04.

OFR 75–84. Movable Crusher System—Concepts and Applications, by R. N. Johnson, R. W. Utley, and E. S. Burkhardt. Dec. 1982. 178 pp. 48 figs. The objective of this report was to evaluate the feasibility and desirability of a movable in-pit crusher combined with conveyors to substantially reduce or eliminate truck or train haulage in large open pit nonfuel mineral mines. The report includes an introduction and summary of previous work, an analysis of movable crusher system components, a description of the selected system, a review of possible movable crusher system applications, and requirements for future work to bring about the general availability of such systems. Research done under contract J0295004 by Gard, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–185297; paper copy price code A09.

OFR 76–84. Methodology Development for Mine Life Safety System Evaluation, by R. S. Nutter, N. S. Smith, W. R. Voltz, P. Klinkhachorn, and D. F. Tuthill. June 6, 1982. 428 pp. 82 figs. A methodology was developed for qualitative safety hazard evaluation and quantitative reliability analysis of mine monitoring and control systems. Detailed application of these techniques were made to two commercial monitor-control systems and to a microprocessor-based system. A controlled environmental test was conducted on a set of one of the commercial system's outstations. A software reliability evaluation methodology was also developed and applied. Research done under contract J0100057 by the West Virginia University. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84–182765; paper copy price code A19.

OFR 77–84. Alertness Monitor Evaluation, by John A. Stern, Robert Goldstein, and Barbara D. Strock. Dec. 31, 1983. 26 pp. 1 fig. Procedures were developed to evaluate the nature and timing of eye blinks and closures, and these variables were related to alterations in performance. Impaired performance is frequently indexed by alterations in these variables, suggesting that monitoring aspects of oculometric activity, such as the eye blink, may become useful predictors of impaired performance. What may be equally or more important is that such information can be used to alert equipment operators and prevent accidents. The analyses suggest that impaired performance is associated with the occurrence of eye closures, even in tasks where vision is not used, such as making judgments about durations of auditory stimuli. If such closures occur in conjunction with slow eye movements in the horizontal plane, the likelihood of signals being missed is further enhanced. Blinking during the period of stimulus presentation also results in an enhanced likelihood of a signal being missed. Research done under contract H0222012 by Washington University. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–183276; paper copy price code A03.

OFR 78–84. Development of a Conveyor Belt Service Machine, by James L. Eirls. Dec. 1983. 109 pp. 47 figs. A self-contained conveyor belt service machine was designed, developed, fabricated, and demonstrated for the Bureau of Mines. The

machine is battery-powered, rubber-tired, and capable of handling, storing, and transporting conveyor belting, wire rope, and associated structures for sectional conveyor belts. While moving the tail section to its next position, the machine discharges the belting, wire rope, and belt structures. The belting is elevated and separated to provide for the insertion of the structures with minimum manual effort. A hydraulic system provides the power for steering, braking, winding or unwinding belting and wire rope, and to operate a load-bed conveyor, connection hitches, and external hydraulic tools. A pneumatic system is available to operate air-impact tools. The machine can function in coal seams as narrow as 48 in, double-wind conveyor belting 42 in wide and 400 ft long, load or unload 3/4-in wire rope on two separate reels, and be controlled by two operators. A complete belt move using this machine requires only four persons. Successful underground demonstrations were conducted in coal mines in West Virginia and Kentucky. Research done under contract J0333926 by Tracor MBA. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-184845; paper copy price code A06.

OFR 79-84. Development of a Hydride Fuel System for Underground Mine Use, by Ned Baker and Frank Lynch. Apr. 15, 1983. 56 pp. 23 figs. Details are given of a hydride fuel system to provide 5 kg of H_2 to fuel a Caterpillar engine previously modified to operate on hydrogen fuel and intended to power an underground mining vehicle. The fuel system was installed onto the engine, and the engine-fuel system was tested under cold-start conditions and a full range of engine loads and speeds. Refueling tests were also performed. The fuel system will support full engine power and allow delivery of at least 3/4 power on a continuous basis from cold-start conditions. Research done under contract H0202034 by Eimco Mining Machinery International. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-182773; paper copy price code A04.

OFR 80-84. Development of a Mine Air Contaminant Measurement Program—Diesels and Explosives, by W. L. Wagner, D. E. Marano, K. L. White, B. F. Craft, and W. J. Kennedy. June 1983. 74 pp. 12 figs. This report presents a quality control approach to the derivation of strategies for monitoring a work environment; specifically, the environment in underground mines where diesel-powered equipment and blasting agents are used. The approach is presented as a series of 22 steps called the Monitoring Strategy Development Scheme. The scheme is an orderly method for selecting from a number of options a strategy or tactics to cost effectively meet the requirements of a chosen objective related to the monitoring of breathing zone air quality. The scheme provides a format to quantify many of the factors that influence the selection of one strategy or tactic over another, and to ensure that important considerations are not neglected. The premise that breathing zone air in a work environment can be considered to be a manufactured product and that conventional quality control approaches are applicable is introduced. Typical approaches to the quality control of manufactured products and how these approaches can be applied to the selection of monitoring strategies are discussed. Research done under contract J0100004 by the University of Utah. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-183078; paper copy price code A04.

OFR 81-84. Comminution and Simulation Using Rod and Ball Mills, by Douglas W. Fuerstenau. Dec. 1983. 82 pp. 47 figs. This report presents the results of an investigation of comminution in tumbling mills. Five topics involved with ball- and rod-mill grinding kinetics were studied, and the results were analyzed in terms of phenomenological size reduction and transport models. Continuous rod-mill grinding was found to be characterized by high Peclet numbers that permit simulation to be carried out by several methods. The dry-batch ball-mill grinding of mineral mixtures showed that the breakage rates of the components were composition-dependent but time-independent and were normalizable with specific energy. Locked-cycle tests on mineral mixtures showed that a grinding circuit may take a long time to attain steady state, during which time the composition of the mill holdings, and hence the breakage rate of the components, continuously changed. The study revealed that under plant conditions, grinding circuits can be in transience perpetually. The transport of mineral mixtures through drums showed complex size and/or density-dependent segregation, thereby simplifying the modeling of the continuous grinding of complex feeds. Wet-batch rod-mill grinding on single minerals showed that the normalization of breakage kinetics is valid for slurries of constant pulp density at different holdups but cannot be extended to slurries varying in pulp density. Research done under contracts J0113022 and J0123049 by the University of California—Berkeley. Available for reference at the following facilities: AD/MMR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-184746; paper copy price code A05.

OFR 82-84. Chromium Recovery From Tanning Wastes by Pyrolysis and Sulfuric Acid Leaching, by John Porter, Jr., Robert Lollar, Carl V. Huber, and Leo Devarenne. Sept. 1983. 136 pp. 12 figs. A study was conducted to evaluate the feasibility of recovering chromium from pyrolyzed tanning wastes by sulfuric acid leaching and reusing the final product in the tanning industry. Separate batches of tannery waste treatment sludge and finished leather and blue leather scraps were pyrolyzed in a batch furnace under varying temperature and atmospheric conditions. A bench-scale leaching evaluation was then conducted on each batch of pyrolyzed material to determine chemical composition and screen various leaching alternatives that could be pursued on a pilot scale. Next, chromium liquors were produced in a pilot-scale recovery system by sulfuric acid leaching. A tannage evaluation of these liquors was conducted on calfskin and pigskin. An additional batch of blue leather scrap was pyrolyzed in a rotary hearth furnace and leached on a bench scale to determine the effect a different pyrolysis process would have on chromium recovery. The tannage potential

of this liquor was also evaluated on calfskin and pigskin. The results indicated that chromium could be recovered from pyrolyzed tanning wastes with sulfuric acid; however, tannage with the resultant liquors was not acceptable. Comparable tannage results were obtained with the extract from the rotary hearth char; however, chromium recovery from this was lower. An economic analysis of this recovery method shows that it is not feasible or practical. Research done under contract J0113110 by the Tanners' Council of America, Inc. Available for reference at the following facilities: ALRC, AVRC, LIB, MSHA, NMH&SA, PRC/B, RERC, SLRC, and TURC. Copies of this report will not be available for purchase.

OFR 83–84. Preparation of Baseline Training Materials for Assisting Compliance and Accident Reduction in the Metal and Nonmetal Mining Industry, by J. H. Adkins, P. Krois, M. Hinton, J. Nussbaumer, and D. Leonard. Mar. 1983. 95 pp. 27 figs. The goal of this program was to produce a set of baseline health and safety training materials that could be used by the metal and nonmetal mining industry to reduce injuries and to comply with Federal training requirements. The materials developed are arranged in a two-level outline format. The first level provides the title, course goals, background, and topical outline. The second level provides a detailed outline of the course content. Each of the required units in the baseline guides have one or more self-checks. These are designed to be suggestive of evaluation techniques the users can develop for themselves. An instructor's guide and a mining terms glossary are included. Research done under contract J0308011 by the Bendix Corp. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–184852; paper copy price code A05.

OFR 84–84. Development and Trials of a Commercially Practical Roof Fall Warning System, by James E. Aplin, Dave Fish, and Arnis Mangolds. Mar. 1983. 157 pp. 63 figs. Previous studies have shown that fracturing of roof strata precedes ultimate failure, and that the fracture development causes an accompanying increase in apparent resistivity of the strata. Using this principle, a microprocessor-controlled resistivity roof fall warning system (RRFWS) was developed that automatically sequences through and records up to 32 electrodes that may serve as either voltage or current electrodes. This capability permits increased coverage with a minimal number of required electrodes. The data are stored in a nonvolatile memory and on an optional printout, making the system nonsusceptible to loss of mine power. To further save battery power, the system's electronics shut down between readings, except for a carbon molybdenum steel real-time clock. At a preprogramed interval, the RRFWS reactivates and repeats the sequence. If the absolute change or the rate of change of resistivity exceeds a predetermined limit, the system is capable of sounding an alarm. In addition to the monitor, a stainless steel modified split-set electrode was also developed that permits long-term, corrosion-free contact. Research done under contract H0202029 by Foster-Miller, Inc. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–182807; paper copy price code A08.

OFR 85–84. Characteristics of a Radon Diffusion Chamber With Electrical Collection Using Plastic Nuclear Track Detectors, by Allen L. Frank and Eugene V. Benton. Sept. 1983. 17 pp. 5 figs. A portable radon diffusion chamber was tested with electrical collection of radon daughter nuclei for enhancement of sensitivity. The detector was small enough to be worn suspended from a belt. With a battery-supplied high voltage, the sensitivity was found to be 1.43 tracks/cm^2 per pCi-h/ℓ of ambient radon at 50% relative humidity. The track densities on the surfaces of the CR-39 plastic nuclear track detectors were found to be nonuniform, making the determinations of average densities with high accuracy difficult. The fabrication of electrets for use in the detector was investigated in accordance with published techniques with negative results. Research done under contract J0123037 by the University of San Francisco. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–184209; paper copy price code A02.

OFR 86–84. Evaluation of the Safety of Underground Blasting Procedures, by W. G. Freeman, J. G. Babcock, M. L. Christo, G. P. Chitombo, and J. R. Biller. Nov. 1980. 139 pp. 31 figs. This study provides recommendations for improved safety in underground blasting procedures based on in-mine observations of blasting practices in 30 underground metal, nonmetal, and coal mines; analyses of blasting accidents since 1980; and existing State and Federal regulations pertaining to the storage and use of explosives. Results of these analyses and observations indicate that (1) blasting accidents have declined but are an important contributor to the hazards of underground mining; (2) existing regulations are essentially adequate; (3) greater emphasis should be placed on human errors, unsafe practices, and the enforcement of existing regulations; and (4) future revisions of these regulations and standards should be organized and their intent coordinated to eliminate ambiguities. Research done under contract J0199012 by International Mining Consultants, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–193838; paper copy price code A07.

OFR 87–84. Improvements to the Seismic Detection and Location Procedure, by Roy J. Greenfield. Dec. 1983. 49 pp. 20 figs. This report discusses three factors that relate to the seismic detection and location of trapped miners. (1) As part of the modeling procedure to explain the seismic waveforms observed on surface seismic subarrays, the force-time function of the source must be known. Accelerometer records of a source timber show the force is approximately one-half sinewave and that floor blows have a longer dwell time than roof bolt blows, leading to smaller amplitude for floor blows. (2) Comparisons were made between the least squares and MINER location methods using both statistical simulations and actual data. The comparisons showed the methods give similar accuracy for events inside the array with seven subarray

arrival times. However, for fewer subarrays, or for events outside the array, the least squares method is more accurate. (3) Refraction surveys to determine the rock velocity used for source location calculations should be approximately 1,200 ft long. To obtain accurate locations, small refraction surveys 165 ft long can and should be used to detect very slow soil layers under each subarray. Research done under contract J0318047 by the Pennsylvania State University. Available for reference at the following facilities: AD/MR, ALRC, AVRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, AND TURC. Order ONLY from NTIS: PB 84-193713; paper copy price code A03.

OFR 88-84. Data Security for In-Mine Transmission. Final Report—Part II, by Jon G. Bredeson, Hossein Hashemi, and K. Sreedhar. Apr. 1982. 76 pp. 29 figs. Part I of this report contained a survey of noise measurements made by a number of researchers. This information was used to calculate bit error rates for mine communication systems. Part II, this report, examined available probability information of the noise envelope for noise measured in the mining environment. The exceedance probability distribution was averaged for available noise data and was shown to be modeled closely by Middleton's class B model. The noise power at the output of several communication links was scaled appropriately and together with the signal power a probability of burst error was calculated. The protocols were analyzed to determine the probability of undetected burst error for each communication system and then plotted versus distance. Various data communication protocols are used in equipment for the communication purposes. Some protocols are used very extensively in all types of communications systems, while others are designed for special systems. The report analyzes several protocols and gives recommendations for their use. Research done under contract J0308024 by the University of Oklahoma. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-185081; paper copy price code A04.

OFR 89-84. Feasibility of an Underground Hydraulic Coal Mine Near Wilkeson, Washington, by William C. Cooley, Arthur W. T. Grimley, and Walter W. Kaufman. Sept. 10, 1983. 174 pp. 35 figs. This report presents a technical and economic study of the feasibility of establishing an underground hydraulic coal mine in the Wilkeson, WA, quadrangle, 25 miles southeast of Tacoma. The deposit contains reserves of more than 200 million tons of metallurgical coal. It is found in nine seams of minable thickness in a complex set of anticlines, synclines, and faults. Typical dip angles are up to 60°, with minable seam thickness of 6 to 17 ft. A mine plan was made for a 200-million-ton-per-year clean mine using two shafts to access the deposit at a depth of 2,500 ft. The mining method uses water jets to break coal by sublevel retreat mining, fluming to a sump, and pumping the minus 0.25-in coal to a preparation plant on the surface. The plus 0.25-in coal is hoisted by skip. Cleaned coal is shipped by rail for export. A middlings product would be sold as thermal coal. Research done under contract J0133913 by Terraspace Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-184100; paper copy price code A08.

OFR 90-84. Predicting Mine Effluent and Ground Water Quality Prior to Mining, by William C. Hood. Mar. 20, 1984. 190 pp. 46 figs. A leaching column technique that produces effluent similar in quality to coal mine drainage in the eastern interior basin was developed. The columns are charged with 1,000 g of crushed overburden and cycled through the leaching process once a week for 12 weeks. Interrelationships among the important chemical constituents are very similar to those present in actual mine drainage waters, but the overall concentrations of ions are more dilute in the leachates. Multiplying the leachate concentrations by a factor of 4.5 gives values similar to mine waters. Available data suggest that each of the leaching cycles represents about 3 yr of natural weathering, so that the leaching technique can predict the evolution of the mine drainage water over a time span of nearly 40 yr. Use of the leaching technique with drill core samples should provide a method of approximating mine drainage quality in advance of mining and should be useful in identifying potentially toxic units in the overburden. However, the results should be considered to be a worst case situation because the technique does not consider the effects of reclamation. Research done under grants G1105065 and G1195014 by Southern Illinois University—Carbondale. Available for reference at the following facilities: AD/MR, AVRC, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-189752; paper copy price code A09.

OFR 91-84. Development of Roof Control Criteria for Underground Longwall Mining, by S. S. Peng. Feb. 1984. 216 pp. 79 figs. The purpose of this study was to analyze the effects of strata behavior on longwall panels caused by mining. The study was focused on the weighting phenomena and their effects on front abutments, and the chain pillar stability and pillar design under various roof conditions. Using the three-dimensional finite element, the overburden depth, mechanical properties of the immediate roof and the main roof, panel width, and size of the chain pillar were analyzed. Four models were used to simulate various phases of panel production under various combinations of the above parameters. Model 1 simulated the beginning of panel mining, model 2 simulated the passage of the longwall face of more than half the panel length, model 3 simulated the completion of panel productions, and model 4 simulated the second panel mining. By applying the multiple-regression model to analyze the finite element results, the following were developed: (1) a formula that classifies the type of roof strata at the face area, (2) formulas that predict the first weighting and periodic weighting lengths, and (3) a formula that designs the chain pillar size. Research done under grants G111-5541 and G5105055 by West Virginia University. Available for reference at the following facilities: DRC, LIB, PRC/B, SRC, and TURC. Copies of this report will not be available for purchase.

OFR 92-84. The Environmental Consequence of Burial Depth of Toxic Spoils and of Excessive Compaction of Prime Land on the Growth of Plants, by Richard I. Barnhisel. Dec. 31, 1983. 200 pp. 5 figs. The objectives of this report were to (1) determine the minimum depth of soil, nontoxic spoils, or treated spoils re-

quired to control the environmental effects that toxic spoils may have on the growth of agronomic plants and (2) determine the consequence of excessive compaction (bulk density) on restored prime land on the yield of those plants. Timothy, alfalfa, corn, soybeans, and wheat were used in determining the effect of soil burial depth and liming; alfalfa, corn, soybeans, and wheat were the crops used in testing the effect of compaction on growth. From a chemical point of view, acidic spoils do not need to be buried by 120 cm or 4 ft of soil, provided that adequate lime is applied to these spoils as a barrier prior to placement of good-quality topsoil and that only forage crops are to be grown. The burial depth must be increased to as much as 75 cm when grain crops such as corn and soybeans are to be grown. A conventional farm tractor-mounted subsoiler increased yields of soybeans and corn the first 1 or 2 yr, but the effect was diminished with time. Subsoiling did not produce significant increases for alfalfa or wheat. However, ripping with a bulldozer produced significant yield responses, especially for corn and soybeans, that have lasted for at least 3 yr. The ripping effectively reduced the bulk density at least within the zones through which the ripper had passed. Liming the upper 20 cm of subsoil significantly increased yields of alfalfa, corn, and soybeans. There also appeared to be an interaction between this lime treatment and soil depth. Research done under grants G1105025 and G1115214 by the University of Kentucky. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 93–84. Survey of Electrostatic Hazards Detection and Minimization, by R. W. Courtney and R. W. Johnson. Mar. 1982. 116 pp. 23 figs. The objective of this study is to make a critical evaluation of the magnitude and extent of electrostatic hazards in typical U.S. mining operations and to assess the adequacy of techniques, materials, and equipment for detecting and minimizing these hazards. This was accomplished with an incident-accident survey, mine visits, literature search, and engineering analysis. It was concluded that it would be desirable to (1) utilize ground fault interrupters to minimize stray current from electrical utilities, (2) decrease the current and electrostatic sensitivity of electric detonators used in areas with a high incidence of lightning strikes or troublesome stray currents, (3) institute quality control and test standards for blasting material and protective devices, (4) establish an electrostatic monitoring program for loading ammonium nitrate and fuel oil in plastic-lined holes, and (5) establish risk criteria for operator exposure in mines. Research done under contract J0308113 by Hercules Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–186709; paper copy price code A06.

OFR 94–84. Methane Control in an Advancing Section of an Underground Coal Mine, by Danny W. Hagood, Richard C. Pate, and John W. Stevenson. Dec. 1983. 39 pp. 19 figs. The drilling of horizontal boreholes as a means of degasification in advance of mining was tried at the Jim Walter Resources, Inc., No. 4 Mine. In a joint venture with the Bureau of Mines, a series of horizontal boreholes were drilled in the panels of an advancing continuous miner section. The combined methane gas production rate ranged from 205,000 to 680,000 cfd with individual in-seam horizontal holes producing up to 332,000 cfd. The methane liberation from the ribs for the entire panel length decreased from an average 8.75 to 4.05 cfm per 100 ft of entry, a 54% reduction. The gas concentration as measured at the surface discharge point normally ranges from 85% to 95% methane. As a result of the significant reduction in methane liberation rates, a 50% increase in productivity from the section was realized. Research done under contract S0395033 by Jim Walter Resources, Inc. Available for reference at the following facilities: DRC, LIB, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84–185057; paper copy price code A03.

OFR 95–84. A Model for the Evaluation of Systematic Variability in Composition and Thickness of High Sulfur-High Ash Coals, by Alan C. Donaldson and John J. Renton. Feb. 1984. 108 pp. 64 figs. The purpose of this project was to provide a coal model to geographically describe the composition and thickness of a coal seam in sufficient detail to ensure an efficient and effective mining utilization and reclamation plan for coal before it is mined. The study focuses on high sulfur and high ash coals of the central and northern Appalachians. Data from approximately 500 cored wells of mainly Pittsburgh coal but also Redstone, Sewickley, and Waynesburg coals were provided by industry and used in the analysis. An additional 652 samples were collected and chemically analyzed. The coals were selectively examined using Mossbauer spectrometer analyses of pyrite-pyrrhotite; acid production when oxidized; and petrography by radiographs and an image scanner, scanning electron microscope, and reflected light. The report includes a better method than is presently used to predict acid mine waters and a method to improve the prediction of lateral coal-quality changes within a seam from limited samples. Research done under grants G1105090, G1115542, and G1195050 by West Virginia University. Available for reference at the following facilities: AD/MR, LIB, and OSM. Copies of this report will not be available for purchase.

OFR 96–84. The Use of Fe/Mn Oxide-Rich Fracture Coatings in the Geochemical Exploration for Precious Metal Deposits: A Comparison With Standard Rock and Soil Geochemistry, by Lawrence T. Larson, Robert H. Carpenter, and Walter C. Crone. Jan. 1984. 119 pp. 42 figs. The effectiveness of Fe/Mn oxide-rich fracture coatings as a geochemical medium for precious metals exploration is evaluated relative to conventional litho- and pedogeochemistry. Sampling of fracture coating, rock, soil, and stream sediments in areas of known disseminated gold in the Pinson Mine and Preble Prospect and potential bonanza-type near the Comstock Lode mineralization indicates that the technique is scientifically valid. Fracture coating samples contained an average of 18.8, 7.5+, 7.4, and 4.5 times more Sb, Au, As, and Hg, respectively, than rock samples at Pinson, and 10.2, 5.2+, 2.7, and 1.6 times more Sb, Au, As, and Hg, respectively, than rock samples at Preble. A higher contrast is obtained relative to soil and stream sediment samples. The geochemical halos obtained from fracture coating samples cover larger areas than those obtained from rock or soil samples and accurately reflect the locations of known mineralization. Larger exploration targets are defined as a result. Research done under grants G1105038 and

G1115321 by the University of Nevada—Reno. Available for reference at the following facilities: AD/MMR, AD/MR, AVRC, LIB, and RERC. Order ONLY from NTIS: PB 84-189653; paper copy price code A06.

OFR 97-84. Coal Waste Disposal Survey. Coal Refuse—An Increasingly Serious Problem for Colorado Plateau Production, by Susan M. White, W. Kent Ostler, and Cyrus McKell. July 1982. 67 pp. 26 figs. This study presents information on the nature of coal refuse and disposal practices on the Colorado Plateau. Samples were collected and analyzed to provide information to help formulate alternative methods for reclaiming refuse piles. The analyses were based on determining the capability of unmodified refuse to provide a suitable medium for plant growth. Local topsoils that would be used in reclamation were used as standards. Potential environmental hazards were also assessed. A general cost analysis was done for both surface and underground disposal and the advantages and disadvantages of each were assessed. Several problems were identified that, if solved, would increase the effectiveness of State regulatory programs. Research done under contract J0333931 by the Plant Resources Institute. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-185073; paper copy price code A04.

OFR 98-84. An Analog Device for Simulation of Hardrock Mine Ventilation, by H. Wright, R. Lundquist, and B. Murray. May 1983. 73 pp. 15 figs. The purpose of this report is to assess the feasibility of an analog "black box" approach to mine ventilation simulation in which electronic or mechanical elements are physically interconnected in order to model an underground ventilation network. The black box approach to ventilation simulation involves the use of electronic or fluid-mechanical elements that have the proper square law dependence between pressure and flow. These elements would be assembled in a configuration that represents the ventilation network. When activated, the flows or pressures can be measured. Branch resistances can be easily changed to simulate new test conditions such as a regulator readjustment or breakthrough between sections. Both the fluid-mechanical and analog electronic models can be made that have the capability to model nonlinear flow in networks such as mines. The fluid-mechanical device has a practical limitation of perhaps 25 to 30 branches and more design tailoring. The market for analog simulators is perhaps two to three hundred systems, and there is a noticeable price sensitivity above $5,000. Research done under contract J0318017 by Bolt Beranek and Newman Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-185065; paper copy price code A04.

OFR 99-84. System for Handling Supplies in Underground Coal Mines, by Ani Chitaley and Ricardo A. Diaz. Apr. 22, 1983. 49 pp. 17 figs. A new method was developed to handle supplies in underground bituminous coal mines. A survey indicates industrywide implementation potential for the proposed method. Reduction of supply handling accidents by as much as 73% and improvements in the productivity of face operations by at least 3% are anticipated benefits. The new method is based on the palletization of daily supplies and the use of a forklift to carry out the handling tasks at the underground section. The forklift demonstrated several important features necessary for underground supply handling such as compactness, maneuverability, visibility, ease of control, and auxiliary attachments for hoisting, carrying timber, and pulling. Design improvements are recommended for future generation underground forklifts that relate to higher speed, increased battery duty cycle, higher payload, and modified traction steering to eliminate plowing of soft mine floors. Research done under contract H0188049 by Booz, Allen & Hamilton Inc. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-186741; paper copy price code A03.

OFR 100-84. Research Study on the Technology for Control of Environmental Noise From Off-Road Haul Trucks, by John L. Dahle. Sept. 1983. 93 pp. 29 figs. This report documents research efforts that were undertaken to design, install, and test noise abatement devices for use on off-highway haul trucks operating in surface mines. The objective of the program was to reduce the environmental noise from haul trucks. The noise reduction devices that were developed utilized existing technology and were tested on a 50-ton haul truck. The work emphasized the reduction of noise emitted from the engine compartment, which included the use of side shields, sound absorbing material, improved radiator shroud design, and a modulating clutch fan. Noise tests were conducted using modified SAE test procedures for measuring sound levels around a stationary and moving machine, and inside the operator compartment. Test results showed a maximum of 4 dBA reduction measured 16 ft from the truck. Interior cab noise was reduced 6 dBA with the windows and vents closed. Research done under contract J0218020 by Woodward Associates, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-186733; paper copy price code A05.

OFR 101-84. Development of a Multiple Unit Continuous Haulage System, by G. J. Hundman and P. W. Meisel. July 1983. 326 pp. 138 figs. The objective of this research was to design a method to continuously convey coal from a mining machine to a main haulage belt with the fewest operators. The multiple-unit, continuous-haulage (MUCH) system was designed to provide the capacity to convey the coal. The MUCH system has one operator who steers the lead vehicle, following the mining machine. All the remaining vehicles follow the path of the lead vehicle with their conveyors automatically lining up between the lead vehicle and mine section panel belt. This is accomplished by linkages on the vehicles that are interconnected by steering bars. An operator steers the discharge vehicle when outby travel is required. Surface tests indicate the system should track and retrack successfully in square-pillar underground room-and-pillar mines with 18-ft-wide entries and slopes up to 10 pct. For 60° pillar plans, the minimum entry width required is 15 ft. The tests also indicate the system will convey over 8 ton/min of coal around 90° corners without excessive spillage. Research done under contract J0333941 by Dresser Industries,

Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-188630; paper copy price code A11.

OFR 102-84. A Feasibility Study for the Detection of Weak Electromagnetic Signal/Bursts With Hard-Limited Arrays, by M. Kanefsky and A. Q. K. Rajput. Nov. 1981. 138 pp. 30 figs. The objective of this report was to investigate the use of a noncoherent detector based on polarity-coincidence statistic. Two channel, polarity-coincidence and polarity-difference, statistics were analyzed. The signal, common to both channels, consists of sinusoidal bursts where the exact frequency of the signal is nearly known, but other parameters such as amplitude, phase, and pulse starting time are unknown. The noise inputs are dependent, narrow band, Markov processes. It is shown that the performance depends not only on the signal uncertainties, but on the precise shape of the cross-correlation functions between the noise inputs. By using two polarity-difference statistics in addition to the polarity-coincidence statistic, it is shown that the decrease in performance, as well as the cost of hard limiting due to correlated inputs, can be made small. Research done under contract J0318033 by the University of Pittsburgh. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-188846; paper copy price code A07.

OFR 103-84. Investigation of the Interaction Between Acid Mine Water and Concentrator Wastes, by Frank E. Diebold and Dennis R. Jenke. Nov. 1982. 107 pp. 14 figs. The waste water treatment system of the Anaconda Mining Co. in Butte, MT, was physically and chemically characterized, modeled on a computer, and investigated with respect to alternate systems for economic heavy metal recovery. The system involves lime addition to a mixture of acid underground copper sulfide mine water, acid effluent water from the iron-induced precipitation of copper from acid leach solution, and basic suspensions of solid effluent from a concentrator plant. Experimental chemical analysis and predictive computer calculations show that the monosulfate and disulfate complexes of transition metals and alkaline earths are 40% of the total dissolved metal load of both acid streams. The suspended solids in the basic concentrator slurries are dominated by quartz and pyrite and also contain kaolinite, muscovite, biotite, and undissolved lime. The mixture of these three streams results in major reductions in concentrations of Al, Cu, Fe, Mg, Mn, Si, and Zn and a pH of >7, with Ca, Na, K, and SO_4^{-2} being the major dissolved ions. The treatment system was simulated in the laboratory and modeled on a computer. The computer program is capable of accurately predicting the amount of lime required to reach a desired effluent water. Preliminary research indicated the usefulness of electroprecipitation as a means of recovering the valuable metal load and providing an EPA acceptable effluent. Research done under contract J0295042 by the Montana College of Mineral Science and Technology. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 104(1)-84. Volumes I Through III of Acquisition, Storage, and Classification of Engineering and Geological Data for Surface-Mine Design and Reclamation, by James C. Cobb, Konstanty F. Unrug, Alan D. Smith, and Richard A. Smath. June 1983. 471 pp. 77 figs. A computer-based information system for engineering and geological data pertaining to surface mining was developed. The information system is interactive, allowing the user to access all data, analyze data, input new data, and to obtain plots of programs on demand. Five computer programs were developed to access and analyze these data. The programs give results for all engineering tests for each rock type, plots of test results against depth, plots of test results against each other, and geologic descriptions of all cores sampled. A statistical analysis, using multiple-linear regression, hypothesis testing, power analysis, stepwise regression, and model building, was performed on the data generated by this project. Research done under grants G1105068 and G1195018 by the University of Kentucky. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and PRC/B. Copies of this report will not be available for purchase.

OFR 104(2)-84. Volumes IV Through VI of Acquisition, Storage, and Classification of Engineering and Geological Data for Surface-Mine Design and Reclamation, by Edward A. Kryza, Joseph G. Turner III, and Roger L. Weinheimer. June 1983. 367 pp. 103 figs. Forty-seven samples from the Middle Pennsylvanian Breathitt Formation were examined petrographically to determine which shale attributes most directly influence slake durability. The study combined thin section examination with X-ray diffraction analyses of clay mineral orientation and clay mineralogy. Slake durability indices were obtained using a 60-min, one-cycle test and oven-dried samples. Multiple-linear regression indicates a high degree of correlation between slake durability indices and two measured shale characteristics, clay percent and clay mineral orientation. A discriminant function, using these two characteristics, proved successful in differentiating slakable from durable shales, correctly classifying 37 of the 47 tested samples. Research done under grants G1105068 and G1195019 by the University of Kentucky. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and PRC/B. Copies of this report will not be available for purchase.

OFR 105(1)-84. Ground and Air Vibrations Caused by Surface Blasting. Volume I. Executive Summary, by Jaak J. K. Daemen, Ross C. Barkley, Amitava Ghosh, Clayton R. Morlock, and Sally A. Shoop. Sept. 1983. 121 pp. 46 figs. Ground and air vibrations induced by large surface blasts were monitored and the field results and a number of published results were used to assess the performance of existing predictors and for the development of improved prediction methods. Monitoring was performed with four seismographs giving complete wave records at limestone quarries, coal strip mines, and an open pit copper mine. Conventional analysis includes least square fitting of peak particle velocities and peak air overpressures with scaled distance formulations. Frequency content was analyzed and correlated with blast design. One new method to predict ground vibrations induced by blasting is an analytical predictor that accounts for inelastic attentuation and geometrical spreading, and calculates the peak velocity as a function of

charge weight and distance. Statistical analysis of case studies confirms the consistent improvement over conventional scaled distance predictors. A second new predictor is a computer program simulating blasts including blast geometry, charge distribution, and detonation sequence and simulating propagation of individual pulses to any point of interest where effects are summed. A complete blast vibration results, allowing prediction of frequency of content and duration as well as peak velocities. Research done under grants G5105010 and G5115041 by the University of Arizona. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and TCRC. Order ONLY from NTIS: PB 84-191931; paper copy price code A06.

OFR 105(2)-84. Ground and Air Vibrations Caused by Surface Blasting. Volume II. Ground Vibration Monitoring and Assessment of Conventional Predictors, by Sally A. Shoop and Jaak J. K. Daemen. Sept. 1983. 193 pp. 86 figs. Thirty-seven blasts were monitored using either 3 or 4 seismographs at 4 coal strip mines and at a limestone quarry. Statistical analysis of the data shows that square root, cube root, and site specific scaling methods predict peak particle velocities with about the same degree of reliability. Some mines have peak particle velocities that are significantly lower or higher than the Bureau of Mines averages. This suggests that the option provided by the proposed regulations of the Office of Surface Mining in 1983 to adjust blast designs based on site specific measurements could be highly beneficial both to operators and to the public. The frequency spectra reveal that the predominant frequencies were generally less than 50 Hz, but several blasts had a significant amount of energy up to 125 Hz. In some cases the vibration energy was concentrated at frequencies corresponding to the delay intervals. Research done under grants G5105010 and G5115041 by the University of Arizona. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and TCRC. Order ONLY from NTIS: PB 84-191949; paper copy price code A09.

OFR 105(3)-84. Ground and Air Vibrations Caused by Surface Blasting. Volume III. Computer Simulation Predictor of Ground Vibrations Induced by Blasting, by Ross C. Barkley and Jaak J. K. Daemen. Sept. 1983. 237 pp. 85 figs. A computer program was written to simulate ground vibrations induced by multiple-hole surface blasts. The program is an inexpensive and relatively easy to use tool for predicting the principal blast vibration characteristics that determine damage and annoyance potential: peak particle velocity, frequency content, and pulse duration. The program generates a complete ground motion history by superposing at any surface position the vibrations induced by each individual explosives charge. It requires specification of and allows accounting for the blast geometry, initiation sequence, position with respect to blast, pulse characteristics induced by each charge, and propagation laws. A methodology is outlined to determine the necessary variables either on the basis of site investigations or by backcalculation from measured blast vibration records. The latter procedure was applied to blasts from two coal strip mines. It was determined that the main difficulties are backcalculating individual pulses, propagation parameters, and delays. It was shown that a normal distribution of delays influences the results and the response of a single degree of freedom structure significantly. Research done under grants G5105010 and G5115041 by the University of Arizona. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and TCRC. Order ONLY from NTIS: PB 84-191956; paper copy price code A11.

OFR 105(4)-84. Ground and Air Vibrations Caused by Surface Blasting. Volume IV. A New Analytical Predictor of Ground Vibrations Induced by Blasting, by Amitava Ghosh and Jaak J. K. Daemen. Sept. 1983. 315 pp. 28 figs. A new analytical formula for predicting ground vibrations induced by blasting is proposed. One factor accounts for geometrical spreading and one factor corresponds to inelastic attenuation. The geometrical spreading function is based on likely source geometries idealized as either square root, cube root, or site specific scaling and on the propagation characteristics of predominant wave types. The inelastic attenuation is approximated by an exponential function. The empirical constants in these functions are backcalculated from field measurements. Regression analyses were performed on 23 sets of measured data to determine the validity and effectiveness of the proposed method. In many cases, the proposed method gives better correlation than the conventional method. In most of the remaining cases, there was no difference between the two methods. Best-fit lines given by the proposed method fit the data trend very well, especially at large scaled distances. At large distances the proposed method gives a prediction much closer to the actual values than the conventional methods. The statistical analyses do not show much difference between square root, cube root, or site specific scalings. Research done under grants G5105010 and G5115041 by the University of Arizona. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and TCRC. Order ONLY from NTIS: PB 84-191964; paper copy price code A14.

OFR 105(5)-84. Ground and Air Vibrations Caused by Surface Blasting. Volume V. Air Vibrations: Monitoring and Predictor Assessment, by Clayton R. Morlock and Jaak J. K. Daemen. Sept. 1983. 175 pp. 61 figs. Airblasts were monitored at four coal strip mines and at a limestone quarry. Thirty-seven production blasts were monitored with 3 seismographs resulting in 111 complete air pressure records. Instrumentation selection and use are described. Data analysis includes an assessment of the predictability of peak overpressures by means of the cube root scaled distance law. It was found that predictability for the cases studied is not good. An extensive discussion of possible explanations is included. A detailed analysis of the frequency content of the observed airblasts, of considerable importance in evaluating potential annoyance problems, was made for all records. A computer program was written to simulate airblasts induced by multiple-hole blasts. A series of small experimental blasts were detonated and monitored to allow an assessment of the program. It is clear that airblasts, especially when induced by very small charges and monitored at very close distances, are highly sensitive to detonation times. Retrofitting of airblast records occasionally was possible, but considerably improved fieldwork is required to validate or refute the computer model. Research done under grants G5105010 and G5115041 by the University of Arizona. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, and TCRC. Order ONLY

from NTIS: PB 84-191972; paper copy price code A08.

OFR 106-84. Testing Jet Fans in Metal/Nonmetal Mines With Large Cross-Sectional Airways, by Michael F. Dunn, Francis S. Kendorski, Mohammad O. Rahim, and Amitabha Mukherjee. July 1983. 132 pp. 55 figs. The objective of this work was to study the way in which jet fans are used to improve ventilation in metal and nonmetal mines with large cross-sectional areas and to develop guidelines for optimizing this performance. Two different sized jet fans and three separate mines were used in the study. The report gives guidelines on optimal fan location and attitude for ventilating open airways, face areas, and dead headings. The results are only for mines with initially low mean entry air velocities and should not be extrapolated to mines with higher air velocities. The appendix, "Using Auxiliary 'Jet Fans' in Large Underground Metal/Nonmetal Mines: A Handbook," is available also as a separate report, OFR 107-84. Research done under contract J0318015 by Engineers International, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-196393; paper copy price code A07.

OFR 107-84. Using Auxiliary "Jet Fans" in Large Underground Metal/Nonmetal Mines: A Handbook, by Michael F. Dunn, Francis S. Kendorski, Mohammad O. Rahim, and Amitabha Mukherjee. July 1983. 20 pp. 5 figs. This handbook was prepared to provide a quick reference for use by frontline supervisors, ventilation engineers, and mine planners in selecting and using jet fans in a variety of conditions in large underground metal and nonmetal mines. Discussions covering jet fan characteristics, selection and use criteria, and do's and don'ts for easier operation, safety, and performance are included. The handbook is based on research at three underground metal and nonmetal mines with cross-sectional areas of 900 to 2,000 ft^2. The handbook also appears in its entirety in OFR 106-84, "Testing Jet Fans in Metal/Nonmetal Mines With Large Cross-Sectional Airways." Research done under contract J0318015 by Engineers International, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-196401; paper copy price code A02.

OFR 108-84. Development of Sampling and Analytical Methods for Toxicants in Diesel Exhaust Streams, by K. T. Menzies, K. J. Beltis, and C. M. Wong. Mar. 15, 1983. 155 pp. 24 figs. The objective of this study was to develop and validate sampling and analytical methods for selected diesel exhaust contaminants. Three compound classes were studied including polynuclear aromatic hydrocarbons (PAH), light oxygenates (carbonyls), and heavy oxygenates (odorants). Sampling and analysis were developed and validated in a laboratory and evaluated in a diesel exhaust or mine air matrix. A high-performance liquid chromatographic (HPLC) method was evaluated for analysis of aldehydes and ketones in diluted diesel exhaust and mine air. Sampling schemes to collect carbonyls in these two matrices were also developed. A sampling method to collect odorants in diesel exhaust was developed by limited modification of available sampling schemes. The odorant analysis method evaluation is based on a diesel odor analysis system that utilizes liquid chromatography. The analytical methods developed for analysis of PAH utilized either a reverse phase HPLC or a capillary column gas chromatography-mass spectrometry technique coupled with various sample preparation steps. The developed procedures were found to be suitable for exhaust emission analyses. Interferences are minimal in all methods except for the HPLC analysis of PAH where PAH derivatives may interfere. The results of validation experiments indicate good recovery of specific compounds based on standard studies for individual methods. Research done under contract J0308005 by Arthur D. Little, Inc. Available for reference at the following facilities: DRC, LIB, MSHA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-196625; paper copy price code A08.

OFR 109(1)-84. Development of a Dewatering System for Controlling Fracture Dominated Inflow for Acid Mine Drainage Abatement, by Gerald Ahnell, David R. Buss, Robert M. Cohen, and Richard R. Parizek. May 1983. 210 pp. 48 figs. A mine dewatering strategy utilizing fracture sited wells drilled from the surface above a historically wet underground coal mine in Preston County, WV, successfully demonstrated the effectiveness of such a strategy to reduce mine water inflows and increase mine productivity through improved working conditions. The strategy has the potential to be cost effective by greatly reducing the total volume of water likely to enter the mine workings and require costly handling and treatment while minimizing the impact on shallower domestic water supplies. This report outlines five site-independent prerequisites for a cost-effective mine dewatering approach. Research done under contract H0202002 by Skelly and Loy. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 109(2)-84. Development of a Dewatering System for Controlling Fracture Dominated Inflow for Acid Mine Drainage Abatement, Appendices, by Gerald Ahnell, David R. Buss, Robert M. Cohen, and Richard R. Parizek. May 1983. 212 pp. 42 figs. A mine dewatering strategy utilizing fracture cited wells drilled from the surface above a historically wet underground coal mine in Preston County, WV, successfully demonstrated the effectiveness of such a strategy to reduce mine water inflows and increase mine productivity through improved working conditions. The strategy has the potential to be cost effective by greatly reducing the total volume of water likely to enter the mine workings and require costly handling and treatment while minimizing the impact on shallower domestic water supplies. This report, the appendices, contains several documents that present a preliminary assessment of the test minesite, a guide for exploration drilling at the site to evaluate the effectiveness of fracture sited wells, and raw data and interpretations of a variety of well tests performed at the demonstration site. Research done under contract H0202002 by Skelly and Loy. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and

TURC. Copies of this report will not be available for purchase.

OFR 110(1)–84. Relationship of Underground Diesel Engine Maintenance to Emissions. Volume I, by Ronald Branstetter, Robert Burrahm, and Harry Dietzmann. Dec. 1983. 104 pp. 57 figs. Gaseous and particulate exhaust emissions from 20 diesel engines in service at 5 underground mines were measured with high-accuracy instrumentation. The engines were checked for faults or maladjustments. The vehicle and engine maintenance organization was studied at each mine and an idealized maintenance program was devised. Faults were induced in a new diesel engine to determine their effect on the characteristics of the exhaust emissions. The results, conclusions, and recommendations for this investigation are presented in volume I. Research done under contract H0292009 by the Southwest Research Institute. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–195510; paper copy price code A06.

OFR 110(2)–84. Relationship of Underground Diesel Engine Maintenance to Emissions. Volume II, by Ronald Branstetter, Robert Burrahm, and Harry Dietzmann. Dec. 1983. 217 pp. 59 figs. Gaseous and particulate exhaust emissions from 20 diesel engines in service at 5 underground mines were measured with high-accuracy instrumentation. The engines were checked for faults or maladjustments. The vehicle and engine maintenance organization was studied at each mine and an idealized maintenance program was devised. Faults were induced in a new diesel engine to determine their effects on the characteristics of the exhaust emissions. Volume II contains a discussion of mine vehicle maintenance, references, a bibliography, and the appendixes. Research done under contract H0292009 by the Southwest Research Institute. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–195528; paper copy price code A10.

OFR 111–84. Demonstration of Fresnel Lens Blind Area Viewers on Large Underground Mine Vehicles, by James L. Eirls. Feb. 1983. 44 pp. 32 figs. The low profile, fresnel lens, blind area viewer (BAV) developed for use on large haulage vehicles in open pit mines was evaluated to determine the BAV's adaptability to the underground environment. The safety potential was verified at two test mines where operators found the BAV useful in observing well-lighted objects in otherwise normally blind areas, although limited clearance for large vehicles in some areas caused damage problems. The limited vehicular traffic in the underground mines did not emphasize the inherent value or cost effectiveness of the BAV on underground haulage as it did on large vehicles in open pit mines. Research done under contract J0215029 by Tracor MBA. Available for reference at the following facilities: AD/MR, AFOC/J, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, SRC, TCRC, and WFOC. Copies of this report will not be available for purchase.

OFR 112–84. Catalytic Chlorination of Alumina, by Y. K. Rao and M. K. Soleiman. Aug. 1983. 59 pp. 21 figs. This work is concerned with the kinetics of the chlorination process for making aluminum. The method investigated consisted of a conventional thermogravimetric unit comprised of a Cahn electrobalance and a vertical tube furnace. Small samples of Al_2O_3:3C mixtures were reacted with He-Cl_2 atmospheres under isothermal conditions. The reduction kinetics were deduced from the weight loss measurements. Temperature has a particularly strong effect on the reduction kinetics, suggesting that the chemical kinetic factors are very dominant in this system. The rate constant shows a first-order dependence on chlorine pressure at low temperatures (about 750° C), but the dependence becomes highly nonlinear at 900° C and above. The reaction kinetics were strongly improved by catalytic reagents, the foremost among these being the fluorides of sodium and calcium. The latter is inexpensive and potentially the most attractive of the catalytic additives found. The mechanism of catalysis involves complex mixed fluoride-chloride species acting as active intermediates. Research done under grants G1105054 and G1115531 by the University of Washington. Available for reference at the following facilities: AD/MI, AD/MMR, ALRC, AVRC, LIB, RERC, RORC, SLRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–196484; paper copy price code A04.

OFR 113–84. Processing of Mineral Fines by Column Flotation, by Kal V. S. Sastry. Sept. 30, 1982. 63 pp. 23 figs. Froth flotation is the most successful method of beneficiating mineral fines. The process is carried out in completely stirred vessels known as flotation cells. It was recently found that countercurrently operated flotation columns, with air bubbles uprising through downflowing slurry, show a definite potential to efficient and selective separation of fine particles. This report presents details and results from a research program that was directed toward understanding the principles governing the column flotation. Influence from a number of process variables was studied by using mixtures of finely ground dolomite and quartz. The column response was determined in terms of (1) recovery and grade of dolomite in the concentrate, and (2) holdup and solids concentration profiles within the column. The report includes a comprehensive analysis of the experimental results and the column flotation process. Research done under grant G1115062 by the University of California—Berkeley. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, SLRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 114–84. Erodibilities and Eroded Size Distribution of Western Kentucky Mine Spoil and Reconstructed Topsoil, by B. J. Barfield, R. I. Barnhisel, J. L. Powell, M. C. Hirschi, and I. D. Moore. Dec. 1983. 205 pp. 38 figs. The objective of this study was to develop data on the erodibility and size distribution of eroded sediment from mine spoil and reconstructed topsoils and subsoils typical of western Kentucky surface mined lands. Standard erosion plots were constructed of shale, subsoil, and topsoil at the Alston surface mine of Peabody Coal Co. Rainfall was developed using a plot-sized rainfall simulator. Each plot was evaluated under tilled and compacted conditions. One compacted condition was developed with a wheeled compactor and another

with a dozer and scraper pan. Runoff, sediment yield, and size distribution data were collected for each plot. Complete descriptions of each plot and the test apparatus and instrumentation are given. A discussion of the experimental procedures and data analysis procedures are included, and the results and conclusions are summarized. Research done under grants G1105069, G1115211, and G5195021 by the University of Kentucky. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 115–84. Elastic Stress Wave Propagation in Underground Hardrock Mining, by John B. Ligon and R. L. Whipple. Dec. 1983. 218 pp. 109 figs. Blast-induced stress waves propagating along the surface of a drift of an underground hard-rock mine were recorded and analyzed. Resistance strain gauges, accelerometers, and a velocity pickup were used to make the measurements. Although a full face blast was recorded, the stress waves were initiated by single borehole blasts for the majority of the project. A special instrument trailer was designed, constructed, and utilized during the project. A reliable strain wave transducer was developed to measure the stress waves propagating on the drift surface. A correlation study between strain and acceleration signals for P-waves was made that agreed well with theory. The use of stemming was found to reduce strain and acceleration magnitudes as predicted. Research done under grants G1105030 and G1115261 by the Michigan Technological University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 116–84. Performance and Test Criteria for DC Fuses—Phase I, by E. K. Stanek and D. O. Wiitanen. Mar. 1984. 177 pp. 46 figs. The goal of this research was the development and test criteria for dc fuses used in coal mines. Field tests were conducted in 10 coal mines in which transients were initiated on the dc system from which the parameters of the dc mine electrical power system could be determined. The data processing involved the use of a Fourier analyzer to filter noise and fit an exponential curve to the field waveforms. From this analysis it was possible to find the dc system resistance, inductance, and time constant. The survey of nationally recognized laboratories was conducted to establish that the recommended test criteria were practical. The development of test criteria for dc fuses used in mines was based on the measurement of parameters in the field, the survey of testing laboratories, literature searches, laboratory tests, etc. A computer program was written to analytically predict the parameters measured in the field. This approach has limitations but reasonable agreement with the results was obtained. A brief laboratory testing program was carried out to verify the practicality of the recommended criteria and establish the accuracy of the conclusions concerning dc fuse performance. Research done under contract J0328085 by Michigan Technological University. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-202662; paper copy price code A09.

OFR 117–84. Assesment of Dispersing Tracer Gas With Ventilation Air Stream To Detect Mine Fires, by Mervin D. Marshall. Oct. 1983. 69 pp. 25 figs. A remote heat-activated stench gas-tracer gas mine alarm system was developed to reduce the time between fire detection and personnel notification. The stench gas-tracer gas system contains ethyl mercaptan for personnel warning and a fluorocarbon for tracer gas detection by instrumentation. A system was also developed that can be interfaced with multiplex mine phones. In-mine tests were conducted and several systems were presently installed in a hard-rock mine. Research done under contract J0199031 by MSA Research Corp. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-202696; paper copy price code A04.

OFR 118–84. Stratiform Massive Sulfide Deposits in the Mt. Henry Clay Area, Southeast Alaska, by Jan C. Still. 1984. 65 pp. 8 figs. The Bureau of Mines in 1983 examined the Skagway B-4 Quadrangle in southeast Alaska for volcanic host rocks similar to those that host the stratiform world class Windy Craggy copper-cobalt-gold deposit located across the U.S.-Canadian border 50 miles to the northwest. Such rocks were found between the Jarvis and Boundary Glaciers in what is now called the Mt. Henry Clay area. This area was mapped and investigated for stratiform deposits similar to the Windy Craggy deposit. Investigations indicate that the Mt. Henry Clay area massive sulfide occurrences are stratiform, have a similar mineralogy, and are in a geologic setting similar to that of the Windy Craggy deposit. However, the Windy Craggy ore zone consists predominately of pyrrhotite-pyrite-chalcopyrite while the occurrences in the Mt. Henry Clay area consist predominately of barite-sphalerite-pyrite. During 1983 the Jarvis Glacier occurrences, which contain small amounts of cobalt, were discovered in the area by Bureau personnel; commercial mining personnel discovered the important Mt. Henry Clay zinc-copper-silver-gold deposit. Investigations indicate that the Mt. Henry Clay area is highly mineralized and a target for the discovery of stratiform massive sulfide deposits. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AD/MDA, AFOC/J, and LIB. Copies of this report will not be available for purchase.

OFR 119–84. Study of Availability and Composition of Metal Bearing Wastes, by R. Krishnaswamy. Apr. 13, 1984. 128 pp. 13 figs. Waste streams generated by mineral, metallurgical, and consumer industries carry in them recoverable metals or minerals of economic or strategic importance. This report summarizes the results of a study identifying the major waste streams, evaluating current practices of waste treatment, and their development requirements. Priorities are identified for the developmental work by assigning weightage factors from economic, strategic, and environmental importance as well as on the lead time that may be required for process development. The study covers the following industries and wastes in the United States: titanium extraction and fabrication, aluminum smelters, chromite-bearing refractory and foundry sand wastes, and spent and scrapped mercury batteries. Research done under contract J0134050 by N. H. Parker, P.E. & Associates. Available for reference at the

following facilities: ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-207091; paper copy price code A07.

OFR 120-84. Development of Foreign Economic Indices. Phase I for Philippines, by Alice M. Chieruzzi. Mar. 1983. 118 pp. 15 figs. This report presents the development of economic indices for the Philippines for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-208883; paper copy price code A06.

OFR 121-84. Development of Foreign Economic Indices. Phase I for Zambia, by Alice M. Chieruzzi. Apr. 1983. 92 pp. 12 figs. This report presents the development of economic indices for Zambia for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-208891; paper copy price code A05.

OFR 122-84. Low Glare Illumination System, by Charles W. Maus. Mar. 23, 1984. 88 pp. 25 figs. A low-glare illuminating system using fiber optics was developed for the Bureau of Mines. Fiber bundles transmit light from sources to luminaires. Light is from tungsten halogen lamps in two dichroic reflectors. Six lamps are housed together with a stepdown transformer in one enclosure. Three conceptual designs were made before development of the fiber optic concept. A fluorescent concept used two F8T5 lamps in a unique W-shaped reflector. The reflector gave the appearance of eight lamps. An incandescent concept used a rectangular solid plastic luminaire molded with a reflector and diffuse surface. A lamp enclosure was mounted on its end. The early fiber optic concept was changed for the final development. As finally produced, the luminaire had a lower profile and a curved underside for painting as a reflector. The top surface was abraded for diffusion. The lamp enclosure at first was for a single lamp. This was changed to six lamps in one enclosure for simplified wiring. Plastic fiber optic bundles were expensive to manufacture and economical glass fiber bundles were obtained. Nonelectrical fiber bundles make the system one of minimum electrical damage vulnerability. Research done under contract J0113006 by Mine Safety Appliances. Available for reference at the following facilities: ALRC, AVRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-207935; paper copy price code A05.

OFR 123-84. Development of a Machine Mounted Respirable Dust Monitor, by Richard M. Spooner and John L. Bennett. Mar. 1978. 82 pp. 9 figs. This report encompasses the fabrication of a prototype respirable dust sampler and detector assembly for mining machine-mounted dust monitoring application, the design and fabrication of support electronics, and laboratory testing as defined in phase I of the work. The hardware was fabricated in accordance with the phase I design and modified to improve the performance and to comply with customer requests. Modifications involved the filter media, electronic flow controller, motorized and manual lift mechanisms for the transitional heads, speed reducer for the filter media transfer drive, a power supply for each Geiger-Muller tube, and a pressure-sensitive taper roller bracket revision. The functional and environmental testing indicated the prototype hardware functioned within the specified requirements. Research done under contract H0166186 by the Bendix Corp. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-207927; paper copy price code A05.

OFR 124-84. Theoretical Investigation of Seismic Waves Generated in Mines, by Roy J. Greenfield. Sept. 1982. 77 pp. 33 figs. Theoretical studies were performed on the propagation of seismic waves by trapped miners through the overburden of coal mines. These studies formed the basis for a geophone array and instrumentation design for the reception and recording of signals from a trapped miner. The studies, coupled with field tests, enable the performance of the trapped miner seismic system to be placed into a probablistic framework. The results show that the system should be capable of detecting the signal from a trapped miner for ranges exceeding 1,000 ft. Studies were also performed on the use of in-mine geophones for locating trapped miners. The results indicate that this approach may have an advantage over geophones placed on the surface of mines in the situation when either the mine is very deep or surface seismic noise is very high. Research done under grant G1055044 by Pennsylvania State University. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, IFOC, LIB, MSHA,

NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–207919; paper copy price code A05.

OFR 125–84. Feasibility of Gold and Copper Mining in the Chugach National Forest, Alaska, by Gary E. Sherman and Uldis Jansons. July 29, 1983. 55 pp. 8 figs. Preliminary economic mining feasibility studies of gold and copper deposits were conducted by the Bureau of Mines to estimate the mining costs in the Chugach National Forest, AK, in 1982. Lode and placer gold mines and open pit and underground copper mines were modeled. Cost data for the lode and placer gold mines were based on actual operating costs when available. Cost estimates for the copper mines were obtained using the Bureau's cost estimating system and may fall within ±25 pct of the actual costs. Underground gold mining appears economically feasible for a deposit with reserves of 100,000 tons containing greater than 0.5 oz per ton over a 4-ft mining width. A gold price of $456 per ounce is required for the operation to break even. Placer gold mining operations of 100, 500, and 1,000 yd^3 per day were modeled. At a gold price of $400 per ounce, these operations would break even at grades of 0.03, 0.012, and 0.009 per ounce of gold, respectively. An 11,000-ton-per-day open pit copper mine appears to be economically borderline at metal prices of $0.70 per pound of copper, $0.37 per pound of zinc, $400 per ounce of gold, and $10 per ounce of silver. A 1,650-ton-per-day underground copper mine would require a copper price of $0.75 per pound and a zinc price of $1.96 per pound to be economic. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, IFOC, LIB, and WFOC. Copies of this report will not be available for purchase.

OFR 126–84. Investigation of Blast-Induced Underground Vibrations From Surface Mining, by Michael K. Phang, Thomas A. Simpson, and Robert C. Brown. Dec. 1983. 433 pp. 60 figs. The objective of this study is to evaluate an instrumentation and field monitoring program designed to record and monitor surface blasting effects on underground coal mine openings. Potential damage criteria and guidelines were developed by quantifying the relationship between identifying the nature and degree of underground vibrations and damage produced in a mine on the underground structure. To predict the characteristics of underground vibrations occurring from a surface blast, the propagation relations of underground vibrations from surface blasting were established through the use of measuring devices. Part of the study provides an approach to the design of an instrumentation and field monitoring program for use in investigating the damage criteria of surface blasting on underground coal mine openings. Research done under grants G5105008 and G5115011 by University of Alabama. Available for reference at the following facilities: AD/MR, DRC, IFOC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 127–84. A Bibliography on Surface Mine Blasting, by Thomas A. Simpson and Michael K. Phang. Apr. 1984. 41 pp. The apparent rise in the use of explosives by the mining, quarrying, and construction industries over the past few years has prompted increased research in blasting and the attendant noise and vibrations accompanying detonation. Reliable information is needed to develop guidelines that will ensure adherence to blast designs made for protecting lives and property. This bibliography comprises many references that could be useful to researchers investigating blasting techniques and procedures. Research done under grant G1134101 by University of Alabama. Available for reference at the following facilities: AD/MR, LIB, OSM, PRC/B, and TCRC. Copies of this report will not be available for purchase.

OFR 128–84. Mining Properties Acquisition Costs: Kantishna Hills and Dunkle Mine Study Areas, Denali National Park, Alaska, by Dowl Engineers and PLANgraphics, Inc. 1983. 179 pp. 7 figs. This report describes the methodology and results of estimating the overall mineral resource value and the present cost of acquiring mineral property interests in the Kantishna Hills and Dunkle Mine study area of Denali National Park and Preserve in south-central Alaska. Previous studies have underestimated the value of acquiring these properties. The cost of acquiring both placer and lode claims based on current market value is estimated to be about $157.2 million. The acquisition cost includes the value of the patented surface estate. Research done under contract S0134043. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, and LIB. Copies of this report will not be available for purchase.

OFR 129(1)–84. 1983 Mineral Resource Studies: Kantishna Hills and Dunkle Mine Areas, Denali National Park and Preserve, Alaska. Volume I. Text, ed. by Vance V. Thornsberry, Calvin J. McKee, and William G. Salisbury. Apr. 1984. 251 pp. 55 figs. In 1983, mineral resource studies were conducted in the Kantishna Hills and Dunkle Mine study areas of the Denali National Park and Preserve, AK. Fieldwork included geologic mapping, geochemical and geophysical surveys, placer studies, and drilling. The Kantishna Hills area contains an estimated 688,000 oz of placer gold in 43 million cubic yards of gravels. The gold was probably derived by erosion of precious-metal vein deposits. Lode mineralization appears to be principally related to the Spruce Creek Sequence of metamorphosed- and volcanosedimentary deposits that contain modest reserves of antimony, gold, silver, lead, and zinc in vein and stratiform deposits. The area also contains black shale and volcanic environments exhibiting newly identified evidence of stratabound base- and precious-metal mineralization. Regional geochemical anomalies indicate other potentially mineralized areas. Mineralization of the Dunkle Mine study area appears to be related to an igneous complex and two regional structural zones hosted by sedimentary, metasedimentary, and metavolcanic rocks. Geochemical and geophysical evidence suggests the igneous complex is permissive for the formation of potentially large-tonnage breccia pipe deposits containing copper and gold, and for poryphyry-type deposits of copper and molybdenum. Numerous small structurally controlled base- and precious-metal deposits are present in the area but none has yet proven to be economic in character. Up to 350,000 tons of coal may be present in Tertiary sedimentary deposits. Production from the Kantishna Hills study area through 1983 totaled 85,000 oz gold, 265,000 oz silver, 540,000 lb lead, and 4,400,000 lb antimony. The Dunkle Mine area has produced approximately

64,000 tons of coal. Research done under contract S0134031 by Salisbury & Dietz, Inc. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, LIB, and PRC/B. Copies of this report will not be available for purchase.

OFR 129(2)–84. 1983 Mineral Resource Studies: Kantishna Hills and Dunkle Mine Areas, Denali National Park and Preserve, Alaska. Volume II. Appendices, by Jeffrey H. Levell, Vance V. Thornsberry, William G. Salisbury, and David A. Smith. Apr. 1984. 809 pp. 195 figs. In 1983, mineral resource studies were conducted in the Kantishna Hills and Dunkle Mine areas of the Denali National Park and Preserve, AK. Fieldwork included geologic mapping, geochemical and geophysical surveys, placer studies, and drilling. The Kantishna Hills area contains an estimated 688,000 oz of placer gold in 43 million cubic yards of gravels. The Dunkle Mine study area appears to be related to an igneous complex and two regional structural zones hosted by sedimentary, metasedimentary, and metavolcanic rocks. Volume II of this three-volume report contains the appendices. Research done under contract S0134031 by Salisbury & Dietz, Inc. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, LIB, and PRC/B. Copies of this report will not be available for purchase.

OFR 129(3)–84. 1983 Mineral Resource Studies: Kantishna Hills and Dunkle Mine Areas, Denali National Park and Preserve, Alaska. Volume III. Plates, by Salisbury and Dietz, Inc. Apr. 1984. 20 pp. In 1983, mineral resource studies were conducted in the Kantishna Hills and Dunkle Mine areas of the Denali National Park and Preserve, AK. Fieldwork included geologic mapping, geochemical and geophysical surveys, placer studies, and drilling. The Kantishna Hills area contains an estimated 688,000 oz of placer gold in 43 million cubic yards of gravels. The Dunkle Mine study area appears to be related to an igneous complex and two regional structural zones hosted by sedimentary, metasedimentary, and metavolcanic rocks. Volume III of this three-volume report contains plates to be used in conjunction with volumes I and II. Research done under contract S0134031. Available for reference at the following facilities: AD/MDA, AFOC/A, AFOC/F, AFOC/J, LIB, and PRC/B. Copies of this report will not be available for purchase.

OFR 130–84. Development of a Deep-Penetrating Borehole Geophysical Technique for Predicting Hazards Ahead of Coal Mining, Phase II, by Sidney A. Suhler, Oren Tranbarger, and Merle E. Converse. Aug. 14, 1981. 87 pp. 44 figs. The objective of this work was to develop a deep-penetrating borehole geophysical technique for predicting hazards ahead of coal mining. Various methods were evaluated to determine their potential for detecting geological and work-related hazardous conditions and their practicability of implementation. The study indicated that a borehole pulse electromagnetic reflectometer (radar) had the most promise as a viable field technique. Based on the results, a borehole monostatic baseband pulse radar was designed, developed, and tested in prototype form. Field tests of the prototype model showed that underground features were detectable by the technique. Follow-on developments included the design and construction of an engineering model radar that would overcome the problems associated with the prototype model and also provide enhanced detection capabilities. These developments lead to an advanced design borehole radar system providing a directional antenna in a 3-in-diam probe. The information reported herein relates to the theory of operation, operating instructions, and maintenance procedures for the advanced design engineering model radar system. Research done under contract H0252033 by Southwest Research Institute. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-239599; paper copy price code A05.

OFR 131–84. Design, Develop and Demonstrate the Use of Hollow Cutter Bars/Evaluation of Wet Bar Techniques, by Terry Muldoon, Ken Heller, Gary Anderson, and John McCoy. Dec. 1983. 139 pp. 70 figs. Three dust control systems for use in noncoal room-and-pillar mining were designed, fabricated, and evaluated. The first system, a hollow cutter bar, was designed to capture dust in the kerf at the cutting zone. The system was marginally effective in reducing dust levels because of the lack of control over other sources. Large quantities of material captured by the system made it operationally questionable. The second system, a machine-mounted exhaust system, was extremely effective in capturing virtually all of the dust generated in the heading. The captured dust was ducted out of the heading and exhausted downstream in the crosscut. However, exhausting the dust without scrubbing creates problems for personnel working downstream of the cutting machine. Successful application would require changes to the mine ventilation system and mining sequence. The third system injected foam from an on-board generator through a channel to the cutting zone at the tip of the bar. Results showed that foam, using one-third to one-half the total fluid quantity, was equally effective when compared with the mine's current system. Research done under contract H0308049 by Foster-Miller, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-215045; paper copy price code A07.

OFR 132–84. Extension of Low Coal Canopy Technology To Include Drilling and Cutting Machines, by Hanns Billmayer. Aug. 15, 1983. 56 pp. 31 figs. Low coal canopies have been a source of controversy since their introduction into the mining industry. Canopies have been designed to protect the operator from roof falls and contact with the roof. In many cases, however, this protection has been achieved at the expense of operator visibility and ease of ingress and egress. The intent of this program was to improve the operator protection from numerous hazards and to improve the visibility, comfort, and ability to get in and out of the operator compartment without difficulty. Canopy hardware was built for a cutter and a face drill. Design improvements are described herein. Research done under contract H0318007 by Wyle Laboratories. Available for reference at the following facilities: DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-215052; paper copy price code A04.

OFR 133–84. Subsidence Over a Room-and-Pillar Coal Panel in Southern West Virginia, by T. Z. Jones

and K. K. Kohli. Sept. 1983. 77 pp. 10 figs. This study was sponsored by the Bureau of Mines as part of its ongoing subsidence research program. The study involved installation of surface survey monuments over a room-and-pillar panel in southern West Virginia, eastern coal province. Monitoring was conducted for a period of 6 months. Maximum subsidence was 1.48 ft and occurred near the center of a two-panel span, one of which was monitored as part of the study and the other adjacent to it. This is equal to 31 pct of the extracted coal height. The angle of draw over the pillared panels was 24°. The width-to-depth ratio over the pillared panels was 0.85. A maximum surface horizontal strain of 0.003 was detected near the center of the monitored panel. The overburden lithology consists of interlayered sandstone, shales, and coal with 50 pct of the overburden being sandstone layers 5 ft thick or greater. Research done under contract J0382010 by West Virginia Institute of Technology. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–220177; paper copy price code A05.

OFR 134–84. Coal Mine Hazard Detection Using Synthetic Radar, by James C. Fowler. Dec. 1983. 74 pp. 48 figs. The objective of this investigation was to develop and field test a prototype synthetic pulse radar system for in-seam hazard detection. The system consists of three major components: (1) the control unit, (2) the transmitter and antenna, and (3) the receiver and antenna. The system employs a hetrodyne receiver and two synthetizers that are phase-locked together with a 1-MHz offset. A fiber optic link is used to help eliminate direct feedthrough. The transmitted frequencies are in the 20- to 160-MHz range, with a minimum frequency spacing of 100 kHz, providing a time window of 10,000 ns. The system is packaged with self-contained batteries for in-mine use. A secondary processor was designed and breadboarded to display data in the field. This processor, or any other minicomputer, can access the system using standard serial or parallel interfaces. The work was based upon the results of a previous Bureau of Mines contract, "Coal Mine Hazard Detection Using Synthetic Pulse Radar," OFR 79–81. This report summarizes the previous work, describes the results of four field tests, and discusses the advantages and disadvantages of this new type of radar. Research done under contract H0212016 by XADAR Corp. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84–220672; paper copy price code A04.

OFR 135–84. Development and Evaluation of Near-Mine Stimulation Techniques for Coalbed Degasification, by G. W. Murrie, J. T. Popp, C. M. McCulloch, and D. J. Steele. May 1984. 127 pp. 52 figs. The purpose of this project was to determine the effects of foam stimulation treatments on mining conditions in underground coal mines. Underground investigations were conducted to characterize the geological and mining conditions both before and after the holes were stimulated. Of 12 holes that were drilled at minesites in Kentucky, Pennsylvania, Utah, and West Virginia, 4 were mined through and mining progressed within 75 ft of a fifth before mining plans were altered because of unassociated reasons. The fracture fluids were tagged with fluorescing paint pigments to enable their underground pathways to be detected with an ultraviolet light and accurately mapped. At the holes that were intercepted by mining, the induced fractures were all contained within the coal seams. Horizontal fracturing at the seam-roof interface and along an inseam binder was more extensive than the vertical fracturing, which was confined primarily to the more friable portion of the seam. The mining conditions, roof, floor, and support requirements were unaffected by the stimulation treatments. Research done under contract J0333908 by Dames & Moore. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–220664; paper copy price code A07.

OFR 136–84. Ultralightweight Oxygen Container, by Ben Aleck. Nov. 1983. 32 pp. 15 figs. Technology to develop high-pressure gas cylinders that are 40 pct lighter than comparable fiberglass-wrapped aluminum cylinders was developed. The new cylinders were of cryobulged stainless steel overwrapped with a higher strength-to-weight ratio filament. Although a 40-pct decrease is significant, the weight savings on smaller cylinders, such as those used in escape apparatus, is very small and would not be cost effective. Open-circuit apparatus that use large bottles, such as for firefighting, would find weight savings worth pursuing. Research done under contract J0100043 by Grumman Aerospace Corp. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84–220730; paper copy price code A03.

OFR 137–84. Fundamental Investigation of Phosphate Bonding, by James F. Benzel. Nov. 1983. 72 pp. 25 figs. This investigation utilized single crystals to study phosphate bonding, eliminating surface area and particle shape as variables and allowing the effect of crystallographic orientation to be evaluated. The morphology of the reaction products when H_3PO_4 was reacted with alumina single crystals was related to the crystal face index. Star-shaped dendrites formed on the low index faces and equiaxed crystals formed on faces that did not correspond to low index planes and polycrystalline samples. The tensile strength of $(11\bar{2}0)$ and (0001) alumina bicrystals increased as their surface finish was improved. The tensile strength of $(11\bar{2}0)$ alumina bicrystals bonded with $NaH_2PO_4 \cdot H_2O$ or Glass H are greater than (0001) bicrystals produced under the same conditions. The tensile strength of $(11\bar{2}0)$ alumina bicrystals bonded with $NaH_2PO_4 \cdot H_2O$ varies with the amount of rotational mismatch between the crystals. Strength maximums occurred at 0° and 180° and a minimum of 90°. It appears that this strength pattern is related to the twofold symmetry of this plane. Combination of both rotational and tilt mismatch reduced the strength of $(11\bar{2}0)$ and (0001) bicrystals to almost zero. The strength decreases associated with these types of bicrystal mismatches could be related to differences in thermal expansion with direction or bond misalignment. Research done under contract J0123041 by Georgia Institute of Technology. Available for

reference at the following facilities: ALRC, AVRC, LIB, and PRC/B. Order ONLY from NTIS: PB 84–220748; paper copy price code A04.

OFR 138(1)–84. The Development of Guidelines for Closing Underground Mines: Executive Summary. by Allan M. Johnson, Linneas W. Laage, and Donald James Butler. Dec. 31, 1983. 40 pp. Case histories were used to document and evaluate deficiencies in underground mine closures that have resulted in postoperation problems such as subsidence shaft failures, acid or toxic water drainage, and others. Three underground mining districts in the United States were investigated: (1) An iron mining district in Michigan, (2) coal mining districts in eastern Ohio and southern Illinois, and (3) three metal mining districts in central Colorado. The studies show that problems from acid water drainage, subsidence, and inadequately protected mine shafts are the most severe and widespread. Suggestions of a technical nature are presented as partial solutions to some of these problems. It was determined that preclosure evaluations could result in the identification of some potential problems that may occur after a mine is closed. Early recognition of the problems would be an advantage because of the options available to mine operators to either prevent them or to plan for their occurrence. Mine closure and reclamation should be considered as a part of mining and be incorporated in the mining plan, which would result in reduced environmental impact and would be achieved at a lower overall cost. Research done under grants G1105033 and G1115262 by Michigan Technological University. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 138(2)–84. The Development of Guidelines for Closing Underground Mines: Colorado Districts, by Donald James Butler. 1983. 164 pp. 57 figs. The purpose of this research was to study mine-related problems in several underground mining districts with the goal of developing guidelines or suggestions for improved closing procedures for underground mines that would reduce or eliminate these problems. This report documents conditions of closed underground mines in three Colorado mining districts—Leadville, Westcliffe, and Cripple Creek-Victor. Research done under grants G1105033 and G1115262 by Michigan Technological University. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 138(3)–84. The Development of Guidelines for Closing Eastern Underground Coal Mines, by Linneas W. Laage. 1982. 143 pp. 41 figs. The purpose of this research was to study mine-related problems in several underground mining districts with the goal of developing guidelines or suggestions for improved closing procedures for underground mines that would reduce or eliminate these problems. This report documents conditions of closed underground mines in three eastern coal mine districts—two in Ohio and one in Illinois. Research done under grants G1105033 and G1115262 by Michigan Technological University. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 138(4)–84. The Development of Guidelines for Closing Underground Mines: Michigan Case Histories, by Allan M. Johnson. Dec. 1983. 132 pp. 51 figs. The purpose of this research was to study mine-related problems in several underground mining districts with the goal of developing guidelines or suggestions for improved closing procedures for underground mines that would reduce or eliminate these problems. This report documents conditions of closed underground mines in the Menominee Range of northern Michigan. Research done under grants G1105033 and G1115262 by Michigan Technological University. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 139–84. The Use of Coal Wastes for the Production of Alumina, by H. Y. Sohn. Dec. 29, 1983. 71 pp. 31 figs. The United States has become more and more dependent on foreign sources for bauxite, the primary source for aluminum at the present time, because its bauxite resources are considered inadequate as a long-range supply. However, domestic low-grade aluminum resources, including coal wastes, are considered unlimited. The development of a suitable method for using coal wastes for alumina extraction will also alleviate coal waste disposal problems. This report describes three methods of extracting alumina from domestic coal wastes using their carbon contents as a fuel and a reductant of silica contained therein. Research done under grants G1105089, G1115493, and G1195049 by the University of Utah. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, RERC, and TURC. Order ONLY from NTIS: PB 84–223460; paper copy price code A04.

OFR 140–84. Development of Engineering and Cost Data for Foreign Gold and Silver Properties, by Robert E. Green and Derek J. Ottley. Jan. 7, 1983. 49 pp. This paper comprises 107 technical and profile reports on major gold and silver mines and deposits of the world, exclusive of the United States and the centrally controlled economy countries. The evolving mine and deposit lists and the accompanying criteria classifications are explained along with verifications and justifications for adding or deleting specific mines or deposits to the lists. Tabulated summaries of property data include reserves and resources, assays, production, and operating costs. Figures for specific mines and deposits are given in ranges of values to protect the confidentiality of individual owners and operators. Research done under contract J0215039 by Davy McKee Corp. Available for reference at the following facilities: AFOC/J, DRC, LIB, IFOC, SRC, and WFOC. Order ONLY from NTIS: PB 84–229004; paper copy price code A03.

OFR 141–84. Development of Environmentally Attractive Leachants. Volume II, An Experimental and Theoretical Study of Uranium and Pyrite Dissolution Kinetics, by Robert S. Schechter, Larry W. Lake, and Terry R. Guilinger. Feb. 29, 1984. 549 pp. 153 figs. This report describes the results of flow tests on the rate and ultimate yield of uranium and pyrite leaching

under conditions representative of carbonate in situ uranium leaching. The effects of cation type, pH, carbonate and oxygen concentrations, and flow rate were investigated for uranium leaching. Leachant cation, pH, and carbonate concentration had little effect on uranium leaching, but the leaching rate depended on oxidant concentration to ½ order. The insensitivity to cation type led to a new process whereby the leach solution is preceded by a preflush containing the chloride of the leaching cation. The preflush prevented permeability losses associated with carbonate precipitation and clay swelling caused by certain cations. The effects of leachant cation, pH, carbonate and oxidant concentration, and particle size were also studied for pyrite leaching. The reaction products were elemental sulfur, thiosulfate, sulfate, and an unidentifiable sulfur species. The fate of iron was geothite, amorphous iron, oxyhydroxides, and lepidocrocite. Research done under contract H0282016 by the University of Texas—Austin. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-232669; paper copy price code A23.

OFR 142–84. Effects of Longwall Mine Subsidence on Overlying Aquifers in Western Pennsylvania, by D. Pennington, J. G. Hill, G. J. Burgdorf, and D. R. Price. May 1984. 130 pp. 58 figs. Ground water levels and subsidence were monitored over a longwall panel of a deep coal mining operation in western Pennsylvania. The monitoring network includes 11 ground water monitoring wells completed to measure water level changes in separate shallow and deep aquifer zones and 50-ft surveyed subsidence stations parallel and perpendicular to the panel centerline. Monthly monitoring data were collected during the premining, mining, and postmining time periods. Aquifer testing and borehole geophysical logging were conducted during premining and postmining conditions to document any changes in aquifer properties and ground water flow patterns. Results indicate ground water declines were located with respect to the mining face and mined longwall panel. Dewatering of the deep aquifer zone caused a significant water level decline in deep wells; however, the shallow aquifer zone was isolated from major impacts by an aquitardal layer during the 1-yr period. Transmissivity data were greatly impacted by fracturing in the highly anisotropic aquifer system. Borehole geophysical logging indicated changes in ground water flow patterns and zones of increased fracturing from subsidence. Research done under contract J0199063 by SMC Martin Inc. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 84-236710; paper copy price code A07.

OFR 143–84. Development of Commercial Quiet Rock Drills, by Piyush K. Dutta and Peter W. Runstadler, Jr. Sept. 1983. 114 pp. 44 figs. This report describes the design, development, and manufacture of production stoper drills and the results of their field tests. It is shown that underground stoper drill noise level can be reduced from 118 dBA to below 100 dBA by using pneumatic drills. The design concept of these drills is a radical departure from the standard valved rifle bar type drill machine design to a drill featuring a valveless independent rotation system, use of an integral muffler, and a shroud tube. Six drills were manufactured in a standard commercial drill manufacturing setup and organization. The design and production technology proved that commercially viable quiet drills can be made available for mine use. Research done under contract J0177125 by Creare Products Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, MSHA/P, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-232644; paper copy price code A06.

OFR 144–84. Low-Profile Portable Crusher for Underground Mining Applications: Construction and Testing, by H. Miller, S. Cobey, and J. Murphy. June 15, 1983. 126 pp. 45 figs. This report presents the results of a development and testing program for a portable low-profile crusher. The unit has an extremely low vertical profile considering its size and capacity. The crushing jaws that form the crushing chamber are inclined, with the lower jaw mounted for eccentric movement relative to the stationary upper jaw. This provides efficient crushing while also forcing material through the crushing chamber. As a result, the inlet feeder can be disposed horizontally. To facilitate correct processing of different materials, the size of the discharge opening and the action of the movable crushing jaw are variable. The unit also incorporates a feeder hopper and discharge conveyor that provides for efficient ore handling through the machine. Tests demonstrated the crusher's high capacity, efficiency, and reliability. During testing, the unit crushed over 120,000 tons of materials of up to 32,000 psi compressive strength at production rates in the 200- to 350-ton/h range. The unit operated smoothly under simulated low-headroom conditions and proved readily transportable. Research done under contract H0282037 by Eagle Crusher Co., Inc. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-232578; paper copy price code A07.

OFR 145–84. National Prototype Copper Mining Water Management Plan, by Jacqueline V. Rich. Aug. 1, 1983. 153 pp. 17 figs. The objective of this study was to develop best management practices for the use of water at mines in the Globe-Miami, AZ, copper mining district. This paper, the concluding report in a series of 10, investigated the relationship between surface and ground water quality and copper mining. Methods to prevent, minimize, mitigate, or treat polluted water were identified and evaluated. Best management practices are incorporated in a recommended plan to manage the area's water quality. Research done under contract J0205039 by the Central Arizona Association of Governments. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-232586; paper copy price code A08.

OFR 146–84. Restoration of Groundwater Quality After In Situ Uranium Leaching, by Jerry R. Riding and Frank J. Rosswog. Aug. 1979. 363 pp. 63 figs. In situ solution mining of uranium has several environmental advantages over other mining techniques. The leaching of uranium, however, alters the

ground water in the aquifer where the leaching occurs. A requirement of the mining technique is the control of objectionable materials that are introduced into the water. This report reviews the state of the art in restoring ground water quality. Current restoration practices discussed include disposal wells and solar evaporation ponds. Sweeping techniques by producing waterflow from all wells during restoration and recirculating techniques by recharging water from a surface purification plant are evaluated. Methods for predicting the effectiveness and costs of current methods are presented. Possible alternatives for restoration of the ground water quality are described. Research done under contract J0275028 by Ford, Bacon & Davis Utah Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-232875; paper copy price code A16.

OFR 147-84. Front-End Loader Training System, by Jane Applegate and Kristine Krupp. Dec. 1983. 110 pp. 45 figs. This report documents efforts to design, develop, and test a training approach that would assist front-end loader operators in the acquisition of skills and awareness to reduce the probability of their involvement in accidents in the mining environment. The goal of this project was to prepare and use, on a trial basis, a training method and materials that would be generally applicable to any loader and surface mining operation while at the same time be adjustable by mine personnel to meet the specific needs of each mining operation. This resulted in the Front-End Loader Training System, a structured, performance-based training approach with diverse instructional aids and classroom and on-machine training experiences. Validation of the system at a large western mine demonstrated the utility and flexibility of the training approach and materials. Research done under contract H0308034 by Woodward Associates, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-232594; paper copy price code A06.

OFR 148-84. Roof Bolt Anchorage Quality Indicator/Tension Decay Equalizer, by Anil Mahyera and A. H. Jones. Nov. 1983. 158 pp. 131 figs. This report presents the results of a laboratory and field research program to design and develop a torque-thrust controlled bolter with the capability to (1) predict the "quality of anchorage" attained while installing mechanical anchor roof bolts and (2) improve the uniformity and tension levels achieved among a group of roof bolts. The prediction accuracy of the anchorage quality algorithm ranged from low to moderate because of the complexity and variability of the phenomena involved. The best roof support with mechanical anchor bolts was achieved by simply installing them under proper torque-thrust control with a hardened washer under the bolthead. The results showed a threefold uniformity improvement and a 75% increase in mean tension levels over conventionally installed roof bolts. Research done under contract H0282047 by Terra Tek, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 84-231455; paper copy price code A08.

OFR 149-84. Development and Validation of a Training Program for Operators of Underground Non-Coal Equipment, Volume I, by Chuck Semple. Feb. 1984. 98 pp. 4 figs. This report describes the development of training materials for the operators of underground mining equipment in the underground metal and nonmetal mining industry. The objective was to determine the effectiveness and acceptability of these training materials and to provide the validated training materials to the industry. Ten modules were developed, based on industry need according to accident frequency, accident severity, and exposure to equipment. The final modules were an average 20 min long and used slides with synchronized narration on cassette tapes. Testing materials are included for use by the mines. Research done under contract H0308067 by the Canyon Research Group. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-237205; paper copy price code A05.

OFR 150-84. Monitoring and Control of Mine Air Diesel Pollutants: Tailpipe Emissions Measurements, Aftertreatment Device Evaluation and Quantification of Diesel and Coal Fractions of Particulate Matter With Raman Spectroscopy, by John H. Johnson, David H. Carlson, Mark D. Osborne, Edward O. Reinbold, Bahne C. Cornilsen, and Veeryooth Lorprayoon. Nov. 15, 1982. 182 pp. 56 figs. The objective of this research was to provide engineering guidelines and methodologies for the control of air quality in dieselized underground mines. The work includes investigations of the interrelationship between ventilation and diesel operational and control parameters, develops measurement technology and methods, and evaluates emission control devices specific to the operation of diesels in dead-end entries. The report includes a description of the emissions measurement apparatus, monitoring methods and evaluation, evaluation of on-board CO_2 monitors, selective analysis for diesel soot in coal mine dust samples, exhaust control techniques using a mine air quality laboratory, and technical papers. Research done under contract J0199125 by Michigan Technological University. Available for reference at the following facilities: AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 84-239151; paper copy price code A09.

OFR 151-84. Placement and Evaluation of High-Modulus Backfill, by Koehler Stout, Leroy Friel, Edward Van Eeckhout, and Brian Woodward. Aug. 11, 1983. 208 pp. 94 figs. Previous work indicates that hydraulically placed backfill can be strengthened severalfold by various placement methods. Sunshine mill tailings were tested by these placement methods and strength increases up to 30 times over the ordinary placement methods were achieved. A computer simulation study of the test stope in the Sunshine Mine showed that a high-modulus fill absorbs up to 27 pct of normal stresses versus 7 pct for normal fill while reducing maximum convergence 28 pct versus 8 pct for normal fill. Although high-modulus fill was not placed in the test stope during this research, various instrumentation was pur-

chased, designed, and built to record necessary data in the stope. Stress gauges were placed in the pillars and recorded data corresponded closely with theoretical projections. Research done under contract J0295052 by Montana College of Mineral Science and Technology Alumni Foundation. Available for reference at the following facilties: AD/MR, DRC, LIB, MSHA, NMH&SA. OSM, PRC/B, and TCRC. Order ONLY from NTIS: PB 84-239144; paper copy price code A10.

OFR 152-84. Minerals Availability Directory of Mineral Deposits for 23 Strategic Mineral Commodities, by Luis V. Coppa and Carl A. DiFrancesco. May 1984. 216 pp. 7 figs. This Bureau of Mines open file report is a directory of 23 major mineral commodities, both foreign and domestic. Nonconfidential information from the Advanced Deposit Information and Tracking System data base covering worldwide market economy country mineral properties being evaluated by the Division of Minerals Availability have been abstracted for use in this report. Abstracts include applicable data on location, commodities present, company name, mining method, and operational status. Research done by the Division of Minerals Availability. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 84-239185; paper copy price code A10.

OFR 153-84. Development of Foreign Economic Indices. Phase I for Australia, by Alice M. Chieruzzi. Dec. 1982. 171 pp. 20 figs. This report presents the development of economic indices for Australia for the period from 1965 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-103703; paper copy price code A08.

OFR 154-84. Development of Foreign Economic Indices. Phase I for Bolivia, by Alice M. Chieruzzi. Dec. 1983. 114 pp. 5 figs. This report presents the development of economic indices for Bolivia for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight fctors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-103687; paper copy price code A06.

OFR 155-84. Development of Foreign Economic Indices. Phase I for Canada, by Alice M. Chieruzzi. Dec. 1982. 44 pp. 4 figs. This report presents the development of economic indices for Canada for the period from 1965 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-104321; paper copy price code A08.

OFR 156-84. Development of Foreign Economic Indices. Phase I for Chile, by Robert Smith. Oct. 1983. 141 pp. 8 figs. This report presents the development of economic indices for Chile for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-104495; paper copy price code A07.

OFR 157-84. Development of Foreign Economic Indices. Phase I for Germany, F.R., by Alice M. Chieruzzi. Jan. 1983. 103 pp. 12 figs. This report

presents the development of economic indices for the Federal Republic of Germany for the period from 1965 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-104446; paper copy price code A06.

OFR 158-84. Development of Foreign Economic Indices. Phase I for Greece, by Alice M. Chieruzzi. Dec. 1983. 97 pp. 13 figs. This report presents the development of economic indices for Greece for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-103695; paper copy price code A05.

OFR 159-84. Development of Foreign Economic Indices. Phase I for Guatemala, by Robert Smith. Dec. 1983. 77 pp. 6 figs. This report presents the development of economic indices for Guatemala for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-106854; paper copy price code A05.

OFR 160-84. Development of Foreign Economic Indices. Phase I for Japan, by Alice M. Chieruzzi. May 1983. 88 pp. 11 figs. This report presents the development of economic indices for Japan for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-152445; paper copy price code A05.

OFR 161-84. Development of Foreign Economic Indices. Phase I for Jordan, by Alice M. Chieruzzi. Dec. 1983. 129 pp. 17 figs. This reports presents the development of economic indices for Jordan for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-107688; paper copy price code A07.

OFR 162-84. Development of Foreign Economic Indices. Phase I for Morocco, by Clifford F. Zinnes. Dec. 1982. 148 pp. 11 figs. This report presents the development of economic indices for Morocco for the period from 1965 through 1981. The work was

done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-107936; paper copy price code A07.

OFR 163-84. Development of Foreign Economic Indices. Phase I for Peru, by Robert Smith. Oct. 1983. 144 pp. 9 figs. This report presents the development of economic indices for Peru for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-105914; paper copy price code A07.

OFR 164-84. Development of Foreign Economic Indices. Phase I for South Africa, by Alice M. Chieruzzi. Dec. 1982. 178 pp. 18 figs. This report presents the development of economic indices for the Republic of South Africa for the period from 1965 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-106540; paper copy price code A09.

OFR 165-84. Development of Foreign Economic Indices. Phase I for Sweden, by Alice M. Chieruzzi. May 1983. 85 pp. 9 figs. This report presents the development of economic indices for Sweden for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-152452; paper copy price code A05.

OFR 166-84. Development of Foreign Economic Indices. Phase I for Syrian Arab Republic, by Robert Smith. Dec. 1983. 84 pp. 4 figs. This report presents the development of economic indices for the Syrian Arab Republic for the period from 1970 through 1981. The work was done through the Bureau of Mines Minerals Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair costs, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-107027; paper copy price code A05.

OFR 167-84. Development of Foreign Economic Indices. Phase I for United Kingdom, by Clifford F. Zinnes. May 1983. 94 pp. 10 figs. This report presents the development of economic indices for the United Kingdom for the period from 1970 through 1981. The work was done through the Bureau of Mines Miner-

als Availability Program under contract. The contract calls for the development of 12 index time series describing factor input costs in the mining sector of 95 countries. The index time series describe the costs of (1) mining wages, (2) construction wages, (3) equipment and repair parts, (4) bits and related steel, (5) timber and lumber, (6) fuel, (7) powder and blasting agents, (8) tires, (9) construction materials, (10) industrial materials, (11) transportation, and (12) electrical power. The indices were developed primarily for use in the Bureau's Minerals Availability Program in assessing the worldwide availability of nonfuel minerals and, when combined with weight factors being developed by Bureau personnel, will be used to perform instantaneous updates of all costs relating to the mining industry. Research done under contract J0225001 by Phoenix Associates, Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, OSM, and WFOC. Order ONLY from NTIS: PB 85-103745; paper copy price code A05.

OFR 168-84. Geostatistics for Resource/Reserve Estimation, by Luis V. Coppa, Eric K. Green, and Choon K. Quan. June 1984. 116 pp. 43 figs. Since its inception in 1910, the Bureau of Mines has been the principal Federal agency involved in ore reserve estimations using such traditional methods as polygons of influence and variations of inverse distance weighting. While adequate for estimating the average ore grades in a mining block or section, these methods do not provide a consistent way of quantifying the reliability of the estimates. This report describes a technique for enhancing ore reserve estimations using geostatistics, the methodology of which combines the spatial and random aspects of geologic phenomena into a formal theoretical framework for deriving the estimation variance of ore reserves. Correctly used, geostatistics enables confidence intervals to be placed around ore reserve estimates calculated from drill hole data. A geostatistical software system was obtained from the U.S. Geological Survey and installed, after slight modifications, on the Bureau's Wang computer. System testing and validation were conducted using a simple textbook-type example. This was then followed by variogram analysis, point kriging, and block kriging of data from a previously worked section of a uranium mine. Kriging provides the best linear unbiased estimator in the sense that its estimation variance (kriging variance) is a minimum. The kriging variance then determines the accuracy of a reserve estimate and the risk associated with a financial decision based on that estimate. Research done by the Division of Minerals Policy and Analysis and the Division of Minerals Availability. Available for reference at the following facilities: AD/MDA, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-105781; paper copy price code A06.

OFR 169-84. The Development of Engineering and Cost Data for Foreign Graphite Properties, by Thomas P. Oxford. Feb. 1984. 19 pp. Natural graphite is used in a wide variety of applications where its unique physical, thermal, and electrical properties are exploited. Availability products are broadly classified as either crystalline or amorphous. The Sonora district of northwestern Mexico is the most important supplier of amorphous graphite to the United States. Crystalline flake varieties are available from Canada, Brazil, Madagascar, India, the Republic of Korea, Mexico, Norway, the Federal Republic of Germany, and Zimbabwe. Lump graphite is available from Sri Lanka. Ore is retrieved from both underground and open pit sources, and froth flotation is the primary upgrading process. This report summarizes studies on graphite completed under contract and is presented as a project overview. The number and description of various technical reports that were prepared and submitted are outlined. Various property list changes implemented by contract modifications are noted. Methods of data acquisition and analyses are described and useful findings of the studies are discussed. Difficulties and problems experienced during the project are highlighted, providing hints for improvement to future Minerals Availability Program commodity studies. Research done under contract J0225019 by Zellars-Williams, Inc. Available for reference at the following facilities: AD/MDA, AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-103737; paper copy price code A02.

OFR 170-84. Development of Engineering and Cost Data for Foreign Fluorspar Properties, by Robert B. Fulton III, Gill Montgomery, Mary L. Pearson, and Richard Waissar. May 1984. 43 pp. This report presents summaries of data and estimates for 52 fluorspar properties in Mexico, Thailand, China, Morocco, Tunisia, Italy, Spain, the Republic of South Africa, France, the United Kingdom, Kenya, Namibia, and the Federal Republic of Germany. Data include deposit type, resource tonnage and grades, mining and beneficiation methods, annual production, fluorspar products and byproducts, work force requirements, and capital and operating cost estimates. For operating properties, engineering and cost data were developed for present and anticipated levels of production. Hypothetical operations were assumed for undeveloped deposits. Research done under contract J0225010 by Dames & Moore. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-103729; paper copy price code A03.

OFR 171-84. Minerals Availability Nickel Deposit Abstracts, by William L. Rice. July 1984. 451 pp. This Bureau of Mines open file report on nickel is one of a series of minerals availability commodity deposit abstracts. Nonconfidential information from the Minerals Availability Program data base covering domestic and foreign nickel properties and deposits has been abstracted for use in the report. Abstracts include applicable data on location, published reserves and resources, geology, mine and beneficiation systems, and operation information. Research done by the Western Field Operations Center. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-107613; paper copy price code A20.

OFR 172-84. Characterization of Georgia Kaolins as Ores of Aluminum, by John E. Husted. Sept. 1983. 178 pp. 256 figs. Quantities of kaolin in Georgia in contiguous or single bodies were established by previous work to be sufficient for an alumina industry. The need for characterization of this kaolin to determine its suitability as an ore of aluminum resulted in the studies described herein.

It was determined in an area about 7 by 27 miles, known as the Wren district, that approximately 5.9 billion short tons of kaolin averaging 35.55 pct Al_2O_3 exists in an essentially continuous clay body. The Macon-Sandersville district consists of discontinous kaolin bodies averaging 35.28 pct Al_2O_3 with an average thickness of 28 ft. Tonnages for this district were not available. One hundred and twenty core samples of kaolin were analyzed for K_2O, CaO, MgO, Al_2O_3, TiO_2, Cr_2O_3, Fe_2O_3, SiO_2, P_2O_5, and F. The P_2O_5 and F were analyzed by wet chemistry methods, and the others were analyzed by electron microprobe. Seventy-nine of the samples were from the Wrens district, 40 were from the Macon-Sandersville district, and 1 was from the Andersonville district. Emission spectroscopic analyses were made to qualitatively determine all elements present for each core. X-ray diffraction studies were made of each core to determine mineral species present. Scanning and transmission electron microscope pictures are given for each core sample. Elevations, overburden thickness, and kaolin thickness are given for each core site as well as map locations. Isopachs for overburden and kaolin thickness are given for the Wren district. Research done under contract J0188120 by Georgia Institute of Technology. Available for reference at the following facilities: ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 173–84. Stream Sediment, Float, and Bedrock Sampling in the Porcupine Mining Area, Southeast Alaska, by Jan C. Still. 1984. 20 pp. 3 figs. The Bureau of Mines in 1983 collected stream sediment, float, and bedrock samples in the Porcupine mining area near Haines in southeastern Alaska. The samples were collected for possible indications of massive sulfide mineralization similar to that found at the world class Windy Craggy copper-cobalt-gold deposit near the United States-Canadian border, 50 miles to the northwest. Such indications were found at several locations. Samples collected in the Mosquito Lake vicinity contained up to 360 ppm Pb, 210 ppm Co, 0.033 ppm Au, and 1.437 ppm Ag; samples collected in the Porcupine Road vicinity contained up to 1,300 ppm Zn, 280 ppm Pb, 100 ppm Co, 0.092 ppm Au, and 1.437 ppm Ag; samples collected at scattered locations between the Tsirku River and Jarvis Glacier contained up to 770 ppm Zn, 1,400 ppm Cu, 310 ppm Pb, 310 ppm Co, 0.186 ppm Au, and 3.686 ppm Ag. Also, a sample collected in Little Boulder Creek contained 870 ppm Zn, 400 ppm Cu, and 100 ppm Pb while a sample collected in Muncaster Creek contained 1,500 ppm Cu, 360 ppm Co, 0.165 ppm Au, and 1.881 ppm Ag. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Copies of this report will not be available for purchase.

OFR 174–84. Columbium in the Gold- and Tin-Bearing Placer Deposits Near Tofty, Alaska, by D. D. Southworth. 1984. 25 pp. 5 figs. The Tofty mining district, near Manley Hot Springs in north-central Alaska, has been the scene of placer gold mining since 1906 and has produced more than 100,000 tr oz of gold and several hundred tons of byproduct tin, in the form of placer cassiterite. Although opencut mining methods are currently employed, drift-mining methods were formerly utilized to mine the gold- and tin-bearing gravels. As part of the current Bureau of Mines Alaska-wide assessment of critical and strategic minerals, splits of concentrate samples collected in the 1950's from 11 tailings piles representative of the presently inactive Tofty drift mines were reanalyzed in 1983 for tantalum and columbium (niobium). Most of these concentrates contained between 0.2 and 4.5 pct Nb. Tantalum was detected, but not measured, in only three samples. Relatively higher average niobium values from tailings piles on either side of a small hill suggest a possible intrusive source there at shallow depth. Niobium occurs in the Tofty area in the mineral columbite that could be recovered as a byproduct during placer mining of gold and/or tin. An estimated 100,000 lb of recoverable Nb_2O_5 are inferred to be present in the Tofty placer deposits. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/J, ALRC, IFOC, LIB, RERC, and WFOC. Copies of this report will not be available for purchase.

OFR 175–84. Cobalt-Bearing Deposits Related To Mineral Terranes of Alaska, by William S. Roberts. 1984. 10 pp. 1 fig. Cobalt minerals or anomalous concentrations of cobalt associated with sulfide minerals have been identified in 21 deposits in Alaska. Undoubtedly other deposits exist, but there has been little economic incentive to search for cobalt in Alaska and none has been produced. In the known deposits, cobalt occurs in trace amounts recoverable only if the deposit is mined for other minerals and if the cobalt can be concentrated during mining and milling. Two of the known cobalt occurrences (Brady Glacier and Yakobi Island) are in large copper-nickel deposits. A third (Bornite) is associated with a large copper sulfide deposit. A fourth occurrence (Jarvis Glacier) was recently discovered in a geologic setting possibly favorable for massive sulfide deposits similar to the Windy-Craggy copper-cobalt deposit in nearby British Columbia, Canada. Seventeen of the known cobalt occurrences are in mineral terranes that have been mapped as favorable for finding cobalt. Four of the occurrences are in areas where information had been too scanty to map terranes. This emphasizes both the lack of data on Alaskan mineral resources and the need to periodically update the mineral terrane maps. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AD/MDA, AFOC/J, ALRC, IFOC, LIB, RERC, and WFOC. Copies of this report will not be available for purchase.

OFR 176–84. Geologic and Geochemical Investigation of the "Nail" Allochthon, East-Central Alaska, by D. D. Southworth. 1984. 26 pp. 1 figs. The "Nail" allochthon, east-central Alaska, was investigated by the Bureau of Mines in cooperation with the State of Alaska, Div. of Geological and Geophysical Surveys', as part of an effort to develop more definitive information on Alaska's critical and strategic mineral reserves. The peridotites and former peridotites in the vicinity of the vertical angle bench mark Nail constitute an approximately 8-mile-long, 2,000-ft-thick thrust sheet of probable Permian age that overlies a complex assemblage of Paleozoic(?) greenschist-facies metamorphic rocks. An extensive zone of carbonate alteration is present at the base of the ultramafic thrust sheet. The mineralized zone contains up to 17 pct MgO. The remote location and inaccessibility of the zone render it subeconomic at this time. Although the peridotites at Nail Ridge usually contain 2 to 4 pct chromite, metallurgical tests by the Bureau's Albany Research

Center indicate it to be a high-magnesium, high-aluminum chromite of submarginal grade. Neither platinum-group metals nor gold in significant amounts are present either in the bedrock or as placer concentrations in the streams draining the study area. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/J, ALRC, IFOC, LIB, RERC, and WFOC. Copies of this report will not be available for purchase.

OFR 177–84. Substitution of Platinum Metal Crucibles Used in the Glass Industry, by Mir Akbar Ali. Aug. 1984. 56 pp. 24 figs. A research and development study was conducted wherein commercial tin oxide (SnO_2) was evaluated as crucible material for melting optical-quality glasses. Several sintering aids for SnO_2 were examined. Laboratory-scale SnO_2 crucibles were fabricated by dry pressing, slip casting, and isostatic pressing processes. Corrosion resistance, surface characteristics, and the forming process itself were evaluated using the scanning electron microscopy technique. Research done under contracts J0113098 and J0123056 by Glass & Ceramics International, Inc. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 85-106888; paper copy price code A04.

OFR 178–84. Chromite Occurrences in the Kaiyuh Hills, West-Central Alaska, by Jeffrey Y. Foley, Toni Hinderman, Donald E. Kirby, and Cheryl L. Mardock. 1983. 27 pp. 5 figs. Chromite occurrences in poorly exposed ultramafic rocks in the Kaiyuh Hills area, west-central Alaska, were investigated. This report describes the local geology, chromite occurrences, and results of chemical analyses on 32 samples and metallurgical tests that were performed on 4 deposits in the area. Total estimated reserve potential for the four deposits is between 17,000 and 37,000 tons of contained Cr_2O_3. One 3-ft-wide nearly massive band that contains between 50 and 60 pct chromite is estimated to have a strike length of almost 300 ft. This deposit is estimated to contain between 2,000 and 5,000 tons of Cr_2O_3 in high-chromium chromite. Numerous other low-grade occurrences with between 3 and 10 pct chromite contain discontinuous bands up to several inches wide over areas measuring tens of feet wide and up to several hundred feet long. Three of the larger low-grade occurrences that contain between 3 and 4 pct chromite are estimated to contain between 15,000 and 32,000 tons of Cr_2O_3 in high-chromium and high-iron chromite. Potential exists for additional chromite in buried occurrences and in placer deposits in streams that drain the area. Research done by the Alaska Field Operations Center and C. C. Hawley and Associates, Inc. Available for reference at the following facilities: AFOC/J, ALRC, IFOC, LIB, RERC, and WFOC. Order ONLY from NTIS: PB 85-106219; paper copy price code A03.

OFR 179(1)–84. Guidelines for Open-Pit Ore Pass Design. Volume I, by D. F. Hambley, W. G. Pariseau, and M. M. Singh. Sept. 1983. 169 pp. 36 figs. The objective of this investigation was to develop a manual for the design, construction, and maintenance of vertical and inclined ore pass systems for use in underground haulage from open pit mines. The work included an extensive information search, novel analyses in rock flow theory, cost and time estimation for shaft and raise construction methods, and development of design criteria for the ore pass proper, dump point, and draw point. Research done under contract J0205041 by Engineers International, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-106425; paper copy price code A08.

OFR 179(2)–84. Guidelines for Open-Pit Ore Pass Design. Volume II—Design Manual, by D. F. Hambley and M. M. Singh. Sept. 1983. 139 pp. 34 figs. The objective of this investigation was to develop a manual for the design, construction, and maintenance of vertical and inclined ore pass systems for use in underground haulage from open pit mines. The manual is comprehensive and deals with all aspects including location, design, construction, and operating considerations. In the construction section, all applicable raising and shaft sinking methods are considered and cost estimates and advance rates are provided for each. The design process is divided into several sections—rock flow requirements, support design, dump point design, and draw point design. Use of this manual provides open pit planning engineers with a means of designing and assessing the feasibility of ore passes for their operations. Research done under contract J0205041 by Engineers International, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-106433; paper copy price code A07.

OFR 180–84. Remote Manual Control Roof Bolter, by Peter de Bakker. Dec. 1983. 155 pp. 49 figs. The objective of this investigation was to determine the feasibility of remote installation of roof support and the capabilities and limitations of the operator to perform simple functions needed in providing reliable, economical, remote-control roof bolting. The bolter was to be capable of placing longer-than-seam-height bolts up to 10 ft long, from a seam height of 36 to 72 in, while keeping the operator under canopy and supported roof. The machine, called the REM bolter, is a low-profile unit that utilizes a flexible shaft roof drill, a roof bolt inserter, and a newly designed roof bolt lifter-torquer. Efforts were made to strike a successful compromise between automation and manual control. In a controlled laboratory environment, the REM bolter remotely installed 1,000 bolts. The machine was tested in an operating coal mine where 500 holes were drilled and bolts were installed over a 4-month period. All tests show that the operator of a machine of this kind can quickly and repeatedly install roof bolts remotely from the operator compartment about 8 ft away from the drilling-bolting action. Research done under contract H0202009 by Foster-Miller, Inc. Available for reference at the following facilities: ALRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 85-106201; paper copy price code A08.

OFR 181–84. Innovative Recontouring of Abandoned Surface Coal Mined Lands, by Peter Bowen, Glenn Philips, Graham Mathieson, Gene Consalis, and Gus Tausan. Sept. 1983. 123 pp. 10 figs. The purpose of this investigation was to identify innovative materials-handling systems suitable for spoil bank

recontouring applications on abandoned coal mine lands. Nine specific sites, considered typical of abandoned mine lands in the United States, were examined. Recontouring costs for the sites were estimated first using conventional reclamation equipment (dozers, scrapers, etc.) as a base case, and second using large dragline stripping equipment for comparison. Using the cost and efficiency data generated during the studies, five innovative techniques were devised and applied to appropriate sites for cost estimation. The techniques involved an examination of the effects of modifying recontouring plans to reduce costs, the use of special bulldozer blade equipment, the use of special bucket pullback types of excavation systems, the application of hydraulicking, and the application of cast blasting to recontour highwall material. Research done under contract J0295048 by Golder Associates, Inc. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-106870; paper copy price code A06.

OFR 182-84. Field Test of a Post-Disaster Communication System, by M. P. Ristenbatt, E. K. Holland-Moritz, and K. Metzger. Dec. 1983. 51 pp. 14 figs. A new postdisaster communication and location system using through-the-earth electromagnetic wave propagation was tested at the Bureau of Mines Lake Lynn Experimental Mine. Successful detection of the signal, estimated to be at a signal-to-noise ratio (SNR) of −30 dB, was accomplished using a coherent integration time of 4.46 min. The transmitted waveform consisted of a repeating pseudonoise maximal length sequence phase modulating a 1,950-Hz carrier. The receiver used a sliding-window matched filter, optimal for signal known exactly except for phase and starting time, implemented via a special purpose processor. Parallel processing permits adaptive signaling where the detection (integration) time is determined by the actual input SNR encountered. The field test demonstrates a trapped miner detection system that is about 36 dB more sensitive than the current pulsed system. The increased sensitivity permits some desired combination of increased range, shorter detection time, and reduced transmitter power or antenna size. The combination of pulse-compression-type signal, coherent integration, parallel processing, and output peak-detection algorithms permits implementation of an ultrareliable detection system. The same combination is compatible with digital pulse position modulation and emitter position location strategies. Research done under contract J0123030 by University of Michigan. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-109270; paper copy price code A04.

OFR 183-84. Mine Power System Safety and Reliability Improvement. Part II, by Herman W. Hill, Jr., and Elmer W. Collins. Sept. 1983. 21 pp. 3 figs. This report describes field tests that were performed to determine hazard rates for four critical mine power system components: the molded-case circuit breaker, the undervoltage relay, the ground check monitor, and the ground fault relay. Techniques of data analyses are given along with the experimental method and calculations of hazard rates. Detailed descriptions are given of all observed failures. Recommendations are made for improving the reliability of these devices. Research done under contract J0199119 by West Virginia University. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-109288; paper copy price code A02.

OFR 184-84. Oil Shale Creep Testing at Elevated Temperatures, by Krishna P. Sinha, Thomas F. Borschell, and John F. Schatz. July 6, 1983. 162 pp. 90 figs. An investigation was made to determine the creep behavior of oil shale at elevated temperatures. Work done on creep behavior of geological materials was reviewed and triaxial creep tests on oil shale were planned. Tests at temperatures up to 250° C and axial stress up to 3,000 psi were conducted at no confinement and at confining pressures equal to one-third and two-thirds of axial stress. Wide variations in the elastic properties as well as creep characteristics are exhibited. Creep deformation is more pronounced at elevated temperature but no definite quantitative remarks can be made regarding effect of grade of oil shale due to wide scatter and limited number of data points. Primary creep can be described by a power law. Secondary creep seems to be an experimental function of deviatoric stress. Tertiary creep was not observed within the test period. Research done under contract J0205013 by Terra Tek Inc. Available for reference at the following facilities: AD/MR, DRC, LIB, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85-106417; paper copy price code A08.

OFR 185-84. Ground-Water Monitoring in the Tucson Copper Mining District, by Pima Association of Governments. July 1983. 99 pp. 43 figs. Ground water tailings pond monitoring in the Upper Santa Cruz Basin Mines Task Force Special Studies Area was performed to determine the nature and extent of aquifer contamination from copper tailings pond recharge in the basin. A monitoring program for each of three mining areas (Mines A, B, and D) was developed. Analyses of data show that recharge from Mine A ponds caused increased hardness, sulfate, and total dissolved solids in local ground water. However, pumpage in the area has controlled most of the water's movement. Pond recharge from Mine B led to similar conditions, and the degraded water is moving towards a local public-supply well. Pumpage from Mine D interceptor wells is controlling some, but not all, of the movement of recharge seepage from ponds in that area. Recommendations include the need for enhanced monitoring programs at each current minesite, development of a monitoring program for the Mine C area, development of water budgets for all mines, investigation of tailings pond compaction and sliming, establishment of mine closure plans for containment of recharged pond water, and the need for additional interceptor wells in several locations. Research done under contract J0215006. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-106862; paper copy price code A05.

OFR 186-84. The Economic Effects of Subsidence From Underground Coal Mining on Agricultural Land in Illinois, by Harold D. Guither. Jan. 30, 1984. 60 pp.

2 figs. The objective of this study was to determine the economic impact of subsidence from underground coal mining on agricultural lands in Illinois. In a survey of Illinois agricultural extension advisers, the presence of subsidence from underground coal mining was reported in 31 counties. The most frequently reported problems were the presence of depressions or potholes, standing water in depressed areas, surface drainage disruption, broken tile lines, and reduced crop yield. The most frequently reported attempts to restore productivity from subsidence damage were to dig surface drainage ditches, haul in fill dirt, fill in depressions with tractor and blade or land leveler, and replace tile lines; success was varied. Positive identification of all subsidence occurrences and measurement of the area affected is very elusive. Probably about 2 pct of the agricultural land that overlies underground mines is affected, but on specific farms and specific fields, occurrences may affect much more of the land. Farmland with subsidence occurrences is usually appraised at a lower value, sells at a discount, and is assessed for real estate taxes at a lower rate. Research done under contract H0222010 by University of Illinois—Urbana-Champaign. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC, SRC, and TCRC. Order ONLY from NTIS: PB 85-109296; paper copy price code A04.

OFR 187(1)–84. Erodibility and Related Soil Properties of Three Reclaimed Surface Mined Soils, by Otto Robert Stein, Jr. May 1983. 133 pp. 5 figs. A study was conducted to determine erodibilities of different reclamation treatments and an unmined soil at three Indiana strip mine sites. A rainfall simulator was used to artificially erode plots constructed within seven treatment categories and the unmined soil. Soil erodibility was assessed in terms of the universal soil loss equation (USLE) K factor. Values for K calculated from field data were compared with values predicted from independently measured soil properties. Differences in soil erodibility between treatments were site specific. Unmined soil had the highest calculated erodibility at one site, but at two other sites soils having reclaimed A horizons were highest. Shaley overburden treatments had the lowest calculated erodibility. Predicted soil erodibility was usually lower than that calculated from field data. Site specific slope gradient factors were developed for reclaimed A horizon treatments. Research done under grants G1105022 and G1115181 by Purdue University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 187(2)–84. Erodibility of Reclaimed Surface Mined Land, by D. T. Hahn, O. R. Stein, Jr., C. B. Roth, J. K. Mitchell, and W. C. Moldenhauer. May 1983. 20 pp. Adequate and cost effective erosion control is an important component in most plans for reclamation of surface mined land. Despite the fact that much is known about erosion of agricultural lands, insufficient conclusive knowledge is available about erosion of reclaimed surface mined land. This study was conducted to characterize the erodibility of reclaimed surface mine land relative to unmined cropped land and to evaluate the accuracy of the universal soil loss equation in estimating erosion from reclaimed soils. A rainfall simulator was used to measure runoff and erosion rates from plots at three Indiana surface mines. The relation of erosion of the reclaimed soils was not completely constant with that from the cropped soils. Significant differences in erodibility were observed between reclaimed and nonreclaimed topsoils as well as reclaimed topsoils and reclaimed subsoils. Research done under grants G1105022 and G1115181 by Purdue University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Copies of this report will not be available for purchase.

OFR 188–84. The Development of Engineering and Cost Data for Foreign Sulfur Properties, by Thomas P. Oxford. Feb. 1984. 17 pp. Iron pyrite, recovered from massive pyrite deposits or as a byproduct of the flotation of complex sulfide ores, is an important feedstock in many local areas. Its use has diminished substantially over the past decade owing to increased availability of sulfur recovered from petroleum refining or from the smelting of metal sulfide concentrates. Outside the United States, but within other market economy countries, the important Frasch sulfur deposits are in Mexico and Iraq. Deposits amenable to exploitation by the Frasch method are those that can be melted and extracted by injection of hot water and compressed air. Data concerning both Frasch and pyritic sulfur properties are summarized herein. The report summarizes the results of work completed under contract and is presented as a project overview. The number and descriptions of the various technical reports prepared and submitted are outlined. Various property list changes implemented by contract modifications are noted. Methods of data acquisition and analyses are described and useful findings of the study are discussed. Difficulties and problems experienced during the project are highlighted. Research done under contract J0225020 by Jacobs Engineering Group Inc. Available for reference at the following facilities: AD/DMA, AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-107159; paper copy price code A02.

OFR 189–84. Adaptive-Noise-Cancellation Techniques for Through-the-Earth Electromagnetics. Volume II, by Frederick H. Raab. Sept. 1983. 121 pp. 63 figs. An electromagnetic (EM) system to locate trapped miners at coal mine depths was investigated. The use of such a system in deep mines requires transmission at extremely low frequencies (ELF) and a reduction in the effective noise level beyond that which can be obtained by acceptable integration times. Automatic-noise-cancellation (ANC) techniques reduce the effective noise level by combining several received signals that contain correlated noise. The signals can be obtained from either a remote magnetic antenna or a local electric antenna. This report presents the results of a simulation of the use of ANC techniques in a through-the-earth EM system. A multicomponent ELF noise model that incorporates impulsivity, direction of arrival, and ground characteristics was developed. Nonlinear processors (NLP) for ELF noise were compared and the adaptive clipper was found to be preferable. Direct-matrix-inversion (DMI) and least-mean-square ANC techniques were compared and the DMI algorithm was preferable. The performance of the combined NLP-ANC system was evaluated by simulation, and effective noise reductions between 5 and 30 dB were obtained for typical ELF-noise conditions. While improvements of the individual systems were not additive, maximum noise reduction was obtained when both were included. Research

done under contract J0318070 by Green Mountain Radio Research Co. Available for reference at the following facilities: AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-111409; paper copy price code A06.

OFR 190-84. Coal Injector for Coarse Slurry Transport, by Mackenzie Burnett, Leslie S. Rubin, Andrew Harvey, John C. Roberge, Robert L. Cardenas, and Hans Hug. Dec. 1983. 262 pp. 91 figs. An inducer-type pump, capable of injecting dry coal into a hydraulic transport pipeline was developed and installed in a specially designed and fabricated slurry injector vehicle. The full-scale prototype injector system can deliver up to 11 ton/min of coal into an 8-in pipeline at pressures up to 95 lb/in^2. The injector operates on centrifugal principles with flow passing axially through a helical-pitched conical rotor. Water is delivered to the pump through an annular slot at the atmospheric pressure coal inlet. The spinning rotor maintains an air-core vortex of water that pressurizes the discharge housing. A screw feeds coal through the open inlet into the vortex. The inner radius of the vortex contracts as pressure is increased, giving a limiting maximum pressure that is proportional to the square of the rotor speed. Below this limit, flow rate, discharge pressure, and rotor speed are independent variables. The self-powered, 42-in-high slurry injector vehicle follows and receives run-of-mine coal from a continuous miner, reduces the top size to 3 in, and delivers the sized coal to the injector feed screw for slurry formation and pumps it through a mobile hose attached to the vehicle's outby end. Research done under contract J0333914 by Foster-Miller, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-149441; paper copy price code A12.

OFR 191-84. The Effectiveness of Organization and Management Training on Safety and Productivity in Metal/Non-Metal Underground Mining, by Fred E. Fiedler, Cecil H. Bell, Jr., Martin H. Chemers, and Dennis Patrick. Nov. 17, 1983. 296 pp. 25 figs. A demonstration project on the feasibility and effectiveness of two management interventions—management training and organization development—for improving productivity and safety in metal and nonmetal mines was investigated. The management training intervention was conducted at Texasgulf Co.'s trona mine, using three nearby trona mines as controls. The organization development intervention took place in Hecla Mining Co.'s Lucky Friday Mine, using the highly similar Star Mine as control. The two management interventions seemed about equally effective in reducing accidents and injuries, as well as Mine Safety and Health Administration citations, and the management intervention at the Texasgulf mine also appeared to have led to substantial improvement in mine productivity. Research done under contract J0387230 by Perceptronics, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-163285; paper copy price code A13.

OFR 192-84. Technique for In Situ Leach Simulation of Uranium Ores, by David C. Grant, Don C. Seidel, and Ivan L. Nichols. May 1984. 66 pp. 26 figs. In situ uranium mining offers the advantages of minimal environmental disturbance, low capital and operating costs, and reduced mining development time. It is becoming an increasingly attractive mining method for the recovery of uranium from secondary ore deposits. To better understand the process, a laboratory technique was developed and used to study and simulate both the chemical and physical phenomena occurring in ore bodies during in situ leaching. The simulation technique was used to determine effects of leaching variables on permeability, uranium recovery, and postleach aquifer restoration. This report describes the simulation system and testing procedure in sufficient detail to allow the construction of the system and to perform the desired leaching tests. Research done under contract H0262004 by Westinghouse Electric Corp. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-145902; paper copy price code A04.

OFR 193-84. Summary of a Technique for Heap Leach Simulation on Uranium Ores, by Hal D. Peterson, Don C. Seidel, and Ivan L. Nichols. Apr. 1984. 43 pp. 15 figs. A technique was developed for simulation of heap leaching uranium ores in 2-ft-diam columns constructed such that ores as coarse as minus 4-in could be treated in bed depths from 8 to 18 ft with test condition variations. The technique consisted of the separate steps of ore preparation, column loading, charge wetting, leaching, washing, and residue recovery. For the ores studied, sulfuric acid was found to be generally superior to alkaline lixiviants. The rate of uranium extraction by acid leaching proved to be primarily a function of percolation rate, alkalinity of the ores, and oxidant requirements of the ores. Column leaching was closely comparable to field-scale heap leaching terms of uranium extraction rate and recovery results. Acid and oxidant requirements were lower for the field-scale operation. All column tests, as well as the field-scale heap, achieved in excess of 96-pct uranium extraction on a Bear Creek, WY, ore. Research done under contract H0252022 by Colorado School of Mines Research Institute. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-145811; paper copy price code A03.

OFR 194-84. Minerals Availability Cobalt Deposit Abstracts, by William L. Rice. Sept. 1984. 374 pp. The Bureau of Mines report on cobalt is one of a series of minerals availability commodity deposit abstracts. Nonconfidential information from the Minerals Availability Program data base covering domestic and foreign cobalt properties and deposits has been abstracted for use in the report. Abstracts include applicable data on location, published reserves and resources, geology, mine and beneficiation systems, and operation information. Research done by Western Field Operations Center. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-114643; paper copy price code A16.

OFR 195–84. Practices for Protecting and Enhancing Fish and Wildlife on Coal Surface-Mined Land in Central and Southern Appalachia, by Richard E. Ambrose, Charles R. Hinkle, and Calvin R. Wenzel. Mar. 1983. 223 pp. 51 figs. This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current State and Federal legislation was reviewed to determine those practices that were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the central and southern Appalachia region of the United States. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements of each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included. Research done under contract J0100089 by Science Applications, Inc., as a result of an interagency agreement between the Fish and Wildlife Service and the Bureau of Mines. Available for reference at the following facilities: AFOC/J, ALRC, AVRC/DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC and WFOC. Order ONLY from NTIS: PB 83-237073; paper copy price code A10.

OFR 196–84. Practices for Protecting and Enhancing Fish and Wildlife on Coal Surface-Mined Land in the Green River-Hams Fork Region, by Bettina R. Proctor, Richard W. Thompson, Jane E. Bunin, Kenneth W. Fucik, George R. Tamm, and Edward G. Wolf. Mar. 1983. 256 pp. 47 figs. This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current State and Federal legislation was reviewed to determine those practices that were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the Green River-Hams Fork region of the United States. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements for each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included. Research done under contract J0100089 by Science Applications, Inc., as a result of an interagency agreement between the Fish and Wildlife Service and the Bureau of Mines. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 83-252064; paper copy price code A12.

OFR 197–84. Practices for Protecting and Enhancing Fish and Wildlife on Coal Surface-Mined Land in the Powder River-Fort Union Region, by Bettina R. Proctor, Richard W. Thompson, Jane E. Bunin, Kenneth W. Fucik, George R. Tamm, and Edward G. Wolf. Mar. 1983. 261 pp. 46 figs. This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current State and Federal legislation was reviewed to determine those practices that were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the Powder River-Fort Union region in the United States. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements for each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included. Research done under contract J0100089 by Science Applications, Inc., as a result of an interagency agreement between the Fish and Wildlife Service and the Bureau of Mines. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 83-237081; paper copy price code A12.

OFR 198–84. Practices for Protecting and Enhancing Fish and Wildlife on Coal Surface-Mined Land in the Southcentral U.S., by Richard E. Ambrose, Charles R. Hinkle, and Calvin R. Wenzel. Mar. 1983. 243 pp. 52 figs. This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current State and Federal legislation was reviewed to determine those practices that were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the south-central region of the United States. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements of each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included. Research done under contract J0100089 by Science Applications, Inc., as a result of an interagency agreement between the Fish and Wildlife Service and the Bureau of Mines. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 83-252049; paper copy price code A11.

OFR 199–84. Practices for Protecting and Enhancing Fish and Wildlife on Coal Mined Land in the Uinta-Southwestern Utah Region, by Bettina R. Proctor, Richard W. Thompson, Jane E. Bunin, Kenneth W. Fucik, George R. Tamm, and Edward G. Wolf. Mar. 1983. 264 pp. 44 figs. This handbook contains information on the best current practices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current State and Federal legislation was reviewed to determine those practices that were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the Uinta-southwestern region of the United States. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements of each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included. Research done under contract J0100089 by Science Applications, Inc., as a result of an interagency agreement between the Fish and Wildlife Service and the Bureau of Mines. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, ad WFOC. Order ONLY from NTIS: PB 83-252056; paper copy price code A12.

OFR 200–84. The Development of Engineering and Cost Data for Foreign Potash Properties, by Thomas P. Oxford. Feb. 1984. 18 pp. Potash concentrate is used as an agricultural fertilizer material, typically at grades in excess of 95 pct KCl (potassium chloride). The term "potash" is commonly accepted to include KCl, potassium sulfate, and certain mixed

salts that include magnesium as well as potassium. The primary application of these products is agricultural use. At present, the largest producer in market economy countries is Canada, and production is intended almost entirely for export. The balance of the market economy production outside the United States is accounted for by Europe and the Near East (specifically, through brine recovery from the Dead Sea). This report summarizes studies completed on potash under contract and is presented as a project overview. The number and descriptions of the various technical reports prepared and submitted are outlined. Property list changes implemented by contract modification are noted. Methods of data acquisition and analyses are described and useful findings are discussed. Difficulties and problems experienced during the project are highlighted. Research done under contract J0225011 by Jacobs Engineering Group Inc. Available for reference at the following facilities: AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 85-119410; paper copy price code A02.

OFR 201-84. Recovery of Manganese From Low-Grade Domestic Sources, by S. Malhotra, S. Margolin, R. F. Machacek, V. Vejins, W. S. Kelly, and M. Laurila. Sept. 1984. 166 pp. 7 figs. The objectives of this study were to evaluate existing data on low-grade domestic ores, classify the various deposits, determine applicability of promising new beneficiation technologies to these ores, review extraction processes for manganese recovery of these sources, rank the extraction process against each deposit, and examine the cost and profitability of the three most promising processes. Of the 23 districts or deposits that were investigated, 8 were identified as having recoverable resources of manganese exceeding 1 million metric tons. Based on state-of-the-art technology, 16 processes were evaluated for detailed cost evaluation studies. The three most promising processes were (1) the Leute-Dean ammonia-leaching process that solubilizes the manganese as a carbamate complex, (2) the Nossen nitric acid process that forms a soluble manganese nitrate, and (3) the sulfur dioxide process that forms manganese sulfate for recovery. A 35-pct manganese concentrate was used for evaluation and the size of the plant was assumed at 1,000 tons per day. Of the three processes evaluated, the Nossen nitric acid process appears to be the most promising for further development. Research done under contract H0222005 by Arthur D. Little, Inc. Available for reference at the following facilities: AD/MMR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-119378; paper copy price code A12.

OFR 202-84. Preliminary Investigations on Solvent Extraction Kinetics, by D. J. MacDonald and C. H. Elges. Sept. 1984. 15 pp. 3 figs. As a contribution to Bureau of Mines research on the fundamentals of liquid-liquid extraction applied to extractive metallurgy, a preliminary investigation was made on the kinetics of solvent extraction. Equipment was designed and constructed for measurement of rates of solvent extraction. Equipment was designed and constructed for measurement of rates of solvent extraction by the rising drop and Lewis cell methods. The report includes a bibliography on solvent extraction kinetics in extractive metallurgy. Research done by the Reno (NV) Research Center. Available for reference at the following facilities: AD/MMR, ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 203-84. Research To Improve Health and Safety Programs in the Mining Industry. Volume I, by Louis Schaffer and Donna Atchison. Apr. 1983. 260 pp. 62 figs. The objectives of this research were to determine whether a model health and safety program could be defined in terms that would enable its application to mines of all types and, if such a model program could be defined, to determine through evaluations in two mining companies whether it would achieve measurable improvements. This report describes the model, how it was applied in the field, and how it was evaluated. Anecdotal data to illustrate common kinds of safety problems and their solutions are included. Research done under contract H0308076 by Woodward Associates, Inc. Available for reference at the following facilities: AD/MR, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85-151009; paper copy price code A12.

OFR 204-84. Treatment of Mine Drainage From Abandoned Mines by Biological Iron Oxidation and Limestone Neutralization, by Richard L. Harris, Thomas O. Tiernan, John Hinders, Joseph G. Solch, Brent E. Huntsman, and Michael L. Taylor. May 1984. 113 pp. 61 figs. To treat or mediate small flows from acid mine drainage (AMD) sources, a low-cost and low-maintenance treatment method was developed and field tested at an AMD site in Ohio. Phase I studies commenced in June 1982 using a portable bog with five chambers of *Sphagnum* moss (41.3 ft^3) to one of limestone (8.3 ft^3). AMD flow rates ranged from 2 to 18 $gal \cdot h^{-1}$(0.12 to 1.1 $L \cdot min^{-1}$). Phase II studies began in July 1983 during which the chamber ratio of 5:1 for *Sphagnum* to limestone was altered to 4:2. AMD flows averaged 22 $gal \cdot h^{-1}$ (1.4 $L \cdot min^{-1}$). During phase II, the first chamber length of 12 linear ft (8.3 ft^3) of *Sphagnum* moss was found to reduce on average 88% of the ferrous iron at a rate of 5.5 $mg \cdot L^{-1} \cdot h^{-1}$ (1.8 $mg \cdot L^{-1} \cdot ft^{-3}$ of moss). Four chamber lengths or 48 linear ft (33.0 ft^3) of moss reduced on average 50% to 60% of the total iron concentrations in the AMD water at a rate of 1.8 $mg \cdot L^{-1} \cdot h^{-1}$ (0.6 $mg \cdot L^{-1} \cdot ft^{-3}$ of moss). After passage through the limestone bed, pH of the treated AMD water increased up to 0.8 pH unit. Acidity was reduced from 12% to 43% at a rate of 74 $mg \cdot L^{-1} \cdot h^{-1}$ $CaCO_3$ through one 12-linear-ft chamber length (8.3 ft^3) of limestone. Once the AMD flow was stabilized, the portable bog was found to be effective in treating the low-flow AMD by increasing pH and reducing the acidity, ferrous iron, and total iron concentrations. Research done under contract J0113033 by PEER Consultants, Inc. Available for reference at the following facilities AD/MR, ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 205-84. Explosion Proofing of Large Vehicles, by Norbert Paas. May 1984. 275 pp. 116 figs. This report presents a novel non-water-consuming method for explosion-proofing the exhaust system of large diesel vehicles for gassy mines. Recommendations for modifications of the present regulations and procedures for testing and certification are based on a comprehensive study of regulations and practices of mining and nonmining industries around the world. Research done under contract J0113070 by Foster-Miller, Inc. Available for reference at the following facilities: AD/MR,

DRC, LIB, MSHA, NMH&SA, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85–145803; paper copy price code A12.

OFR 206–84. Analysis of Economic Impact of Fatal/Nonfatal Accidents in Surface Coal and Metal/Nonmetal Mines, by Daniel G. Di Canio. Nov. 1983. 145 pp. 44 figs. This report describes a computer-based accident cost indicator model (ACIM) for estimating tangible costs of occupational injuries, illnesses, and fatalities in the U.S. mining industry. The report includes studies performed to expand the scope of the ACIM to all mining sectors and validation of ACIM cost element estimation algorithms with actual costs of mining-related injuries and illnesses. A study of the effect of a fatal accident on production in surface coal and metal-nonmetal mines, based on samples of 15 fatalities in underground and surface mines, is presented. Evidence of significant long-term decline in postfatality production at six of eight underground samples is included. The average loss is shown to be 1.8% of annual mine production. A study of accident costs in U.S. mining from 1975 through 1981 using the ACIM indicates that total annual costs increased from $180,000,000 in 1975 to $379,000,000 in 1981, a 15% annual increase after adjusting for inflation, with mining companies bearing 45% of the total and expected wage losses to mining families accounting for 42%. The study shows total costs of $12,400 per accident and $674,000 per fatal accident for 1981. Research done under contract J0113005 by SRI International. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85–145787; paper copy price code A07.

OFR 207–84. Accident Cost Indicator Model Reference and User Manual, by Daniel G. Di Canio. Aug. 1983. 148 pp. 38 figs. This manual contains reference information and instructions for using the Bureau of Mines accident cost indicator model (ACIM) software as implemented on the VAX-11/780 computer with the virtual memory system (VMS). The objective of the manual is to provide the following capabilities: (1) execution of ACIM search and display procedures from the VAX-VMS command level by nonprogramming ACIM users, (2) access to the mine accident cost data bases for all mining sectors and file-management procedures by developers of private software, and (3) annual updating of the mine accident cost data bases by the ACIM manager. Research done under contract J0113005 by SRI International. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85–145795; paper copy price code A07.

OFR 208–84. Erosion and Reclamation Plots: Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining, by J. V. Bonta and P. Sutton. Dec. 1983. 62 pp. 14 figs. An erosion and reclamation experiment was conducted on a geologic site in east-central Ohio to determine the effect of slope and reclamation treatments on hydrologic, sediment loss, and vegetative variables. Analyses of the fallow plot data showed that a topsoiled surface significantly decreased soil loss, but was of borderline significance in affecting peak flow when compared with spoil. The application of 1 and 2 tons of mulch reduced soil loss 3.8 to 10 times, respectively, compared with no-mulch plots, but was of borderline significance in explaining runoff and peak flow changes. Treatment effects on vegetative establishment and growth were measured over a 2-year period. Mulch rates increased plant growth and vegetative canopy cover of the soil surface most during the vegetative established period. When plots were compared and seeded a second time, plant growth differences were smaller. Research done under contracts J0166054 and J0166055 by the U.S. Department of Agriculture and Ohio State University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85–145845; paper copy price code A04.

OFR 209–84. Results in Jefferson County, Ohio: Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining, by C. R. Amerman, J. V. Bonta, T. J. Harlukowicz, G. F. Hall, N. E. Smeck, W. A. Dick, J. R. Page, and A. C. Razem. Dec. 1983. 177 pp. 51 figs. Watershed J11 in Jefferson County, OH, was instrumented in 1977 as one of three watersheds established for the purpose of investigating surface mining and reclamation effects on local hydrology, sediment discharge, and sediment and water quality. Each watershed was less than 50 acres in size, and was in a different geologic setting within southeastern Ohio. Surface runoff and ground water levels were monitored. Samples were taken for sediment determination and chemical analyses prior to mining. Monitoring and sampling continued throughout the period of watershed disturbance caused by mining and reclamation activities that began in May 1980. A pseudo-postreclamation period followed the initial cessation of human-machine activity on the watershed. A second reclamation effort occurred in the fall of 1981. A true final postreclamation period was not monitored at this site because the erosion control practice failed after each reclamation. Research done under contracts J0166054 and J0166055 by the U.S. Department of Agriculture and Ohio State University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85–149276; paper copy price code A09.

OFR 210–84. Final Report: Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining, by C. R. Amerman, J. V. Bonta, T. J. Harlukowicz, G. F. Hall, N. E. Smeck, W. A. Dick, J. R. Page, D. L. Forster, P. Sutton, A. C. Razem, and R. W. Jeppson. Jan. 1984. 35 pp. 3 figs. An investigation was begun in 1976 on the impact of surface mining and reclamation on the hydrology and water quality of surface and subsurface waters. The study was conducted in the Ohio coal surface mining region and considered three different coalbeds of Pennsylvanian age. The basic research unit at each site consisted of a watershed of less than 50 acres with an accompanying sediment pond and instrumentation for monitoring climatic variables. The watershed was instrumented to monitor ground water levels and surface water flow and to collect samples of both for water quality analyses. Each site was monitored throughout an approximate 5-year period that included a premine subperiod, a mining and reclamation subperiod, and a subperiod consisting of the initial years of the postreclamation condition. After regrading of spoil was complete

at one of the sites, a number of 72.6-ft-long plots were instrumented on spoil and topsoiled areas. Four different slopes were used to study erosion processes and the effectiveness of reclamation treatments on the establishment of vegetative cover on a reclaimed surface. The treatments consisted of different topsoil and different mulching depths. Concurrent with the watershed and plot studies, an investigation was conducted on the economics of complying with reclamation laws in Ohio and the development or adaptation of surface and subsurface hydrology simulation models for conditions in the region under study. Research done under contracts J0166054 and J0166055 by the U.S. Department of Agriculture and Ohio State University. Available for reference at the following facilities: AD/MR, DRC, LIB, OSM, PRC/B, SRC, and TCRC. Order ONLY from NTIS: PB 85–149292; paper copy price code A03.

OFR 211–84. Evaluation and Comparison of Linear and Branching Delivery Systems, by Jerry A. Wichser. Aug. 1984. 102 pp. A series of linear programmed instruction modules was developed in the general subject areas of blasting technology and explosives safety and electrical training. The programs (modules) were developed in the form of tape and slide plus workbook materials, while the branching format evolved from the Lincoln terminal system from the Massachusetts Institute of Technology, through several other teaching machines and microcomputers, and finally settling on Radio Shack TRS-80 microcomputer models I and III. Initial validation figures indicate that essentially the same results are attained from both methods, with the most noticeable difference being an approximate 25% savings in study time with the branching modules. Research done under contract J0387234 by AMAX Coal Co. Available for reference at the following facilities: ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 85–149078; paper copy price code A06.

OFR 212–84. Guideline Manual for Hopper/Crusher/Conveyor Systems Used With Front-End Loaders, by James W. Martin, Thomas J. Martin, Donald W. Gentry, Matthew J. Hrebar, and Thomas P. Bennett. Aug. 1982. 186 pp. 55 figs. This user's manual analyzes the application, selection, and performance of hopper-crusher-conveyor systems used with front-end loaders in surface mining operations. It is designed to be used in conjunction with its companion manual, "Guideline Manual for Front-End Loader Load-and-Carry Applications," OFR 169–82. Aspects of the application are covered as well as design considerations of the hopper-crusher-conveyor units. Lists of equipment manufacturers and crusher specifications, together with a series of checklists, are included for preliminary analyses. Research done under contract J0205045 by Martin Consultants, Inc. Available for reference at the following facilities: AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 85-139954; paper copy price code A10.

OFR 213–84. Concentrations of Cobalt and Other Metals in the Western Crazy Mountains, Interior Alaska, by James C. Barker. Aug. 8, 1984. 44 pp. 12 figs. The U.S. Bureau of Mines made a reconnaissance in the western Crazy Mountains for cobalt and associated metals as part of the Alaska-wide critical and strategic metals program. The area, located about 75 miles north of Fairbanks in central Alaska, is underlain by complexly faulted, predominantly clastic sedimentary rocks bordering the Tintina Fault system. Above background metal concentrations were found to occur in altered fault zones, tectonic breccias, soils, and ground water seeps and precipitates that either cut or are derived from the faulted clastic sedimentary rocks. Up to 0.115 pct cobalt and more than 2.0 pct zinc were detected in soil samples. Spring precipitates contained up to 1.3 pct zinc, 0.037 pct tungsten, and other metals. Some locations lacked cobalt but contained anomalous amounts of copper, lead, zinc, silver, and other metals. No outcropping of primary metallic minerals was located because of colluvium and vegetation cover and extensive deep leaching. Therefore, whether the metal values encountered are due to primary deposits with economic development potential or are the results of concentration by ground water from low-grade sources is unknown. The presence of cobalt, nickel, and zinc, and the identification of minor tin and tungsten indicate that further investigation is warranted. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/J, ALRC, IFOC, LIB, RERC, and WFOC. Copies of this report will not be available for purchase.

OFR 214–84. Regional Distribution of Critical and Strategic Minerals in the Kantishna Hills Area, Denali National Park and Preserve, Alaska, by Rodney E. Jeske. Oct. 16, 1984. 97 pp. 57 figs. In 1984, the U.S. Bureau of Mines studied the abundance and distribution of critical and strategic minerals in the Kantishna Hills study area of the Denali National Park and Preserve, AK. The study is a continuation of the 1983 mineral resource study of the area mandated by Section 202(3)(b) of the Alaska National Interest Lands Conservation Act. Several areas containing anomalous critical and strategic minerals were identified. Analytical results for reconnaissance placer, panned concentrate, and stream sediment samples for the 1983 study were statistically treated and anomalous samples and their distribution identified. The elements evaluated were cobalt, chromium, gallium, germanium, manganese, palladium, platinum, nickel, tin, tantalum, titanium, tungsten, and columbium. Anomalies exist within areas of known mining activity and mineral occurrences as well as in areas with no previously known mining or mineral occurrences. Ten main anomalous areas identified for tin, tungsten, tantalum, titanium, columbium, cobalt, nickel, and germanium should be considered target areas for future critical and strategic mineral exploration. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/A, AFOC/F, AFOC/J, ALRC, IFOC, LIB, and WFOC. Copies of this report will not be available for purchase.

OFR 215–84. Strategic and Critical Mineral Development Potential of the Chugach National Forest, South-central Alaska, by Robert B. Hoekzema. 1984. 64 pp. 11 figs. This report is one of several Bureau of Mines reports concerning mineral development potential of the Chugach National Forest, AK. Anomalous data for selected strategic and critical minerals including antimony, chromium, cobalt, fluorspar, gallium, manganese, nickel, quartz crystals, tin, and

tungsten were compiled from previously published Bureau reports and unpublished Bureau data. Deposits containing anomalous quantities of these commodities were identified and given mineral development potential ratings. Moderate mineral development potential exists for two manganese, three nickel, and one cobalt deposit. Cobalt, gallium, and nickel could be produced as byproducts should copper deposits such as those on Latouche and Knight Islands be developed. Low mineral development potential exists for antimony, chromium, fluorspar, and tungsten, and other cobalt, manganese, and nickel deposits. The mineral development potential for tin and quartz is unknown. Research done by the Alaska Field Operations Center. Available for reference at the following facilities: AFOC/J, ALRC, IFOC, LIB, and WFOC. Copies of this report will not be available for purchase.

COMPUTER TAPE

The following computer tape and documentation are available only from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Checks or money orders should be made payable to the U.S. Department of Commerce. NTIS also accepts American Express, MasterCard, and VISA credit cards in payment for all services. NTIS prices are subject to change; therefore, price codes are given. Contact NTIS for a current copy of the domestic or foreign order price schedule.

CT 1–83. Modernization of the BMINES Computer Code. Volume I: User's Guide. Volume II: Methodology, by David E. Van Dillen, Richard W. Fellner, Robert D. Ewing, and Thomas J. R. Hughes. Sept. 23, 1981. This is a static, two- and three-dimensional, nonlinear, finite element computer program for the analysis of structural and geological systems and is designed specifically for application to the mining problems involving the simulation of excavation in construction sequences. The program is intended for practical analysis, and an effort was made to foresee difficulties in using it. The program uses the direct stiffness method of structural analysis. Degrees of freedom are defined at nodal points and element stiffnesses are assembled to form a symmetric, banded global stiffness matrix. Nodal point forces, which include external loads and internal resisting forces, are expressed in a global load vector. Incremental displacements are obtained from the global load vector and global stiffness matrix by a banded triangulation of the global stiffness matrix, reduction of the load vector, and then back substitution of the reduced load vector into the triangulated stiffness matrix. Part of the reduction operations are performed in local double precision to reduce error propagation, and size limitations have been eliminated. The program includes the capability of prescribing initial states and stress. The output available includes both printed and plotted responses. A restart capability for the calculation phase is included so that large problems may be split into several runs. An attempt was made to lengthen the useful life of the program by making it simple to add new elements, to expand the material model descriptions, and by making the program efficient for and compatible with a wide variety of computers. The model is written in Fortran 4 and is currently operational on a CDC Cyber 176 computer. Approximately 131K words of memory are required with 3 overlays. Source tape is in ASCII character set. Character set restricts preparation to 9-track, ½-inch tape only. Identify recording mode by specifying density only. Call NTIS Computer Products (703–487–4763) if you have any questions. Research was done under contract H0282022 by Agbabian Associates. NOTE: NTIS lists this under the title. **"BMINES: Static, Three-Dimensional, Nonlinear, Finite Element Computer Program for Application to Mining Problems."** Order computer tape with documentation from NTIS: PB 83–221572, price code T14. Documentation only may be obtained from NTIS by ordering PB 83–221564 to obtain the 616-page user's guide in volume I (paper copy price code A99) and PB 83–221556 to obtain the 45-page methodology in volume II (paper copy price code A03).

MINERAL LAND ASSESSMENTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Field Assessment and Evaluation Program Staff, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

1981

MLA 1–81. Summary of Mineral Resources of the Lake Fork RARE II Area (Study Area 6290) Baker and Wallowa Counties, Oregon, by Martin D. Conyac. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 2–81. Mineral Resources of the John Muir Wilderness; Fresno, Inyo, Madera, and Mono Counties, California, by Frederick L. Johnson, Horace K. Thurber, Richard W. Morris, Thomas J. Peters, and D. S. Lindsey. 1981. 18 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 3–81. Mineral Resources of the Big Butte-Shinbone (5145), East Fork (5226), Murphy Glade (5298), and Wilderness Contiguous (5137) RARE II Proposed Additions to the Yolla Bolly-Middle Eel Wilderness, Trinity, Tehama, and Mendocino Counties, California, by Warren D. Longwill. 1981. 13 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 4–81. Summary Report on Mineral Resources of the West Pioneer RARE II Area, No. 1–006, Beaverhead County, Montana, by John R. Benham. 1981. 12 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 5–81. Mineral Resources and Potential of Goat Rocks RARE II Areas, No. 6036, Parts A, C, and D, Lewis and Yakima Counties, Washington, by Thomas J. Peters and J. Mitchell Linne. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 6–81. Mineral Resources of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (RARE II Areas No. 1–158 G, Gallatin Divide; and H. Hyalite), Gallatin and Park Counties, Montana, by Terry J. Close, J. Douglas Causey, Spencee L. Willett, and Clayton M. Rumsey. 1981. 11 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

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OFR 205–84	PB 85–145803	A12
OFR 206–84	PB 85–145787	A07
OFR 207–84	PB 85–145795	A07
OFR 208–84	PB 85–145845	A04
OFR 209–84	PB 85–149276	A09
OFR 210–84	PB 85–149292	A03
OFR 211–84	PB 85–149078	A06
OFR 212–84	PB 85–139954	A10
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RI 8409	PB 80–144876	A02
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RI 8430	PB 81–148272	A03
RI 8431	PB 81–135006	A02
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RI 8433	PB 81–104580	A02
RI 8434	PB 81–148223	A03
RI 8435	PB 81–148199	A03
RI 8436	PB 81–104333	A02
RI 8437	PB 81–135014	A02
RI 8438	PB 81–147100	A02
RI 8439	PB 81–147266	A03
RI 8440	PB 81–149007	A03
RI 8441	PB 81–162695	A02
RI 8442	PB 81–147118	A02
RI 8443	PB 81–147274	A03
RI 8444	PB 81–151995	A09
RI 8445	PB 81–148140	A02
RI 8446	PB 81–135022	A03
RI 8447	PB 81–148215	A03
RI 8448	PB 81–148256	A03
RI 8449	PB 81–104291	A03
RI 8450	PB 81–150088	A04
RI 8451	PB 81–147423	A02
RI 8452	PB 81–147142	A04
RI 8453	PB 81–148306	A04
RI 8454	PB 81–150161	A02
RI 8455	PB 81–147407	A03
RI 8456	PB 81–147381	A02
RI 8457	PB 81–150005	A03

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RI 8459	PB 81-147316	A02
RI 8460	PB 81-160152	A05
RI 8461	PB 81-157646	A03
RI 8462	PB 81-148389	A02
RI 8463	PB 81-147431	A02
RI 8464	PB 81-147282	A02
RI 8465	PB 81-147308	A02
RI 8466	PB 81-150120	A02
RI 8467	PB 81-150104	A03
RI 8468	PB 81-150179	A02
RI 8469	PB 81-150047	A03
RI 8470	PB 81-150153	A03
RI 8471	PB 81-148165	A03
RI 8472	PB 81-148249	A02
RI 8473	PB 81-147126	A02
RI 8474	PB 81-150039	A03
RI 8475	PB 81-148173	A03
RI 8476	PB 81-148157	A03
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RI 8478	PB 81-148231	A03
RI 8479	PB 81-160236	A05
RI 8480	PB 81-149049	A02
RI 8481	PB 81-150096	A03
RI 8482	PB 81-160251	A02
RI 8483	PB 81-156994	A03
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RI 8485	PB 81-148918	A06
RI 8486	PB 81-157018	A02
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RI 8489	PB 81-160863	A02
RI 8490	PB 81-160871	A03
RI 8491	PB 81-160327	A03
RI 8492	PB 81-181620	A02
RI 8493	PB 81-179921	A02
RI 8494	PB 81-180077	A03
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RI 8501	PB 81-179970	A02
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RI 8506	PB 81-157828	A03
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RI 8508	PB 81-227118	A04
RI 8509	PB 81-180002	A03
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RI 8512	PB 81-198533	A02
RI 8513	PB 81-196693	A02
RI 8514	PB 81-197196	A03
RI 8515	PB 81-196735	A03
RI 8516	PB 81-198038	A02
RI 8517	PB 81-197154	A02
RI 8518	PB 81-197139	A03
RI 8519	PB 81-197170	A02
RI 8520	PB 81-198574	A02
RI 8521	PB 81-197188	A03
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RI 8524	PB 81-227415	A03
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RI 8540	PB 81-230286	A03
RI 8541	PB 82-104662	A03
RI 8542	PB 81-231441	A04
RI 8543	PB 81-231060	A02
RI 8544	PB 81-231078	A03
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RI 8552	PB 82-128851	A03
RI 8553	PB 82-107004	A02
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RI 8555	PB 82-104381	A03
RI 8556	PB 82-135906	A03
RI 8557	PB 82-128547	A03
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RI 8559	PB 82-128562	A02
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RI 8565	PB 82-135526	A03
RI 8566	PB 82-129347	A02
RI 8567	PB 82-145434	A04
RI 8568	PB 82-135534	A02
RI 8569	PB 82-135583	A03
RI 8570	PB 82-145418	A05
RI 8571	PB 82-135476	A03
RI 8572	PB 82-135708	A02
RI 8573	PB 82-135716	A02
RI 8574	PB 82-145426	A02
RI 8575	PB 82-145376	A03
RI 8576	PB 82-176330	A02
RI 8577	PB 82-142860	A03
RI 8578	PB 82-179631	A02
RI 8579	PB 82-159682	A03
RI 8580	PB 82-158957	A02
RI 8581	PB 82-160268	A02
RI 8582	PB 82-159849	A02
RI 8583	PB 82-158940	A03
RI 8584	PB 82-158932	A03
RI 8585	PB 82-160276	A06
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RI 8587	PB 82-158924	A03
RI 8588	PB 82-177304	A02
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RI 8598	PB 82–177312	A03
RI 8599	PB 82–158684	A03
RI 8600	PB 82–158734	A02
RI 8601	PB 82–176579	A02
RI 8602	PB 82–141045	A02
RI 8603	PB 82–177791	A02
RI 8604	PB 82–176603	A02
RI 8605	PB 82–176587	A03
RI 8606	PB 82–176595	A02
RI 8607	PB 82–193178	A03
RI 8608	PB 82–195314	A03
RI 8609	PB 82–195355	A02
RI 8610	PB 82–194895	A02
RI 8611	PB 82–195363	A02
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RI 8614	PB 82–195348	A02
RI 8615	PB 82–194903	A02
RI 8616	PB 82–201310	A02
RI 8617	PB 82–202987	A03
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RI 8634	PB 82–202342	A02
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RI 8642	PB 82–221318	A02
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RI 8645	PB 82–220286	A03
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RI 8647	PB 82–220260	A02
RI 8648	PB 82–217035	A02
RI 8649	PB 82–221383	A02
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RI 8651	PB 82–220229	A02
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RI 8655	PB 82–233719	A02
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RI 8657	PB 82–232463	A03
RI 8658	PB 82–233727	A02
RI 8659	PB 82–232471	A02
RI 8660	PB 82–233735	A02
RI 8661	PB 82–232497	A02
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RI 8663	PB 82–232125	A02
RI 8664	PB 82–232109	A02
RI 8665	PB 82–232091	A03
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RI 8670	PB 82–232117	A03
RI 8671	PB 82–260464	A05
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RI 8677	PB 82–262791	A02
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RI 8684	PB 82–257163	A02
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RI 8686	PB 82–263492	A02
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RI 8688	PB 82–255894	A02
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RI 8723	PB 83–157834	A03
RI 8724	PB 83–157701	A02
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RI 8726	PB 83–171801	A03
RI 8727	PB 83–171900	A02
RI 8728	PB 83–156893	A02
RI 8729	PB 83–143974	A03
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RI 8735	PB 83–171819	A02
RI 8736	PB 83–178731	A03
RI 8737	PB 83–175877	A03
RI 8738	PB 83–179820	A02
RI 8739	PB 83–179762	A02
RI 8740	PB 83–184234	A02
RI 8741	PB 83–187559	A02
RI 8742	PB 83–187567	A02
RI 8743	PB 83–197582	A03
RI 8744	PB 83–187575	A02
RI 8745	PB 83–172197	A02
RI 8746	PB 83–187534	A02
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RI 8751	PB 83–187542	A02
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RI 8754	PB 83–197608	A02
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RI 8756	PB 83–214296	A02
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RI 8763	PB 83–214379	A02
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RI 8775	PB 83–240457	A02
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RI 8788	PB 83–250092	A02
RI 8789	PB 84–116755	A03
RI 8790	PB 84–114883	A03
RI 8791	PB 84–100841	A02
RI 8792	PB 84–113547	A02
RI 8793	PB 84–116607	A02
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RI 8871	PB 84–213503	A03

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RI 8878	PB 84–213487	A03
RI 8879	PB 84–235282	A02
RI 8880	PB 84–225903	A02
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TPR 112	PB 81–196701	A02
TPR 113	PB 81–197931	A02
TPR 114	PB 82–135724	A02
TPR 115	PB 82–195876	A02
TPR 116	PB 82–194853	A02
TPR 117	PB 82–221326	A03
TPR 118	PB 82–220732	A02
TPR 119	PB 83–171793	A02
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TPR 122	PB 84–116615	A02

ARTICLES IN OUTSIDE PUBLICATIONS

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

1980

OP 1–80. Identification and Quantification of Asbestos and Other Mineral Particulates, by William J. Campbell. Proc. Symp. on the Impact of Federal Health, Safety, and Environmental Regulations on the Ceramic Industry, 81st Ann. Meeting, Am. Ceram. Soc., Cincinnati, Ohio, Apr. 30–May 1, 1979, December 1979, pp. 55–66. Optical and electron microscopic methods are compared for their identification and quantification of fibrous particles in air, water, and bulk samples. Limitations of the Federal regulatory optical counting procedures for asbestos are considered when applied to materials of interest to the ceramic industry.

OP 2–80. Impact of Recent Cobalt Supply Situation on Magnetic Materials and Applications, by G. Y. Chin, S. Sibley, J. C. Betts, T. D. Schlabach, F. E. Werner, and D. L Martin. IEE Trans. on Magnetics, v. MAG–15, No. 6, November 1979, pp. 1685–1691. In 1978, the cobalt market was thrown into a state of great uncertainty, with soaring prices, limited supply, and accelerating demand. A critical shortage threatened to develop but never really materialized. To a great degree, the prices cobalt commanded on the free market induced Zambia, after consultation with other producers, to hike its prices. The effect was self-perpetuating, with each pricing-tier increase, producer and free market, encouraging the other to escalate. In each instance, Zaire followed suit. These developments took place against a background of a lack of readily available effective substitutes. Barring unforeseen developments that could greatly reduce the available supply, such as a previous production shutdown that lasted for several months, the supply of cobalt is likely to remain tight, but not critically short, for the next several years. Prices are expected to remain relatively high. Over the long term, 1985 and beyond, prospects are good for more readily available cobalt at more reasonable prices. Domestic production of cobalt and mining of deep sea cobalt-bearing manganese nodules could satisfy domestic demand and eventually result in lower prices. Thus, the short-term outlook is rather pessimistic, while over the long term the present precarious situation could be reversed.

OP 3–80. Development of a Mine Shaft Fire and Smoke Protection Prototype System, by Guy A. Johnson. Proc. 3d West Virginia University Conf. on Coal Mine Electrotechnology, Morgantown, W. Va., Aug. 4–6, 1976, pp. 20–1—20–4. This report describes the efforts by the Bureau of Mines and FMC Corp. to define the mine shaft fire and smoke hazard problem, then design, fabricate, and in-mine test prototype hardware for a system that better protects miners and the mine than the shaft-collar rings now commonly used. The resulting mine shaft fire and smoke protection system involves both thermal and smoke detectors, remotely controlled smoke doors at the shaft station, and remotely controlled sprinklers. The system was successfully demonstrated by an actual fire test in the Silver Summit shaft near Wallace, Idaho, in the spring of 1975. Long-term, in-mine testing of alternative system designs is currently being conducted to show that the system has credibility as a reasonably priced, reliable piece of improved mining health and safety hardware.

OP 4–80. Fused-Salt Electrowinning and Electrorefining of Rare-Earth and Yttrium Metals, by E. Morrice and M. M. Wong. Miner. Sci. Eng., v. 11, No. 3, July 1979, pp. 125–136. Increasing demands for rare-earth and yttrium metals in the preparation of special alloys and other uses have greatly enhanced their status as industrial metals. In this paper, a review is made by the Bureau of Mines of fused-salt electrowinning of individual rare-earth metals, yttrium metal, and mischmetal from the respective chlorides and oxides. Preparation of alloys of yttrium metal and rare-earth metals by fused-salt electrolysis and electrorefining of yttrium metal is also included in this review. Particular attention is devoted to the problems encountered in the electrolysis and progress made in the development of the technology.

OP 5–80. Chemical Monitoring of the In Situ Leaching of a South Texas Uranium Orebody, by R. W. Potter II, M. A. Clynne, J. M. Thompson, V. L. Thurmond, R. C. Erd, N. L. Nehring, K. A. Smith, P. J. Lamothe, J. L. Seeley, D. R. Tweeton, G. R. Anderson, and W. H. Engelmann. U.S. Geol. Survey Open File Rept. 79–1144, 1979, 54 pp. The Federal Bureau of Mines and the U.S. Geological Survey measured the changes in formation water chemistry during the initial stages of in situ uranium leaching at a site in south Texas, using $(NH_4)_2CO_3$ as the leach solution. Cores and ground water were analyzed before leaching. Water samples were taken from test wells between injection and recovery wells as leach solution replaced the ground water. Measurements were made at least daily of temperature, pH, U, Na, K, Ca, Mg, SiO_2, NH_4, HCO_3, CO_3, SO_4, and Cl. The data were needed for developing and verifying a computer simulation model of the geochemical reactions involved in in situ uranium leaching.

OP 6–80. Acoustic Emission Techniques Applied to Slope Stability Problems, by Raymond M. Stateham and Robert H. Merrill. Rockslides and Avalanches Vol. 2. Engineering Sites, ed. by B. Voight; ch. 16 in Development in Geotech. Eng., v. 2, No. 14B., 1979, pp. 577–593. Techniques and instru-

ments used to detect instability in rock masses around underground mines have been refined and applied to the detection of instability in rock slopes. From the number and magnitude of the acoustic emissions in the rock mass, engineering estimates of slope instability can be made. The electronic apparatus has advanced from early tube-type circuitry to solid-state circuitry capable of amplifying the output of accelerometers, velocity gages, and pressure gages used to detect acoustic emissions (rock noises). Some of the techniques, instruments, and results at four open pit mines are described. The results of these studies show that the techniques can be used to predict failure, monitor the progress of the failure, and provide evidence that earthquakes can affect the stability of a pit wall.

OP 7–80. Magnetic Properties of Mischmetal-(Co,Cu,Fe,Mg) Alloys, by J. W. Walkiewicz and M. M. Wong. IEEE Trans. on Magnetics, v. MAG-15, No. 6, November 1979, pp. 1757–1759. To relieve the dependence for critical and strategic minerals through conservation and substitution, the Bureau of Mines investigated alloys containing mischmetal (MM), cobalt, copper, magnesium, and iron for use in permanent magnets in place of the scarce samarium-cobalt alloys. The magnetic properties of selected MM-Co-Cu-Mg and MM-Co-Cu-Mg-Fe alloys were evaluated. Magnets were fabricated by powder metallurgy that consisted of arc-melting the metals, crushing and grinding the resultant alloy, alining and compacting the powder, and sintering the green compacts.

OP 8–80. Inhibition of Pyrite Weathering by Recycling of Selected Effluents, by Fraser M. Walsh, Robert L. Stone, and William H. Engelmann. Proc. Underground Coal Mining Symp., Coal Conf. and Expo V, Louisville, Ky., Oct. 23–25, 1979, pp. 139–146. Pyrite weathering is responsible for the large loads of acid and iron in streams associated with coal mine regions of Appalachia. This paper is derived from a study funded by the Bureau of Mines and describes briefly (1) the work done to verify the mechanics of weathering of pyrite entrained in fresh coal mine face material, (2) the importance of iron bacteria in catalyzing pyrite weathering, and (3) the successful laboratory test of a method for inhibiting these bacteria. Preliminary results of the ongoing laboratory tests are described. These results show that iron bacteria catalyze pyrite weathering by a factor of 4 and this catalysis can be stopped by increasing the iron concentration of water influent to the mine face material to 100 ppm. The technical basis for a practical field method for reducing by 80 percent the acid and iron loads from coal mine operations is described.

OP 9–80. Electron Radon Daughter Dosimetry, by John Durkin. Health Phys., v. 37, December 1979, pp. 757–764. Daily exposure of uranium mining personnel to ^{222}Rn daughters has established the need for a device that will continually monitor an individual's exposure. Such a device has been built and tested with promising results. The device is an electronic dosimeter using both a solid-state detector and circuitry, and is a personal instrument worn throughout the working shift. Since the instrument is in close proximity to the miner and measures continually, it provides a more accurate account of total cumulative exposure, and avoids the errors caused by the present technique of spot checking the environment. The system permits the measurement of cumulative exposures to airborne radon progeny, expressed in units of working level hours.

OP 10–80. Research on a More Effective Use of Mineral Resources—A Mission of the United States Bureau of Mines, by T. A. Henrie and F. Block. Proc. 2d Internat. Symp. on the Mineral Resources Potential of the Earth, Hannover, Federal Republic of Germany, Apr. 18–20, 1979, pp. 24–38. The standard of living in the United States and other industrialized nations depends heavily on mineral resources, particularly metals. Per capita consumption of metals is high, and it increases each year. The growth rate is most rapid in those countries that are just beginning to industrialize, which means greater competition for mineral resources than ever before. Therefore, it is imperative to conserve these resources by the most efficient use possible. This paper discusses some of the new mineral-processing technologies investigated by the Bureau of Mines in this vital mission.

OP 11–80. Wear-Resistant Materials for Coal Conversion Components, by J. E. Kelley and H. W. Leavenworth, Jr. Proc. 4th Ann. Conf. on Materials for Coal Conversion and Utilization, Gaithersburg, Md., Oct. 10–12, 1978, pp. III–32—III–37. The need for improved wear-resistant materials for valves, nozzles, and other wear-prone components has been demonstrated by frequent failures in gasification and liquefaction pilot plants. The key to the development or selection of improved materials is a thorough understanding of the behavior of existing materials in both laboratory and pilot plant environments. This Bureau of Mines paper presents results of research to evaluate materials in these environments, recommendations on the best currently available materials, and the use of accumulated data to develop better materials.

OP 12–80. Citrate Process Demonstration Plant—Construction and Testing, by Richard S. Madenburg, Laird Crocker, Laurance L. Oden, John M. Cigan, and R. Dean Delleney. Proc., Symp. on Flue Gas Desulfurization, Regenerable Processes Session, Las Vegas, Nev., March 1979, EPA-600/7-79-167b, v. 2, July 1979, pp. 761–791. This Bureau of Mines paper discusses the construction of the citrate process demonstration plant, the mechanical and prestartup testing, and the test and evaluation program. A brief description of the process, recent material evaluations, and an assessment of application of citrate technology to other industrial SO_2-emitting sources are presented.

OP 13–80. Demonstration of SO_2 Scrubbing of Flue and Stack Gases by Citrate Absorption, by William A. McKinney and W. I. Nissen. Pres. at Am. Min. Cong. Min. Conv., Los Angeles, Calif., Sept 23–26, 1979, 14 pp. The Bureau of Mines citrate process for scrubbing SO_2 from industrial waste gases comprises absorption of SO_2 from cooled and cleaned gases in a solution of sodium citrate, citric acid, and sodium thiosulfate, followed by reacting the absorbed SO_2 with H_2S to precipitate elemental sulfur and regenerate the citrate solution for recycle. Laboratory investigations established process parameters; then pilot plant testing at a copper smelter and a lead smelter confirmed process, operational, and performance parameters and established the design basis of commercial demonstration of the citrate process. The demonstration plant represents a joint Government-industry effort to apply the citrate process to an existing 60-Mw coal-fired, electricity generating powerplant. Construction of the demonstration plant was scheduled to be completed in August 1979, and acceptance testing was to start immediately afterwards. Following the plant accept-

ance test, plans call for the test and evaluation of the plant operation for 1 year.

OP 14–80. Projections and Forecasts of U.S. Mineral Demand by the U.S. Bureau of Mines, by V. Anthony Cammarota, Jr., William J. Mo, and Barry W. Klein. Proc. 109th AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–29, 1980, pp. 69–71. The Bureau of Mines forecasting system consists of statistical and contingency analyses. Ordinary least-squares regression analysis is the statistical technique used to obtain U.S. demand projections for mineral commodities by end use categories in the year 2000. The year 2000 projections for the independent or explanatory variables used in these linear regressions are based on the Data Resources, Inc., macroeconomic model that forecasts gross national product and detailed Federal Reserve Board industrial production indexes. Among the resulting regression lines that best explains the variation in the dependent variable is the one that is chosen and its associated end use projection in 2000 is published in the Bureau's Mineral Commodity Profile series. The other important component of the Bureau of Mines forecasting system is contingency forecasting that takes into account the judgmental factors. The effects on demand from such factors as technological advances, environmental issues, government policies and regulations, and consumer tastes are considered.

OP 15–80. Evaluation of the Methane Gas Content of Coalbeds: Part of a Complete Coal Exploration Program for Health and Safety and Resource Evaluation, by William P. Diamond. Proc. 2d Internat. Coal Exploration Symp., Denver, Colo., Oct. 1–4, 1978; Coal Explor., v. 2, 1979, pp. 211–222. The explosion hazard of methane-air mixture has become an increasingly serious problem in mine planning. As mining progresses to greater depths or develops in new, previously unmined areas, an advance assessment of methane gas potential can be essential for a safe and economic mine development program. The Bureau of Mines, as part of its Coal Mine Health and Safety Program, has developed a simple, inexpensive test to accurately measure the methane content of coal samples obtained from exploration cores. The gas content of the coal per unit weight determined by this "direct method" test can be used as a basis for a preliminary estimate of mine ventilation requirements and to determine if degasification of the coalbed in advance of mining should be considered. The test results also can be used to estimate the methane resources of coalbeds in specific geographic areas. With the eventual decline in conventional domestic gas production and increased price of natural gas, commercial production of coalbed gas will become a reality.

OP 16–80. Directional Drilling for Coalbed Degasification in Advance of Mining, by William P. Diamond and David C. Oyler. Proc. 2d Ann. Symp. on Methane Recovery From Coalbeds, Pittsburgh, Pa., Apr. 18–20, 1979, pp. 162–176. The Bureau of Mines has conducted research in directional drilling for degasification in advance of mining since 1973. This technique is designed to combine the highly successful underground horizontal degasification drilling technology with surface drilling methods. The use of directional drilling techniques will be particularly useful in areas where access to gassy coalbeds is not possible underground, and where topography makes multiple sites for vertical degasification holes impractical or prohibitively expensive. This report presents the development of the directional drilling technique in detail along with a description of the Bureau's current directional drilling program at the Emerald mine near Waynesburg, Pa.

OP 17–80. Ferric Chloride Leach-Electrolysis Process for Production of Lead, by M. M. Wong, F. P. Haver, and R. G. Sandberg. Proc. 1980 World Lead-Zinc Symp., Las Vegas, Nev., Mar. 27–29, 1980, pp. 445–454. The Bureau of Mines, under a cooperative research agreement with lead producers, is conducting a feasibility study of a process to minimize pollution caused by sulfur oxide and lead. The process involves ferric chloride leaching of galena to produce lead chloride and fused-salt electrolysis of the lead chloride to produce lead and chlorine. The chlorine produced by electrolysis is used directly to regenerate ferric chloride in the leach solution. The study is being conducted in a process development unit designed to produce about 500 pounds per day of lead metal, operating on an integrated basis. This report describes the equipment and operating procedures, and presents a preliminary evaluation of the results with respect to process performance, equipment corrosion, impurity buildup, and air monitoring.

OP 18–80. Production and Uses of Zinc, by V. Anthony Cammarota, Jr. Ch. in Zinc in the Environment. John Wiley & Sons, Inc., New York, pt. 1, 1980, pp. 1–38. The organization of the zinc industry is discussed with details given on mining, milling, smelting, and refining of zinc by various processes. The geology of major deposits are described. Environmental and economic factors in the industry are given. World mine and smelter data have been tabulated since 1950 to indicate trends in world production. The United States was the largest producer of zinc metal from 1901 to 1971, but has lost this position as smelters closed. Since 1951, U.S. production has shifted from the Western States to the Eastern States, with the result that a higher proportion of zinc is being extracted from zinc ores rather than mixed ores. The use of zinc as a metal, dust, and in compounds is described. U.S. demand is expected to grow at an annual rate of about 2 percent to the year 2000. After about 1990 zinc batteries for automobile propulsion and electrical load leveling could become important.

OP 19–80. Alaska's Minerals: A Look at 1979, by David Carnes. Alaska Construct. & Oil, January 1980, pp. 40–43. This article outlines mineral exploration, mining, and petroleum activity that occurred in Alaska during 1979. Small placer mines, located in the State's known gold placer districts, increased total production during the year, but reduced production from the leading gold producer caused an overall decline in total gold production. Sand and gravel production, coupled with crushed stone, produced the largest revenues in the mineral industry. Coal production was limited to a single operation that produced approximately 730,000 short tons of coal. Mineral exploration was at a slightly reduced level compared with the previous year. Major companies explored on the Seward Peninsula, the De Long Mountains, Brooks Range, Interior Alaska, and Southeastern Alaska. Extensive exploration for outlining ore body configuration occurred at Greens Creek and Quartz Hill. Daily oil production during 1979 reached over 1.4 million barrels per day, putting Alaska in 2d place among the 50 States for daily oil production. The proposed natural gas line received approval by the Department of the Interior, but actual construction is running

into financial difficulties. The first oil and gas lease sale since 1974 was conducted during 1979.

OP 20–80. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Central and Southern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. Proc. Mineral Resource Potential of California Conf., Sacramento, Mar. 27–28, 1980, pp. 54–70. The Federal Bureau of Mines has investigated the occurrence and recovery of byproduct heavy minerals from sand and gravel operations as a means of assessing the Nation's resources. Sand samples from 63 locations in central and southern California were treated to yield heavy mineral concentrations. The mineral compositions of the concentrates were characterized by chemical and mineralogical examinations. Additional large quantities of concentrates were prepared from selected deposits that contained significant quantities of heavy minerals. Beneficiation studies were performed on these concentrates to recover individual mineral products. Gold was recovered by amalgamation; platinum-group metals and radioactive minerals were recovered by flotation; and magnetite, ilmenite, and chromite were recovered by magnetic and high-tension separation techniques.

OP 21–80. Recovering Byproduct Heavy Minerals From Sand and Gravel Operations in Northern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. Proc. Aggregate, Sand and Gravel Conf., Reno, Nev., May 5–9, 1979, pp. 4–33. The Bureau of Mines, as part of an effort to maximize minerals and metals recovery from domestic resources, has investigated sand and gravel, placer gold, and industrial mineral operations in northern California. Sand samples from about 50 locations were treated by gravity separation to yield heavy mineral concentrates (black sands). Mineral compositions of the concentrates were determined by chemical analysis and mineralogical examination. Individual zircon, ilmenite, magnetite, platinum-group metals, thoria, and silica products were prepared from heavy mineral concentrates by selective separation using low- and high-intensity magnetic, high-tension, and flotation equipment.

OP 22–80. Pneumatic Beneficiation of Mica Ores, by C. E. Jordan, G. V. Sullivan, and B. E. Davis. Pres. at Soc. Min. Eng., AIME, Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, SME Preprint 80–7, 8 pp. The Bureau of Mines, as part of its effort to maintain an adequate supply of minerals and metals to meet national economic and strategic needs, is conducting research on the pneumatic recovery of coarse mica. A system of crushers, screens, and zigzag air classifiers is used to concentrate coarse liberated mica particles from mica ore and from the waste tailings of abandoned mica operations. The plus 0.21-mm-size mica is effectively recovered by this method. The mica concentrates produced contain over 90 pct mica. The method recovered up to 78 pct of the mica in the samples. As a dry concentration method, the pneumatic beneficiation technique may be advantageous to areas of limited water resources.

OP 23–80. Recycling of Waste Magnesite-Chrome Refractories, by E. Martin and A. V. Petty, Jr. Pres. at TMS-AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980; TMS Paper Selection A80–40, March 1980, 15 pp. The Bureau of Mines, as part of its program to conserve mineral resources through secondary resource recovery, determined the feasibility of recycling magnesite-chrome refractories from copper and steel furnaces. Physical and chemical beneficiation processes were investigated to remove contaminants prior to recycling. Samples of the beneficiated material were formed into briquets, and modulus of rupture data were determined.

OP 24–80. A Bureau of Mines for the 80s, by Lindsay D. Norman. Min. Cong. J., Reprint, December 1979, 4 pp. The paper presents a general explanation of the recent reorganization of the Bureau of Mines and attempts to convey a meaningful understanding of the new organization. New purposes and principal ways in which the Bureau can more effectively serve the public interest are described along with an idea of the Bureau's objectives and the importance of individual efforts in attaining them.

OP 25–80. Criterion of Failure for Design of Rock Mass Structures as Determined by Borehole Shear Tests, by Louis A. Panek. Proc. 4th Cong., Internat. Soc. for Rock Mechanics, Montreux, Switzerland, Sept. 3–7, 1979, pp. 509–515. To meet the need for improved field test instruments, hardware and procedures were developed for rapidly determining the in-place shear strength of coal and rock. The hydraulically operated device is permissible, portable, and can be used in 3-inch boreholes at depths up to 100 feet. Field tests in a number of mines, coal, nonmetallic, and hard rock, show that the tester is practical for mine use, especially where recovery of unbroken core for laboratory tests would be difficult. In addition to eliminating the "good rock only" bias inherent in laboratory testing, the tester offers the advantages that many tests can be quickly performed in a single borehole and the results are available immediately. A technical paper presented to an international meeting in 1979 shows that the test data obtained for four different coals and four rock types are equivalent to those for conventional triaxial tests, the best laboratory strength test. The shear strength of coal and rock is important in determining pillar crushing, floor heaving, overburden collapse, roof bolt anchorage, and cutability and drillability of the materials.

OP 26–80. Recovery of Barite From Tailings Ponds and Bypassed Mining Waste, by G. V. Sullivan and W. E. Lamont. Pres. at Soc. Min. Eng., AIME, Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, 5 pp. As part of its program to conserve domestic mineral resources through advancing mineral resources technology, the Bureau of Mines conducted investigations to determine the feasibility of recovering high-grade barite concentrates, suitable for use as well-drilling mud, from current and old waste pond materials and materials bypassed in present mining operations. Flotation studies of waste pond samples from Missouri and Nevada yielded barite concentrates containing over 95 pct $BaSO_4$ with recoveries of 86 and 96 pct, respectively, of the barite in the flotation feed. Flotation studies of a hard-rock sample from Georgia, currently bypassed in mining, yielded a barite concentrate containing 97 pct $BaSO_4$ with an attendant recovery of 97 pct of the barite.

OP 27–80. Preparation of Dilution-Stable Aqueous Magnetic Fluids, by Sanaa E. Khalafalla and George W. Reimers. Pres. at 2d Internat. Conf. on Magnetic Fluids, Orlando, Fla., Mar. 24–27, 1980; IEEE Trans., v. MAG-16, No. 2, March 1980, pp. 178–183. The extension of the Bureau-developed peptization technique for kerosine-base fluids to the

preparation of the aqueous variety was possible when oleic acid was replaced by dodecylamine. The fluids thus prepared were, however, not stable toward dilution. When dodecanoic (lauric) acid was used instead of dodecylamine as the dispersing agent, the resulting aqueous magnetic fluid was found to be more stable toward dilution with water. In this second generation water-base magnetic fluid, the dodecanate anionic dispersing agent is superior to the commonly used dodecylamine cationic dispersing agent. Chemisorption of dodecanate anion on the magnetite surface proper by chemically bonding to surface iron atoms is contrasted to the mere adsorption of a cationic surfactant on the solution side of the electric double layer.

OP 28–80. Characteristics of a Potassian Winchite-Asbestos From the Allamoore Talc District, Texas, by Ann G. Wylie and Charles W. Huggins. Can. Mineral., v. 18, February 1980, pp. 101–107. Asbestos from the Diablo prospect, Allamore talc district (Texas) has cell dimensions a 9.944(5), b 17.951(6), c 5.271(4) A, β 104.41(5)° (powder-diffraction data); the data are consistent with space groups $C2$, Cm, or $C2/m$. Chemical analyses indicated a potassian winchite-asbestos, $(K_{0.43}Na_{0.02})$ $(Na_{1.12}Ca_{0.68}Mg_{0.20})$ $(Mg_{4.82}Al_{0.11}Fe^{3+}_{0.07})$ $(Si_{7.99}Al_{0.01})$ $O_{21.55}(OH_{1.88}F_{0.51})$. Low indices of refraction, $n\alpha' = 1.576$ to 1.596, $n\gamma' = 1.590$ to 1.600, are probably related to the presence of fluorine and the low Ca and Fe contents. EDAX indicates that their variability is related to Na, K, Ca, and Mg contents. In composition, this asbestos probably ranges from a potassian richterite to a potassian winchite. The asbestos habit is here well developed: fibers are composed of fibrils 200 to 400 A wide, oriented with c axes parallel, but with no preferred orientation of a and b. This fibril-bundle structure explains the optical properties of parallel extinction and anomalous interference figures. This asbestos is considered a product of low-temperature metasomatism of a siliceous dolomite. The chemical and physical characteristics described here are consistent with this interpretation.

OP 29–80. Electrical Energy Required to Cut and Deliver Coal Out of a Continuous Miner Section, by George J. Conroy and James H. Green. Trans. Soc. Min. Eng., AIME, v. 266, 1980, pp. 1929–1935. Results of a long-term program of electrical parameter measurements in underground coal mine working sections, performed by the Pennsylvania State University under Bureau of Mines sponsorship, are utilized as the basis for an analysis of the electrical energy requirements during operation. A model section is hypothesized, developed from the average or most representative characteristics as determined from tabulations of the measurements. Performance factors of the model section's machine complement are then analyzed, particularly with regard to the energy required per ton of raw coal cut and delivered from the section. Results are given in kilowatt-hours per ton.

OP 30–80. Gearing Up To Control Trace Elements During Mineral Processing, by Thomas A. Henrie. Min. Cong. J., v. 66, No. 4, April 1980, pp. 18–20. Gearing up to control trace elements during mineral processing involves obtaining all the information available about the operations of the various processors. This Bureau of Mines paper describes the need for precise terms and methodology needed for trace minerals, the environmental impact of polutants not documented, a matrix to identify problems, properties of chemical compounds and how they differ from component elements, and the confusion in assessing the need for environmental controls. The paper also describes why it is important for processors to know about the compounds at each step and how they can add body to existing knowledge.

OP 31–80. A Transient Dust-Flame Model: Application to Coal-Dust Flames, by Edward J. Kansa and Henry E. Perlee. Combust. Flame, v. 38, 1980, pp. 17–36. A transient model of dust combustion is presented in which processes such as solid pyrolysis, gaseous combustion, solid-gas combustion, radiation transport, mass and thermal diffusion, and convection have been considered. It is assumed that each dust particle and its immediate-gaseous envelope do not influence their nearest-neighboring similar systems. Application of this model to coal dust-air mixtures yields results in good agreement with the experimental observations of other researchers.

OP 32–80. Vegetative Stabilization Tests on an Acidic Copper Tailing, by W. R. McDonald and M. B. Shirts. Pres. at SME-AIME Fall Meeting and Exhibit, Tucson, Ariz., Oct. 17–19, 1979, SME Preprint 79–321, 8 pp. The Bureau of Mines conducted field tests on acidic copper tailing as part of its program to devise, improve, and demonstrate technology for stabilizing mining and mineral processing wastes. Results are presented from successful 1/8- and 1-1/2-acre demonstration revegetation plots established in 1973–74 on an abandoned copper tailing pond located on public land adjacent to Holden Village, Wash. The tailing was neutralized with treatments of either dolomitic lime or limerock and fertilized with processed sewage sludge and/or commercial fertilizer. Plant growth covering 60 percent of the surface was achieved on both test plots. Regar brome, Tegmar intermediate wheatgrass, and tall wheatgrass provided the best plant growth and surface coverage. In neutralizing the tailing, the pH of 6.8 was not achieved; however, good plant growth occurred in areas where the pH ranged from 2.9 to 5.8.

OP 33–80. Preparation of Specialty Ferrochromium (9 Wt. %C) From a Domestic Chromite, by Philip E. Sanker, Ralph H. Nafziger, and George H. Reynolds. J. Metals, v. 32, No. 1, March 1980, pp. 49–52. An example of studies by the Bureau of Mines to develop technology to tap domestic sources of critical minerals is presented. Ferrochromium containing 62.5 wt-pct Cr and 9.1 wt-pct C was produced from a domestic chromite using an open-bath technique in an electric furnace. The high-carbon ferrochromium product in powder form was successfully tested in fusion welding processes for hardfacing.

OP 34–80. Dewatering Fine-Particle Suspensions With Direct Current, by Richard H. Sprute and Dennis J. Kelsh. Pres. at Soc. Min. Eng., AIME, Meeting, Las Vegas, Nev., Feb. 24–28, 1980; proc. Fine Particles Processing Symp., American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, v. 2, ch. 91, May 1980, pp. 1828–1844. Slow-setting, fine-grained suspensions can often be dewatered and densified by applying direct current between buried electrodes. Although water removal rates and power expenditures depend on physical and chemical properties of the treated slurries, metal mine tailings from Idaho, Colorado, and Mexico have responded well in laboratory testing, as have 29 samples of ultrafine coal waste from

mines in nine States. This Bureau of Mines report reviews field tests at two Idaho metal mines and describes the recent installation at the Henderson molybdenum mine near Empire, Colo., and the treatment of coal sludge at a Clinchfield Coal Co. preparation plant near Dante, Va.

OP 35–80. Underground Mine Evacuation Plans Analyzed by Computers, by Douglas Tesarik, David Nicholson, and A. B. Boghani. Mine Safety and Health, Mining Safety and Health Administration, v. 4, No. 5, October-November 1979, pp. 14–16. The most important element in escaping from an underground mine during fires and other emergencies is an effective evacuation strategy and plan. The Bureau of Mines has developed a computer program to evaluate and construct mine evacuation procedures and plans. The paper illustrates the program's application for practical use by the mining industry.

OP 36–80. ROPS Field Performance—A Status Report, by Jack L. Woodward and Stephen Swan. Pres. at Earthmoving Industry Conf., Central Illinois Section, Peoria, Ill., Apr. 14–16, 1980; SAE Tech. Paper 800679, 9 pp. The question, "Are ROPS providing adequate operator protection?" is addressed by conducting analyses of rollover accidents and reviewing ROPS certification test data. It was found that ROPS generally exceed structural performance requirements and do reduce the number of injuries and deaths due to rollovers on mining and construction machines. It was also determined that the severity of rollovers vary widely between different types of machines, that quality control during ROPS fabrication is very important, and the chances of surviving a rollover are enhanced substantially by wearing a seat belt.

OP 37–80. Drilling Long Horizontal Coalbed Methane Drainage Holes From a Directional Surface Borehole, by William P. Diamond and David C. Oyler. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8968, pp. 341–346. Three primary horizontal methane drainage holes totaling 2,428.4 meters (7,967 feet) have been completed in the Pittsburgh coalbed from a directional surface borehole. Directional control and sidetracking techniques developed during the project increased the horizontal drilling rate from 24.4 meters (80 feet) per day initially to 64.9 meters (213 feet) per day on the third horizontal hole. Drilling data indicate that horizontal holes can be drilled substantially longer than the maximum 977 meters (3,207 feet) achieved.

OP 38–80. Influence of Coalbed Characteristics and Geology on Methane Draining, by Gerald L. Finfinger, Leonard J. Prosser, Jr., and Joseph Cervik. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8964, pp. 319–324. Methane drainage in advance of mining using horizontal holes continues to expand. Interpretation of coalbed characteristics and geology in relation to drilling procedures and gas flows will provide additional information for further development of this technique. A study conducted in the Pittsburgh coalbed at Bethlehem Mines Corp., Marianna mine 58, showed the effect of coalbed discontinuities, such as clay veins and sandstone channels, on drilling of horizontal boreholes, and on gas flows. It has shown the need to adapt drilling techniques to the varying degrees of hardness encountered within the same coalbed.

OP 39–80. Ilmenite Reduction by a Carbon Injection Technique, by R. H. Nafziger and R. R. Jordan. 37th Electric Furnace Conf. Proc., AIME, Detroit, Mich., Dec. 4–7, 1979, v. 37, July 1980, pp. 178–189. Declining domestic reserves of high-grade ores have stimulated interest in the efficient use of more plentiful materials such as ilmenites and titaniferous magnetites for the production of pigment-grade TiO_2 and raw materials for steelmaking operations. Materials containing high levels of TiO_2 cannot be used in blast furnace operations, owing to the formation of titanium carbide and/or nitride. These deposits increase the viscosity of the slag so that reduction reactions occur with difficulty. Success was achieved by reducing titaniferous materials in an electric-arc furnace under carefully controlled conditions. Traditionally, the preparation of charge materials for the reduction of titaniferous ores and concentrates in an electric-arc furnace was accomplished either by mixing the carbonaceous reductant with the charge or by pelletizing the reductant with the ore. In most cases, carbon utilization ranging from 29 to 39 pct were realized when coke was used with or without woodchips. Reserves of domestic coking coals were limited. Therefore, use of alternate byproduct or readily available reductants should be encouraged. In addition, conventional techniques for adding carbonaceous reductants to electric-arc furnaces often result in undesirable environmental degradation.

OP 40–80. Methane Drainage From the Mary Lee Coalbed, Alabama, Using Horizontal Drilling Techniques, by John H. Perry, Leonard J. Prosser, Jr., and Joseph Cervik. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8967, pp. 335–340. The Bureau of Mines has developed several techniques for draining methane from coalbeds in advance of mining. Drilling long horizontal holes from an underground location is one of these techniques which has been successfully demonstrated in the Pittsburgh and Sunnyside coalbeds. A similar project was successfully conducted in the Mary Lee coalbed at Jim Walter Resources Inc., No. 4 mine. In a year about 1.13 million m^3 (40 MMcf) of methane was recovered from the coalbed.

OP 41–80. Completion Techniques and Production Data From Vertical Methane Drainage Boreholes, Jawbone Coalbed, Dickenson County, Virginia by Peter F. Steidl, Michael A. Trevits, and William P. Diamond. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8965, pp. 325–328. Five vertical methane drainage boreholes have been completed in the Jawbone coalbed at the Clinchfield Coal Co. McClure No. 1 mine in Dickenson County, Va. Foam stimulation treatments were used to increase gas production from the boreholes. After 15 months the cumulative gas production from the first hole was 310,000 cu m (11 MMcf) with production averaging 700 cu m/d (25,000 cu ft/d).

OP 42–80. Determining the Feasibility of Using Vertical Boreholes to Drain Gas From the Pocahontas No. 3 Coalbed, Buchanan County, Va. by Michael A. Trevits, Walter L. Richards, and Hilmar A. Von Schonfeldt. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8966, pp. 329–334. In July 1979, a project was established to determine the feasibility of using vertical boreholes to degasify the Pocahontas No. 3 coalbed in advance of mining. To date, three

methane gas drainage boreholes have been completed near the Virginia Pocahontas No. 5 mine in Buchanan County, Va. Various coalbed reservoir tests and in situ stress determinations have been performed. Hydraulic stimulation treatments were designed and implemented at two boreholes, followed by preliminary gas and water production testing.

OP 43–80. Influence of Graphite Morphology on the Damping Properties of Selected Cast Iron Structures, by A. Visnapuu, B. A. Betts, and L. A. Neumeier. 37th Electric Furnace Conf. Proc., AIME, Detroit, Mich., Dec. 4–7, 1979; July 1980, pp. 304–306. Increasing attention has been directed toward a need for better structural materials to reduce equipment noise in metallurgical and other industries in compliance with imposed noise restrictions. One of the goals of the Bureau of Mines is to minimize the undesirable environmental conflicts, impacts, and occupational hazards associated with mining and mineral processing operations. Toward this goal, the Bureau of Mines has investigated damping and other properties of experimental cast irons. It was shown that damping capacity and toughness intermediate to high-damping, brittle gray cast iron and low-damping, tough ductile cast iron can be installed in "hybrid" cast iron with a compacted graphite structure intermediate to the flakes of gray cast iron and the nodules of ductile iron. Damping capacity of ductile iron can also be enhanced by hot working reduction. Comparative damping data are given for hybrid cast iron, conventional gray and ductile cast irons, and steels containing various amounts of carbon and subjected to a variety of heat treatments.

OP 44–80. Oil Mining, by Richard A. Dick and Sheldon P. Wimpfen. Sci Am., v. 243, No. 4, October 1980, pp. 156–161. Conventional drilling and pumping removes less than half of the oil in an average petroleum reservoir. As the price of oil rises, mining it underground or at the surface becomes economically more attractive. This report discusses the size of this potential resource and methods for its recovery.

OP 45–80. Diffraction Jig for Philips Electronics Diffractometers, by Charles W. Huggins and Stephen D. Cramer. Norelco Rep., v. 27, No. 1, April 1980, p. 40. An X-ray diffraction jig for use on Philips electronics diffractometers was designed and fabricated at the Avondale Research Center primarily for use on corrosion research using 3/8-in-diam metal electrodes that were covered with corrosion films and geothermal scales. The jig was constructed of an aluminum alloy and will handle a variety of sample sizes and shapes up to 1.5 by 2.0 cm. The jig dimensions and a sample illustration are given in the paper.

OP 46–80. Thermal Decomposition of Monomethylamine Nitrate, by Yael Miron. J. Hazardous Mater., Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, v. 3, 1980, pp. 301–321. Monomethylamine nitrate (MMAN), was used during World War II as an ingredient for bomb and shell loading. Now it is used as a component in some water gel formations. Knowledge of its dissociation and/or decomposition mode would be desirable, but none was found in the open literature. MMAN decomposition was observed through differential scanning calorimetry, thermogravimetric analysis, and mass spectrometry. The effect of small amounts of iron oxide, rust, and copper on MMAN decomposition was also assessed. These compounds have shown catalytic activity in the decomposition of ammonium and hydrazine nitrates.

OP 47–80. The Bureau of Mines Shaft and Research Facility in the Oil Shales of Colorado, by Stephen Utter. Pres. at 83d National Western Min. Conf., Denver, Colo., Feb. 6–8, 1980; pub. in 1980 Mining Yearbook. Colorado Mining Association, Denver, June 1980, pp. 164–170. As part of a program to assess the environmental problems that would attend the mining of oil shale, the Bureau of Mines blind-bored a 10-ft-diam shaft to a depth of 2,371 feet in the Piceance Creek Basin and installed an 8-ft-diam steel casing to a depth of 2,352 feet. This pioneer shaft penetrates two aquifers, the rich Mahogany oil shale zone, and virtually the full thickness of oil shale and accessory minerals in the Parachute Creek member of the Green River Formation. A surface plant consisting of a headframe, hoist, and support facilities was erected, and the shaft was equipped with hoisting, ventilating, pumping, and service systems. Cutouts or windows were made in the shaft lining, and stations were opened on the 1,844- and 2,079-foot levels. A 10- by 10-foot entry was driven on the 2,079-foot level, and bulk samples of oil shale, dawsonite, and nahcolite were mined for processing tests. Problems with methane gas and ground water were encountered, and grouting was required.

OP 48–80. Environmental Assessment of an Oil Shale Installation, by Stephen Utter. Proc. 6th Ann. UMR-DNR Conf. on Energy, Rolla, Mo., Oct. 16–18, 1980, v. 6, pp. 481–485. The Bureau of Mines constructed a research facility in the oil shale deposits of the Piceance Creek Basin in northwestern Colorado. The purpose of the installation is to identify the environmental effects that could be expected from future commercial oil shale mines and to develop technology needed to resolve or mitigate environmental problems. This report describes the installation, outlines the research program for which the environmental assessment was made, and presents the findings of the assessment.

OP 49–80. W Recovery From Searles Lake by Ion Exchange, by P. B. Altringer and P. T. Brooks. Tungsten News, v. 18, No. 3, Summer 1980, pp. 3–4. An effective ion exchange operation to remove tungsten from Searles Lake brines using a pilot unit that has been operating since July 1979 at the Kerr-McGee Corp., Trona, Calif., is described. The extractive technique, developed by the Bureau of Mines, is based on a new tungsten-selective resin designated QRF. The objectives of the investigation includes (1) proving the operational viability during seasonal changes in brine properties, (2) providing a tungsten-rich solution to enable completion of tungsten recovery research, and (3) supplying data for system escalation to enable recovering nearly 227,000 kg per year of tungstic oxide.

OP 50–80. Theoretical Evaluation of Radon Emanation Under a Variety of Conditions, by John C. Edwards and Robert C. Bates. Health Phys., v. 39, August 1980, pp. 263–274. A cylindrical coordinate mathematical model to calculate ^{222}Rn flux and movement was developed considering ^{222}Rn production, decay, and diffusion in a multilayered, porous, permeable matrix. Air movement, transporting radon through the media, satisfies Darcy's law and is influenced by the air (barometric) pressure applied at the surface. Two zones of porous material have been defined, one with ^{222}Rn production term (the uranium ore zone) and the other without this

term to simulate shotcrete or concrete ground support. A provision is made to evaluate the effect of a pinhole in an otherwise impermeable sealant. Comparisons are made between field measurements and predicted values. Specific examples are given of ^{222}Rn losses through pinholes for cases of linearly varying and static barometric pressures. The results suggest factors to consider in uranium mine radon control. For example, pinholes are not a serious problem since it appears that several thousand 2-mm-diam pinholes per square meter are required to cause a significant loss of a barrier coating's effectiveness.

OP 51–80. Consolidation of Industrial Clay Wastes, by B. J. Scheiner, J. R. Zatko, and A. G. Smelley. Proc. Environmental Symp. '80, New Orleans, La., Apr. 7–10, 1980, pp. 477–486. The Bureau of Mines is developing a dewatering technique for phosphatic clay slime waste produced in Florida phosphate facilities. The technique consists of mixing the slime waste with a flocculant, polyethylene oxide, and dewatering the resulting agglomerate on a rotary screen. Slimes containing a nominal 3 wt-pct solids have been dewatered to solids contents of 20 to 30 pct. This paper describes a series of laboratory investigations applying the Bureau-developed dewatering technique to a variety of ultrafine waste materials.

OP 52–80. Thermodynamic Properties of $KAlO_2$, by R. P. Beyer, M. J. Ferrante, and R. R. Brown. J. Chem. Thermodynamics, v. 12, 1980, pp. 985–991. As part of a goal to advance mineral technology, to reduce energy use, and to abate pollution, the Bureau of Mines generates thermodynamic quantities on various minerals and metals. This study on potassium aluminate was undertaken to further this aim. Although of possible importance to the cement and ceramic industries, the current interest in potassium aluminate is its role in magnetohydrodynamic (MHD) power generation. Potassium, in the form of a seed material used to enhance the electrical conductivity of the high-temperature MHD generator plasma, reacts with alumina. Alumina is a major constituent of coal slag and a material of construction in MHD power generators. A better understanding of the potassium and alumina interaction will help with the problems of corrosion, seed material recycling, etc.

OP 53–80. Testing and Development of Materials for Catalytic Coal Gasification Process Equipment, by H. Heystek and N. S. Raymon. Proc. 5th Ann. Conf. on Materials for Coal Conversion and Utilization, Gaithersburg, Md., Oct. 7–9, 1980, pp. IV-1—IV-7. Catalytic coal gasification (CCG), one of the most promising third generation coal conversion processes, is based on reaction of coal and steam in the presence of an alkali metal catalyst to achieve high production of methane at a rate equivalent to second generation high British thermal unit process, but at lower temperatures and pressure. Additional advantages include reduced energy requirements, the elimination of a separate methanation reactor, and the ability to process caking coals. At present, few data are available to aid in selecting metal and refractory materials for reliable, low-cost services under the conditions prevailing in the CCG reactor itself. The objectives of this research are to determine the effect of CCG environments on metal and refractory materials of construction by exposure to CCG reactor conditions in a laboratory simulator and to identify the attack mechanisms of CCG environments on metals and refractories so that materials offering improved performance at lower cost can be identified.

OP 54–80. Retreatment of Tailings To Recover Barite, by W. E. Lamont, E. G. Davis, and G. V. Sullivan. Proc. 7th Miner. Waste Utilization Symp, Chicago, Ill., Oct. 20–21, 1980, pp. 26–33. The feasibility of recovering barite by retreatment of tailings was demonstrated in investigations by the Bureau of Mines. The investigation was part of the Bureau's program to conserve domestic mineral resources through advancing mineral resources technology. A primary objective was to produce concentrates that would be suitable for use in oil well drilling mud applications. Two samples of tailings were received from Nevada that represented the fine and very fine fractions of waste from an operating plant. Concentrates containing over 96 pct $BaSO_4$ were readily obtained from each. Barite recovery was 96 pct for the fine tailings and 86 pct for the very fine tailings. Treatment of a low-grade Missouri tailing by sizing and flotation resulted in a concentrate containing 96 pct $BaSO_4$ and an 86 pct recovery of the barite. A Georgia material responded in similar fashion with the concentrate containing 97 pct $BaSO_4$ and a barite recovery of 82 pct. All flotation concentrates had specific gravities in excess of the 4.20 specification for drill mud applications.

OP 55–80. Cobalt and Nickel Recovery From Missouri Lead Ores, by D. L. Paulson, W. M. Dressel, and R. M. Doerr. Proc. 7th Miner. Waste Utilization Symp., Chicago, Ill., Oct. 20–21, 1980, pp. 127–134. In its continuing effort to improve the utilization of domestic resources, the Bureau of Mines is developing procedures to recover up to 2.5 million pounds of cobalt and 3.5 million pounds of nickel lost annually in processing Missouri lead ores. The procedures include a physical method for producing a Co-Ni enriched product from a commercial lead mill Pb-Cu flotation rougher concentrate and a hydrometallurgical process for treating the enriched product and/or Co-Ni bearing lead smelter mattes and drosses. In the physical separation process, the Pb-Cu rougher concentrate is separated by wet high-intensity magnetic separation and the magnetic fraction (chalcopyrite concentrate) is reground and floated to produce a high-grade copper concentrate and a tailing product containing over 3.5 pct cobalt and 5 pct nickel. In the hydrometallurgical process, both the Co-Ni bearing tailing product and lead smelter mattes are leached with manganese dioxide and sulfuric acid to obtain cobalt, nickel, copper, lead, manganese sulfates, and elemental sulfur. At 85° to 100° C, the cobalt, nickel, and copper are solubilized as sulfates leaving a residue of $PbSO_4$, sulfur, and gangue. The residue can be returned to a smelter for lead recovery and the soluble metals are recovered from the leach solutions by caustic purification (removal of arsenic and iron) and sequential sulfide precipitations. The products are copper sulfide (62 pct copper) and Co-Ni sulfide (up to 50 pct combined cobalt and nickel). The manganese is reclaimed from the leach liquor as manganese oxide to be used for recycling.

OP 56–80. Surface Charge Heterogeneity in Amphibole Cleavage Fragments and Asbestos Fibers, by Joseph E. Schiller, Sequoyah L. Payne, and Sanaa E. Khalafalla. Pres. at ACS National Meeting, Washington, D.C., Sept. 9–14, 1979; pub. in Science, v. 209, Sept. 26, 1980, pp. 1530–1532. Aspect ratio and electrophoretic mobility data for amphibole particles reveal that short fibers and blocky cleavage

fragments have a smaller net change than highly elongated particles. Asbestos fibers and cleavage fragments of the same dimensions exhibit the same net negative surface charge but positively charged ends and negatively charged lateral surfaces.

OP 57–80. Time-Dependent ^{222}Rn Samples Loss From Small Samples, by Robert C. Bates. Health Phys., v. 39, November 1980, pp. 799–801. A research plan was prepared to measure the effect of moisture on the ^{222}Rn emanation coefficient in small uranium ore samples. One version of the plan called for the sealed can to be counted after a long storage and then opened to let the free radon escape. However, a question arose about the information on many emanation coefficient measurements (for example, Ha36, Ki32, Sh70, St57, and Wa51). Reported values for ^{219}Rn, ^{220}Rn, and ^{222}Rn generally differ by less than a factor of 10, which is considerably less than expected from linear diffusion theory (1, 3.7, 290, for ^{219}Rn, ^{220}Rn, and ^{222}Rn, respectively) (Ta78). This small difference suggests that radon escape is very rapid, and hence the steady-state flux might be reached within tens of seconds. None of the papers, however, specifically address the question; therefore, the Bureau of Mines performed the analytical study reported in this note.

OP 58–80. Challenges of the 1980's From the Perspective of the U.S. Bureau of Mines, by Ralph C. Kirby and Donald G. Kesterke. Proc. 8th Ann. Min. and Met. Div. Symp. and Exhibit, Phoenix, Ariz., May 14–16, 1980 (pub. as Instrumentation in the Mining and Metallurgy Industries), v. 7, pp. 19–26. This paper covers some of the underlying factors and forces that will shape the mining and metallurgical industries during the 1980's. The discussion includes what the Bureau of Mines plans to do about these forces and the Bureau's present reaction.

OP 59–80. Industrial Wastes, by S. L. Law. McGraw Hill Encyclopedia of Environmental Science. McGraw-Hill Book Co., Inc., New York, 2d. ed., 1980, pp. 387–396. Approximately 334 million metric tons of industrial processing residues are generated annually with 10 to 15 percent being classified as hazardous by the U.S. Environmental Protection Agency. Problems arising from improper disposal of these wastes are discussed along with several highly publicized examples including Love Canal in Niagara Falls, N.Y., and Valley of the Drums in Stump Gap Creek, Ky. Hazardous wastes are broken down by geographic regions and by industry. Waste waters and gaseous wastes are discussed as well as solid wastes. Sections on waste recycling, waste exchange, waste disposal options, and industrial discharges to publicly owned treatment works are included.

OP 60–80. Adapting Conventional Sputtering Equipment for Coating Long Tubes and Strips, by R. L. Lincoln and R. Blickensderfer. J. Vac. Sci. Technol., v. 17, No. 5, September–October, 1980, pp. 1252–1253. A method for adapting conventional sputtering equipment to coat long tubes and strips was devised at the Albany (Oreg.) Research Center, Bureau of Mines. This research was part of an effort to meet the Bureau's goal of minimizing the need for critical minerals through conservation, using coatings of metals applied by techniques such as sputtering, cladding, or surface alloying.

OP 61–80. Water Recovery and Disposal of Clay Waste Slimes, by B. J. Scheiner and A. G. Smelley. Proc. 1980 Symp. on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, Ky., Dec. 1–5, 1980, pp. 249–253. As part of research conducted in its mission to effect pollution abatement, the Bureau of Mines is developing a dewatering technique that allows for disposal of mineral wastes, for reuse of water now lost with these wastes, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer that has the ability to flocculate and dewater materials containing clay wastes. A variety of different clay wastes have been successfully dewatered in laboratory experiments. Coal-clay waste was consolidated from 4 to 57 wt-pct, potash-clay brine waste from 20 to 62 wt-pct, phosphatic-clay waste from 16 to 49 wt-pct, uranium mill tailings from 15 to 67 wt-pct, and talc tailings from 10 to 53 wt-pct. The consolidated materials can be handled by mechanical devices such as trucks and conveyors for disposal in mined-out areas.

OP 62–80. Contact Filtration of Asbestos Fibers With Magnesium Oxide, by Joseph E. Schiller and Sanaa E. Khalafalla. Pres. at 109th AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, SME Preprint 80–108, pp. 1–7 As part of its research on identification of asbestos fibers, the Bureau of Mines discovered a method to remove asbestos fibers from water. The process and its theory of operation is described in this report. The surface charge of amphibole minerals in potable water was negative and, in common with most other silicate minerals, the isoelectric point of amphibole asbestos fibers is in the pH range 4 to 6. Magnesia is one of the rare oxides with a high isoelectric point of about 11. The surface of magnesium oxide will be positively charged in water at pH 6 to 8, while the electric charge on amphibole asbestos fibers is negative. Because of the electrical attraction of these oppositely charged solids, it was possible to remove negatively charged asbestos fibers by percolating water that contained suspended asbestos through a porous bed of magnesium oxide particles. Scanning electron photomicrographs indicated that essentially complete removal of the fibers was accomplished. Other materials tested as contact filter media and found to be effective or partially effective were sand, calcite, carbon, diatomaceous earth, and cellulose. Acidic aluminum collected amphibole fibers but not chrysotile fibers.

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OP 1–81. Fire-Fighting Mini, by Donald N. H. Chi and Henry E. Perlee. Datamation Mag., September 1980, pp. 217–220. Research computer systems usually begin by filling several critical needs and then expand as demand develops among other groups in the laboratory. This paper describes the computer network used by the Bureau of Mines at the Pittsburgh Research Center in conducting and overseeing research related to health and safety in mines and in mine environmental technology.

OP 2–81. Preventing Frictional Ignitions, by Welby G.

Courtney. Coal Min. & Proc. J., v. 8, No. 1, January 1981, pp. 48–58. This article reviews the history of frictional ignitions in U.S. Coal mining operations, laboratory studies of the problem, and specific remedial measures that can be implemented by mine operators to alleviate the frictional ignition problems.

OP 3–81. Health and Safety, by Robert Marovelli. Compress. Air (subarticle in Coal's Future: The Experts' Views), v. 85, No. 10, October 1980, pp. 14–15. Since the oil embargo of 1974, there has been less growth in the demand and consumption of coal than previously forecasted. Concern about the importation of oil brought a strong move toward increasing the consumption of coal during 1974–77, and a large amount of coal mining equipment was sold. But the mining producers overbought equipment, and the slackening-off of the market has produced a significant amount of unused equipment. This article discusses how this slackening-off of the market has affected the coal industry and the advantages and disadvantages of expanding the coal industry in the United States.

OP 4–81. Cobalt: A Strategic and Critical Resource for Industrialized Nations, Supplied by Developing Nations, by Scott F. Sibley. Natural Resources Forum, United Nations, v. 4, No. 4, October 1980, pp. 403–413. In 1978, the world cobalt market was abruptly thrust into a state of great uncertainty, with soaring prices, limited supply, and accelerating demand. A critical shortage threatened to develop but never really materialized. However, this situation dramatized Western nations' vulnerability to supply disruption. A number of factors, including limited natural occurrence, unfavorable market conditions, and accelerating demand for cobalt, combined to bring about these unstable conditions.

OP 5–81. Field Stress Corrosion Tests in Brine Environments of the Salton Sea Known Geothermal Resource Area, by J. P. Carter and S. D. Cramer. Mater. Performance, v. 19, No. 9, 1980, pp. 13–16. Corrosion research is being conducted by the Federal Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. As part of this research, a 30-day stress corrosion test was conducted at the Salton Sea Known Geothermal Resource Area on seven iron- and nickel-base alloys in four brine and steam process streams using wellhead brine from geothermal well Magmamax 1. The tests showed transgranular cracking of AISI 316L stainless steel and intergranular and transgranular cracking of AISI 430 stainless steel in all four process streams. E-Brite 26–1 exhibited intergranular and transgranular cracking in three of the four process streams. Carbon steel, Inconel 625, and Hastelloys G and C-276 show no evidence of stress corrosion cracking.

OP 6–81. Coal Liquefaction, by Franklin D. Cooper. Encyclopedia of Energy, McGraw-Hill Book Co., Inc., New York, 2d ed., 1980, pp. 136–139. This article discusses four direct-liquefaction processes, two indirect-liquefaction processes, and developing third-generation processes. Also discussed are production constraints, prospects and issues, hydrogen for liquefaction processes, costs, and modifications of second-generation direct liquefaction processes.

OP 7–81. Corrosion in Geothermal Brines of the Salton Sea Known Geothermal Resource Area, by S. D. Cramer and J. P. Carter. Geothermal Scaling and Corrosion, ed. by L. A. Casper and T. R. Pinchback, ASTM STP 717, 1980, pp. 113–141. Corrosion research is being conducted by the Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. High chromium-molybdenum iron-base alloys, nickel- and titanium-base alloys, and titanium-zirconium-molybdenum alloy exhibited good resistance to general, crevice, pitting, and weld corrosion and stress corrosion cracking in laboratory tests in deaerated brines of the Salton Sea Known Geothemal Resource Area (KGRA) type at 232° C and in brine containing dissolved carbon dioxide and methane. Only titanium-base alloys were resistant to corrosion in oxygenated Salton Sea KGRA-type brine. Copper adversely affected the resistance to general corrosion of low-alloy steels in deaerated brine, whereas chromium, nickel, silicon, and titanium improved it. Carbon steel, type 4130 steel, and types 410 and 430 stainless steels exhibited poor corrosion resistance in field tests in five brine and steam process streams produced from geothermal well Magmamax 1. These alloys were highly susceptible to pitting and crevice corrosion. General corrosion rates were high for carbon and type 4130 steels.

OP 8–81. Eastern Cement Kiln Dust Characterization, by B. W. Haynes, S. L. Law, and J. A. Jolly. Met. Soc., AIME, TMS Paper Selection A81–39, February 1981, 10 pp. Cement kiln dust (CKD) is a waste product that accumulates at the rate of 12 million tons per year in the United States. In proposed hazardous waste guidelines in 1978, the Environmental Protection Agency (EPA) placed CKD in the "Special Wastes" category pending more information on the composition, characteristics, and degree of hazard posed by this waste. In 1980, the Special Wastes category was removed, but a 3-year study of the hazard potential of CKD has been proposed by EPA. An exploratory evaluation of the resource recovery potential and environmental effects of the metals present in the dust has been underway during this period at the Bureau of Mines Avondale Research Center. Results of the first phase of this research—CKD from the east coast—will be discussed including major, minor, and trace element concentrations; mineralogy; iron chromatographic and thermal information; and EPA hazardous waste leach test results.

OP 9–81. Surface Subsidence Due to Underground Longwall Mining in the Northern Appalachian Coal Field, by K. K. Kohli, S. S. Peng, and R. E. Thill. Pres. at SME-AIME Ann. Meeting, Las Vegas, Nev,, Feb. 24–28, 1980. SME Preprint 80–53, 8 pp. Since the adoption of the Surface Mining Reclamation and Control Act of 1977 there has been a sudden rise in demand on guidelines for minimizing surface subsidence and its associated structural damages. A 10-month survey resulted in a collection of surface subsidence surveys that was conducted by coal companies in the Northern Appalachian coal field over the past 20 years. This paper presents the preliminary results of the longwall subsidence data

OP 10–81. Vibration and Air Blast Noise From Surface Coal Mine Blasting, by Patrick Linehan and John F. Wiss. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–336, 6 pp. Vibration and air blast noise from blasting were evaluated during a research program sponsored by the Bureau of Mines. Blast variables were studied using small-scale model tests to evaluate specific variables as well as interactive effects, followed by experiments

with production blasts at the surface coal mines. Experimental data showed that the primary variables affecting the ground vibration amplitude are the charge weight per delay and the length of the delay interval. Blast variables with a significant affect on the overpressure amplitude include the charge weight per delay, the length of the delay, burden and spacing, stemming amount and type, direction of initiation, charge depth, and amount of detonating cord and cover.

OP 11–81. Dust Control Systems, by John N. Murphy. Proc. 3d Ann. Min. Institute, University of Alabama, Apr. 15–17, 1980, 30 pp. This paper presents an overview of the Bureau of Mines Respirable Dust Control Program. Completed and ongoing developments in the areas of dust generation, ventilation, scrubbers, personal protection, and instrumentation are discussed.

OP 12–81. Damage to Residential Structures From Surface Mine Blasting, by David E. Siskind. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–362, 17 pp. The Bureau of Mines has studied the problem of cracking in residential structure walls from vibrations produced by blasting in surface mines. Direct observations were made of blasting damage consisting primarily of cosmetic cracking in plaster and gypsum board walls. Measurements of structure response and also application of the response spectra analysis single-degree-of-freedom model were used to quantify the frequency dependence of the safe level criteria. An overall summary analysis was performed and data obtained from nine previous studies, including the three analyzed earlier by the Bureau for Bulletin 656 published in 1971. Separate analysis of the high- and low-frequency damage cases, structural response, and two types of construction resulted in the establishment of safe vibration levels ranging from 12 mm/sec to 50 mm/sec (0.5 in/sec to 2.0 in/sec).

OP 13–81. Hypothetical Mine Models and Input-Output Requirements for Copper-Nickel Mining in Minnesota, by David L. Veith. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–330, 21 pp. As the basis for the State of Minnesota's Regional Copper-Nickel Study environmental evaluation, hypothetical mine models were developed ranging in ore capacity from 5.35 to 2.00 x 10^6 mtpy. Open pit and underground mining operations were defined utilizing conventional methods of ore extraction. Processing of the copper-nickel sulfide material involved conventional bulk flotation of the valuable minerals, with maximum water recycle and tailing disposal. Flash smelting and electrolytic refining of the concentrate resulted in 0.10 x 10^6 mtpy copper plus nickel metal, plus associated cobalt and precious metals. Variations in model parameters allowed environmental trade-offs to be identified.

OP 14–81. Seepage Through Partially Saturated Soils Below a Uranium Tailings Pond, by E. G. Zahl and G. L. Bloomsburg. Proc. 1st Internat. Conf. on Uranium Mine Waste Disposal, Vancouver, British Columbia, Canada, May 19–21, 1980; American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, ch. 30, December 1980, pp. 445–455. A finite-element computer program, UNSAT2, that simulates unsaturated flow is described and applied to a tailings pond near East Gas Hills, Wyo. Information necessary to run the program are tables of relative conductivity versus moisture content and capillary pressure versus moisture; porosity and saturated conductivity; and initial pressures, boundary conditions, and spatial coordinates for each nodal point. A 10-year simulation is made of the tailings pond based on existing field data and assumptions and interpolations where field data are lacking. The final phreatic surfaces through the cross section are similar but higher than measured values, probably due to limitations in assigning boundary conditions. UNSAT2 program results simulate actual conditions much better than saturated flow analysis. Limitations of applying the program to typical tailings ponds are lack of historical data, cost, and difficulty in obtaining representative data to determine relative conductivity—capillary pressure—moisture content relationships, and assigning realistic boundary conditions compatible with the program. Further work on the program could make it an effective method of analyzing flow beneath new, properly instrumented, tailings ponds.

OP 15–81. An Overview of Materials and Corrosion in Geothermal Systems, by J. P. Carter, S. D. Cramer, and R. K. Conrad. Pres. at Energy-Sources Technol. Conf. and Exhibition, New Orleans, La., Feb. 3–7, 1980 (pub. in Materials and Corrosion Problems in Energy Systems, ed. by W. J. Lochmann and M. Indig), pp. 17–1—17–10. For the past several years the Bureau of Mines has been involved in the development of the geothermal mineral resources of the Imperial Valley, Calif. The brines produced from geothermal reservoirs in this area are extremely corrosive. Furthermore, the brines readily form complex scales during processing that complicate the corrosion process and interfere with process operations. This paper presents examples of corrosion and materials problems encountered at some of the major geothermal systems presently being developed.

OP 16–81. Infrared Pyrometers for Measuring Dust Explosion Temperatures, by K. L. Cashdollar and M. Hertzberg. Modern Utilization of Infrared Technol. VI, SPIE, v. 253, 1980, pp. 254–260. This paper describes the design of two infrared optical pyrometers used to study dust explosions. One is a six-wavelength pyrometer that can measure both dust particle temperature and gas temperature by observing continuum and gas band emission in the 1- to 5-μm infrared region using PbSe detectors. The second pyrometer measures particle continuum emission in the 0.8- to 1.0-μm region of the near infrared using Si detectors. Temperature data are presented for both laboratory- and full-scale mine explosions.

OP 17–81. The Corrosion Behavior of Niobium in Hydrochloric Acid Solutions, by B. S. Covino, Jr., J. P. Carter, and S. D. Cramer. Corrosion, v. 36, No. 10, October 1980, pp. 554–558. Studies to better understand the corrosion behavior of niobium in hydrochloric acid solutions have been conducted as part of the Bureau of Mines effort to conserve mineral resources in the United States. A study of the general corrosion behavior of niobium as a function of acid concentration, time, oxygen, and added ferric ion is reported. Weight loss (corrosion) tests were performed in air saturated (agitated and static) and helium saturated (agitated) hydrochloric acid solutions ranging from 1*N* to 10*N* at temperatures from 35° to 100° C and exposures up to 60 days. The 30-day corrosion rates ranged from

0.0 μm/y in 35° C air saturated (agitated) 1*N* HCl to 230 μm/y in air saturated (static) 9.8*N* HCl at 85° C. Although the corrosion rates decreased rapidly for times up to 30 days, the rates for 30 and 60 days were essentially identical. The presence of air did not affect the corrosion rate of niobium, while the presence of only 70 ppm of ferric ion reduced the corrosion rate in most air saturated 5*N* and 10*N* HCl solutions.

OP 18–81. An Overview of Sulfur-Extended Asphalt Usage, by W. C. McBee, T. A. Sullivan, and D. Saylak. Pres. at FAA Eastern Region Airport Eng. Seminar, Hershey, Pa., Mar. 3, 1980; pub. in Asphalt Pavement Construction: New Materials and Techniques, ed. by J. A. Scherocman, ASTM STP 724, pp. 39–63. Interest in the use of sulfur in highway pavement construction has been stimulated by unpredictable increases in cost and by uncertainty as to the future availability of asphalt cement as a result of the current "energy squeeze." As a consequence, bid prices for asphalt cement, which have almost tripled over the past 3 years, are expected to rise even more. Recent studies and experimental field tests have shown that sulfur can, under certain circumstances, replace as much as 35 vol-pct of the asphalt cement used in asphaltic concrete mixes. The unique properties of sulfur, both alone and when blended with asphalt, have also shown potential for use in recycling old bituminous pavements. This paper attempts to put into perspective the state-of-the-art in design, preparation, placement, and performance evaluation of sulfur-extended asphalt (SEA) pavement mixtures. Various methods of binder preparation are discussed and, where possible, compared on the basis of their physical and engineering properties. The status of three domestic experimental field trials utilizing these methods is reviewed. The potential use of SEA binder to recycle old bituminous pavements is also presented. Theoretical in-service performance predictions of SEA pavement materials are compared with conventional asphalt cement on the basis of their rutting potential, resistance to cracking, slope variance, and serviceability index. Finally, recommendations for future work are discussed.

OP 19–81. Electrochemical Determination of Thermodynamic Properties of Molybdenite (MoS_2), by S. C. Schaefer and N. A. Gokcen. High Temp. Sci., v. 12, 1980, pp. 267–276. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology, thermodynamic properties of molybdenite (MoS_2) were determined with high-temperature galvanic cells employing stabilized zirconia as the electrolyte.

OP 20–81. Recovery of Molybdenum and Rhenium From Concentrates by an Electrooxidation-Solvent Extraction—Carbon Adsorption Technique, by B. J. Scheiner and D. L. Pool. Pres. at Internat. Cong., Inst. Min. Eng., Santiago, Chile, Nov. 23–29, 1980; Anales Congr. Cincuentenario Min. Cobres Porfidicos, v. 2, pp. 122–148. The Bureau of Mines has demonstrated an electrooxidation-solvent extraction-carbon adsorption technique for recovering molybdenum and rhenium from offgrade concentrates in a process research unit (PRU) operating at a feed rate of 3.4 to 4.7 lb of concentrate per hour. The flow sequence consists of metal values by electrooxidation, liquid-solid separation by thickening, acidification and chlorate ion removal by sulfur dioxide treatment, solvent extraction to concentrate the molybdenum and rhenium, separation of molybdenum and rhenium by carbon adsorption, and metal recovery by crystallization. Molybdenum and rhenium were recovered as ammonium paramolybdate and ammonium perrhenate. Based on PRU results, an industrial-sized cell was constructed and tested for extraction of metal values from offgrade molybdenite concentrates.

OP 21–81. Dewatering of Thickened Phosphate Clay Waste From Disposal Ponds, by B. J. Scheiner and A. G. Smelley. Pres. at AIME Ann. Meeting, Chicago, Ill., Feb. 21–26, 1981, TMS Paper Selection A81–6, 9 pp. The Bureau of Mines, as part of its mission to effect pollution abatement, conducted research to develop a technique for dewatering phosphate clay waste from disposal ponds. Phosphate clay waste was dewatered from 11.8 pct to greater than 20 pct solids using 0.53 lb of polyethylene oxide (PEO) per ton of dry solids. Dewatering was accomplished by mixing the clay waste with PEO and treating the resulting flocs on a static screen followed by further treatment on a rotating trommel screen. Discharge from the trommel screen, when placed in a column 23 inches in diameter and 11 feet in height, continued to dewater to greater than 28 pct solids in 90 days.

OP 22–81. Methanol Synthesis Catalysts From Thorium-Copper Intermetallics. Preparation and Evaluation, by Elizabeth G. Baglin, Gary B. Atkinson, and Larry J. Nicks. I&EC Prod. Res. and Develop., v. 20, No. 1, March 1981, pp. 87–90. Bureau of Mines research into the use of intermetallic compounds as catalytic materials has shown catalysts prepared from binary alloys of copper and thorium to be active for the synthesis of methanol from carbon monoxide and hydrogen. Activation of the alloys resulted in oxidation of the thorium yielding high surface area catalysts containing copper interspersed on thoria. For example, catalysts prepared from $ThCu_x$ alloys by air oxidation at 400° C had surface areas as high as 35 m^2/g and produced up to 6.7 times as much methanol as a traditional $Cu/ZnO/Al_2O_3$ catalyst from $16H_2$:CO synthesis gas in a continuous-flow microreactor at 280° C and 60 atm pressure. Standard inlet space velocity was 31,000 h^{-1}.

OP 23–81. A Drop Impact Sampler, by Lung Cheng and Warren G. Cross. Environ. Sci. Technol., v. 15, No. 4, April 1981, pp. 459–463. The drop impact sampler developed by the Bureau of Mines is based on the stain technique for measuring airborne drops. The stain technique requires a calibration curve to relate stain and drop diameters at a known impact velocity, usually the terminal value. However, physical constraints limit sampler location, making it difficult to attain the terminal value and thereby introducing complications; extrapolation of a calibration curve based on the spherical quiescent model to large drops results in an erroneously large diameter. The new sampler eliminates these difficulties and makes it possible to determine rates of depositions and spatial concentrations. The sampler can measure drop diameters ranging from 0.005 to 2.5 mm and is suitable for water sprays, raindrops, and carry-over drops such as from cooling towers. Laboratory tests have shown that the sampler is reliable, rugged, lightweight, and easy to use.

OP 24–81. Direct Flotation of Potash From Insoluble-Slime-Bearing Sylvinite and Carnallite Ores, by Donald G. Foot, Jr., and Jerry L. Huiatt. Pres. at AIME Ann. Meeting, Chicago, Ill., Feb. 22–26, 1981, SME Preprint 81–74, 8 pp. The Bureau of

Mines devised a direct flotation method for treating low-grade carnallite ($KCl\text{-}MgCl_2 \cdot 6H_2O$) and sylvinite (a mixture of KCl and NaCl) ores characterized by a high content of water-insoluble impurities. The procedure consists of (1) flocculation-depression of the insoluble slimes, (2) decomposition leach (carnallite only), (3) potash rougher, cleaner, and recleaner flotation, and (4) final product leaching. The technique eleminates the necessity of removing the water-insoluble slimes by mechanical or flotation desliming. Laboratory results demonstrated that the direct flotation procedure, when compared with conventional techniques, yielded equivalent or improved flotation results with equal or less reagent consumptions. The direct flotation method recovered 81.6 pct of the solid-phase KCl from carnallite ore and 79.7 pct of the KCl from sylvinite ore in final products containing 60.5 pct and 60.9 pct K_2O. A flowsheet incorporating the described flotation procedure is presented.

OP 25–81. Biogeochemistry of Acid Mine Drainage and a Method to Control Acid Formation, by R. L. P. Kleinmann, D. A. Crerar, and R. R. Pacelli. Min. Eng., v. 33, No. 3, March 1981, pp. 300–305. A bacterium, *Thiobacillus ferrooxidans*, is of prime importance in the formation of acid drainage from pyritic material. Above pH 4.5, *T. ferrooxidans* increases initial acidification; below pH 4.5, it allows acidification to continue by oxidizing Fe^{2+}. Below a pH of approximately 2.5, the activity of Fe^{3+} is significant and results in steady-state cycling between oxidation of pyrite by Fe^{3+} and bacterial oxidation of Fe^{2+}. Laboratory and field tests demonstrate that inhibition of *T. ferrooxidans* by controlled release of anionic detergents can inexpensively reduce pyrite oxidation and acid formation.

OP 26–81. Computer Program To Aid in Adjusting Particle Size Distribution, by Arthur V. Petty, Jr., and D. B. Nevin. Am. Ceram. Soc. Bull., v. 60, No. 4, April 1981, pp. 506–507. Numerous situations in which particle size must be matched to a predetermined distribution or the distribution of a sample must otherwise be altered. Normally, this alteration requires screening the entire sample into various mesh sizes and recombining to form the desired distribution, or using extensive and time-consuming iterative calculations. A computer program to aid in these calculations was developed by the Bureau of Mines for use on a basic processing system. The program determines the quantity of material that must be added to a sample to adjust its size distribution to approximate that of a standard. Operating in an interactive mode, the program will accept up to 20 size fractions as input or will use a standard $\sqrt{2}$ distribution, depending on input commands. Also required as input are the particle size distributions of the standard and the sample to be adjused, the limit of error on the adjustments, and the mass (in grams) of the sample to be prepared.

OP 27–81. Platinum-Group Minerals in Alluvial Deposits, by J. Sjoberg and J. M. Gomes. Pres. at Precious Metals Conf., Reno, Nev., Nov. 17–20, 1980; pub. in California Geol., v. 34, No. 5, May 1981, pp 91–98. The Bureau of Mines is investigating the recovery of byproduct heavy minerals from California sand and gravel deposits as a means of more effectively utilizing these mineral resources. In one phase of the study different platinum-group metal (PGM) minerals are being identified to determine if variations in their geograhical distribution exist. Platinum-group mineral concentrates were recovered containing up to 1,000 oz/ton PGM. More than 20 PGM minerals were identified by SEM/microprobe analysis of samples from 12 areas of northern and central California. Major minerals identified were ferroplatinum, sperrylite, and osmiridium. Several mineral phases not previously reported in the literature as occurring naturally were tentatively identified. There are indications of the existence of variations in the geographical distribution of the major PGM minerals. The history, occurrence, geology, and uses of the platinum-group metals are discussed.

OP 28–81. Regeneration of Waste Chromic Acid Etching Solutions in an Industrial-Scale Research Unit, by L. C. George, D. M. Soboroff, and A. A. Cochran. Proc. 3d EPA/AES Conf. on Advanced Pollution Control for the Metal Finishing Industry, Kissimmee, Fla., Apr. 14–16, 1980; v. EPA-600, No. 2-81-028, February 1981, pp. 33–36. Substantial amounts of chromium are lost in various surface-finishing operations and pollution problems are created when spent solutions containing hexavalent chromium and sulfuric acid are discarded. Laboratory research has shown that these spent etching solutions can be regenerated in a diaphragm cell. When the spent solution is placed in the anode chamber, most of the Cr^{3+}, produced during etching operations, is oxidized to Cr^{6+}. Impurity metals dissolved during the etching operation are transferred to the catholyte. When waste brass etchants are treated, about one-third of the copper and zinc is removed. The energy consumption is less than 9 kwhr/kg of sodium dichromate regenerated. Similar results are obtained with spent printed-circuit-board etchants and rinse waters from plastic etching operations. An industrial-scale research unit capable of oxidizing up to 0.5 kg/hr of trivalent chromium has been operated to demonstrate the viability of the recycling techniques. Regenerated brass etchants evaluated by two companies equaled or exceeded the performance of fresh etchants.

OP 29–81. State-of-the-Art Guideline Manual for Design, Quality Control, and Construction of Sulfur-Extended-Asphalt (SEA) Pavements, by W. C. McBee, T. A. Sullivan, and J. O. Izatt. Fed. Highway Admin., U.S. Dept. Trans., FHWA-IP-80-14, August 1980, 52 pp. Interest in the use of sulfur in highway pavement construction has been stimulated by unpredictable increases in cost and the relative uncertainty as to the future availability of asphalt cement (A/C) along with the potential surplus of sulfur in the near future. These events have led to the development of a new binder: a sulfur-extended-asphalt (SEA) binder. This new binder replaces some of the asphalt with sulfur in conventional asphalt paving plants. The mix material can be transported, laid, and compacted with standard paving equipment. Studies of SEA pavements indicate that their properties are comparable and in some cases may prove to be superior to those of conventional asphalt pavements. The manual presents state-of-the-art guidelines for design, quality control, safety factors, and construction of these newly developed pavements. A nonproprietary, direct mixing method and four proprietary methods of producing the SEA mixtures are described.

OP 30–81. Role of Sulphur in SEA Pavements, by W. C. McBee, P. A. Romans, T. A. Sullivan, and R. R. Uhde. Pres. at Sulphur-81 Internat. Conf., Calgary, Alberta, Canada, May 25, 1981;

pub. in Sulphur Res. & Develop., v. 4, pp. 5–12. As part of the Bureau of Mines Sulfur Utilization Program, paving materials were developed in which sulfur replaced up to 35 pct of the asphalt binder volume. These sulfur-extended asphalt (SEA) materials, along with those developed by private concerns, have been used to construct experimental highways in 20 States. Very little information has been obtained on the behavior of the materials during in-service aging. The sulfur microstructural features of core samples obtained from highways constructed using all existing SEA technologies are described. In addition, the activation energy for diffusion and solubility limits of sulfur in asphalt were determined for a typical paving asphalt. A mechanism for nucleation and growth of crystalline sulfur in the pavement is presented and related to the structure developed in the material.

OP 31–81. Dewatering of Coal-Clay Waste Using Polyethylene Oxide as a Flocculant, by B. J. Scheiner, Annie G. Smelley, and Jalna Zatko. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 20 pp. The Bureau of Mines is developing a dewatering technique for coal-clay wastes. The technique consists of mixing coal-clay waste with the flocculant polyethylene oxide (PEO) and dewatering the resulting flocs on a hydrosieve screen followed by further dewatering on a rotary trommel screen. Coal-clay waste slimes containing from 7 to 28 weight-percent solids have been consolidated up to 50 weight-percent solids using about 0.5 lb of PEO per ton of dry solids.

OP 32–81. Application of a Dewatering Technique to Industrial Wastes, by Annie G. Smelley and B. J. Scheiner. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 13 pp. In research conducted as part of its mission to effect pollution abatement, the Bureau of Mines has developed a specialized flocculation dewatering technique that may have wide application in the disposal of industrial wastes. This method allows for reuse of water previously lost with the wastes, eliminates or reduces the need for storage ponds, and facilitates recovery of mineral values. The flocculants used are high molecular weight polymers such as polyethylene oxide and polyacrylamides that can form strong, tough flocs with the wastes.

OP 33–81. Effect of Ion Exchange on Dewatering Phosphate Clay Waste With Polyethylene Oxide, by D. A. Stanley, P. M. Brown, and B. J. Scheiner. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 14 pp. As part of its mission to provide technology to assure a continuing supply of minerals, the Bureau of Mines conducted research to obtain a better understanding of how clays are flocculated by polyethylene oxide (PEO). The Bureau is presently developing a dewatering technique in which PEO is used to flocculate phosphatic clay waste and the resulting flocs dewatered on static and rotary screens. During the field testing of this technique, a clay waste was encountered that could not be dewatered readily. Studies indicated that the clay contained trace amounts of sulfides and that a portion of the exchange ions on the clay were probably hydrogen ions. Replacement of the exchange ions with calcium ions and agitation of the clay to oxidize the sulfides reduced the PEO requirements, which resulted in the clay being readily dewatered in both laboratory and large-scale field tests.

OP 34–81. The Limits of Flammability of Pulverized Coals and Other Dusts, by Martin Hertzberg, Kenneth L. Cashdollar, and Charles P. Lazzara. Proc. 18th Internat. Symp. on Combustion, Ontario, Canada, Aug. 9, 1980; The Combustion Institute, 1981, pp. 717–729. The limits of flammability of pulverized coals and other dusts were measured in a 7.8-liter system that provided accurate control of the significant experimental variables. The data are consistent, reproducible, and reliable, and the system is recommended as the standard for dust flammability studies.

OP 35–81. Inhibition of Acid Mine Drainage Formation: The Role of Insoluble Iron Compounds, by John W. Nebgen, William H. Engelmann, and Douglas F. Weatherman. Pres. at Inst. Environ, Sci. Ann. Meeting, Philadelphia, Pa., May 11–14, 1980; pub. in J. Environ. Sci., v. 24, No. 3, May-June 1981, pp. 23–27 This paper contains findings and conclusions from a 2-year study concerning chemical agents for the inhibition of acid mine drainage (AMD) formation. Three materials containing pyrite were evaluated in detail, but only one was a strong producer of AMD. Analysis of the experimental results strongly suggest that the rate at which pyrite is oxidized can be lowered substantially if the iron products from pyrite oxidation are kept insoluble. Analysis of the data does not distinguish between the lack of availability of soluble ferric ion as an oxidant or the exclusion of air by a ferric oxide coating. Either mechanism is compatible with the experimental data. Thus, methods to keep aqueous ferric ion minimized, for example, through insolubilization or maintaining high Fe^{++}/Fe^{+++} ratios, appear to be important in the chemical inhibition of AMD formation.

OP 36–81. Estimating Mine Pillar Strength From Compression Tests, by L. A. Panek. Trans. Soc. Min. Eng., AIME, v. 268, 1981, pp. 1749–1761. Using an approach based on the theory of similitude, a general equation and related concepts were developed that provide new insights to an old problem. The load-bearing capacity (strength) of a square, rectangular, or cylindrical prism of a brittle material such as rock, coal, or concrete is expressed as the mathematical product of a size effect, a shape effect, and a function of the mechanical properties (deformability, cleat-joint spacing, and friction) of the pillar, roof, and floor materials. Through an application of multivariate statistical analysis, the results of assorted tests (laboratory and in situ) and observations of failed pillars can be combined into a fundamental scaling equation, which provides a unified, consistent approach to the estimation of mine pillar strength. The form of the equation is sufficiently general to be able to incorporate refinements in the characterization of the structural parameters, as they become available through future analysis and experimentation. Analysis of the published test data suggests that pillar compressive strength (per unit of area) is proportional to the cube root of the pillar width, and that the height effect can be described as the superimposing of a variable size effect (characteristic of the material) on the constant width effect.

OP 37–81. Prereduction and Melting of Domestic Chromites, by Ralph H. Nafziger, Phillip E. Sanker, Jack E. Tress, and Robert A. McCune. Proc. 38th Electric Furnace Conf., Iron and Steel Soc., AIME, Pittsburgh, Pa., Dec. 11–12, 1980, pp. 27–45. The Bureau of Mines has prereduced domestic chromites to provide a suitable charge material for

the production of ferrochromium in an electric arc furnace. As part of the Bureau's goal to economically and efficiently recover metal values from domestic resources, this investigation has shown that prereduction of domestic chromites increases productivity and decreases electric energy consumption, compared with results where unreduced materials were used. Approximately 75 pct chromium metallization and 75 pct total metallization were realized when high-iron chromites from Montana were prereduced with coal char and coke breeze in a batch rotary kiln. Chromium and total metallizations near 95 pct were obtained when a metallurgical-grade chromite was prereduced. Satusfactory ferrochromium for the production of stainless steel was produced in an electric arc furnace from all of the prereduced materials.

OP 38–81. Deformation and Cracking of a Concrete-Lined Tunnel in a Rock Mass Subjected to a Changing State of Strain, by Louis A. Panek. Proc. 22d U.S. Symp. on Rock Mechanics, Cambridge, Mass., June 29-July 2, 1981, pp. 328–334. As part of an investigation of ground movements around a zone of caving ground, measurements were made of the deformation of a 90-meter length of mine tunnel. The tunnel lay astride the path of an approaching caved zone 64 meters wide, which eventually undermined the tunnel. The approach of the caving zone caused the rock mass around the tunnel to expand laterally and downward toward the cave, resulting in a gradual sinking of a portion of the tunnel and distortion of the tunnel section, which led to the fracturing of the concrete lining. Longitudinal extension and bending of the axis of the tunnel were measured, as well as the distortion of the tunnel cross section, using extensometers and tiltmeters of simple design. The approach was to monitor basic deformation components that could be conveniently measured by mine personnel, making maximum use of off-the-shelf hardware, to show that definitive data can be generated thereby. Especially notable was the demonstrated capability to determine from a triangular configuration of cross tunnel extensometer measurements the principal directions of deformation within the surrounding rock mass. By increasing the number of gage points from 2 to 3, three times as much information is obtained as by measuring roof-to-floor convergence.

OP 39–81. Effects of High Pressure, High Temperature Steam-Containing Environments on Alumina Refractory Concretes, by Leon Y. Sadler III, Nancy S. Raymon, Kenneth H. Ivey, and Hendrik Heystek. Am. Ceram. Soc. Bull., v. 60, No 7, July 1981, pp. 703–706. This paper describes results obtained in a study of the response of alumina-based refractory concretes to coal dry-ash gasifier environments. The investigations were designed to determine the relationship between observed refractory property changes after exposure to dry-ash gasifier environments and variables such as exposure temperature, steam partial pressure, gas velocity, aggregated and cement composition, and the presence of alkalis. Both commercially available and laboratory-formulated refractory concrete compositions, ranging from 45 to 95 pct alumina and containing low, intermediate, and high-purity calcium aluminate cements were studied. The refractories were exposed to environments at pressures ranging from 2.9 to 7.0 MPa (400 to 1,000 psig) and at temperatures ranging from 760° to 1,000° C. In some exposures, alkalis were introduced into the exposure environment. The steam-induced volatilization and vapor-phase transport of silica from the refractories under a variety of conditions were also studied.

OP 40–81. Smoke Characteristics of Coal-Lined Tunnel Fires, by Kenneth L. Cashdollar, Joseph M. Singer, Calvin K. Lee, and Charles D. Litton. Fire and Mater., v. 5, No. 2, 1981, pp. 47–51. Characteristics of smoke particulates generated from a coal fire in a ventilated model tunnel were investigated by laser optical transmission and by electron microscopy. Average particle diameter and mass concentration of the smoke were determined as a function of the temperature and stoichiometry of the coal tunnel fire. Smoke particle sizes ranged from 0.2 to 0.9 μm, with larger particle sizes associated with higher smoke concentrations. These coal smoke data are relevant to several aspects of underground mine safety including the development and location of smoke detection instruments, the understanding of the fire (toxic fume) hazards, and the development of new fire protection and control techniques.

OP 41–81. Potential Production Capacity of Metallurgical Coke, by Franklin D. Cooper. Iron and Steel Eng., v. 58, No. 9, September 1981, pp. 52–57. A method for determining the annual potential production capacity (ppc) for captive blast furnace coke is described together with examples relating battery age to productivity, time, and worker hour distributions for coke-oven operations and production costs. Based on a practical best fit combination of known operating variables involving more than 140 captive oven batteries, the study shows that the U.S. steel industry currently has blast furnace coke ppc equivalent to about 62 to 64 million tons annually of coke-related finished steel shipments.

OP 42–81. Bureau of Mines New Stopping Designs—An Update, by Edward D. Thimons and Fred N. Kissell. Min. Cong. J., v. 67, No. 7, July 1981, pp 1–4. Conventional stoppings of concrete block or wood walls covered with mortar-type sealants, urethane foams, or heavy brattice cloth work well in many mining applications, but the time and cost of constructing and maintaining them can make them impractical, especially when only temporary stoppings are needed. They do not lend themselves to use at or near the working faces of mines where heavy blasting is done because of the damage they incur. This paper describes the parachute stopping, quick-fix blowout stopping, and damage-resistant brattice, recently developed by the Bureau of Mines, that are much more suitable for such applications.

OP 43–81. Preparation of Cell Feed Materials for Aluminum and Magnesium Production, by James A. Barclay. Pres. at Workshop on Electrochemistry Applied to Processing of Lunar Materials, Houston, Tex., Sept. 12, 1979; Space Solar Power Review, v. 12, 1981, pp. 259–269. Magnesium chloride for electrolysis to magnesium in a fused-salt bath is made by reacting seawater with milk of lime to precipitate magnesium hydroxide, separating the latter from the barren seawater, dissolving the hydroxide in hydrochloric acid, and crystallizing and drying the compound $MgCl_2 \cdot 1.5H_2O$. Solar evaporation of Great Salt Lake brine, followed by spray drying, also is practiced. Dolomite may be calcined and ground to a fine powder to be mixed with ferrosilicon for reduction to magnesium in vacuum retorts by a nonelectrolytic process. Alumina for smelting to aluminum in Hall-Heroult cells is pre-

pared from bauxite by pressure digestion with strong NaOH solution, thickening, and filtration to separate a waste "red mud," and crystallization of $Al_2O_3 \cdot 3H_2O$ in the presence of seed crystals. The $Al_2O_3 \cdot 3H_2O$ then is calcined to Al_2O_3. The Bureau of Mines and other research on the recovery of alumina from nonbauxitic aluminous materials is discussed, and possible applications of acid leaching, alkaline sinter-caustic leaching, and carbochlorination processes to lunar materials are briefly evaluated.

OP 44–81. Potential "Met" Coke Production Capacity: The Case Is Anything But Closed, by Franklin D. Cooper. 33 Metal Producing, v. 19, No. 9, September 1981, pp. 65–67. A method for determining the annual potential production capacity (ppc) for captive blast furnace coke is described together with examples of relating battery age to productivity, time, and work-hour distributions for coke-oven operations and production costs. Based on a practical best fit combination of known operating variables involving more than 140 captive oven batteries, the study shows that the U.S. steel industry currently has blast furnace coke ppc equivalent to about 62 million to 64 million tons annually of coke-related finished steel shipments.

OP 45–81. The Error in Working-Level Hour. Calculations When the α-Energy From the Radon Daughters Is Not Discriminated, by John Durkin. Health Phys., v. 41, No. 3, September 1981, pp. 477–481. Exact working-level hour cumulative exposure measurements require knowledge of all the potential α energy in 1 liter of air, with this α energy coming from the decay of RaA and RaC' daughters. This can be done by measuring α emission from the daughters with a system that also determines the energy of the α particle, and is, therefore, able to determine which daughter decayed. However, simple counting of total α emission and the assignment of a predetermined energy to the α particle whose value is prescribed from statistical studies of typically found daughter ratios, allow acceptable accuracies in working-level hour measurements.

OP 46–81. Determination of Ground Pressure Existing in a Viscoelastic Rock Mass by Use of Hydraulic Borehole Pressure Cells, by Paul H. Lu. Proc. Internat. Symp. on Weak Rock, Tokyo, Japan, Sept. 21–24, 1981, 7 pp. Accurate magnitude of the biaxial ground pressures existing in a viscoelastic rock mass can be determined by pressure convergence tests with a combination of one cylindrical and two flat hydraulic pressure cells installed in a single hole drilled into that rock mass. Consequently, the triaxial ground pressures can be measured by drilling a pair of orthogonal holes for such instrumentation. Unlike most of the known methods of in situ stress determination that determine the magnitude of the stress indirectly from the elastic stress-strain relation by measuring strain or displacement in place and modulus of deformation in the laboratory, this method directly measures the in situ stress without any knowledge of the value of modulus of deformation. Furthermore, the complete state of stress existing in the viscoelastic rock mass also can be determined by this method if other techniques are supplemented for determining the directions of the principle stresses. In this paper, the theoretical background, measuring equipment, and measurement procedure are discussed. Validity of tions of the principal stresses. In this paper, the are demonstrated by the in situ measurements conducted for a variety of rock types.

OP 47–81. A Comparison of American Safety Performance to Other Countries, by Robert L. Marovelli. Min. Con. J., August 1981, pp. 45–51. Comparisons are made of indicators of safety performance in the United States and primarily the European coal-producing countries of the United Kingdom and the Federal Republic of Germany. Caveats are made that safety performance for U.S. room-and-pillar mining is being compared with European longwall mining and that even a comparison confined to U.S. longwall mining versus European longwall mining would be indirect at best due to important differences in mine development (e.g., U.S. multiple entries versus European single entries) and mining operations.

OP 48–81. Thermodynamic Properties of Aluminum Sulfide (Al_2S_3), by M. J. Ferrante, J. M. Stuve, H. C. Ko, and R. R. Brown. High Temp. Sci., No. 14, 1981, pp. 91–108. Research done at the Bureau of Mines has produced calorimetric data for the low temperature heat capacity from 12 to 312 K and the high temperature relative enthalpy from 400 to 800 K for aluminum sulfide (Al_2S_3). The heat capacity measurements yielded $S°_{298} = 27.927 \pm 0.05$ cal K^{-1} mol^{-1} for the standard entropy at 298.15 K (1 cal = 4.1840 J). The standard enthalpy of formation at 298.15 K, $\Delta Hf°_{298} = 155.6 \pm 0.9$ kcal mol^{-1}, was determined by hydrochloric acid solution calorimetry. The results were combined with the published data for pure aluminum and sulfur to obtain a complete set of thermodynamic data for Al_2S_3 from 0 to 900 K at appropriate temperature intervals.

OP 49–81. Thermodynamic Properties of Cuprous and Cupric Sulfides, by M. J. Ferrante, J. M. Stuve, and L. B. Pankratz. High Temp. Sci., v. 14, 1981, pp. 77–90. Low-temperature heat capacities of Cu_2S(c) and CuS(C) have been measured from 5 to 310 K with an adiabatic calorimeter. The results yielded $S°_{298} = 27.76$ for Cu_2S and $S°_{298} = 16.05$ for CuS, where $S°_{298}$ is the standard entropy at 298.15 K in cal $K^{-1}mol^{-1}$ (1 $cal_{th} = 4.184$ J). High-temperature relative enthalpies have also been measured with a copper-block calorimeter from 298 to 1,600 K for Cu_2S and from 298 to 780 K for CuS. Two solid-solid transitions have been observed for Cu_2S upon heating, the first at 376 K with an isothermal heat absorption of 865 cal mol^{-1}, and the second at 720 K with an isothermal absorption of 280 cal mol^{-1}. The enthalpy of fusion at 1,400 K was 3,070 cal mol^{-1}. No solid-solid phase transitions were observed for CuS from 5 to 780 K. All related thermodynamic properties have been tabulated.

OP 50–81. An Algorithm for Multidimensional Combusting Flow Problems, by Edward J. Kansa. J. Comput. Phys., v. 42, No. 1, July 1981, pp. 152–194. Mathematical effort in combusting fluid flow has been limited due to the numerical difficulties associated with the highly nonlinear processes such as Arrhenius chemical kinetics, radiation, and turbulence superimposed upon fluid flow. Traditional explicit schemes become inefficient in typical combustion problems because the stability requirement is more stringent than the accuracy requirement. The approach taken in this paper is to combine the best features of the block implicit (BI)-ADI partial differential equation (PDE) scheme with the best features of the stiff ordinary differential equation (ODE) schemes and the damped Newton-Raphson and steepest descent nonlinear equation schemes. The resulting algorithm for the highly nonlinear

PDE's for combustion problems is very robust and efficient over a wide range of phenomena.

OP 51–81. Selective Extraction of Metals From Pacific Sea Nodules With Dissolved Sulfur Dioxide, by S. E. Khalafalla and J. E. Pahlman. J. Metals, v. 33, No. 8, August 1981, pp. 37–42. A rapid and efficient—almost instantaneous and quantitative—method was devised to differentially leach manganese, nickel, and cobalt to the exclusion of copper and iron from deep sea nodules. In this method, a given weight of raw sea nodules ground to -200 mesh in an aqueous slurry is contacted for 10 min at room temperature with a specified quantity of SO_2. An independent leaching parameter, R, was defined as the ratio of the number of moles of SO_2 in the leaching solution to the weight of sea nodules. Variation of metal extraction with R generates sigmoidal curves characteristic of the metals extracted. A threshold value of R is required to initiate the leaching of a given metal from the mixed oxides. Once the threshold is reached, the metal recovery can rise above 95% in less than 10 min. For increasing value of R the extractability of various metals from Pacific sea nodules by SO_2 follows the order: Mn > Ni > CO >> Fe, AL, Cu. Disparity in the R values permits a variety of selective leaching systems and metal separations simply by changing the quantity of SO_2 in the contact solution.

OP 52–81. The Determination of Chrysotile in Insulation Samples Using Combined TGA–GCA, by John V. Scalera. Proc. North Am. Thermal Analysis Soc. Conf., New Orleans, La., Oct. 19–21, 1981, v. 2, No. 51, pp. 303–309. The identification and quantification of asbestos in insulation materials was investigated by the Bureau of Mines Particulate Mineralogy Unit. One of the objectives is to provide technical assistance on mineral particulate-related problems to other Federal agencies. Quantification of the asbestos content in insulation and construction materials is necessary for the U.S. Environmental Protection Agency to evaluate the potential health risk from exposure to airborne fiber. Gas chromatographic analysis (GCA) of the effluent gases from a thermogravimetric analysis (TGA) balance can provide quantitative data concerning the composition of insulation samples. The GCA peak related to the dehydration of chrysotile occurs within the temperature range of 560° to 660° C. Using chrysotile standards, a linear relationship is obtained relating the summation of the peak heights for water evolved within this 100° C range and the mass of chrysotile present in the sample. The use of a narrow 100° C range to acquire the dehydration data for chrysotile minimizes interferences from hydrates that decompose at lower temperatures and amphiboles that decompose at higher temperatures, for example, gypsum and amosite. GCA data also allow avoiding misinterpreting TGA thermograms for chrysotile when actual $CaCO_3$ decomposition is involved by resolving weight losses in the dehydration range of chrysotile into components of water and CO_2.

OP 53–81. Alumina From Nonbauxitic Resources, by R. C. Kirby and J. A. Barclay Proc. Internat. Committee for the Study of Bauxite, Alumina, and Aluminum, ISCOBA-AIM Conf., Cagliari, Italy, Sept. 26–28, 1979, No. 16, 1981 v. 11, pp. 1–12. Although the United States produces nearly one-third of the world's primary aluminum, it must import more than 90 percent of the bauxite and alumina needed. To test and improve various raw material-process technology alternatives to the Bayer-bauxite process for alumina production, the Bureau of Mines is engaged in an extensive research and development effort. Information thus obtained will be used for decisionmaking on further large-scale testing of the process showing the greatest potential for producing alumina from a domestic nonbauxitic resource. The paper discusses recent research in the Bureau's alumina miniplant project, miniplant support research, and contract studies leading to the preliminary design of a 20-ton-per-day alumina pilot plant.

OP 54–81. Improved Fire Resistance Test Method for Belt Materials, by J. M. Kuchta, M. J. Sapko, F. J. Perzak, and K. E. Mura. Fire Technol., v. 17, No. 2, May 1981, pp. 120–130. A moderately scaled apparatus was developed for determining the fire resistance characteristics of mine conveyor belts and similar type materials. The test method overcomes the limitations of existing laboratory-scale methods and provides a measure of both ignitability and flammability in quantative terms. Data are presented for nine belt materials, and fire resistance ratings are proposed in terms of the flame spread rate, heat release rate, and critical ignitor heat flux.

OP 55–81. Modified-Sulphur Concrete Technology, by William C. McBee, Thomas A. Sullivan, and Bing W. Jong. Proc. Sulphur-81, Internat. Conf. on Sulphur, Calgary, Alberta, Canada, May 25–28, 1981, pp. 367–388. As part of a program to find uses for plentiful resources, the Bureau of Mines has developed a sulfur concrete technology in which chemically modified elemental sulfur is utilized with suitable mineral aggregates to formulate durable, corrosion-resistant materials of construction. This paper describes the chemical, physical, and mechanical characteristics of both sulfur cement and concretes, and the current state-of-the-art for the manufacture of the materials. Specialized use applications in chemical and metallurgical process environments and current performance data are described.

OP 56–81. Recovery of Zinc From Wastewater Treatment Sludge, by J. B. Stephenson, E. R. Cole, and D. L. Paulson. Res. and Conservation, v. 6, No. 3–4, November 1981, pp. 203–210. Preliminary laboratory work done under a Memorandum of Agreement between the Bureau of Mines Rolla Research Center and the Harrison Radiator Div., General Motors, Corp., has indicated that zinc can be recovered from wastewater treatment sludges generated at the Harrison plant at Lockport, N.Y. The method developed at the Rolla Research Center, Rolla, Mo., for extracting zinc from the sludge involves roasting, leaching-purification, and electrowinning. Roasting to combust the organic fraction and leaching with H_2SO_4 to stabilize the zinc proceeded routinely. Purification and electrowinning followed standard practice for a commercial zinc electrowinning plant, but because of the large amounts of deleterious impurities coextracted with the zinc, as much as 50 times greater than normally encountered in a commercial operation, an extensive modification of the purification procedure was necessary. Zinc was electrowon with good current efficiency and deposit morphology. Residues are being characterized to determine the feasibility of recovering valuable constituents prior to disposal in an environmentally acceptable manner.

OP 57–81. Gasification Pilot Plant Evaluation of CVD Coated Hardware, by J. B. Stephenson and H. O. McDonald. Proc. 8th Internat. Conf. on Chemical Vapor Deposition 1981, Chantilly-Gouvieux, France, Sept. 15–18, 1981, v. 81–7, November 1981, pp. 642–652. The Bureau of Mines, under an interagency agreement with the U.S. Department of Energy (DOE), investigated the feasibility of coating the critical surfaces of valves by chemical vapor deposition (CVD). The purpose of the research was to increase the wear resistance of the valves for use in the abrasive and erosive environment of coal conversion and utilization processes. In-service testing of the CVD-tungsten ball seat was conducted at the DOE Morgantown Energy Technology Center (METC) in Morgantown, W. Va. Tungsten CVD coatings were reproduced on nickel-plated carbon steels and stainless steels by the hydrogen reduction of the tungsten hexafluoride at 325° to 600° C. Tungsten-coated 6-, 10-, and 12-inch (0.15-, 0.25-, and 0.30-meter) ball valve seats were prepared for METC evaluation in their low-Btu coal gasification pilot plant. Use of the CVD-tungsten coated ball valve seat as a seal surface was determined to be satisfactory by METC under their process conditions. Little or no significant wear, other than a lapping effect, was noted on the valve seal surface after 1,230 cycles of operation.

OP 58–81. Recovery of Barite From Tailings Ponds and Bypassed Mining Waste, by G. V. Sullivan and W. E. Lamont. Min. Eng., v. 33, No. 11, November 1981, pp. 1632–1634. As part of its program to conserve domestic mineral resources through advancing mineral resources technology, the U.S. Department of the Interior, Bureau of Mines, conducted investigations to determine the feasibility of recovering high-grade barite concentrates, suitable for use as well-drilling mud, from current and old waste pond materials and materials bypassed in present mining operations. Flotation studies of waste pond samples from Missouri and Nevada yielded barite concentrates containing over 95% $BaSO_4$ with recoveries of 86% and 96%, respectively, of the barite in the flotation feed. Flotation studies of a hard-rock sample from Georgia, currently bypassed in mining, yielded a barite concentrate containing 97% $BaSO_4$ with an attendant recovery of 97% of the barite.

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OP 1–82. Methane Control on Longwall—European and U.S. Practices, by Joseph Cervik. Pres. at Soc. Min. Eng., AIME, Ann. Meeting, New Orleans, La., Feb. 18–22, 1979; ch. 9 in Longwall-Shortwall Mining, State of the Art, 1981, pp. 75–80. Common methods of controlling gob gas in U.S. mines are by means of ventilation of gob areas and gas drainage through surface boreholes. Costs of drilling surface gob holes increase as deeper coalbeds are mined. Where gob holes cannot be drilled because of topography, ventilation is the only means of control. Even then, sufficient air may not be available to dilute methane in the bleeder entries to acceptable levels. Thus, new methods of gob gas control need to be developed that are independent of surface topography, and of the mine ventilation system, less costly than present systems. Except for slight variations in procedures and equipment, Great Britain, the Federal Republic of Germany, France, Belgium, Poland, and Czechoslovakia use a common methane control method that is different from the systems generally used in the United States. This Bureau of Mines paper reviews European mining methods, mining conditions, and methane control technology and discusses their applicability to U.S. mines.

OP 2–82. Recovery of Gold and Other Heavy Minerals From Alluvial Deposits: Equipment and Practices, by J. M. Gomes and G. M. Martinez. Proc. Internat. Gold/Silver Conf., Reno, Nev., May 21–23, 1981, 12 pp. The potential for recovering gold and other heavy mineral byproducts from sand and gravel operations is discussed. The Bureau of Mines recently completed a study to determine heavy minerals present in the west coast sand and gravel deposits. Methods and equipment used for the recovery of gold and other heavy minerals in the deposits are discussed. Flowsheets for the recovery of gold and for the possible recovery of other heavy mineral byproducts are shown.

OP 3–82. Comparative Anatomy of a Pottsville Lithic Arenite and Quartz Arenite of the Pocahontas Basin, Southern West Virginia: Petrogenetic, Depositional, and Stratigraphic Implications, by David W. Houseknecht. J. Sediment. Petrol., v. 50, No. 1, March 1980, pp. 3–20. Appalachian carboniferous stratigraphy remains controversial partly because of unclear petrogenetic, depositional, and stratigraphic relationships displayed by Pottsville sandstones, which have been interpreted as being of either alluvial or barrier-beach origin. Two associated sandstones of the New River Formation of southern West Virginia provide the setting for a detailed examination of this problem. The Lower Raleigh lithic arenite consists of elongate and lobate, dip-oriented bodies that display erosional bases, interfinger laterally with shales, fine upward at the top, and are unidirectionally trough cross-bedded basinward. The Upper Raleigh quartz arenite consists of elongate, dip-oriented bodies updip in the basin and elongate and lobate, strike-oriented bodies downdip. The quartz arenites display erosional bases, interfinger laterally with shales, fine upward at the top, and are unidirectionally planar cross-bedded basinward. Evidence suggests that Lower Raleigh detritus was derived from a southeasterly metamorphic-sedimentary source terrane and deposited in high-constructive lobate deltas. Upper Raleigh quartzose detritus may have been derived from coarse-grained alluvial facies equivalents of Lower Raleigh deltaic facies and deposited in deltas whose margins were modified by marine processes. It appears that the Lower and Upper Raleigh sandstones are not deltaic and barrier-tidal facies equivalents, thus negating gross regional stratigraphic relationships implied by the barrier model. Additionally, these conclusions suggest that use of quartz arenite as a unique lithogenetic rock type for predictive purposes is prone to error.

OP 4–82. Anticipating Coal Mining Problems in Hartshorne Formation, East-Central Oklahoma, Using Sedimentary Facies Analysis, by David W. Houseknecht and Anthony T. Iannacchione. Am. Assoc. Pet. Geol. Bull., v. 64, May 1980, p. 724; Okla. Geol. Notes, v. 40, No. 5, October 1980, p. 209. This study of sedimentary facies associated with the Hartshorne coalbeds of east-central Oklahoma provides an oppor-

tunity for preventive planning to minimize mining problems

OP 5–82. Methane Production Potential From Hartshorne Coal Beds in Deep Parts of Pittsburg, Coal, and Hughes Counties, Oklahoma, by Anthony T. Iannacchione and David W. Houseknecht. Am. Assoc. Pet. Geol. Bull., v. 65, No. 8, August 1981, pp. 1499–1500. This paper discusses the methane production potential investigation performed by the Bureau of Mines of the Hartshorne coalbeds in the Arkoma Basin, Okla.

OP 6–82. Predicting Zones of Potentially Unstable Coal Mine Roof Based on Consideration of Sedimentary Facies: A Case Study, by Anthony T. Iannacchione, James P. Ulery, Frank E. Chase, David M. Hyman, and Donald G. Puglio. Pres. at 1980 Ann. Meeting, Geol. Soc. of America, Atlanta, Ga., Nov. 17–20, 1980, abs. with Programs, v. 12, No. 7, p. 453. This study demonstrates the use of geological data in prediction of slickensided transition zones and will aid in projecting main entries under the most competent roof and in planning an effective roof support system for advancing sections of a coal mine.

OP 7–82. Mineral Industries, by Thomas G. Langton and Phillip N. Yasnowsky. The Encyclopedia of Mineralogy, Encyclopedia of Earth Sciences. ed. by K. Frve. Hutchinson Ross Publishing Co., Stroudsburg, Pa., v. 4B, 1981, pp. 258–270. This encyclopedia article gives a brief and general discussion of the development of the mineral industry to its present state and its role in the national economy. Selected mineral data, with an accompanying textual discussion on reserves, production, import reliance, and consumption are provided.

OP 8–82. New Closure Rate Instruments for Retreat Mining Operations, by James R. McVey and Wayne L. Howie. Min. Eng., v. 33, No. 12, December 1981, pp. 1699–1700. The Bureau of Mines Spokane Research Center has constructed an intrinsically safe closure-rate instrument that provides the mine operator a means for predicting an imminent roof fall during pillar robbing. This improves operator and machine safety and prevents delays in digging out equipment. The instrument system consists of two rugged retrievable extensometers connected by long electrical cables to a digital readout unit for reading closure and closure rate. Once a predesignated closure rate is reached, the extensometer is retrieved by pulling it from the imminent roof fall area by the electrical cable. The equipment and mine personnel are also pulled back to await the fall, which usually occurs within minutes after the designated rate is reached. Although the unit is primarily designed for retreat mining operations, it can be used for any activity requiring measurement of displacement or rate of displacement with a measurement range of zero to 6 inches with 0.1 percent accuracy for openings 4½ to 12 feet.

OP 9–82. Stop #21. Steeply Dipping Upper Freeport Coal, by D. G. Puglio and A. T. Iannacchione. Proc. 9th Internat, Cong. of Carboniferous Stratigraphy and Geology, Urbana, Ill., May 10–June 2, 1979; pub. in Geology of the Northern Appalachian Coal Field, Guidebook, Field Trip No. 2, ed. by J. Donahue and H. B. Rollins, pp. 27–28. Coalbeds that dip nearly vertically have not previously been seen in Pennsylvania west of the Allegheny Front. This paper discusses some steeply inclined coalbeds that were observed during a field trip west of West Bolivar, Westmoreland County, Pa.

OP 10–82. High-Constructive, Tidally Influenced Deltaic Sedimentation in Arkoma Basin: Desmoinesian Hartshorne Sandstone, by D. W. Houseknecht, Mark A. Kuhn, Albert P. Matteo, Jr., David J. Steyaert, John F. Zaengle, and Anthony T. Iannacchione. Am. Assoc. Pet. Geol. Bull., v. 65, No. 8, August 1981, p. 1499. This paper describes the probable origin of the Hartshorne Sandstone and associated fine-grained facies of the Arkoma basin located in Arkansas and Oklahoma. Understanding the genesis of these delta plain facies reportedly will enhance petroleum and coal exploitation efforts within the Hartshorne of the Arkoma basin.

OP 11–82. Occurrence and Recovery of Rutile From Western Copper Mill Tailings, by G. V. Sullivan and T. O. Llewellyn. Pres. at SME-AIME Fall Meeting and Exhibit, Denver, Colo., Nov. 18–20, 1981, SME Preprint 81-333, 7 pp. The Federal Bureau of Mines examined tailings samples from 13 western copper operations to determine the potential for recovering rutile. Results showed that six of the samples contained sufficient liberated titania to be considered potential sources. One sample contained 0.75 percent TiO_2 or 0.40 percent liberated rutile. Batch flotation studies developed a procedure that recovered 70 percent of the liberated rutile at a grade of 34.7 percent TiO_2. Sulfuric acid leaching studies on 12 of the samples dissolved 100 to 2,200 grams Cu per ton of tailings; leaching of the slimes showed slightly more copper was dissolved, 1,800 to 3,300 grams Cu per ton of minus 10-micrometer material. Bulk sulfide flotation of nine of the samples resulted in concentrates that contained 0.38 to 2.0 percent Cu and 0.7 to 2.1 and 6.9 to 42.9 grams per ton Au and Ag, respectively.

OP 12–82. Improved Optical Probe for Monitoring Dust Explosions, by R. S. Conti, K. L. Cashdollar, and I. Liebman. Rev. Sci. Instr., v. 53, No. 3, 1982, pp. 311–313. An improved optical probe was developed to monitor dust-cloud concentration in explosions even in the presence of dust flame radiation. Principal features of the probe include a pulsed light-emitting diode and a photodetector with optical interference filter to reduce flame radiation. The probe has a U-shaped configuration and air jets to keep the windows dust free. Experimental data are presented for a coal dust explosion.

OP 13–82. Retractable Core Bit Drilling System, by W. C. Larson, W. W. Svendsen, J. F. Hoffmeister, and R. E. Cozad. Pres. at SME-AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, SME Preprint 80–116, 16 pp.; Min. Eng., v. 34, No. 2, February 1982, pp. 163–170. This paper presents the background, history, and current development of a retractable core bit for a wireline drilling system. Design criteria, concept development, and system of the retractable bit system are discussed, including laboratory test results.

OP 14–82. Computer Simulation of Zirconium-Hafnium Separation by Countercurrent Extraction, by D. J. MacDonald. Sep. Sci. Technol., v. 16, No. 10, 1981, pp. 1355–1371. In carrying out research and development on an improved method for production of reactor-grade zirconium oxide, the Bureau of Mines has prepared a computer program capable of accurately predicting the stage-by-stage performance of a multistage countercurrent solvent extraction system for separation of zirconium from hafnium using a tertiary amine extractant. The results were used to plan laboratory experiments using a multistage countercurrent mixer-settler unit. The number of

extractor stages, number of scrubber stages, feed solution concentrations, scrubber solution concentration, feed flow, scrubber flow, and organic-phase flow are the significant variables. The computer simulation indicates the effects of changes in the pertinent variables and makes it possible to locate the best combination of variables without a prohibitively large number of time-consuming experiments.

OP 15–82. Development of an In-Line Water Spray Cooler, by J. F. McCoy, A. Whillier, K. S. Heller, and E. D. Thimons. J. Mine Vent. Soc. S. Afr., v. 35, No. 1, January 1982, pp. 1–6. This paper describes an experimental program financed by the Bureau of Mines for the development of an in-line cooler using direct water-to-air contact heat exchange. The direct water-to-air contact design eliminates problems of dust buildup on cooling surfaces, a frequent problem of fin-coil coolers in mines. While direct-contact coolers such as spray chambers are relatively tolerant to dust loading, their thermal performance, in practice, has not been viewed in the United States as competitive with counter-flow, fin-coil-type exchangers. This is believed to be due to the negligible experience with the direct water-to-air coolers in North American mines. The purpose of this paper is to describe a successful experience with a water spray-type cooler. The program consisted of resolving initial specifications, design, development of the cooler including laboratory testing, and in-mine testing at the Homestake Gold Mine in South Dakota.

OP 16–82. Insoluble Crosslinked Starch Xanthate as a Selective Flocculant for Sulfide Minerals, by S. C. Termes, R. L. Wilfong, and P. E. Richardson. Pres. at AIME Ann. Meeting, Dallas, Tex., Feb. 14–18, 1982, Reprint 82–171, 8 pp. This paper discusses recent Federal Bureau of Mines research on the selective flocculation of various minerals with insoluble crosslinked starch xanthate (ISX). ISX is insoluble, has a shelf life of over a year when kept cold, and has a higher molecular weight due to crosslinking than the soluble noncrosslinked starch xanthate used in previous flocculation studies on nonsulfide minerals. ISX readily flocculates a number of sulfide mineral fines but not silicious gangue. Floc formation, floc size, and settling rate are strongly dependent on pH, with the pH dependence differing for each mineral. Bornite has been selectively flocculated from bornite-quartz mixtures, and the bornite containing flocs were separated from the unflocculated quartz using decantation and washing procedures.

OP 17–82. Engineering Properties of Coal Measure Rocks, by Richard E. Thill and James A. Jessop. Pres. at 111th SME-AIME Ann. Meeting, Dallas, Tex., Feb. 14–18, 1982, SME Preprint 82–146, 26 pp. Engineering properties of rock are essential in most phases of mining from site reconnaissance through mineral processing. Review of the literature indicates, however, that property data is scarce for most coal measure rocks in the United States. The Bureau of Mines has undertaken a wide-ranging testing program to provide more complete property data for coal strata in the U.S. coal basins. The property data are expected to have applications in geophysical exploration, development of premining and hazard detection probes and instrumentation, mine design, engineering and rock mass classification, subsidence engineering, and ground control. This paper describes the comprehensive program encompassing in situ geological, geophysical, and geotechnical properties and laboratory determinations of acoustic, electromagnetic, physical, mechanical, and index properties and discusses results for 500 feet of coal measures at a mine site in the northern Appalachian, eastern coal province.

OP 18–82. A Review of Potential Domestic Raw Materials as Substitutes for Refractory-Grade Bauxite, by Dale E. Wittmer. Proc. 111th AIME Ann. Meeting, Dallas, Tex., Feb. 14–18, 1982; pub. in Light Met., 1982, pp. 23–35. The Bureau of Mines characterized foreign and domestic bauxites and domestic high-alumina grogs with respect to chemical and mineralogical analyses and refractory properties. Domestic raw materials such as ferruginous bauxites, saprolites, and zunyite were evaluated as substitutes for imported refractory-grade bauxite (RGB). Available data on ferruginous bauxite reserves are insufficient to evaluate the potential of upgraded ferruginous bauxite as a RGB substitute. Saprolite deposits of the southeast were evaluated as a source of gibbsite, but results indicate that simple beneficiation procedures would not produce a suitable RGB substitute. Initial evaluation of a synthetic magnesium aluminate spinel produced from aluminum dross as a RGB substitute was encouraging.

OP 19–82. Microbial Processes for Removal of Suspended Clays From Selected Industrial Wastewaters, by Carole L. Brierley, Guy R. Lanza, and Bernard Scheiner. Biotechnology and Bioengineering Symp. John Wiley & Sons, Inc., New York, No. 11, 1981, pp. 507–520. Finely divided clays, generated by beneficiating phosphate, are impounded for up to several decades to effect dewatering. Under contract to the Bureau of Mines, several microbiological processes were tested for aggregating suspended clays. Polymers, isolated from *Leuconostoc mesenteroides*, *Xanthomonas sp.*, and *Beijerinckia indica*, flocculated dilute phosphatic clay-slime at a rate comparable to polyethylene oxide; however, biopolymer-flocculated clays produced turbid supernatants. *Cladosporium cladosporioides*, enriched from phosphatic clay-slimes, produced a bioflocculant, and agitated incubation of *C. cladosporioides* spores, sugar, and yeast extract with phosphatic clay-slimes induced clay-fungus pelletization. Microbiologically mediated clay removal may have application in industrial wastewater clarification.

OP 20–82. An Industrial Application of Sulfur Concrete, by R. H. Funke, Jr., and W. C. McBee. Ch. 12 in Sulfur: New Sources and Uses, ed. by M. E. D. Raymont. ACS Symp. Series 183, 1982, pp. 195–208. In cooperation with the U.S. Department of the Interior, Bureau of Mines, and the Sulphur Institute, ASARCO Incorporated tested components of sulfur concrete, both precast and poured in place, in corrosive environments of sulfuric acid. Favorable endurance of these samples led to a full-scale cooperative demonstration project, which was the rehabilitation of an electrolytic zinc cellhouse basement floor of approximately 21,000 square feet. Sulfur concrete utilizing an aggregate gradation of minus 3/8-inch and minus 1/8-inch materials was produced in a portable asphalt patch mix plant. Mixing and placing operations were conducted without problems. Economics of sulfur concrete versus portland cement concrete are highly variable. Total costs were approximately 15 pct higher than for portland cement. Potential uses are electrolytic cells, holding tanks and vats, and floor and basin areas exposed to acidic environments.

OP 21–82. A Simulation Model for Predicting the Performance of Vibrating Screens, by Douglas C. Grant, Kevin Hennings, Thomas Bobick, and Roy Bartholomae. National Limestone Inst. Operations Day Program Booklet, 1982, pp. 57–72. Replacing a woven wire deck on a vibratory screen with one of another type raises questions as to how screening performance may be expected to vary. This paper describes the development of a digital computer model capable of predicting screen performance and the testing done to provide a data base for correlation and verification. Within the range of operating conditions tested, the simulation model in its present state is generally capable of predicting separation efficiency to within ±2 percentage points. Also, predicted sieve analyses of the underproduct and overproduct are in good agreement with those measured.

OP 22–82. Demonstration of Technology To Recycle Chromic Acid Etchants at Gould, Inc., by Glenn L. Horter and L. C. George. Proc. 4th Recycling World Cong. and Exposition, New Orleans, La., Apr. 5–7, 1982, pp. M/3/5/1—M/3/5/13. The process research unit for the regeneration and recycling of chronic acid-sulfuric acid etching solutions developed by the Bureau of Mines was demonstrated in cooperation with Gould, Inc., in Niles, Ill. The process research unit continuously regenerated and recycled etching solution from a brass etching circuit during normal production throughput for 17 days. Evaluation of the data obtained during the demonstration shows that the etching solution was maintained at an acceptable level of performance, consumption of sodium dichromate was reduced by 68 pct, generation of waste was reduced by 76 pct, and the cost of the operation was reduced by 70 pct.

OP 23–82. Canister Concept Provides Early Fire Warning in Mines, by Mervin D. Marshall, Edward D. Thimons, David W. Kneebone, and Stanley Gross. Min. Cong. J., v. 68, No. 4, April 1982, pp. 64–69. Presently, many metal-nonmetal mines have fire-warning systems that make use of a stench gas, which is released from the surface into the compressed-air lines and/or ventilation air. Usually the stench gas is the volatile liquid ethyl mercaptan, mixed with either Freon 11 or Freon 22 to render it inert. Time delays for the stench gas to reach underground mine personnel and the uncertainty of effectively distributing the gas throughout the mine are disadvantages of these surface-release stench systems. To avoid these problems, MSA Research Corp. and the Bureau of Mines have developed a stench gas canister with a heat-fusible release for use in mine locations susceptible to fire. In the event of a fire near the canister, the heat-fusible alloy melts, releasing the gas into the ventilation air and warning all miners downstream of the fire. With appropriate detectors on the mine exhaust, the tracer gas can provide warning of a fire during off-duty shifts or when no mine personnel are downstream of the release.

OP 24–82. Conservation of Chromium in the Tanning Industry, by Jean J. Tancous and Lawrence C. George. Proc. 4th Recycling World Cong. and Exposition, New Orleans, La., Apr. 5–7, 1982, pp. M/3/2/1—M/3/2/17. The tanning industry uses trivalent chromium in the form of water soluble chromium sulfate for the tanning of hides and skins that are byproducts of the meat industry. The U.S. total demand for dichromate in 1976 was 161,00 tons and the tanning industry used 17% or one-sixth of this amount. The waste generated was 9% or one-eleventh of the U.S. total demand. Because of the concern about chromium usage and waste, the Bureau of Mines and Tanners Council of America Inc. made a study of conservation of chromium in the tanning industry. The chromium wasted is present in leather trimmings and shavings, in the effluents from process procedures, and in sludge generated. Ways to recycle the effluent chromium and to recover the chromium from solid waste will be discussed including the possibility of using the chromium-bearing shavings and trimmings with pelletized stainless steel waste in the steel mill. From bench-scale experiments conducted, it was determined that the most economically feasible way to recover chromium from solid waste is by incineration.

OP 25–82. Characterization — Characterization of Bulk Samples, by U.S. Bureau of Mines. Paper in Characterization, Recovery and Recycling of Electric Arc Furnace Dusts, Lehigh University, Bethlehem, Pa., sec. III, February 1982, pp. III.B–1—III.B–4. Bulk chemical analyses including the EP Toxicity Test were undertaken by the Avondale Research Center. As expected, the alloying elements chromium, nickel, and molybdenum show up prominently in the stainless steel and specialty alloy dusts. The amounts of these elements are sufficient to make recovery a viable activity. Carbon steel dusts are richer in zinc (up to 28 wt-pct) and lead (up to 3.8 wt-pct) because of the greater use of galvanized and other coated products in the melt.

OP 26–82. Chemical and Physical Separation—Bulk Specimens—Task B—Chemical Extraction, by U.S. Bureau of Mines. Paper in Characterization, Recovery and Recycling of Electric Arc Furnace Dusts, Lehigh University, Bethlehem, Pa., sec. IV, February 1982, pp. IV.A–1—IV.A–24. One large representative sample of carbon steel dust and one large representative sample of stainless steel dust were given a series of chemical dissolution or leaching tests by the Rolla Research Center. From the results, it would appear that because of the relatively high unit value of the Cr, Ni, Mo, etc., arc furnace dusts from stainless and specialty steelmaking can best be treated pyrometallurgically for recycle by techniques such as in-plant greenballing and recycling to the furnace, or centralized processing to produce master alloy for recycle.

OP 27–82. Chemical and Physical Separation—Bulk Specimens—Task B—Physical Separation, by U.S. Bureau of Mines. Paper in Characterization, Recovery and Recycling of Electric Arc Furnace Dusts, Lehigh University, Bethlehem, Pa., sec. IV, February 1982, pp. IV.C–1—IV.C–13. One large sample of carbon steel dust and one large sample of stainless steel dust were given physical separation tests by the Twin Cities Research Center. The tests showed that physical separation was of no value in treating high-chromium dust from stainless steelmaking. However, physical separation using wet processing has potential value for treating high-zinc dust from carbon steelmaking. Because of the very small particle size and high specific surface area, separation methods requiring adsorption of chemical reagents are not economically feasible with the present technology and the particle size is too small for specific gravity-based techniques. Low-intensity wet magnetic separation is the most practical method of physical separation. Separation with a typical ceramic permanent magnet wet drum separator yields a low-zinc ferromagnetic product and a zinc-enriched product.

OP 28–82. Reconnaissance of Rare-Metal Occurrences Associated With the Old Crow Batholith, Eastern Alaska-Northwestern Canada, by James C. Barker. Short Notes on Alaskan Geology, 1981. Alaska State Department of Natural Resources, College, Alaska, Geol. Rept. 73, 1982, pp. 43–49. Evidence suggests that the emplacement, tectonics, and chemical composition of the Old Crow batholith, located in eastern Alaska and western Yukon Territory, Canada, are favorable for the occurrence of tin, tungsten, uranium, tantalum, niobium, and other rare metals. This evidence is reinforced by findings of uranium, tin, rare-earth oxides, and base metals during the 1976–80 field seasons.

OP 29–82. Alkaline Igneous Rocks in the Eastern Alaska Range, by Jeffrey Y. Foley. Short Notes on Alaskan Geology, 1981. Alaska State Department of Natural Resources, College, Alaska, Geol. Rept. 73, 1982, pp. 1–5. Previously unreported, alkaline igneous rocks occur in the eastern Alaska Range as two dike swarms, one near the West Fork of the Robertson River and another to the east near the Tok River. These rocks intrude the underlying Precambrian and possibly younger, crystalline metamorphic terrane and are believed to be the youngest igneous rocks in the area. A single potassium-argon age date (69.2 ± 1.5 million years) on biotite indicates that a local, Late Cretaceous thermal event was associated with a stage of alkaline magmatism.

OP 30–82. Method for Automatically Rounding Data on the Wang 2200 in Basic Computer Language, by Scott F. Sibley. Geophys. Res. Ltrs., v. 9, No. 2, February 1982, pp. 120–123. The method described permits any set of numbers within an allowable range to be rounded to any number of significant figures. This is accomplished by generation of an array (rounding position) data bank, which is unique for each combination of the following variables: (1) Chosen decimal position, (2) number range of the number to be rounded, and (3) number of significant figures to which this number is to be rounded. It is especially useful as a subroutine in programs that generate large quantities of figures (such as reserve or resource tonnages) that require rounding.

OP 31–82. Consideration of Overburden Lithology for Subsidence Prediction, by Sathit Tandanand and Larry R. Powell. Proc. Workshop on Surface Subsidence Due to Underground Mining, Morgantown, W. Va., Nov. 30–Dec. 2, 1981, pp. 17–33. Geological differences among various coalfields restrain the applicability of subsidence prediction using existing European methods. To modify these methods for domestic conditions, the Bureau of Mines developed a method of assessment to evaluate the lithological effects on subsidence in the northern Appalachian basin by examining data collected from 16 longwall panels in the coalfield. The assessment is partially completed, and the results to date show that the ratio of maximum subsidence to the extraction thickness, known as the subsidence factor, can be expressed in terms of the width-to-depth ratio by a simple exponential equation that has a coefficient tentatively considered as the subsidence index. This index varies with the lithology of a particular site and can be expressed in terms of the percent distribution of weak and strong rocks in the overburden.

OP 32–82. Thermal Energy Recovery for Deep Mines, by Edward D. Thimons and Robert N. Torbin. Pres. at 1st Mine Ventilation Symp., University of Alabama, Tuscaloosa, Ala., Mar. 29–31, 1982; Eng. and Min. J., v. 183, No. 5, May 1982, pp. 98–99. High temperatures and humidities in deep mines make a comfortable working environment difficult and expensive to maintain. Large quantities of refrigeration water must be carried down long, vertical pipelines. The electrical costs of this refrigeration are rising owing to increased demand and rising kilowatt-hour costs. Converting the energy of falling water into useful work is a well-developed engineering concept. Much of the electric power consumed in the United States is generated this way. Water that flows down long, vertical pipelines into deep mines could be used to operate a turbine at the bottom of the pipeline.

OP 33–82. Identification and Quantification of Asbestos in Construction Materials Using Polarized Light Microscopy: The Need for Standards, by R. L. Virta, K. B. Shedd, and W. J. Campbell. Proc. NBS/EPA Asbestos Standards Workshop, Gaithersburg, Md., Oct. 1–3, 1980; NBS SP 619, March 1982, pp. 34–43. The Bureau of Mines Particulate Mineralogy Unit, in cooperation with the Environmental Protection Agency (EPA), conducted a round robin program to evaluate the reliability of analyses of asbestos-containing building materials by polarized light microscopy. This microscopic technique was selected by EPA as the principal analytical method for asbestos identification and quantification in their program to evaluate the potential health risks from exposure to airborne asbestos in public buildings. Results of the round robin show a need for monomineralic reference samples of asbestos and nonasbestos components of these materials to aid in identification training. Also necessary are bulk standards containing known amounts of asbestos to be used in verification and quality control of quantification techniques.

OP 34–82. Selective Extraction of Tungsten From Searles Lake Brines, by P. B. Altringer, P. T. Brooks, and W. A. McKinney. Sep. Sci. Technol., v. 16, No. 9, 1981, pp. 1053–1069. Tungsten was successfully extracted from the brines of Searles Lake, Calif., in a demonstration unit based on 9 years of laboratory research conducted by the U.S. Department of the Interior, Bureau of Mines. Pilot-scale operation was initiated in July 1979 at the Westend facility of the Kerr-McGee Chemical Corp. at Trona, Calif. The extractive method, based on a novel ion exchange resin, resulted from research supporting one of the Bureau's goals: helping to insure an adequate supply of minerals to meet national economic and strategic needs. The objectives met during pilot testing included proving operational viability during seasonal changes in brine properties, concentrating the tungsten to enable concluding tungsten recovery research, supplying escalation data necessary for commercialization, and confirming earlier small-scale laboratory work. The demonstration unit typically removed 92 percent of the tungsten from alkaline brine using QRF (8-hydroxyquinoline-resorcinol-formaldehyde) resin beads produced by the Bureau. A "merry-go-round" system was employed whereby two 12-inch-diameter resin beds were loaded in series while a third bed was eluted. Testing was concluded after treating over 500,000 gallons of brine. Tungsten, isolated in the primary ion exchange system, was reconcentrated in a secondary ion exchange system. Several tungsten products were produced from tungsten-rich solutions.

OP 35–82. The Effectiveness of Overpressure Ventilation: A Mathematical Study, by Robert C. Bates

and John C. Edwards. Ch. 24 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 149–154. Results are given of a mathematical study by Bureau of Mines personnel of overpressurization ventilation effects in underground uranium mines. The mathematics and computer codes make it possible to analyze many facets of transient and steady-state radon diffusion with Darcy flow. Rapid changes in radon flux occur after imposing a pressure differential across the model. Flux into the model mine drops to near zero and then increases to the steady-state level, while the sink flux increases rapidly and then drops slightly to the steady-state level. Magnitudes of mine flux decreases and sink flux increases are dependent upon the distance from the mine to sink, permeability, and amount of overpressure. Current work on more complex models is also described.

OP 36–82. A Plan for Modeling Uranium Radon Daughter Concentrations, by Robert C. Bates and John C. Edwards. Ch. 38 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 256–259. Modeling uranium mine radiation control methods and natural environmental radon variations is an extremely complex endeavor. A number of authors have examined particular facets of the problem and have proposed models for their area of interest. Bureau of Mines personnel brought together many of these individual studies, and from them have attempted to develop a coordinated plan for modeling radon daughter concentrations in the uranium mine environment. This approach is described.

OP 37–82. Ventilation Cost Impact of Reduced Radon-Daughter Working Levels, by Robert C. Bates. Ch. 159 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 1066–1070. Published information on costs of radon-daughter control in uranium mines was analyzed to develop estimates of the cost per ton for any level of radiation exposure control. All data were converted to 1967 cost of living index to provide a common analysis base. Results of the analysis show that the cost per ton increases exponentially as the radiation level is lowered. A linear relationship with the cost of living index is assumed, and equations and graphs are provided to estimate control cost per ton for any exposure control level and cost of living index.

OP 38–82. Evaluation of Recent Developments in Radon Progeny Measurements, by T. B. Borak, E. Franco, K. J. Schiager, J. A. Johnson, and R. F. Holub. Ch. 66 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 419–425. The evaluation of grab sampling methods for monitoring exposure to radon progeny is presented. Each method is examined individually according to accuracy, precision, and uncertainties attributed to human errors. An analysis of procedures that are common to all measurement methods is included.

OP 39–82. Bureau of Mines Statement of Principles, by John A. Breslin. Ch. 6 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 15–16. Control of radiation hazards in mines is only one of many goals of the Bureau of Mines. Radiation research is only a small part of the Bureau's mine health and safety research program. This paper describes the mission and programs of the entire Bureau of Mines, with emphasis on the mine health and safety program of which the Bureau's radiation research is a part.

OP 40–82. Sandcasting Titanium and Zirconium, by J. M. Burrus and R. K. Koch. Foundry M&T, v. 110, No. 5, May 1982, pp. 43–51. Research conducted at the Bureau of Mines Albany Research Center on alternatives to the rammed-graphite molding process currently used in industry is described. With the alternative molding processes developed in this research, the cost of titanium castings could be reduced to allow cast titanium to substitute for chromium-, nickel-, and cobalt-containing alloys in the transportation and chemical processing industries.

OP 41–82. Instrumentation for Measuring Uranium Miner Exposure to Radon Daughters, by Robert F. Droullard. Ch. 51 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 332–338. The U.S. Bureau of Mines has investigated instrumentation and methods for measuring exposure to radon daughters in underground mine atmospheres. Both personal and area monitors have been studied through in-house and contract research. A field study in uranium mines identified some reliability problems that required additional work for the personal dosimeter systems. Improved versions of continuous working level detectors have been developed and tested for use as area monitors in underground mines. Test results for the personal and area monitors were satisfactory for underground mine applications.

OP 42–82. Bureau of Mines Studies Forest Appraisal Part of RARE II Program, by Steven A. Fechner and Mark P. Meyer. Alaska Miner, v. 10, No. 5, May 1982, pp. 13, 18. Part of the requirements of RARE II withdrawals for the Chugach National Forest require that a mineral assessment be done of the area. The eastern half of the forest, called the SOUND Study Area, has been examined over the past 3 years. This report presents a review of the work so far in the 4-year program.

OP 43–82. Control of Radiation Hazards in Underground Uranium Mines, by John C. Franklin. Ch. 69 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 441–446. Alpha-emitting radon daughter products are a recognized health hazard contributing to the development of lung cancer in persons exposed to excessive concentrations over an extended period. The primary control technique used by the mining industry is dilution with fresh air. Because the uranium is deposited in porous sandstone in most U.S. mines, the control of this hazard with dilution requires excessive volumes of air. As the mines become larger and deeper, the cost for ventilation becomes a major expenditure for the mining industry. Most mines are maintaining levels of radon daughters lower than required by law but to maintain these present levels the mining companies are going to be drilling more vent holes or using other control techniques as the mine expands. These control techniques are being investigated by the Bureau of Mines to determine their effectiveness, cost, and safety for underground use.

OP 44–82. Airborne Radiation Warning System, by John C. Franklin and David M. Shaw. Ch. 148 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981., pp. 980–983. A 32-channel warning system for high working level, fan operation, and airlock-doors has been constructed. The working level monitors have a microcomputer for accumulating the pulses, converting to working level, and triggering an alarm at a variable set point and at one working level. The system can detect changes in air velocity which indicate surface fan failures or changes in the ventilation system. Using this alarm system, the ventilation engineer will be alerted prior to excessive levels of radon daughters being reached so corrective action can be taken.

OP 45–82. Multicomponent Regular Solutions, by N. A. Gokcen. Scripta Metallurgica, v. 16, 1982, pp. 723–727. Statistical thermodynamics of the binary regular solutions is now on a firm basis with a treatment based on the actual enumeration of configurations of molecules in solution. The equations resulting from the first approximation to the binary regular solutions are fairly simple but they become complicated for ternary and multicomponent solutions. Similar equations have not yet been derived for multicomponent solutions. The purpose of this paper is therefore to derive the appropriate equations for multicomponent regular solutions and to discuss briefly their significance.

OP 46–82. A Resin-Loaded Paper X-Ray Fluorescence Method for Determining Uranium in Phosphate Materials, by Benjamin W. Haynes, Jerome Zabronsky, and David L. Neylan. Proc. 30th Ann. Conf. on Applications of X-Ray Analysis, Denver, Colo., Aug. 3–7, 1981, pp. 107–111. An analytical method has been developed at the Bureau of Mines Avondale Research Center for determining uranium in phosphate rock processing and waste materials using a combination of preconcentration and X-ray spectrography. Previous work has shown the usefulness of resin-loaded papers for preconcentration in X-ray analysis on samples of varying matrices. This method allows the determination of other radionuclides in the sample while avoiding the use of alpha spectrometry for determining uranium. A roundrobin analysis of phosphate material samples involving this center and other Bureau of Mines research centers gave results that agreed with values obtained by accepted procedures. Good agreement was also obtained for the certified value of uranium in National Bureau of Standards SRM 120b phosphate rock.

OP 47–82. Factors Affecting Radon Transport and the Concentration of Radon in Mines, by R. F. Holub, P. J. Dallimore, and the Department of Physics and Geosciences, Western Australian Institute of Technology. Ch. 154 in Radiation Hazards in Mining: Control Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 1022–1028. Basic to solving the problem of the role of radon transport on radon concentrations in mines is to establish whether it occurs primarily as diffusion in force flow through porous rock or through fissures in the rock. The laboratory experiments performed involved measurements of diffusion and emanation coefficients, porosity, and permeability of representative rock samples. Significant differences have been found when comparing the results of the laboratory permeability determinations to those of the mine determinations. Considerations of underlying principles, however, suggest that the diffusion and emanation coefficients are the same in laboratory and mine. It was also found that moisture content plays a dominant role in radon transport through rock. Using these concepts and findings, some conclusions about the radon concentrations in mines have been drawn.

OP 48–82. Assessment of Toxicity Impacts Associated With Phosphogypsum in Florid¬, by Alexander May and John W. Sweeney. Proc. Environmental Symp. '82, sponsored by the Fertilizer Inst., San Antonio, Tex., Mar. 8–10, 1982, pp. 97–121. A part of the Bureau of Mines Minerals Environmental Technology research program is to assess problems associated with radium in the large tonnages of phosphogypsum in Florida. Another part is to develop a data base so that, through a continuing research effort, potential environmental problems can be identified and mitigated. The Bureau's Tuscaloosa Research Center conducted research to characterize phosphogypsum to determine if it is hazardous or toxic, and if so, to investigate means of mitigating the situation so that the phosphogypsum could be used in a variety of high-volume applications.

OP 49–82. The Role of the Bureau of Mines in Radiation Hazards Research, by George E. Niewiadomski. Ch. 18 in Radiation Hazards in Mining: Control, Measurement, and Medical Aspects, ed. by M. Gomez. Pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 97–104. This paper highlights the current efforts of the Bureau of Mines radiation hazards research program. It is aimed at obtaining a fundamental understanding of the behavior and transport of radon and radon daughters, developing more accurate and reliable instruments and measurement methods, and developing cost-effective control techniques. Also discussed are the most recent accomplishments and the future research plans of the program.

OP 50–82. Comparative Cavability Studies at Three Mines, by Louis A. Panek. Ch. 9 in Design and Operation of Caving and Sublevel Stoping Mines, pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 91–106. This paper explains the rationale of the Bureau of Mines ongoing investigation that has the objective to develop procedures for precalculating the minimum span required for sustained caving and the size distribution of the caved ore fragments, based on rock mass strength tests and measurements of joint spacing and attitude. With the help of such quantitative design procedures the undercut-cave method can be extended to a much wider range of mineral deposit characteristics.

OP 51–82. Ground Movements Near a Caving Stope, by Louis A. Panek. Ch. 24 in Design and Operation of Caving and Sublevel Stoping Mines, pub. by Society of Mining Engineers of AIME, New York, 1981, pp. 329–354. Measurements of ground movements showed that a halo of cracking develops about a caving stope, extending to distances greater than 100 meters, the principal change of deformation being extension directed toward the cave. The development of the fracture zone of expansion has significant implications with respect to the caving, drawing, and ground support operations.

OP 52–82. Geotechnical Factors in Undercut-Cave Mining, by Louis A. Panek. Underground Mining Methods Handbook, pub. by Society of Mining Engineers of AIME, New York, 1982, pp. 1456–1465.

This paper is a state-of-the-art summary that relates the underlying geotechnical factors to the mining processes and presents approaches to generating the measurement data that are needed to resolve the corresponding problems.

OP 53–82. Large-Scale Dewatering Tests of Phosphate Clay Waste: Progress Report, by B. J. Scheiner, Annie G. Smelley, and D. R. Brooks. Proc. Environmental Symp. '82, sponsored by the Fertilizer Inst., San Antonio, Tex., Mar. 8–10, 1982, pp. 57–70. Recently, the Bureau of Mines developed a dewatering technique for phosphatic clay waste. The technique consists of treating the clay waste with a flocculant such as polyethylene oxide and dewatering the resulting flocs on a mechanical device such as a rotary screen. In small-scale continuous tests at the Bureau's Tuscaloosa Research Center, clay waste was consolidated from a nominal 4 pct solids to about 20 pct solids. Based upon these encouraging results, a field test unit was operated at the Estech Corp.'s City Silver Mine, located near Bartow, Fla. The unit is now operating at the Occidental Suwannee River Mine near White Springs, Fla. This report describes the results of field tests conducted to date.

OP 54–82. U.S. Bureau of Mines Develops Portable Crusher for Underground Hardrock Mines, by Robert L. Schmidt. Eng. and Min. J., v. 183, No. 1, January 1982, pp. 72–75. The high cost of materials-handling in most underground hardrock mines prompted the Bureau of Mines to develop a portable, low-headroom crusher. This equipment can be positioned close to the face to allow the operation maximum utilization of low-cost conveyor haulage. The unit was successfully tested in a limestone quarry, and a long-term production test is planned.

OP 55–82. The Bureau of Mines Automated Minerals Information System—AMIS, by Jon P. Stone and L. Michael Kaas. Proc. 17th Internat. Symp. on computer applications in the mineral industry, Golden, Colo., Apr. 19–23, 1982; ch. 67 in Application of Computers and Operations Research in the Mineral Industry, pp. 740–753. The Automated Minerals Information System (AMIS) is an integrated data base system being developed to support the Bureau of Mines minerals information collection and analysis activities. The system facilitates cross-referencing and integration of domestic and foreign information from a variety of sources. The AMIS provides a central source of minerals information that is versatile and responsive to the needs of problem and policy analysts as well as supporting the needs of those involved in data collection and interpretation. As the AMIS becomes fully implemented, it will become an important tool in forecasting and assessing the impact of policy decisions that affect the supply and demand for minerals. This paper describes the AMIS in detail.

OP 56–82. Brushes Lessen Stopping Leaks, by Robert J. Timko, Mervin D. Marshall, and John C. King. Coal Age, v. 87, No. 4, April 1982, pp. 108–114. Most ventilation air that enters a typical coal mine never reaches the mine working sections. Because of poor stopping construction, the air short circuits to the returns instead. With power costs at the present level and expected to rise, mines are becoming aware that ventilation air is a significant cost of operation. The Bureau of Mines concentrated on practical, low-cost improvements in building concrete block stoppings that would be available to any mine operator. It was found that a strong and airtight block stopping could be built by brushing instead of trowelling on mortars. Using a brush, rather than a trowel, has several benefits. The average mine laborer is more proficient with a brush. The final sealant finish is smooth, and any unsealed holes are apparent. Airtightness is improved at the block joints and around the periphery of the stoppings, where leakage is most prevalent. Finally, in the hands of the mine laborer, this method offers a faster application with less waste.

OP 57–82. Resource and Environmental Assessment of Large-Volume Wastes: Cement Kiln Dust, Phosphate Rock Wastes, and Coal Ash, by Benjamin W. Haynes, Gary W. Kramer, Robert C. Gabler, Jr., and Robert L. Stoll. Proc. 14th Mid-Atlantic Industrial Waste Conf., June 27–29, 1982, College Park, Md., pp. 222–231. The Bureau of Mines Avondale Research Center has investigated the resource recovery potential of three large-volume wastes in response to questions raised concerning some of the potential environmental problems that could be caused by these wastes. These wastes—cement kiln dust, phosphate rock wastes, and coal ash—were chosen because of their potential for resource recovery and possible alternative uses. By determining alternative uses and/or valuable accessory minerals present, the wastes could be converted from a potentially hazardous waste to a resource, reducing adverse environmental effects. Details of these studies on large-volume waste are given including methods of analyses, compositions of the wastes, resource recovery potential, and environmental assessment.

OP 58–82. Mining Picks Up Across the State. Gold Was the 1980 Glamour Metal, by Tom Pittman. Alaska Construction & Oil, v. 22, No. 6, June 1981, pp. 28, 30–31, 34. This paper discusses the mining activity of gold and barite in Alaska during 1980. The discussion includes comparisons of production and prices between 1979 and 1980 and gives estimates for the future.

OP 59–82. How the Six Cleanest U.S. Longwalls Stay in Compliance, by Charles D. Taylor and Robert A. Jankowski. Min. Cong. J., v. 68, No. 5, May 1982, pp. 37–40. The objective of a U.S. Bureau of Mines program was to conduct dust surveys at six longwall sections having double-drum shearers, which were regularly in compliance, and to identify the dust control techniques that were the most effective. As each of the mines selected had a record of regular compliance with Federal Dust Standard, all sampling was "short-term" (often less than 30 minutes) and no attempt was made to relate the survey results to dust sampling results obtained by the companies for compliance purposes. The sampling procedures used during this survey were developed jointly by the Bureau of Mines and Foster-Miller Associates, Inc. In addition to monitoring dust levels, measurements were also taken throughout the shift to monitor airflow along the face, and water usage on the shearer. This program was a cooperative effort of the Bureau of Mines and the Mine Safety and Health Administration.

OP 60–82. Subsidence Control by Backfilling, by Alice S. Allen and James Paone. Ch. 4 in Underground Mining Methods Handbook, ed. by W. A. Hustrulid. Pub. by the Society of Mining Engineers of AIME, New York, 1982, pp. 210–226. The consequences of subsidence become more serious as increasing requirements for mineral products conflict with the needs of an expanding population for surface land area. As a means of controlling

subsidence in urban undermined areas, the Bureau of Mines has developed the pumped-slurry process for backfilling underground mine workings that are inaccessible because of flooding, gas accumulation, or caving. In a mixing tank, fill materials are placed in suspension and conveyed in a closed system through a slurry pump, distribution pipeline, and injection borehole into subsurface mine voids. Materials used for fill include crushed waste rock left from mining and processing, fly ash, and sand. In many areas, the local mine pool provides adequate quantities of water. The objective of backfilling mine voids is to mitigate adverse environmental effects of underground mining. The potential for future subsidence is substantially diminished. If waste mine rock is used for fill material, unsightly waste piles are eliminated, restoring land for higher economic use. Removal of waste piles also eliminates bank fires caused by spontaneous combustion, noxious and poisonous gases, particulate matter, and sediment and acid drainage that may enter nearby streams and ponds.

OP 61–82. Bureau of Mines Research To Improve Underground Metal/Nonmetal Mining Technology, by L. L. Davis. Min. Eng., v. 33, No. 3, March 1981, pp. 305–312. Current research by the Bureau of Mines to develop technology for improving efficiency and productivity in metal/nonmetal mines is described. The research program addresses a wide variety of problems associated with each of the major categories of mining: underground mining, surface mining, in situ mining, and premining investigations. An overview of the Bureau's research activities is given with emphasis on underground mining. In particular, two innovative and promising concepts currently under development are described: a unique shaft sinking system that uses an impact hammer for rock fragmentation, and a low-profile portable crusher for underground hard-rock applications.

OP 62–82. Utilization of Domestic Low-Grade Titaniferous Materials for Producing Titanium Tetrachloride, by G. W. Elger, J. E. Tress, and R. R. Jordan. Pres. at AIME Ann. Meeting, Dallas, Tex., Feb. 14–18, 1982; pub. in Light Met., 1982, pp. 1135–1147. The Bureau of Mines is investigating the use of low-grade domestic titaniferous materials to produce titanium-rich slags as substitutes for imported rutile used in titanium tetrachloride production. This investigation is part of the Bureau's program to develop technology for maintaining an adequate supply of minerals to meet national economic and strategic needs.

OP 63–82. Restoration of Groundwater Quality Following Pilot-Scale Acidic In-Situ Uranium Leaching at Nine-Mile Lake Site Near Casper, Wyoming, by William H. Engelmann, P. E. Phillips, Daryl R. Tweeton, Kent W. Loest, and Michael T. Nigbor. Soc. Pet. Eng. J., June 1982, pp. 382–398. The results of the first restoration effort for a pilot-scale acidic leaching of a uranium ore body in the United States are given. The project was performed under an agreement between the Bureau of Mines and a joint venture consisting of Rocky Mountain Energy, Mono Power Co., and Halliburton Co. The leaching phase is described only briefly; it was reported earlier by Tweeton. Leaching was done with H_2SO_4 (pH range of 1.6 to 3.9) and H_2O_2 (80 to 1,000 ppm) over an 11-month period. The restoration phase began in September 1978 and was completed in 11 months. Water samples were taken from observation wells located between injection and production wells while the leaching solution was decreased in strength. Ground water quality in the leaching ore zone was restored by diluting and neutralizing effects of injecting native groundwater and treated water produced from recovered solution. Recovered water was purified by a combination of chemical precipitation and reverse osmosis. In situ measurements of pH, Eh, dissolved oxygen, conductivity, and temperature were made by a downhole probe in one of the wells. Water samples were taken and analyzed for U, V, Na, K, Ca, Mg, SO_4, P, Cl, F, Fe, Mn, Si, Zn, As, and Se.

OP 64–82. Longwall Cuts Dust Build-up, by Robert A. Jankowski and Joseph Hetrick. Coal Age, v. 87, No. 6, June 1982, 4 pp. A longwall at Barnes and Tucker Coal Co.'s Lancashire No. 20 mine, near Barnesboro, Pa., is controlling respirable dust successfully with a bidirectional shearer featuring a small and a large drum and a cutting sequence that keeps face workers in a split of clean air during most of the mining cycle. The longwall unit, which cuts about 800 tons per shift in a 60-in-thick area of the Lower Kittanning seam, has a consistent record of compliance with a 2.0-mg/m^3 Federal respirable-dust standard. According to a survey the Mine Safety and Health Administration conducted in 1978, the average face worker's exposure to respirable dust at the mine ranged from 1.1 to 2.0 mg/m^3. In 1981, dust exposure was 0.6 to 1.5 mg/m^3 for designated occupations. Air along the 400- to 500-ft-wide longwall face flows into the tailgate and out through the headgate. A separate split of air from the belt entry returns into the gob entry as well. The longwall panel is supplied with 18,000 ft^3/min of air that achieves a face velocity of 200 ft/min.

OP 65–82. Recent Advances in Mine Safety Technologies in the United States of America, by Robert L. Marovelli and Chi-shing Wang. Proc. 11th World Min. Cong., Belgrade, Yugoslavia, May 31–June 3, 1982, v. B, pp. 649–674. Over the past 12 years the U.S. Bureau of Mines almost quintupled its annual expenditures on minerals health and safety research. The expanded research and development program is having significant impact on the advancement of mine safety technologies. This paper highlights some innovations that have been validated by industrial applications or by extensive field demontsrations.

OP 66–82. Recovering Accessory Minerals From Lead and Zinc Process Wastes, by V. R. Miller and D. L. Paulson. Pres. at Resource Recovery and Environmental Issues of Industrial Solid Wastes Symp., Gatlinburg, Tenn., Oct. 28–30, 1981. Pub. in Res. and Conserv., Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, v. 9, August 1982, pp. 95–104. This research is part of a continuing effort to reduce environmental conflicts and occupational hazards associated with mineral processing and to recover valuable constituents in wastes. A laboratory process for lead smelter flue dust (sulfation roasting followed by water leaching) extracts over 95 pct of the Cd and Zn. Ninety-nine percent of the Cd is recovered from solution by sponging with zinc dust, and Zn is electrowon from the resulting solution after purification. The Cd and Zn leach residue consists largely of $PbSO_4$, which is converted to $PbCO_3$ and leached with H_2SiF_6 to produce $PbSiF_6$ electrolyte for lead electrolysis. Accessory minerals (such as Co and Ni) are separated into purification residues for subsequent recovery. A copper-cake residue treatment process consists of leaching with

sulfuric acid to extract Cd and Zn, which are recovered as in the flue dust processing. The insoluble residue, containing Cu, As, Co, and Ni, is leached with manganese dioxide and sulfuric acid to solubilize those metals while leaving a residue of $PbSO_4$. The solubilized metals are recovered from the leach solution by caustic purification (As and Fe removal) and sequential sulfide precipitations. The products are copper sulfide and cobalt-nickel sulfide. The manganese is reclaimed from the leach liquor as manganese dioxide for recycle.

OP 67–82. Ceramic Roadway Aggregates, by A. V. Petty, Jr. Proc. ASTM Committee D–4 Symp. on Road and Paving Materials, Orlando, Fla., Dec. 10, 1980; pub. in Extending Aggregate Resources, ASTM STP 774, 1982, pp. 196–212. Through a cooperative program between the Bureau of Mines Tuscaloosa Research Center and the Federal Highway Administration, ceramic aggregates having high wear resistance and polish resistance were developed. Three hundred aggregate compositions, incorporating a variety of low-cost "waste" materials, were evaluated over a 30-month period. Aggregates are produced using conventional ceramic processing techniques and fired at temperatures ranging from 900° to 1,500° C. British Wheel and Los Angeles Abrasion tests were used for initial screening of the aggregates. These data, in addition to raw materials costs, availability, and energy requirements, were used to select nine compositions for circular track tests at Maryland and North Carolina Highway Department facilities. Economic evaluations showed that present production costs, based on a 1,000-ton-per-day operation, ranged from $10 to $120 per ton of material produced. Guyana bauxite was used as a standard, and several of the selected compositions developed surpassed the bauxite in performance and were lower in cost.

OP 68–82. New Mining Technologies Resulting From U.S. Bureau of Mines Research, by Donald G. Rogich. Proc. 11th World Min. Cong., Belgrade, Yugoslavia, May 31–June 3, 1982, v. B, pp. 397–409. The Bureau of Mines conducts a wide variety of research to improve the technology associated with the exploitation of mineral deposits. These studies, which cover all aspects of surface and underground mining, have produced a number of innovative techniques and equipment that have significant potential benefits in minerals extraction. This paper examines a number of recent developments that have been the product of Bureau of Mines research, with emphasis on the problems to be overcome, the research approach, the resulting developments, and potential benefits. Specific items to be addressed include a retractable drill bit for exploration and development drilling; developments in borehole mining techniques for the exploitation of small, near-surface deposits; new low-headroom crusher developments for room-and-pillar mining; and large-scale crusher developments for open pit mines. These developments have application to a wide variety of minerals exploitation including uranium, limestone, copper, lead, and zinc, as well as problems in minerals exploration.

OP 69–82. Measurement of the Thickness of Amphibole Asbestos Fibers With the Scanning Electron Microscope and Transmission Electron Microscope, by A. G. Wylie, K. B. Shedd, and M. E. Taylor. Proc. 17th Ann. Conf. of the Microbeam Analysis Society, Washington, D.C., Aug. 9–13, 1982. Pub. in Microbeam Analysis—1982, ed. by K. F. J. Heinrich. San Francisco Press, Inc., San Francisco, Calif., Aug. 9, 1982, pp. 181–187. Knowledge of the cross-sectional shape of mineral fibers is important for their accurate dimensional characterization. Two techniques for the measurement of width and thickness of fibers are described and compared: one for the scanning electron microscope (SEM) and one for the transmission electron microscope (TEM). The frequency distributions of log thickness and width determined by these techniques are considerably more accurate when the TEM is used. However, the use of either technique results in essentially the identical quantitative descriptions of the relationship between thickness and width for amosite and crocidolite. A general relationship between thickness and width for amphibole asbestos is log thickness = 0.692 log width — 0.493; a rectangle is a reasonable approximation of its cross-sectional shape.

OP 70–82. Extraction of Leachable Metals and Recovery of Alumina From Utility Coal Ash, by R. C. Gabler, Jr., and R. L. Stoll. Pres. at Resource Recovery and Environmental Issues of Industrial Solid Wastes Symp., Gatlinburg, Tenn., Oct. 28–30, 1981; pub. in Res. and Conserv., Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, v. 9, 1982, pp. 131–142. The extraction of metals from coal ash was investigated as part of a Bureau of Mines program to convert waste materials from a disposal problem to potential secondary resources. The objectives of this study were to produce a more environmentally acceptable waste and offset waste disposal costs with recovered metal values. The research was conducted in two steps: determination of parameters affecting extraction of aluminum from coal ash, and development of extraction-recovery procedures.

OP 71–82. Heteronuclear Compounds of Arsenic and Antimony, by James E. Mauser. Met. Trans. v. 13B, No. 3, September 1982, pp. 511–513. During the roasting of copper ores when both arsenic and antimony sulfides are present, the evolution of arsenic is retarded and the volatilization of antimony increased primarily because of the formation of heteronuclear compounds. These heteronuclear compounds exhibit vapor pressure different from those of their individual parent compounds. Because the arsenic and antimony content in copper ores and concentrates is generally 1 percent or less, the anomalous vaporization behavior of mixed arsenic and antimony oxides and sulfides may be of small magnitude. However, because the phenomenon of preferential antimony volatilization was noted in roasting studies of concentrates and because high-arsenic flue dusts and antimony speiss are sometimes roasted together, the formation of heteronuclear compounds of arsenic and antimony is a factor that should be considered.

OP 72–82. Preparing Rare Earth Silicon Iron Alloys, by E. Morrice and M. M. Wong. Proc. 15th Rare Earth Research Conf., Rolla, Mo., June 15–18, 1981; pub. in The Rare Earths in Modern Science and Technology, ed. by G. J. McCarthy, H. B. Silber, and J. J. Rhyne, v. 3, Aug. 30, 1982, pp. 557–560. As part of its mission to assure the maximum recovery and use of the Nation's mineral resources, the Bureau of Mines investigated an improved procedure for producing rare earth-silicon alloys. For example, a charge consisting of 681 grams of mixed rare-earth oxides, 309 grams of ferrosilicon (75 wt-pct Si), and 182 grams of aluminum metal along with a flux consisting of 681 grams of CaO and 45 grams of MgO was reacted at 1,500° C in an induc-

tion furnace. Good slag-metal separation was achieved. The alloy product contained, in weight-percent, 53 rare earth (RE), 28 Si, 11 Fe, and 4 Al with a rare earth recovery of 80 pct. In currently industrial practice, rare earth recoveries are usually about 60 pct in alloy products that contain approximately 30 wt-pct each of rare earths and silicon. Metallurgical evaluations showed that the alloys prepared in this investigation to be as effective in controlling the detrimental effect of sulfur in steel and cast iron as the commercial rare earth-silicon-iron alloys presently used in the steel industry.

OP 73–82. Use of Low-Btu Gas in Iron Ore Pelletizing, by John C. Nigro. Min. Cong. J., v. 68, No. 8, August 1982, pp. 50–58. The iron ore pelletizing industry has a current energy demand approaching the equivalent of about 4 million tons per year of western coal. In the past, a favorable combination of fuel price and supply led to the use of premium natural gas and No. 2 fuel oil as the major heat sources for the pelletizing process. A shift in premium fuel supplies and price relationships in recent years has forced the industry to seek ways to utilize coal as an alternate source of energy either in direct combustion or through conversion to gaseous or liquid fuels. In 1978, a research program to demonstrate the technical feasibility and practicality of using a hot, raw, low-Btu coal gas as a fuel for high-temperature induration of iron ore pellets was initiated by the Bureau of Mines Twin Cities Research Center. Cooperators in the program include the U.S. Department of Energy and 20 U.S. firms with interests in iron ore, coal, gas, and industrial engineering. Coal gas used in the pelletizing program was derived from gasifying bituminous, subbituminous, and lignite coals. This report summarizes the performance characteristics of a 30-day, around-the-clock gasification-pelletizing test conducted in October and November 1980 with North Dakota Indianhead lignite. Gasification was conducted in a commercial-size, 6.5-foot-diameter, Wellman-Galusha single-stage, fixed-bed, atmospheric producer with a rated capacity of about 30 million Btu per hour. Iron oxide pellets made from a commercial hematite concentrate were fired with the low-Btu gas in a 2.8-foot-diameter by 35-foot-long pilot plant rotary kiln at a rate of 900 pounds of pellets per hour. Gassifier operations at fuel rates up to 3 tons of lignite per hour and hematite pellet induration with raw lignite gas of 160 Btu per standard cubic foot are described.

OP 74–82. Infrared Temperature Measurements of Gas and Dust Explosions, by K. L. Cashdollar and M. Hertzberg. Pres. at 6th Symp. on Temperature, Washington, D.C., Mar. 14–18, 1982, Pub. in Temperature. Its Measurement and Control in Science and Industry, ed. by J. F. Schooley. American Institute of Physics, New York, v. 5, 1982, pp. 453–463. This paper presents temperature measurements of gas and dust explosions. Instrumentation used includes a commercial rapid-scan spectrometer and two multiwavelength infrared pyrometers developed at the Bureau of Mines. The rapid-scan spectrometer has a wavelength range of 1.7 to 4.8 μm and a maximum rate of 800 scans per second. One of the pyrometers is a three-wavelength, near-infrared instrument with a time response of about 20 μsec, and it measures continuum radiation from particles in the flame at wavelengths of 0.8, 0.9, and 1.0 μm. The second infrared pyrometer measures continuum radiation from hot particles at four wavelengths (1.6, 2.3, 3.8, and 5.0 μm) and band emission from carbon dioxide gas at 4.4 and 4.6 μm. It has a time response of about 25 μsec. Temperatures for small- and large-scale methane-air explosions were measured with the rapid-scane spectrometer, based on the absolute radiance and on emission-absorption measurements using a blackbody source. Measurements of both gas and dust temperatures for small-scale dust explosions were made with the rapid-scan spectrometer and the two pyrometers. The two pyrometers have also been used to make temperature measurements within full-scale mine coal dust explosions.

OP 75–82. Refractory Dolomite Raw Materials, by T. A. Clancy and D. J. Benson. Proc. Raw Materials for Refractories Conf., University of Alabama, Tuscaloosa, Feb. 8–9, 1982, v. 1, No. 1, pp. 220–253. As one of its goals to reduce the Nation's dependence on imported strategic and critical materials, the U.S. Bureau of Mines is conducting research to encourage the use of plentiful domestic dolomitic resources. Greater use of our dolomite materials in a variety of refractory processes could reduce our dependence on imported chromite and more expensive seawater periclase. A review of the literature on dolomite refractories has indicated that the United States has traditionally used less dolomite refractories than European countries. Characterization studies of 14 domestic dolomite ores, which included chemical and mineralogical analyses, density and hydration determinations, and microstructure and thermal decomposition evaluations, have shown that there were noticeable differences in the hydration, microstructure, and thermal behavior of the various ores.

OP 76–82. Rock Mechanics Instrumentation and Monitoring for Ground Control Around Longwall Panels, by Paul H. Lu. Proc. Internat. Symp. on State-of-the-Art of Ground Control in Longwall Mining and Subsidence, Honolulu, Hawaii, Sept. 4–5, 1982, pp. 159–166. This report by the Bureau of Mines presents several practical and inexpensive types of rock mechanics instrumentation for ground control around longwall panels. Application of these critical parameters, determined by this instrumentation, to the design and modification of rational longwall-mining systems is also discussed. In order to design or select an optimum mine structure or system, realistic and precise values of the design parameters must be determined in operating mines by (1) measuring ground stresses, (2) mining induced load transfer, and (3) strata movements as well as deformation moduli and rock strengths. Based on these parameters, rational and realistic criteria for mine design can be established by conducting case studies. It was found that several basic design parameters can be easily measured or determined in situ with simple, inexpensive, and practical instruments such as hydraulic borehole pressure cells, automatic recording convergence meters, automatic recording multiple-anchor-point extensometers, and hydraulic pressure recorders.

OP 77–82. Recovery of Metals and Minerals From Selected Processing Wastes, by H. V. Makar, D. M. Soboroff, and F. J. Palumbo. Res. and Conserv., Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, v. 9, 1982, pp. 179–190. To improve metal and mineral recycling technology while minimizing undesirable environmental effects, the Bureau of Mines is devising and evaluating recovery methods for scrap materials that cannot now be processed using conventional techniques. Characterization and leaching tests with chromite tailings, tin recovery from detinning sludges, and conversion of flue dusts

generated by the secondary copper and brass industry to zinc oxide are described. Procedures tested include leaching, mineral beneficiation, and roasting. Resource potential and environmental considerations are discussed.

OP 78–82. The Mechanization of Mining, by Robert L. Marovelli and John M. Karhnak. Sci. Am., v. 247, No. 3, September 1982, pp. 90–102. Today more than 80 percent of the mineral needs of the U.S. economy are met by only 1 percent of the labor force. This paper examines the mechanization of mining in terms of its effect on the mining of coal.

OP 79–82. Dewatering High-Clay Content Preparation Plant Tailings, by Bernard J. Scheiner. Min. Cong. J., v. 68, No. 9, September 1982, pp. 233–234. The U.S. Bureau of Mines, as part of its mission to eliminate health and safety hazards at the mine site, is developing alternate treatment and disposal methods for coal-clay waste. In the preparation of coal to produce low-ash material, a waste product containing fine coal and clay is generated. This waste product, generally minus 28 mesh in size, with the major portion being minus 325 mesh, is difficult to handle owing to the low settling of the fine clay particles. The material is usually processed in a thickener to produce a slurry containing about 30 percent (by weight) solids that is generally impounded behind earthen dams. It has been estimated that about 16 million tons of these waste solids are generated annually. Disposition of the slurries behind dams poses a potential health and safety hazard because of possible dam failure and because months and sometimes years are required for the slurry to settle and thicken naturally.

OP 80–82. Recycled Materials for Refractories, by D. E. Wittmer and A. V. Petty, Jr. Proc. Raw Materials for Refractories Conf., the University of Alabama, Tuscaloosa, Feb. 8–9, 1982, v. 1, pp. 309–328. A major goal of the Bureau of Mines is to investigate technology that can reduce the Nation's dependence on strategic and critical imported raw materials. To this end, the Tuscaloosa Research Center has been involved in a program to investigate the potential of utilizing waste materials to produce refractories containing chromite and alumina. Magnesite-chrome brick have been produced by recycling steel plant waste refractories using conventional beneficiation techniques. In addition, preliminary evaluation of a synthetic high-alumina dross appears promising. Currently, some high-alumina refractory waste materials are being used in commercial refractories and demand is increasing for recycled refractories.

OP 81–82. Heat Capacity From 5 to 300 K of α- and β-TiO, Relative Enthalpy to 1200 K, Enthalpy of Transition, and Thermodynamic Properties to 1265 K, by R. P. Beyer, R. R. Brown, K. O. Bennington, and M. J. Ferrante. J. Chem. Thermodyn., v. 14, 1982, pp. 957–965. The heat capacities of TiO(α) and TiO(β) were measured from 5 to 305 K by adiabatic calorimetry. High-temperature enthalpies up to 1,192 K for TiO(α) were determined by copper-block drop calorimetry. The enthalpy of transition for TiO(α) to TiO(β) was determined by hydrofluoric acid solution calorimetry and by differential scanning calorimetry. The values at 298.15 K of C_p°, $[S^\circ(T) - S^\circ(0)]$, and $-[G^\circ(T) - H^\circ(0)]/T$ are 39.89, 34.26, and 13.75 $J \cdot K^{-1} \cdot mol^{-1}$ for TiO(α), 40.40, 35.75, and 14.65 $J \cdot K^{-1} \cdot mol^{-1}$ for TiO(β). These thermodynamic functions are also calculated from 5 to 1,265 K for TiO(α), and from 5 to 300 K for TiO(β). The enthalpy of transition from α to β at 298.15 K is 4.7 $kJ \cdot mol^{-1}$ and at 1,265 K is 5.4 $kj \cdot mol^{-1}$.

OP 82–82. Large Rock Conveying Systems and Their Application in Open-Pit Mines, by T. W. Martin, J. M. Goris, and T. J. Crocker. Min. Eng., v. 34, No. 10, October 1982, pp. 1481–1485. The current technology of large rock conveyors is reviewed. Based on this investigation, two large rock conveyor concepts have been developed and a test facility investigation designed and fabricated. The Bureau of Mines will test these concepts along with loading and transfer points for handling mine run rock material up to 1.5 m (4.9 ft) in size. An evaluation of open pit mining systems using large rock conveyors documents substantial cost savings when compared with truck haulage.

OP 83–82. Electrochemical Determination of the Thermodynamic Properties of Sphalerite, ZnS(β), by S. C. Schaefer and N. A. Gokcen. High Temp. Sci., v. 15, 1982, pp. 225–237. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of minerals technology, thermodynamic properties of sphalerite ZnS(β) were investigated with a high-temperature galvanic cell employing stabilized zirconia as the electrolyte. In the temperature range 948 to 1,210 K, potential measurements were obtained for the cell.

OP 84–82. Pneumatic Beneficiation of Mica, by G. V. Sullivan and M. H. Stanczyk. Proc. 14th Internat. Miner. Processing Cong. on Worldwide Industrial Application of Mineral Processing Technology, Toronto, Ontario, Canada, Oct. 17–23, 1982, v. 1, No. 1, pp. V6.1–V6.19. The Bureau of Mines has conducted research into the pneumatic recovery of coarse mica pursuant to its objective of devising technology that will help maintain an adequate supply of minerals and metals to meet national economic and strategic needs. The pneumatic beneficiation technique may be advantageous in areas where water resources are limited. Researchers used a Bureau-designed system of crushers, screens, and zigzag air classifiers to concentrate coarse liberated mica particles from mica-bearing materials. A hammer mill, modified by removing 70 of its 80 free-swinging hammers and the crushing screen, proved effective for crushing and delaminating the mica without overgrinding. This pneumatic system was used to concentrate mica ores from Arizona, North Carolina, and South Dakota and waste tailings from Alabama, Georgia, and South Dakota. Using these samples, it was demonstrated that plus 0.21-millimeter-size mica can be effectively recovered by the pneumatic method. Mica concentrates containing more than 90 percent mica were produced with attendant recoveries of up to 78 percent.

OP 85–82. Determination of Sulfonamides in Animal Tissues and Feeds, by Michael H. Thomas and Karen E. Soroka. Ch. 33 in Advances in Thin Layer Chromatography. Clinical and Environmental Applications, ed. by J. C. Touchstone. John Wiley & Sons, Inc., New York, 1982, pp. 425–437. Sulfonamide drugs have proven to be effective antibacterial agents in many food-producing animals. The U.S. Food and Drug Administration has set the tolerance level for the resultant residues in uncooked edible tissues at 0.1 ppm. A rapid screening method to detect these drugs was developed to prevent gas chromatography-mass spectrometry (GC-MS) confirmation analysis of an excessive number of false positive and false negative samples. The method provides the ability to monitor multiple sulfonamides simultaneously at the tolerance level with a

degree of accuracy and precision. The two most significant factors responsible for these characteristics are the internal standard and the preadsorbent spotting zone. For laboratories without access to a GC-MS instrument or a need for confirmatory information, the technique is sufficiently accurate and sensitive to function as the determination procedure. Since 18 to 24 samples can be analyzed completely per day, the procedure offers the added benefit of high sample throughput.

OP 86–82. Gold, by W. C. Butterman and J. M. Lucas. Ch. in On Gold, ed. by H. A. Lipscomb and D. R. Libey. The Waterleaf Press, DeKalb, Ill., 1982, pp. 47–89. This paper was written as part of the approach to gold as an investment in the future, based on the performance of gold in the past. A brief history on gold is presented and the process of investing in gold in a future market is examined in much the same manner as any commodity would be examined in a future market. Only a certain amount of gold is available, and the supply and demand relationships are covered.

OP 87–82. Deep Cutting: Key to Dust-Free Longwalling, by Jonathan Ludlow and Richard J. Wilson. Coal Min. and Proc., v. 19, No. 8, August 1982, pp. 40–43. The correlation between depth of cut and dust generation has been established in laboratory and test fields that have been conducted in the United States and abroad for a number of years. This article describes a recent testing program that has proved the benefits associated with deep and slow cutting on a U.S. longwall face. The tests showed that respirable dust from longwall mining can be significantly reduced without adversely affecting production by simply increasing the depth of cut of the shearer.

OP 88–82. Testing of Fire-Resistant Conveyor Belting, by Frank J. Perzak, Ellsworth R. Spencer, and Michael J. Sapko. Can. Min. Met. Bull., v. 75, No. 884, August 1982, pp. 115–119; reprinted in Fire Prev. in Min. Ind., 1982, pp. 1–5. The fire resistance of several mine conveyor belts is evaluated using a new belt-flammability apparatus developed by the U.S. Bureau of Mines. The test, experimental details, and a calculated flammability index (FI) are described. The FI values are useful for ranking the fire resistance of mine conveyor belts. Values are determined using parameters readily measured with thermocouples, high-temperature flow probes, and a methane-oxygen torch, all of which are components of the Bureau's new test apparatus. The FI varies directly with the flame-spread rate and the rate of heat release during burning and varies inversely with the critical (minimum) ignitor energy output. The fire-resistance ranking of nine different belt types using this moderately scaled apparatus is compared with available full-scale data on belt fires. This comparison shows that the ranking based on the FI is consistent with the full-scale data.

OP 89–82. Vibration and Noise From Blasting, by David E. Siskind. Inter-Noise 82, v. 1, May 17, 1982, pp. 281–284. Adverse environmental effects from blasting continue to be a major problem for the mining industry, the public living near mining operations, and the governmental agencies responsible for setting environmental standards. The Bureau of Mines has established a comprehensive blasting research program dealing with the many technical aspects of generation and propagation of ground vibrations and airblast, structure response and damage, and proper instrumentation. This paper describes the Bureau's programs and lists agencies and industries that are utilizing the results of the Bureau's research.

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OP 1–83. Changing Patterns in Industrial Demand for Sulphur, by D. E. Morse and J. E. Shelton. Paper in International Conference Sulphur '82, Proceedings of the Conference, Volume 1: Preprints, ed. by A. I. More (London, Nov. 14–17, 1982). The British Sulphur Corp. Ltd., London, 1982, pp. 9–19. An attempt has been made to project the level of U.S. industrial sulfur demand in 1990, using various macroeconomic indicators, and using the United States as a model for the world as a whole, a further projection of total world industrial sulfur demand has been made. The potential world demand for current industrial uses for sulfur by 1990 is estimated to be 31.6 million metric tons. The most promising new uses for sulfur are believed to be in road paving materials and sulfur concrete. The potential world demand for new uses by 1990 is estimated to be 6.0 million metric tons. Thus, the total demand for industrial uses in 1990 is projected to be 37.6 million metric tons, which represents an annual growth rate of 5.4 pct from 1981 to 1990.

OP 2–83. Overview of Bureau of Mines Coal Mine Research, by John N. Murphy. Paper in Proc. 13th Annu. Inst. on Coal Min. Health, Safety, and Res. (VA Polytech. Inst., Blacksburg, VA, Aug. 24-26, 1982). VA Polytech. Inst., 1982, pp. 70–95. The Bureau of Mines mining research program is divided into two principal problem areas: (1) health and safety and (2) conservation and development. This paper focuses on the Bureau's coal mine health and safety research program and emphasizes recent accomplishments or new developments that will shortly be available for use by the industry.

OP 3–83. Comparison of Methods for Recovering Metal Values From Salton Sea KGRA Brines, by L. E. Schultze and D. J. Bauer. Geothermal Resour. Council Trans., v. 6, Oct. 1982, pp. 111–113. The Bureau of Mines is investigating methods for recovering metal values from geobrines. Two precipitation techniques were evaluated for recovering selected metal values from Salton Sea Known Geothermal Resource Area brines. Lime addition precipitates more than 95 pct of the iron, manganese, lead, and zinc, while sulfide addition precipitates more than 90 pct of the lead and zinc and lesser amounts of iron and manganese. A comparison of these techniques and a discussion of the respective advantages and disadvantages are presented.

OP 4–83. Dewatering and Consolidation of Coal-Clay Tailing From Preparation Plants, by B. J. Scheiner and P. M. Brown. Paper in Proceedings of the Consolidations and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10–12, 1982), 1982, pp. 133–151. The Bureau of Mines is conducting research on a novel method for dewatering coal-clay waste as an alternative to ponding

now being practiced by the industry. The method consists of mixing coal-clay waste with a flocculant, polyethylene oxide (PEO), and dewatering the resulting flocs in a hydrosieve screen. The technique is being tested in a unit operating at 400 gal/min, located at the Jim Walter's No. 7 Mine in Brookwood, AL. In continuous tests, coal-clay waste has been dewatered from a nominal 3 pct solids to products ranging from 50 to 60 pct solids. When placed in a pit, the dewatered material continues to consolidate to 70 pct solids in several days.

OP 5–83. A Progress Report on Large-Scale Dewatering Tests of Northern Florida Phosphate Clay Waste, by Annie G. Smelley, B. J. Scheiner, and D. R. Brooks. Paper in Proceedings of the Consolidation and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10–12, 1982), 1982, pp. 265–284. The Bureau of Mines is testing a dewatering technique for phosphate clay waste that will recover a portion of the water now being lost using conventional waste disposal methods and produce solids suitable for land reclamation. The technique uses a flocculant, polyethylene oxide (PEO), that forms strong, stable flocs that can be dewatered on a static screen followed by further dewatering on a rotary screen. In field tests conducted in northern Florida, clay wastes containing a nominal 2.5 pct solids have been consolidated to greater than 20 pct solids. The rate at which PEO-treated material continues to dewater in a mine cut is also being investigated. Preliminary results indicate that PEO-treated material will dewater to 29 pct solids in 127 days.

OP 6–83. Quantitative Measurement of Polymeric Bonds Using Viscometric Techniques, by D. A. Stanley, S. W. Webb, and B. J. Scheiner. Paper in Proceedings of the Consolidation and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10–12, 1982), 1982, pp. 468–490. The amount of polyethylene oxide (PEO) required to dewater calcium-exchanged montmorillonite is affected by shear stresses, both during mixing of the clay and polymer and during mechanical deformation of the flocculated mass to remove water. The Bureau of Mines measured changes in viscosity with time at a constant rate of shear for shear rates up to 350 per minute for PEO-montmorillonite mixtures. The energy density of the bonds formed by the PEO-montmorillonite complex then was calculated for two different bond systems. These different bond systems are present because the fundamental clay particles form flocs that are bridged to form aggregates of flocs. The implications of these results as they relate to PEO dewatering of phosphatic clay waste are discussed.

OP 7–83. Using Retroreflective Material To Enhance the Conspicuity of Coal Miners, by Barry H. Beith, Mark S. Sanders, and James M. Peay. Human Factors, v. 24, No. 6, Dec. 1982, pp. 727-735. This study investigated the use of retroreflective material to increase conspicuity of miners. A scaled simulation was created using dolls configured as miners. Twelve observers viewed four configurations of retroreflective material on dolls in 3 body postures at 1 of 3 locations in the visual field. In a subsequent experiment, nine observers compared two configurations. The results confirmed the poor conspicuity of the configuration currently required in mines, which features retroreflective tape on the helmet only. All experimental retroreflective configurations significantly improved detectability over this configuration. Overall, the most cost-effective configurations were those in which the belt and/or armbands were covered with retroreflective material.

OP 8–83. Rapid-Sampling System for Dusts and Gases, by R. S. Conti, M. Hertzberg, F. T. Duda, and K. L. Cashdollar. Rev. Sci. Instrum., v. 54, No. 1, Jan. 1983, pp. 104-108. The Bureau of Mines researched a system for the rapid grab sampling of heterogeneous mixtures of gases and dusts during the preignition and postignition stages of dust explosions. The combustion chamber in which the explosion occurs is first fitted with a hypodermic sampling needle with its inlet end at the desired sampling point within the chamber and its sharp, injecting end protruding outside of the chamber. Rapid sampling (approximately 25 to 50 ms) is achieved with a double-acting, air-pressure-actuated cyclinder. The forward stroke of the cylinder thrusts the rubber septum seal of an evaculated glass sampling tube onto the protruding needle, which punctures the septum, filling the tube with gas and dust from the combustion chamber. The return stroke of the cyclinder reseals the sampling tube by returning the mechanism to its original position. The initial time of sampling and the duration of sampling are independently variable and controlled by a microprocessor. Results obtained with a trimodal distribution of coal dust show no significant size discrimination at least up to 70 μm. Data obtained from laboratory-scale coal dust explosion tests are also presented. Such data provide valuable insights into the basic phenomena involved in explosions.

OP 9–83. Assessment of Effectiveness of Janelid Ventilation, by A. Erickson, K. Heller, and E. Thimons. Min. Congr. J., v. 68, No. 10, Oct. 1982, pp. 39–44. The effectiveness of a loader-mounted fan on diesel vehicles combined with natural convection of a dead heading (the patented Janelid system) was investigated experimentally. The results were obtained using CO_2 as a tracer gas in a one-quarter-scale model heading. Bouyant forces were scaled to establish similarity with full scale. For a loader moving in a typical load-haul-dump cycle, the loader-mounted fan reduced the tracer gas concentration by 26 pct compared with a reduction of 32 pct for a jet fan of four times the flow capacity.

OP 10–83. Statistical Thermodynamics of Long-Range Order, by N. A. Gokcen. Scr. Metall., v. 17, No. 1, 1983, pp. 53–58. Statistical thermodynamics of long-range order are part of the Bureau of Mines program to provide a scientific base for use in developing new alloys and alloy phases. Numerous statistical thermodynamic attempts have been made to formulate the behavior of long-range order in alloys after the work of Gorsky, and Bragg and Williams (GBW). The quasichemical method is often erroneously claimed to be an improvement over the GBW method. The permutation of the bonds in the quasichemical method is made to become the permutation of atoms for zero exchange energy, or when the temperature is sufficiently high, through a dubious normalization process. The normalization process of the quasichemical method yields the same equations for the excess Gibbs energy of solution as without normalization, and the actual enumerations of configurations prove that the permutable entities are the atoms, not the bonds. This communication has a twofold purpose: (1) to show that the permutation of atoms yields proper new equations for order-disorder phenomena after

reasonable corrections and (2) to discuss the errors in the previous regular assembly treatments.

OP 11–83. Computer Model Simulates Screening Process Under Variety of Conditions. Semi-Empirical Approach Allows Researchers More Latitude. Part I, by Douglas C. Grant, Kevin Hennings, Thomas Bobick, and Roy Bartholomae. Pit & Quarry, v. 75, No. 5, Nov. 1982, pp. 59–63. A U.S. Bureau of Mines sponsored program was undertaken by the Advanced Technology Center of Allis-Chalmers Corp. to improve performance modeling of vibrating machines. This work was requested to increase public knowledge of screening performance with emphasis on the performance of nonmetallic decks. The program included extensive testing on a special vibrating screen test apparatus, development of a mathematical model of screening behavior, and incorporation of simulation parameters. The test fixtures and mathematical model are described, and the mathematical results are compared with screen test data.

OP 12–83. Computer Model Simulates Scretning Process Under Variety of Conditions. Semi-Empirical Approach Allows Researchers More Latitude. Part II, by Douglas C. Grant, Kevin Hennings, Thomas Bobick, and Roy Bartholomae. Pit & Quarry, v. 75, No. 6, Dec. 1982, pp. 67–68. A U.S. Bureau of Mines sponsored program was undertaken by the Advanced Technology Center of Allis-Chalmers Corp. to improve performance modeling of vibrating machines. This work was requested to increase public knowledge of screening performance with emphasis on the performance of nonmetallic decks. The program included extensive testing on a special vibrating screen test apparatus, development of a mathematical model of screening behavior, and incorporation of simulation parameters. The test fixtures and mathematical model are described, and the mathemtical results are compared with screen test data.

OP 13–83. A Review of the Deposits and Beneficiation of Lower-Grade Chromite, by Ralph H. Nafziger. J. South African Inst. Min. and Metall., v. 82, No. 8, Aug. 1982, pp. 205–226. This paper reviews the major deposits of lower grade chromite in the world and a wide variety of methods used for the recovery of chromium from these deposits. Gangue materials in more coarsely sized ores can be separated by gravity means, whereas flotation techniques are required for finer grained materials. However, unless there is considerable iron in the ores, physical means cannot increase the Cr-Fe ratios. Chemical techniques such as hydrometallurgical methods, chlorination, roasting and leaching, and smelting are required for this purpose. A greater understanding of the physical properties of chromites and the chemical reactions that take place in the recovery operations is required before the recoveries from lower grade chromites can be maximized. More efficient recovery operations can be realized if it can be shown definitively that the reduction of chromites occurs via either a gas-solid or solid-solid mechanism, for example. The effects of specific impurities on the chromite reduction reactions need to be better understood, as do reagent and pH control in the flotation of chromite.

OP 14–83. Alaska Mining in '83: From Gold to Hardrock & Gravel. The Dollars Are Changing Direction, by Tom L. Pittman and John J. Mulligan. Alaska Construction & Oil, v. 24, No. 1, Jan. 1983, pp. 21-23. This article describes the changing mineral industry and mineral-related activities in Alaska. The sand and gravel industry, placer gold production, mineral legislation, U.S. Bureau of Mines activities, and other developments are discussed.

OP 15–83. Are Zeolites Dimensionally Equivalent to Asbestos? By K. B. Shedd, R. L. Virta, and A. G. Wylie. Paper in Process Mineralogy II: Applications to Metallurgy, Ceramics and Geology (Proc. Symp. sponsored by Metall. Soc. AIME, Dallas, TX, Feb. 15-18, 1982). Metall. Soc. AIME, 1983, pp. 395-399. Questions regarding possible health effects from exposure to zeolites arose when the inhabitants of two villages in Turkey were found to have high incidences of mesothelioma, a disease generally identified with exposure to asbestos. No asbestos deposits are known in the area, but some fibrous zeolites have been found. Further investigations have resulted in conflicting opinions as to whether fibrous zeolites are related to the high incidence of mesothelioma in Turkey. The U.S. Bureau of Mines examined the habits of domestic zeolites by scanning and transmission electron microscopy. Only erionite and mordenite particles possessed acicular to fibrous habits. With the exception of a rarely occurring wooly erionite sample, the fibrous zeolites were not dimensionally equivalent to asbestos.

OP 16–83. Effect of Ferrous Scrap Composition Changes on the Quality of Iron and Steel Castings, by W. L. Swager, H. W. Lownie, Jr., C. E. Mobley, and R. H. Nafziger. Am. Foundrymen's Soc. Trans., v. 90, 1982, pp. 811-819. Because the foundry industry has expressed concern over the possible deterioration of ferrous scrap used as charge material for ironmaking and steelmaking, the Bureau of Mines contracted with Battelle's Columbus Laboratories to determine the extent of the problem and what might be done. Data obtained from the literature, scrap processors and brokers, practicing foundry operators, and trade associations indicate no substantial evidence to support the thesis that the quality of purchased ferrous scrap available to foundries is expected to decline significantly during the next decade. Tramp elements already present will continue to be present in purchased scrap, with B, Cr, Pb, and Sb in iron and Sb, P, and S in steel being of most concern. Continuing lot-to-lot variation will make quality control by foundries increasingly important. Foundries and their suppliers of purchased scrap have the potential to control tramp elements within practical limits. Costs will increase in the long term owing to increased demand for premium grades of scrap, necessary upgrading of scrap to maintain low-tramp levels, and increased expenses to control tramp elements.

OP 17–83. Mineralogy and Beneficiation of Phosphate-Bearing Rocks From Northern Michigan, by Lawrence L. Brown, Albert R. Rule, and Charles B. Dallenbach. Pres. at TMS-AIME Annu. Meeting, Dallas, TX, Feb. 14-16, 1982. Paper in Process Mineralogy II: Applications in Metallurgy, Ceramics, and Geology, ed. by R. D. Hagni. Metall. Soc. AIME, Warrendale, PA, pp. 119–133. As part of the Federal effort to help maintain an adequate supply of fertilizer materials, the Bureau of Mines conducted research to characterize complex low-grade Michigan phosphate materials and to devise methods for recovering fertilizer-grade phosphate concentrates. The rock is from middle Precambrian sedimentary formations in the Marquette Range located in the central part of the Upper Peninsula of Michigan. Occurrence of phosphate-bearing sediments in Precambrian rocks is rare. This deposit,

containing 12 to 15 pct P_2O_5, is believed to be the richest Precambrian phosphate deposit in the United States. Petrographic examination showed that the conglomeritic rock contains crystalline apatite both in "black pebbles" and in quartz matrix. Attrition scrubbing and sizing tests showed that there is no tendency for phosphate to concentrate in any of the sized fractions. In beneficiation tests, which included grinding to minus 325 mesh followed by phosphate mineral flotation using a fatty acid-fuel oil collector, a phosphate concentrate was obtained that had a grade of 30 pct P_2O_5 and a P_2O_5 recovery of 72 pct. This concentrate should be suitable for fertilizer manufacture.

OP 18–83. Mathematical Modeling of Spontaneous Combustion of Coal, by John C. Edwards. Pres. at 112th TMS-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983; TMS Paper Selection A83-21, 16 pp. A mathematical model of spontaneous combustion of coal in a pile was developed. The model simulates under the condition of constant unidirectional flow of air through a bed of uniform coal particles, the temperature rise in the air-and-particle system associated with a first order Arrhenius particle surface reaction. The following transport mechanisms are included: (1) heat conduction into the particle interior, (2) oxygen depletion due to particle surface reaction, (3) diffusion and forced convection of oxygen, and (4) heat conduction and convection in the air. The model is developed as a set of coupled partial differential equations that are solved numerically. A parametric analysis is made of particle size, inlet air temperature, particle packing, and ventilation velocity on the time required for thermal ignition to occur and the depth in the bed at which it occurs.

OP 19–83. Activity Coefficients of Solutes in Binary Solvents, by N. A. Gokcen. High Temp. Sci., v. 15. Mar. 10, 1983, pp. 293-300. The activity coefficients in dilute ternary systems are discussed in detail by using the Margules equations. Analyses of some relevant data at high temperatures show that the sparingly dissolved solutes in binary solvents follow complex behavior even when the binary solvents are very nearly ideal. It is shown that the activity data on the solute or the binary system cannot permit computation of the remaining activities except for the regular solutions. It is also shown that a fourth-order equation is usually adequate in expressing the activity coefficient of a solute in binary solvents at high temperatures. When the activity data for a binary solvent are difficult to obtain in a certain range of composition, the activity data for a sparingly dissolved solute can be used to supplement determination of the binary activities.

OP 20–83. Determination, Estimation, and Correlation of Activities in Hydrometallurgical Ionic Solutions, by N. A. Gokcen. Pres. at 112th AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983; proc. 3d Int. Symp. on Hydrometallurgy, Dec. 15, 1982, pp. 329–340. Methods of rapid determination, estimation, and correlation of aqueous ionic activities are briefly discussed. New data are presented for binary solutions of $AlCl_3$, $Al(NO_3)_3$, $CrCl_3$, $CuSO_4$, NaCl, and $ZnSO_4$. These and other data are used to discuss the limitations of estimation methods.

OP 21–83. U.S. Short-Term Demand Outlook for Soda Ash and Factors Affecting U.S. Soda Ash Availability in the World Market, by Dennis S. Kostick. Chem. and Ind. (London), No. 4, Feb. 21, 1983, pp. 161–165. Soda ash has been used in the United States for nearly 300 years and it is not surprising that most of the end uses have reached maturity and tend to follow the population trend, which for the last several years has been leveling out. The major soda ash markets in the United States are similar to those in other industrially developed countries, namely glass, chemicals, soaps and detergents, pulp and paper, and water treatment. Most of these industries throughout the world have been affected by the general downturn in the world economy, which, in turn, has affected soda ash demand. This paper concentrates on the short-term outlook for soda ash consumption in the United States and some of the factors that will affect the availability of U.S. soda ash for export.

OP 22–83. Reparameterization of the Becker-Kistiakowsky-Wilson Equation of State for Water-Gel Explosives, by V. Krishna Mohan and J. Edmund Hay. Combust. and Flame, v. 50, 1983, pp. 207–218. This paper describes the results of the reparameterization studies on the Becker-Kistiakowsky-Wilson (BKW) equation of state for water-gel explosives. The original set of BKW parameters ($\alpha = 0.5$, $\beta = 0.1$, $K = 11.85$, and $\Theta = 400$) predicts a higher detonation velocity and detonation pressure and a lower detonation temperature compared with the experimental values for these explosives. Among the several combinations of parameters examined, the following set—$\alpha = 0.5$, $\beta = 0.1$, $K = 8.85$, and $\Theta = 1{,}850$—is found to give realistic values for the various detonation properties. Moreover, the predicted and the experimental detonation velocities are seen to be in fair agreement. A comparison of the computed and the experimental (obtained from Crawshaw-Jones measurements) fume characteristics show that (1) inclusion of the wrapper material in the explosive composition increases the concentration of fumes and gives correspondence between the two products such as CO, H_2, NH_3, and CH_4; (2) the measured NO_x concentration is difficult to get in these computations; and (3) calculations of the product compositions for the isentropic expansion of detonation products along the Chapman-Jouguet isentrope give freeze-out temperatures in the range of 1,000 to 1,800 K. These computations were also performed for two ammonium nitrate-fuel oil mixtures and were found to be in good agreement with the experimental data.

OP 23–83. Prereduction and Melting of Domestic Titaniferous Materials, by R. H. Nafziger and R. R. Jordan. Metall. Trans. B, v. 14B, No. 1, Mar. 1983, pp. 55–62. Two domestic ilmenites and one titaniferous magnetite were prereduced by the Bureau of Mines in a batch rotary kiln with coal char to assess the feasibility of this technique in improving melting operations and subsequent electric furnace processing. All three prereduced titaniferous materials were melted satisfactorily in an electric arc furnace to produce iron as a metal suitable for further refining to steel; metallizations ranging from 63 to 83 pct of the iron oxides were achieved. The ilmenites yielded titanium-enriched slags that were amenable to further processing by conventional methods. Prereduction decreased electrode consumption during furnace operation and also conserved expensive electrical energy that otherwise must be used to reduce and melt totally the entire titaniferous materials charge.

OP 24–83. Chelating Crosslinked Starches as Flocculants for Oxide and Hydroxide Mineral Fines, by S. C. Termes and R. L. Wilfong. Pres. at 112th AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983. Soc. Min. Eng. AIME preprint 83–195, 9 pp.; Ch. 18 in

Process Mineralogy III, Applications in Metallurgy, Coal, Concrete, Smelting and Exploration, ed. by W. Petruk (Proc. Symp. sponsored by Process Mineral. Comm., SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983). Soc. Min. Eng. AIME, New York, 1984, pp. 289–305. As part of an effort to provide basic data on the fundamental scientific and engineering principles of minerals beneficiation, the Bureau of Mines is conducting research on the flocculation of mineral fines. This paper presents results of studies using crosslinked starches containing carboxyl, diethanolamine, iminodiacetic acid, and xanthate groups to flocculate hematite, geothite, chromite, manganite, pyrolusite, cuprite, and cassiterite fines. The carboxyl and xanthate derivatives flocculated all minerals except cassiterite; the latter was flocculated by only the diethanolamine derivative. The iminodiacetic acid derivative flocculated hematite, geothite, chromite, cuprite, and pyrolusite fines. Zeta potential measurements were made to help define the reaction mechanism responsible for flocculation. These measurements indicate that electrostatic attraction probably is not involved, except possibly in the case of the diethanolamine derivative. The separation of hematite from quartz by selective flocculation with chelating crosslinked starches under two pH conditions and with two dispersing agents is described. Best recoveries and grades were found when either the carboxyl or xanthate derivative was added at the natural pH of the pulp in the absence of a dispersing agent.

OP 25–83. Control of Diesel Exhaust Emissions in Underground Coal Mines—Single-Cylinder Engine Optimization for Water-in-Fuel Microemulsions, by T. J. Callahan, T. W. Ryan III, G. B. O'Neal, and R. W. Waytulonis. (Proc. SAE Int. Cong. and Exposition on Alternate Fuels for Spark Ignition and Diesel Engines, Detroit, MI, Feb. 28–Mar. 4, 1983.) SAE Tech. Paper Series 830553, 1983, pp. 55–66. The increased use of diesel-powered equipment in underground mines has prompted interest in reducing their exhaust pollutants. Control of particulate emissions without substantial penalties in other emissions or fuel consumption is necessary. This paper describes test results on a prechamber, naturally aspirated, four-cycle diesel engine in which two different concentrations of water-in-fuel emulsions were run. The independent variables comprising the test matrix were fuel, speed, load, injection timing, injection rate, and compression ratio. The dependent variables of the experiment included particulate and gaseous emissions and engine thermal efficiency. Regression analysis was performed on the data to determine how particulate emissions were affected by fuel and engine parameters. Results of this analysis indicated that substantial reductions in particulate emissions could be obtained by utilizing water-in-fuel emulsions.

OP 26–83. Bench-Scale Studies To Recover Alumina From Clay by a Hydrochloric Acid Process, by J. A. Eisele, D. J. Bauer, and D. E. Shanks. Ind. Eng. Chem. Prod. Res. Dev., v. 22, No. 1, 1983, pp. 105–110. As part of its goal of producing cell-grade alumina from clay, the Bureau of Mines conducted bench-scale cyclic tests of the Bureau's proposed clay—HCl leaching—HCl sparging process and investigated in detail the crystallization of aluminum chloride hexahydrate. The composition of recycled leaching liquor was determined for two HCl sparging crystallization conditions: 36% HCl and 26% HCl. Crystallization research showed that cell-grade alumina could not be produced without a recrystallization step.

OP 27–83. Producing Lead Metal From Lead Chloride in a 3,000-Ampere Cell, by C. H. Elges, M. M. Wong, and R. G. Sandberg. Paper in Chloride Electrometall., ed. by P. D. Parker (Symp., TMS-AIME 111th Annu. Meeting, Dallas, TX, Feb. 15–16, 1982). The Metall. Soc., AIME, 1982, pp. 89–100. The Bureau of Mines, under a cost-sharing, cooperative research program with lead producers, is studying a process to eliminate sulfur oxide generation and to minimize lead emissions in the production of lead metal. The new process consists of leaching lead sulfide concentrate with a ferric chloride-brine solution to produce lead chloride, which is then converted to lead metal by fused-salt electrolysis. For 18 months the Bureau operated an integrated process investigation unit, including both leaching and electrolysis sections, which was designed to treat 750 lb of concentrate and to produce 500 lb of lead metal per day. Electrowinning of lead metal is accomplished in a 3,000-amp fused-salt cell at 450° C, utilizing a LiCl-KCL-$PbCl_2$ electrolyte. This paper describes the development, construction, and operation of this 3,000-amp cell.

OP 28–83. Beneficiation of Florida Dolomitic Phosphate Ores, by T. O. Llewellyn, B. E. Davis, and G. V. Sullivan. Pres. at SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983. Soc. Min. Eng. AIME preprint 83–10, 7 pp. The Bureau of Mines conducted studies to recover phosphate from four dolomitic southern Florida deposits not currently mined. The samples contained 5.8 to 10.2 percent P_2O_5 and 1.7 to 4.8 percent MgO. Chemical analyses of sized fractions indicated that no pebble concentrate (plus 1.2 mm) could be produced from these samples. A scheme was developed that consisted of desliming, grinding, scrubbing, and redesliming the ore to produce a flotation feed. Conventional one-step fatty acid-fuel oil batch flotation tests on the samples resulted in concentrates containing 29.0 to 31.3 percent P_2O_5 at flotation recoveries ranging from 72.4 to 96.1 percent of the flotation feed. The MgO content of the concentrates ranged from 0.47 to 1.36 percent. Continuous flotation of the Manatee No. 2 sample indicated that commercial-grade phosphate concentrates analyzing 31.3 percent P_2O_5 and 0.55 percent MgO could be produced with a flotation recovery of 89.9 percent. The MgO content of concentrates obtained from the Manatee No. 1 and Hardee samples was 1.20 to 1.36 percent, respectively. Leaching with aqueous SO_2 reduced the MgO content of these phosphate concentrates to 0.5 and 0.8 percent, but with a concomitant loss in phosphate recovery.

OP 29–83. Fluidized-Bed Decomposition of Aluminum Chloride Hexahydrate, by E. Miller, G. E. Call, P. R. Haskett, and L. J. Nicks. Pres. at 112th TMS-AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1982. Paper in Light Metals 1983, ed. by E. M. Adkins, The Metall. Soc., AIME, pp. 253–271. As part of an investigation by the Bureau of Mines of methods for recovering alumina from domestic nonbauxitic resources, aluminum chloride hexahydrate (ACH) crystals are decomposed in two dense fluidized-bed reactors in series. In the first reactor, ACH is fluidized by the gases of decomposition (HCl and H_2O) produced by indirect heating of the bed and by steam. Concentrated hydrochloric acid may be recovered for use in the process. Partially decomposed solids enter a second fluidized-bed reactor for completion of the decomposition to cell-grade alumina by direct heating with combustion gases. Results from the first-stage decomposition step in a 4-in cylindrical glass reactor and in a tubular bundle reactor are reported. Test conditions

included a fluidization face velocity of 0.4 m/sec, space times of 30 min or longer, heating indirectly to temperatures of 190° to 375° C, and gas compositions of 0 to 43 mol-pct HCl and 100 to 57 mol-pct steam. The direct-heated second-stage reactor, a 4-in alloy cylinder, was operated at a fluidization range of 600° to 1,005° C, and with furnace gases containing steam and oxygen of 17.4 to 57.8 total vol-pct. The product is composed of coarser particles than are normally used in an alumina reduction cell, and contains 0.1 pct chloride, which is not present in Bayer alumina.

OP 30–83. Prereduction and Smelting of Domestic (U.S.) Chromites From Montana and California, by R. H. Nafziger, P. E. Sanker, J. E. Tress, and R. A. McCune. Ironmaking and Steelmaking, v. 9, No. 6, 1982, pp. 267–277. Four chromites from mines in Montana and California were prereduced to provide suitable charge material for the production of ferrochromium in an electric arc furnace. A part of the Bureau of Mines program investigating technology for efficient and economic recovery of metals from domestic resources, this study has shown that prereduction of these chromites increases productivity and decreases electrical-energy consumption with respect to cases when unreduced materials were used. About 75% chromium metallization and 75% total metallization were realized when high-iron chromites from Montana were prereduced with coal char and coke breeze in a batch rotary kiln. Chromium and total metallizations near 95% were obtained when a metallurgical-grade chromite was prereduced. Satisfactory ferrochromium for the production of stainless steel was produced in an electric arc furnace from all the prereduced materials.

OP 31–83. Control of Diesel Exhaust Emissions in Underground Coal Mines—Steady-State and Transient Engine Tests With a Five Percent Water-in-Fuel Microemulsion, by Glenn B. O'Neal, H. E. Dietzmann, T. W. Ryan III, and R. W. Waytulonis. (Proc. SAE Int. Cong. and Exposition on Alternate Fuels for Spark Ignition and Diesel Engines, Detroit, MI, Feb. 28–Mar. 4, 1983). SAE Tech. Paper Series 830555, 1983, pp. 77–83. This paper is the fourth in a series describing work sponsored by the Bureau of Mines to reduce diesel particulate and gaseous emissions through fuel modification. A stabilized water microemulsion fuel developed in previous work was tested in a Caterpillar 3304 NA four-cylinder engine with compression ratio and injection timing and rate optimized for this fuel to demonstrate the emissions reductions achieved. It was tested in both standard and optimum configurations with both baseline DF-2 and optimized microemulsion fuels. Gaseous and particulate data are presented from steady-state tests using a computer-operated minidilution tunnel and from transient tests using a total exhaust dilution tunnel. The optimized engine-fuel combination was effective in reducing particulates and oxides of nitrogen in steady-state tests. However, the standard engine-fuel combination provided the lowest particulate and NO_x emissions in transient tests.

OP 32–83. Dewatering of Fine Particle Clay Waste Using a Flocculant, by B. J. Scheiner and Annie G. Smelley. Pres. at SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983. Soc. Min. Eng. AIME preprint 83–2, 10 pp. The Bureau of Mines is conducting research on a dewatering technique for fine particles generated during the mineral beneficiation process that will recover a portion of the water now being lost using conventional waste disposal methods and significantly reduce the time required for land reclamation. The technique utilizes a flocculant, polyethylene oxide (PEO), that forms strong stable flocs that can be dewatered rapidly on static and/or rotary screens. In field tests, phosphate clay waste has been dewatered from a nominal 2.5 percent solids to greater than 20 percent solids. In other field tests, coal-clay waste has been dewatered from a nominal 3 percent solids to greater than 55 percent solids. In addition, small-scale continuous tests have shown that bentonitic clays can be dewatered from 12 percent solids to 40 percent solids.

OP 33–83. A Large-Scale Impact Spalling Test, by R. Blickensderfer and J. H. Tylczak. Wear, Elsevier Sequoia, the Netherlands, v. 84, No. 3, Feb. 1, 1983, pp. 361–373. A unique test apparatus is described that effectively produces spalling on wear-resistant alloys and can be used to study the causes of spalling. The work was conducted by the Bureau of Mines as part of an effort to minimize the consumption of strategic materials used during the mining and processing of minerals. The test utilizes balls 75 mm in diameter made of the test alloys, which are dropped a distance of 3.5 m. Multiple impacts over a range of energy are produced between the balls. The unique design of the test apparatus provides a multiplying effect that results in 30,000 or more total impacts per hour on 20 or so test alloys. The four major types of failure that were observed on 22 commercial and experimental alloys that received up to 300,000 impacts are discussed.

OP 34–83. Arizona's Artillery Peak Manganese Deposits, by Peter G. Chamberlain. Pres. at SME-AIME Fall Meeting and Exhibit, Denver, CO, Nov. 18–20, 1981. Soc. Min. Eng. AIME preprint 81–367, 8 pp. The Bureau of Mines is conducting research to boost domestic production of manganese. Virtually no mining exists in the low-grade and/or small deposits that occur in this country. One large, low-grade manganese deposit located in west-central Arizona—the Artillery Peak district—was extensively studied and sporadically mined during the 1940's and 1950's. Although manganese mining in the district has been long dormant, recent studies indicate that the deposits may be amenable to economical production by heap and/or in situ leaching methods. A conceptual design for an in situ leaching system features undercutting and blasting a block of ore, leaching with SO_2, and extracting the manganese as a sulfate or oxide. Possible applications to other manganese deposits depend upon formation permeability and specific manganese mineralogy.

OP 35–83. Stability Evaluation of Retreating Longwall Chain Pillars With Regressive Integrity Factors, by Paul H. Lu. Proc. 5th Cong. of the Int. Soc. for Rock Mech., Melbourne, Australia, Apr. 10–15, 1983, v. 2, pp. E37–E40. Profiles of mining-induced loading and residual strength across a pillar vary with the position of the longwall face. The residual pillar-strength profile can be constructed on the basis of laboratory-determined triaxial compressive strength, in which the in situ measured horizontal pressure is considered as the constraint. The vertical-loading profile can be established with the measured vertical pressures. Vertical and horizontal pillar pressures can be measured with hydraulic borehole pressure cells. Defined as the ratio of the integrated total strength to the integrated total load under the profiles, the integrity factor is proposed here as a rational parameter for evaluating chain-pillar stability.

OP 36–83. Simplest Formula of Copper Iodide: A Stoichiometry Experiment, by D. J. MacDonald. J. Chem. Educ., v. 60, No. 2, Feb. 1983, p. 147. An experiment suitable for use in teaching principles of stoichiometry and chemical laboratory techniques is described. It is intended for high school or college courses in general chemistry. The experiment involves dissolving a known mass of copper metal and quantitatively precipitating the copper as copper iodide, CuI. A student using the experiment is given as background information the atomic masses of copper and iodine and is expected to determine the empirical formula of copper iodide, that is, to decide from his or her measurement of its I:Cu atom ratio whether copper iodide is CuI or CuI_2. In use by a group of typical students at the University of Nevada at Reno, the experiment gave an average result for the I:Cu ratio equal to 1.02 with a standard deviation of 0.16.

OP 37–83. Electric Arc Furnace Melting of Simulated Transuranic Wastes, by R. H. Nafziger and L. L. Oden. Pres. at 6th Int. Symp. on the Scientific Basis for Nuclear Waste Management, Boston, MA, Nov. 1–4, 1982; Mat. Res. Soc. Symp. Proc., v. 15, 1983. Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, pp. 639–646. As part of an interagency agreement between the Bureau of Mines, U.S. Department of the Interior, and the U.S. Department of Energy through its contractor, EG&G Idaho, Inc., the Bureau conducted six melting tests at its Albany Research Center to assess the feasibility of melting transuranic-containing wastes. The tests were conducted with simulated wastes in a conventional refractory-lined electric arc furnace. Charge materials included concrete, soil, metal, wood, CaO- and Na_2O-containing waste sludges, cement, and polyethylene mixed in various proportions in both unburned and partially incinerated forms. The investigation showed that it is possible to melt these materials in a 1-metric-ton conventional electric arc furnace and separate the slag and metal provided that suitable fluxes are added to condition the siliceous slags. However, the electric arc furnace cannot be considered an efficient incinerator. The molten slags were poured into 210-liter steel drums having a 0.64-cm-thick steel chill plate on the bottom. All slags were tapped from the furnace satisfactorily. The concrete and sludge materials required the most energy for melting. The highest electrode consumption occurred when the sludges were melted. A high alumina-chrome refractory is satisfactory for use as a furnace lining in melting these wastes. Offgases and particulates from all of the tests were sampled and analyzed. The greatest amounts of particulate matter in the offgas streams were obtained from melting sludges and incinerated wastes.

OP 38–83. The Effect of Ion-Implanted Alloy Additions on the Linear Polarization and Corrosion Fatigue Behavior of Steel, by B. D. Sartwell, R. P. Walters, N. S. Wheeler, and C. R. Brown. Paper in Corrosion of Metals Processed by Directed Energy Beams, ed. by C. R. Clayton and C. M. Preece (Proc. TMS-AIME Fall Meeting, cosponsored by The Metall. Soc. of AIME and Mater. Sci. Div. of ASM, Louisville, KY, Oct. 13, 1981). Metall. Soc. AIME, December 1982, pp. 53–73. As part of the research to determine substitute alloying elements, investigations have been conducted by the Bureau of Mines to determine the effects of different alloying elements, introduced into the substrate by ion implantation, on the corrosion and oxidation behavior of steel. This investigation involved using the three-point linear polarization test to determine the effects of lead and titanium implantation on the aqueous corrosion behavior of iron in a dilute sulfuric acid solution. This technique proved to be a quick, accurate corrosion rate test suitable for evaluating the ion-implanted alloys so that an assessment could be made of the effects of the specific alloy additions on corrosion behavior.

OP 39–83. Filtration of Asbestos and Other Solids With Magnesium Oxide, by J. E. Schiller and S. E. Khalafalla. Pres. at SME-AIME Annu. Meeting, Las Vegas, NV, Feb. 24, 1980. Soc. Min. Eng. AIME preprint 80–108, Mar. 1988, pp. 237–242. Owing to its unique surface properties, magnesium oxide (MgO) is an excellent medium to filter asbestos and other suspended solids from water. MgO operates up to twice as long as a sand filter before backwashing is required while flow rate and filtrate clarity are as good or better with MgO .

OP 40–83. Energy Recovery Using Hydraulic Turbines in Deep Underground Mines, by R. N. Torbin and E. D. Thimons. Mech. Eng., v. 105, No. 4, Apr. 1983, pp. 57–61. Mines in the United States are continually descending to greater depths in the search for minable deposits, but the high temperatures and humidities encountered at these depths make a comfortable working environment difficult and expensive to maintain. To help deal with this problem, the Bureau of Mines awarded a contract to investigate and evaluate commercially available means of energy recovery for the deep mining industry. This paper discusses benefits that can be realized using high-pressure water to operate a turbine, the economic considerations, the use of turbine technology in mine applications, and outlines the research program plan for further study.

OP 41–83. Size and Shape Characteristics of Amphibole Asbestos (Amosite) and Amphibole Cleavage Fragments (Actinolite, Cummingtonite) Collected on Occupational Air Monitoring Filters, by Robert L. Virta. Kim B. Shedd, Ann G. Wylie, and Janet G. Snyder. Ch. 47 in Aerosols in the Mining and Industrial Work Environments. Volume 2. Characterization, ed. by V. A. Marple and B. Y. H. Liu. Ann Arbor Sci. Pub., Ann Arbor MI, Mar. 1983, pp. 633–643. The objective of this study by the Bureau of Mines was to determine if particle populations from asbestiform and nonasbestiform mineral sources can be distinguished through least-squares regression analyses using the relationship:

$$\log_{10} \text{width} = F \log_{10} \text{length} + b$$

where F = fibrosity index, the slope of the regression line

b = intercept on the $\log_{10}$ width axis

Amphibole particles on air monitoring filters from three mining and two industrial sites were characterized by scanning electron microscopy and energy-dispersive X-ray spectroscopy analysis. The data are evaluated using particle length and width summary statistics and compared with analyses by linear regression. Conclusions based on comparison of data manipulation using these two techniques follow: The mining site particle populations are morphologically similar, the industrial site particle populations are morphologically similar, and size and shape characteristics of mining site populations are statistically different from those of the industrial sites. Determination of either an asbestos or a nonasbestos source of amphiboles using linear regression techniques on data obtained from examination of air monitoring filters is a potential application of this technique.

OP 42–83. Adhesion and Hardness of Platinum Coatings Electrodeposited From Molten Salts, by R. P.

Walters, M. J. Lynch, and D. R. Flinn. Plat. and Surface Finishing J., v. 70, No. 5, May 1983, pp. 91–95. Utilizing a direct pull solder method, the adhesion of platinum coatings to TZM and Fe10Cr substrates was determined. The average fracture value was 331 MPa (48,000 lb/in), with fracture occurring in the substrate or in some combination of the substrate, coating, and solder, but not at the deposit-substrate interface, indicating that the true adhesion of the coatings is greater than the measured fracture values. Cross-sectional hardness values were dependent on the average grain width, with hardness values ranging from 52 to 120 HK_{25} at 35 and 8 μm, respectively, from the substrate-coating interface.

OP 43–83. Geologic Estimates and Future Costs of Strip Mining Coal, by Emil D. Attanasi and Eric K. Green. Energy Systems and Policy J., v. 6, No. 3, 1982, pp. 193–212. Geologic coal-resource appraisals, which typically describe the location and general characteristics of coalbeds, do not generally provide enough information to estimate the cost of developing the resource or to predict the escalation of costs expected to result from physical depletion. This paper considers the nature of data and methods of appraisal required to provide this cost information to policymakers. Illinois is used as a prototype area for analysis because of its long history of coal mining and its demonstrated coal reserve base of strippable coal that exceeds all but two of the States in the United States. Evidence of gradual depletion of Illinois strippable coal reserves is provided by declining labor productivity, decreasing average mine size, and increasing overburden depth. The procedures used to estimate the costs of mining remaining deposits indicate that the physical characteristics that will affect mining costs most significantly are depth of overburden, thickness of coal seam, and areal extent of coal of the minable reserve blocks. Findings presented here provide guidelines for the collection of economic and geologic data in order to improve coal appraisals, particularly those currently in progress in the Western United States.

OP 44–83. Infrared Temperatures of Coal Dust Explosions, by Kenneth L. Cashdollar and Martin Hertzberg. Combus. and Flame, v. 51, 1983, pp. 23–35. A comprehensive set of temperature measurements is presented for coal dust explosions as a function of dust concentration. Data include the dependence of explosion temperature on particle size, volatility, oxygen content, and added rock dust. The majority of the data are for constant volume explosions in a laboratory-scale vessel, but data from a coal dust burner flame and full-scale mine dust explosions are also included. In all of the measurements, the gas temperature was significantly higher than the dust particle temperature. The measurements were made with a three-wavelength near-infrared pyrometer and a six-wavelength infrared pyrometer (in the 1- to 5-μm-wavelength region). Some thermocouple measurements are shown for comparison.

OP 45–83. Using the U.S. Bureau of Mines Minerals Availability System for Supply-Demand Analysis, by Eric Green and James Grichar. Mater. and Soc., v. 6, No. 4, 1982, pp. 471–482. In recent years numerous attempts have been made to model nonfuel minerals markets and forecast trends in price, demand, supply, import reliance, etc. On the supply side, econometric models based on historical data were constructed with less than satisfactory results. Such models and their estimates of the future primary supply of nonfuel minerals may be more accurate if the physical characteristics of the known deposits are evaluated using standardized engineering-cost methodology. The Minerals Availability System (MAS) of the U.S. Bureau of Mines transforms this type of deposit information into estimates of potential nonfuel minerals production. MAS estimates potential production from domestic and foreign deposits; this will be done for 34 commodities. This paper shows how MAS can be used in partial equilibrium analysis of the copper market. In particular, a domestic primary supply function is developed based on MAS data; this and other models are then used to predict equilibrium price and quantity under various assumptions.

OP 46–83. Domains of Flammability and Thermal Ignitability for Pulverized Coals and Other Dusts: Particle Size Dependences and Microscopic Residue Analyses, by Martin Hertzberg, Kenneth L. Cashdollar, Daniel L. Ng, and Ronald S. Conti. Paper in Nineteenth Symposium (International) on Combustion (Haifa, Israel, Aug. 8–13, 1982). Combustion Inst., Pittsburgh, PA, 1982, pp. 1169–1180. New data presented for the particle size dependence of the domains of flammability and thermal ignitability for two bituminous coal dusts and for polyethylene powder showed that below some threshold or characteristic diameter, the behavior of all the dusts was independent of particle size and approached that of an equivalent premixed gas. Above the characteristic diameter, the lean limit of flammability and the minimum autoignition temperature increased with increasing particle size. For still larger particle sizes, a critical diameter was reached, above which the dusts were nonexplosive at ambient temperature. Both the characteristic diameter at which a size dependence first appears and the critical diameter above which the dust is nonexplosive increase monotonically with increasing volatility of the dust. The characteristic diameter and critical diameter also increase monotonically with increasing ambient temperature and with increasing oxygen content of the dispersing gas.

OP 47–83. Supply Prospects for the U.S. Copper Industry: Alternative Scenarios: Midas II Computer Model, by W. R. Hibbard, Jr., H. D. Sherali, A. L. Soyster, and L. J. Sousa. Mater. and Soc., v. 6, No. 2, 1982, pp. 201–210. The Midas II linear programming model of the U.S. copper industry was revised to reflect conditions resulting from the 1980–81 recession, the high cost of money, and reduced demand. Various scenarios were run to evaluate the impact of tax reductions, high rates of economic growth, severance tax, and changes in pollution control requirements on copper demand, supply, and price. The most stimulating effects resulted from high demand generated by an increased rate of economic growth. The next most stimulating effects resulted from a 20% tax cut together with no pollution control costs. The tax cut alone caused little change from the base case. The most devastating effects resulted from requiring an 18% rate of return combined with an Intergovernmental Council of Copper-Exporting Countries embargo. The 18% rate of return reduced U.S. production that was made up from imports. When the imports were not available, the impact was drastic. The model seemed to perform appropriately under the circumstances prescribed.

OP 48–83. Mining, by Barry W. Klein and Ronald F. Balazik. Ch. 15 in U.S. Ind. Outlook 1982, pp. 147–150. Mining production is expected to increase in 1982, as was the expectation for 1981.

Tax law changes should encourage investment, and a new cabinet-level council is addressing mineral industry issues and problems. Improvement will be gradual, however, because changes in Government policy do not have immediate effects. This paper covers SIC codes 10 and 14, nonfuel metallic and nonmetallic minerals. SIC code 10 includes ores of such metals as iron, copper, lead, zinc, and molybdenum. SIC code 14 includes both nonmetallics, such as stone, sand and gravel, and clays, and chemical minerals such as phosphate rock, potash, and sulfur.

OP 49–83. Mining, by Barry W. Klein, Annette P. Graham, and Anthony Oprychal. Ch. 16 in U.S. Ind. Outlook 1983, pp. 16-1—16-7. Mining production is expected to increase somewhat in 1983 compared with the relatively low levels in 1982. This anticipated improvement reflects the upturn in the economy forecast for 1983. In April 1982, the President submitted to Congress the National Materials and Minerals Program Plan and Report, which recognizes the vital importance of minerals to the economy and national security. This paper covers SIC codes 10 and 14, metallic and nonmetallic mineral industries, excluding fuels. SIC code 10 includes ores of such metals as iron, copper, gold, molybdenum, and lead. SIC code 14 includes nonmetallics, such as stone, sand and gravel, and clays; and chemical minerals such as phosphate rock, sulfur, salt, and potash.

OP 50–83. The Vapor-Liquid Equilibria of the Aluminum Chloride-Ferric Chloride System, by H. C. Ko, A. Landsberg, and Jack L. Henry. Metall. Trans. B, v. 14B, June 1983, pp. 301–304. Work was undertaken at the Bureau of Mines Albany (OR) Research Center to measure the vapor-liquid equilibria in the aluminum chloride-iron chloride system at realistic pressures. The equilibrium diagram constructed from these data can be used to evaluate the possibility of using distillation for separating iron chloride from aluminum chloride. This work is part of a larger effort to study the carbochlorination of domestic clay as a means to produce anhydrous aluminum chloride for reduction in the more energy-efficient chloride cell.

OP 51–83. Iodine, by P. A. Lyday. Min. Eng., v. 35, No. 5. May 1983, p. 495. In 1982, U.S. iodine demand decreased as the economy remained depressed and iodine prices remained high. Demand decreased 9% to about 36 kt (3,950 st) valued at $48 million. Imports from Japan (81%) and Chile (18%) were the major source of U.S. supply. Two U.S. companies produced at 1981 levels and supplied about 25% of domestic demand. Demand is expected to increase during 1983.

OP 52–83. Feasibility of In Situ Leaching of Metallic Ores Other Than Copper and Uranium, by George M. Potter, Clement K. Chase, and Peter G. Chamberlain. Pres. at 2d SME-SPE Int. Symp. on Solution Mining, Denver, CO, Nov. 18–20, 1981, SME preprint 81-363, 6 pp.; pub. in Interfacing Technologies in Solution Mining, ed. by W. J. Schlitt and J. B. Hiskey. Soc. Min. Eng. AIME, Littleton, CO, 1982, pp. 123–130. Under contractual arrangements with the Bureau of Mines, Mountain States Research and Development, Inc., completed a technological investigation to determine the feasibility of in situ mining of metal commodities other than copper and uranium. The study was based upon available literature and experience. The selection of potential candidates for in situ mining was influenced by economic importance, probable amenability to in situ methods, and environmental considerations. Four metals (or metal pairs) were chosen for feasibility studies: aluminum (with a copper byproduct), gold-silver, and manganese were recommended for further study and action; cobalt-nickel was also recommended contingent upon preliminary laboratory leaching and recovery investigations and field geohydrological work. Mining and recovery plans and an economic evaluation are included. Other metals with potential for in situ leaching are lead-zinc, molybdenum, and vanadium.

OP 53–83. Strategic Planning in the Minerals and Materials Industries in an International Era, by Louis J. Sousa. Mater. and Soc., v. 7, No. 1, 1983, pp. 49–50. Strategic planning is a process in which a firm attempts to clearly define what it is trying to achieve and to identify the optimal paths for achieving these objectives. Materials firms recently have come to place more attention on strategic planning. Foreign competition has increased significantly. For most of the major metals, a slow growth future seems to be in the offing. Strategic planning can provide materials firms with a better understanding of the change that is occurring so rapidly. It can enable a firm to better control as it maneuvers towards the most profitable directions.

OP 54–83. Iron Oxide Pigments, by W. I. Spinrad, Jr. Min. Eng., v. 35, No. 5, May 1983, pp. 495–496. U.S. mine production and shipments of crude iron oxide pigments and finished iron oxide shipments and U.S. imports decreased markedly in 1982 compared with 1981 levels. U.S. exports over the same period increased sharply. Decreases in demand for iron oxide pigments have been caused by curtailed consumption and inventory reduction by most domestic consumers of these pigments.

OP 55–83. State Severance Taxes: An Analysis of the Impact of Rate Changes on Copper Recovery Costs, by Phillip N. Yasnowsky and Annette P. Graham. Mater. and Soc., v. 6, No. 2, 1982, pp. 233–246. This paper uses the Bureau of Mines Minerals Availability System to analyze the possible effect of assumed State severance tax rate changes on copper recovery costs. For a comprehensive background study of severance taxes, the reader is referred to the Bureau's Information Circular 8788.

OP 56–83. Strontium, by J. E. Ferrell. Min. Eng., v. 35, No. 5, May 1983, pp. 510–511. The United States continued as the world's largest producer and consumer of strontium compounds, even though there has been no domestic mining of strontium ores since 1959. Imports dropped sharply for strontium minerals (celestite) from 45 kt (49,699 st) in 1981 to 30 kt (33,075 st) in 1982—the lowest annual tonnage since 1975. More than 99% of the celestite came from Mexico. Strontium compound imports also declined from the 1981 level by about 32% to 1.8 kt (1,942 st).

OP 57–83. Quartz Crystal, by W. Johnson. Min. Eng., v. 35, No. 5, May 1983, p. 506. Industrial quartz crystal continues to be of critical importance to the electronics industry. It is used extensively for military and civilian communications networks requiring precise frequency control, oscillator watches, and numerous other timing devices including automobile microprocessors. Only a minute amount of quartz crystal is used for optical purposes.

OP 58–83. Bromine, by P. A. Lyday. Min. Eng., v. 35, No. 5, May 1983, pp. 487–488. The

article is an overview of the bromine industry during 1982. The United States continued to be the largest producer of bromine in the world. Ethylene dibromide, used as a lead scavenger in gasoline, was the largest area of demand. Sections discuss U.S. development, foreign developments, and outlook for the future of the industry.

OP 59–83. An Econometric Model of the Short-Run Demand for Workers and Hours in the U.S. Auto Industry, by Julius C. Chang. J. Econometrics, Elsevier Science Publishers B.V., North-Holland, v. 22, No. 3, August 1982, pp. 301–316. Based on the labor hoarding theory and the Koyck-type adjustment mechanism, a model of the short-run demand for workers and hours in the U.S. auto industry is developed and estimated using Michigan and U.S. data, respectively. Statistical tests of the model structure are then conducted to confirm the theoretical specifications.

OP 60–83. Recovery of Lead From Battery Sludge by Electrowinning, by E. R. Cole, A. Y. Lee, and D. L. Paulson. J. Met., v. 35, No. 8, August 1983, pp. 42–46. Research by the Bureau of Mines has resulted in a combination electrorefining-electrowinning method for recycling the lead from scrap batteries. The lead metal grids and lugs are separated from the sludge by ball milling, washing, and screening and are melted and cast into anodes for electrorefining by the Betts process using waste fluosilicic acid as the electrolyte. The Betts process, established in commercial use for 80 years, has been well described in the literature and needs no further description here. The sulfate-oxide-metal sludge remaining after separation of the lead metal is treated in a two-step leaching operation with ammonium carbonate, waste fluosilicic acid, and Pb powder to solubilize the lead for recovery by electrowinning. Unlike electrorefining, electrowinning is not being practiced commercially now. Prior attempts to electrowin lead have failed because large quantities of insoluble lead dioxide are deposited on the anodes at the expense of lead deposition on the cathodes. This paper describes bench-scale research for recovering lead from battery sludge by electrowinning that prevents PbO_2 formation at the anodes. The bench-scale work has been successfully completed, and electrowinning experiments are presently being conducted in a 20-liter multielectrode cell.

OP 61–83. Survival Kits for the Breath of Life, by Nicholas Kyriazi. Foote Prints, v. 46, No. 1, June 1983, pp. 18–23. This is a brief discussion of some of the equipment being developed by the U.S. Bureau of Mines to improve the odds for the survival of miners exiting an underground coal mine after an emergency and to enhance the safety of rescue team members recovering the mine. At a lay worker's technical level, a new escape breathing apparatus, a low-profile rescue breathing apparatus, a mine rescue team protective ensemble, and a rescue team helmet are presented with appropriate background information describing their need and operation.

OP 62–83. Thermal Degradation of Oil Shale With Molten Nitrates, by Yael Miron. Thermochim. Acta, Elsevier Science Publishers, B.V., Amsterdam, the Netherlands, v. 65, 1983, pp. 213–237. The present study was conducted at the Bureau of Mines to explore the effect of a variety of molten nitrate salts on the thermal decomposition of one oil shale sample from the Green River Formation. Thermal analysis, coupled with effluent gas analysis, was used for all the tests in which the samples were heated at a constant heating rate. Weight losses of heated oil shale in the presence of nitrates were found to be higher than similar losses in the absence of nitrates. Ammonium nitrate degraded the oil shale at a lower temperature than that at which oil shale started to decompose when heated by itself, or in the presence of sodium nitrate or potassium nitrate. From scanning electron microscopy of the heated oil shale samples, it appears that ammonium nitrate attacked both the inorganic and the organic portions of the shale. These results indicate that a more detailed investigation of the effects of ammonium nitrate, and perhaps other nitrates, on fuel recovery from oil shale will be a worthwhile undertaking.

OP 63–83. How To Design Cabs and Canopies. Part I—Measuring the Problems, by William W. Aljoe. Coal Min. & Proc., March 1983, pp. 61–67. This is the first of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article describes a procedure to define the minimum and practical working heights at which canopies can be used without roofing and without restricting operator comfort or vision.

OP 64–83. How To Design Cabs and Canopies. Part II—Increasing Comfort and Vision, by William W. Aljoe. Coal Min. & Proc., April 1983, pp. 94–118. This is the second of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article examines the problems of operator comfort and vision resulting from the canopies on existing equipment.

OP 65–83. How To Design Cabs and Canopies. Part III—Avoiding and Solving Problems, by William W. Aljoe. Coal Min. & Proc., May 1983, pp. 58–63. This is the third of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article discusses how optimum machine selection, changes in mine operating procedures, and improvements in cab and canopy design can help solve canopy-related problems inherent to low coal mines.

OP 66–83. Heat Capacities of Titanium Disulfide From 5.87 to 300.7 K, by Richard P. Beyer. J. Chem. & Eng. Data, July 1983, pp. 347-348. The heat capacity of TiS_2 was determined from 5.87 to 300.7 K by adiabatic calorimetry. The values at 298.5 K for $C_p°$, $S°(T)-S°(0)$, $-[G°(T)-H(0)]/T$, and $H°(T)-H°(0)$ are 67.34, 78.21, 36.89 J mol^{-1} K^{-1}, and 12.38 kJ mol^{-1}, respectively.

OP 67–83. Noise Control of an Underground Mine Personnel Carrier, by Anthony G. Galaitsis and Thomas G. Bobick. Noise Contr. Eng. J., v. 21, No. 1, July-August 1983, pp. 4–9. The interior noise of a mine-operated rail personnel carrier was reduced by replacing some standard components with acoustically treated components. The latter included

a softer suspension, softer motor mounts, damped panels, sound-absorbing motor enclosures, and helical gears. Depending on operating conditions, the modified vehicle was 6 to 7.5 dBA quieter than an unquieted vehicle. The noise level in the vehicle interior was reduced to approximately 85 dBA at an average vehicle speed.

OP 68–83. The Oxygen Cost of an Escape From an Underground Coal Mine, by Eliezer Kamon, Diane Doyle, and John Kovac. Am. Ind. Hyg. Assoc. J., v. 44, No. 7, July 1983, pp. 552–555. Six 27- to 63-year-old coal miners performed an escape maneuver from an underground mine along a passageway that required walking and running erect or stooped, duckwalking, and crawling. The miners traveled at different speeds, for each mode of locomotion. The minute pulmonary ventilation (V_E), uptake (V_{O_2}), and heart rate (HR), recorded continuously on a magnetic tape via lightweight meters carried on the miners' waists, indicated similar average and peak values for all modes of locomotion. The mean V_E, V_{O_2} (L•min^{-1}, STPD), and HR (b•min^{-1}) were, respectively, 49, 1.63, and 143 for the average values, and 52, 1.92, and 161 for the peak values. Compared to the aerobic capacity obtained during graded treadmill test to exhaustion, the average effort of the escape was performed at 64% and the peak effort at 70% of the miners' aerobic capacity for an escape time of 58 minutes.

OP 69–83. Methane in Pennsylvania Coal: An Overview, by Carla A. Kertis, James P. Ulery, and Roger L. King. Ch. 24 in Pennsylvania Coal: Resources, Technology and Utilization, ed. by S. K. Majumdar and E. W. Miller. PA Acad. Sci., 1983, pp. 439–461. The hazards of methane gas have been associated with coal from the inception of underground mining. Methane occurs in the air of most coal mines because when coal was formed from ancient peat swamps, methane was also formed. The common occurrence of methane and its explosibility when mixed with air are directly responsible for numerous mine disasters. Owing to the inherent gassiness of all underground coal mines, various methods of removing methane have been developed. These degasification techniques have improved safety conditions in coal mines while maintaining high production rates and have facilitated the use of a valuable energy resource.

OP 70–83. Interfacing an XRF Spectrometer and Computer System To Aid Data Management, by D. G. Kuehn, D. C. Lundeen, R. L. Brandvig, and R. H. Jefferson. Am. Lab., v. 15, No. 9, September 1983, pp. 16–23. Data management for X-ray fluorescence spectroscopy can be cumbersome and time-consuming, especially when multielement analyses are required for each sample material. To speed and simplify the process while utilizing existing equipment, the Bureau of Mines has interfaced free-standing X-ray fluorescence and computer systems. This report discusses the implementation procedures in terms of both hardware and software requirements.

OP 71–83. Smelting Ferrochromium From a New Guinea Lateritic Chromite, by R. H. Nafziger. Trans. Inst. Min. Metall. (Sec. C: Miner. Process. Extr. Metall.), v. 92, June 1983, pp. C73–C82. The Bureau of Mines cooperated with the NORD Resources Corp. to evaluate the feasibility of smelting a lateritic chromite concentrate from New Guinea to produce ferrochromium by electric arc furnace processing. One series of five tests was conducted in a nominal 100-kg furnace to evaluate slag compositions, carbonaceous reductants, and smelting characteristics of the chromite. A second series of five 1-ton furnace tests was made to obtain such engineering data as energy consumption, melting rates, and bath temperatures. Results showed that a high-carbon ferrochromium can be prepared from the New Guinea lateritic chromite concentrate, although the phosphorus levels were high. Chromium recovery in the ferroalloy with up to 52 wt % chromium averaged nearly 80%. Energy consumption compared favorably with that reported in commercial practice. Submerged arc operations provided the most efficient smelting conditions. On the basis of results obtained in the small-scale batch operations, agglomeration of the charge materials may not be required. Because of the relatively fine size of the chromite concentrate, carbon requirements should include woodchips to improve operation of the furnace. In general, variables for smelting lateritic chromites are similar to those for the production of high-carbon ferrochromium from offgrade chromites.

OP 72–83. Noise Control for Aggregate Plants, by Robert J. Pokora, Terry L. Muldoon, and Thomas G. Bobick. Pit & Quarry, September 1983, pp. 40–44. Barrier materials, operator enclosures, and resilient materials were used in a demonstration program for retrofitting aggregate plants for noise reduction. The techniques employed in the program can provide guidelines for designing, installing, and evaluating retrofit noise control systems in crushing and screening plants. This article discusses the details of a survey of the nonmetallic mining industry, the design and installation of retrofit noise control treatments, and the field evaluation of those controls under actual operating conditions.

OP 73–83. Specimen Preparation and Sizing by Image Analysis of Respirable Quartz Particles Collected on Coal Mine Air-Monitoring Filters, by J. G. Snyder and C. W. Huggins. Proc. 18th Annu. Meeting, Microbeam Anal. Soc. of America, Phoenix, AZ, Aug. 6–12, 1983; pub. in Microbeam Analysis—1983, ed. by R. Gooley, San Francisco Press, Inc., pp. 22–26. Several quartz standards and respirable coal mine dust samples containing significant amounts of quartz were used to develop a method of quartz particle-size determination by image analysis. Data on the quartz particle size are crucial for the accurate determination of quartz in respirable coal mine dusts collected on air-monitoring filters by MSHA. In this study, three pure ground quartz materials were chosen for particle-size distribution measurements: Minusil -5, Minusil -10, and Silver Bond B. Size distributions for the quartz standards were first determined by a Philips EM 100-B transmission electron microscope as a basis for verification of the results from image analysis. Next, a specimen preparation technique was developed for image analysis. Particle-size analysis was done with a Cambridge Mark II scanning electron microscope interfaced with a Tracor Northern 1310 image analyzer and a Tracor Northern 880 energy-dispersive X-ray spectrometer.

OP 74–83. Hot-Crush Technique for Separation of Cast- and Wrought-Aluminum Alloy Scrap, by Fred Ambrose, R. D. Brown, Jr., Dominic Montagna, and H. V. Makar. Proc. 4th Recycling World Cong.,

New Orleans, LA, Apr. 5-7, 1982; pub. in Conserv. & Recycling, v. 6, No. 1/2, 1983, pp. 63-69. A novel technique for the separation of cast and wrought aluminum alloy scrap is described. This technique, developed by the Bureau of Mines, exploits differences in hot ductility between cast and wrought aluminum. Tests are in progress to demonstrate its use for upgrading mixed aluminum scrap into recyclable grades of wrought and cast alloys. This paper describes (1) process development studies using conventional heating, fragmentizing, and screening equipment and (2) process improvements to enhance commercial development.

OP 75–83. New Technique Vacuums Gob Gas. Cross-Measure Boreholes Controlled Longwall Gob Gas at a Bethlehem Mine, by A. A. Campoli, Joseph Cervik, and F. Burns. Coal Min. Process., v. 20, No. 3, March 1983, pp. 48-51. The cross-measure borehole technique is being developed jointly by the Bureau of Mines and Bethlehem Mines Corp. as an alternative to current U.S. longwall methane control techniques. Small-diameter inclined boreholes are drilled from underground locations into roof strata that will be fractured when the longwall panel is removed. Methane contained in the fractured strata is collected in the cross-measure boreholes and drawn through an underground pipeline to a central surface borehole by a vacuum pump.

OP 76–83. Grouting Methane Drainage Holes in Coalbeds, by Joseph Cervik. Proc. ASCE Spec. Conf. on Grouting in Geotechnical Engineering, New Orleans, LA, Feb. 10-12, 1982, pp. 651-664. Horizontal drainage holes drilled into gassy coalbeds are effective in reducing methane flows into mine workings during mining operations. Drainage holes were drilled 415 to 2,126 ft (126 to 648 m) long. Holes were sealed with cement before interception by the mining machine to avoid formation of explosive methane-air mixtures. The cement slurry consisted of cement, fly ash, and fluidifier. Excess water was used in the slurry to avoid plugging problems because of the distance the slurry was pumped. When the hole was filled with slurry, pressure was increased to squeeze excess water into the coalbed fracture system. Examination of intercepted drainage holes showed that in some cases, water had separated from the slurry and had not been squeezed into the fracture system. In no case was cement slurry forced into the fracture system. In a subsequent study, water content of the slurry was reduced to recommended quantities. Where water flow from drainage holes before grouting was less than 0.5 gal/min (1.9 L/min), holes were satisfactorily sealed. Water flow greater than 2 gal/min (7.6 L/min) before grouting diluted the slurry and water stratified in the hole. When the hole was intercepted, gas pressure forced water and then methane from the hole. The resulting methane accumulation caused the machine-mounted methane monitor to indicate the high methane accumulation, thus deenergizing electrical power to the mining machine.

OP 77–83. Control of Methane in Gob and Bleeders by the Cross-Measure Borehole Technique, by Joseph Cervik and Roger L. King. Proc. 14th Annu. Inst. on Coal Mining Health, Safety, and Research, Blacksburg, VA, Aug. 23-25, 1983, pp. 139-148. In Europe and the United Kingdom, small-diameter drainage holes (cross-measure boreholes) are drilled into strata overlying a longwall to control methane in the gob and to prevent it from mixing with the ventilation air. These drainage holes are connected to an underground pipeline that is maintained under a partial vacuum by surface vacuum pumps. Bureau of Mines tests in the Upper Kittanning Coalbed utilizing the cross-measure borehole system demonstrated the capture of 50 pct of the total methane generated by the mining operation. The angle of the hole above horizontal, depth of penetration of the hole into the gob, and location of the pipeline and collar of the hole are important parameters affecting the performance of the cross-measure borehole technique.

OP 78–83. Reverse Performance Characteristics of Main Mine Fans, by M. F. Dunn, F. S. Kendorski, S. Bhattacharya, V. Rajaram, and E. D. Thimons. Min. Sci. & Technol., Elsevier Science Publishers B.V., Amsterdam, the Netherlands, v. 1, No. 1, October 1983, pp. 59–68. During a mine fire or other emergency, it may be desirable to reverse the airflow in order to provide an escapeway or to isolate a fire. Also, in colder areas, the airflow may be reversed to prevent ice buildup. When reversing main mine fans, the mine operator usually does not know what operating characteristics of flow and pressure to expect. Laboratory and field tests of vane axial main mine fans were conducted to establish forward and reverse performance characteristics under controlled conditions and in typical mine installations. All fans tested were between 81 and 96 in (2.1 and 2.4 m) in diameter. The data obtained suggest that reverse performance characteristics are dependent upon the blade angle and the hub-to-tip ratio. There is also evidence that reverse performance can be predicted for a family of blade angles for a given hub-to-tip ratio. Generally fan quantity is 30% to 60% less in reverse than when operating in the normal forward mode, with static pressure equal to the square of the volume percentage change.

OP 79–83. Methane Drainage Experience With Horizontal Boreholes in a Western Coalbed, by Gerald L. Finfinger, John H. Perry, and Roger L. King. Proc. Australas. Inst. Min. and Metall. Symp. on Seam Drainage With Particular Reference to the Working Seam, Wollongong, NSW, Australia, May 11–14, 1982, pp. 102–115. The Bureau of Mines in cooperation with Kaiser Steel Corp. conducted two methane drainage studies in an advancing section of the Sunnyside No. 1 Mine where production was being severely hampered by methane emissions. Six horizontal boreholes were completed during the studies to an average length of 291 m. Total gas production from the boreholes as of December 1981 has exceeded 6,088,800 m^3. Methane emissions into the section were reduced by 40 pct as a result of the first drainage system. The second drainage system is currently producing 11,328 m^3/d from four boreholes. Mining of the section is expected to begin within 2 years.

OP 80–83. Water Removal From Mine Slimes and Sludge Using Direct Current, by D. J. Kelsh and R. H. Sprute. Drying Technol., v. 1, No. 1, April 1983, pp. 57–81. Recent tests by the Bureau of Mines have demonstrated the effectiveness of electrokinetic dewatering to consolidate a variety of coal and mineral slimes. Material properties and application methods that affect performance are briefly reviewed, and some operating and proposed field installations are described. Application of the method to other slimes and sludges can best be determined through laboratory testing, but certain

physical properties can be helpful predictors of responsiveness.

OP 81–83. Methane Drainage: Development of a Large-Scale Field Demonstration Using Vertical Boreholes, by Roger D. King and Michael A. Trevits. Proc. Australas. Inst. and Metall. Symp. on Seam Drainage With Particular Reference to the Working Seam, Wollongong, NSW, Australia, May 11–14, 1982, pp. 81–88. The United States Steel Corp. in cooperation with the U.S. Government is conducting a large-scale methane drainage field demonstration using stimulated vertical boreholes drilled in advance of mining. A grid pattern of 23 boreholes, isolating approximately 1.5 km^2 of coalbed area, was drilled to the lower bench of the Mary Lee Coalbed, Jefferson County, AL. Upon completion of drilling operations, various hydraulic stimulation treatments utilizing nitrogen-generated foam, water, and gelled fluid were performed to enhance the rate of methane gas removal. Production from the grid pattern began in September 1977 and continued as the last borehole was placed on production during October 1980. To date, in excess of 33,800,000 m^3 of methane gas has been drained as a result of this effort. Underground mining operations were approximately 3.2 km from the grid pattern when production began and have currently progressed to within 1.6 km. Underground interception of the grid is expected in 1986.

OP 82–83. Computer-Implemented Coalbed Methane Data Base, by John C. LaScola, David M. Hyman, and William P. Diamond. Ch. 29 in Proc. 1st SME-AIME Conf. on Use of Computers in the Coal Industry, Morgantown, WV, Aug. 1–3, 1983, pp. 251–257. The U.S. Department of the Interior, Bureau of Mines, has established a computer-implemented coalbed methane data base containing data representing over 2,000 coal samples from approximately 250 coalbeds located in 17 States and 1 Canadian Province. Space for approximately 130 sample characteristics is reserved for each sample record and is divided for access efficiency into three separate physical files. A software package was written to provide a user-friendly environment in which the three files can be manipulated simultaneously. These files can be used interactively in DATATRIEVE 11, a commercially available sorting, retrieval, and report-writing software package, or in any FORTRAN-compatible system for statistical analysis. The data base was established for coalbed methane research in response to the health and safety needs of the mining industry. Possible applications of the data base include mine planning related to the occurrence of gas, as well as delineating areas of resource recovery and utilization.

OP 83–83. Program Computes Radius-of-Curvature Coordinates for Straight, Deviated Holes, by David C. Oyler. Oil & Gas J., v. 81, No. 43, Oct. 24, 1983, pp. 100–108. The Bureau of Mines, U.S. Department of the Interior, has developed a program for the Hewlett-Packard HP-41C(V) that determines the change of position of a drill hole between two survey stations, using the radius-of-curvature calculation method. Values required to perform a single calculation are the bearings, inclinations, and measured depth at each station. The program automatically stores the most recent values of bearing, inclination, and measured depth for use in the next survey and automatically updates a set of hole position coordinate values. The program also asks for magnetic declination and project angle values upon initialization so that bearings obtained from magnetic compass data can be automatically corrected for declination and so that a cross section of the hole can be plotted. The program is friendly to the user, prompting for all required data entry and echoing the entered data and all output data with labels. It is also designed to allow correction of data entry mistakes and erasure of surveys calculated from errant data.

OP 84–83. Coal Cutting Research Slashes Dust, by Wallace W. Roepke. Coal Min. Process., v. 20, No. 2, October 1983, pp. 38–44. The Coal-Cutting Technology Group at the Bureau of Mines Twin Cities (MN) Research Center is investigating ways to reduce primary dust generated by coal cutting. The progression of research within the program is from fundamental laboratory research, to fundamental field research, to field concept verification. Then the Bureau recommends warranted changes and/or prototype development to industry. Currently the group has several projects in each phase of research. The Bureau's current fundamental studies of bit characteristics are directed toward determining the effects of conical bit wear on primary respirable dust generation, energy, and cutting forces; establishing best conical bit mount condition to increase life by enhancing bit rotation; and comparing chisel-type cutters to conical-type cutters. Additionally, to establish a suitable homogeneous reference material for cutting experiments, a synthetic coal with a plaster base is being developed.

OP 85–83. Comparison of Magnetic Properties of Natural Mischmetal and Synthetic Mischmetal Alloyed With Cobalt, Copper, and Magnesium, by J. W. Walkiewicz, E. Morrice, and M. M. Wong. Pres. at 21st Intermag Conf., Philadelphia, PA, Apr. 5–8, 1983; pub. in IEEE Trans. on Magnetics, v. MAG-19, No. 5, September 1983, pp. 2053–2055. One of the objectives of the Bureau of Mines is to develop substitutes for scarce materials. Alloys containing mischmetal, lanthanum, praseodymium, neodymium, cobalt, copper, and magnesium were evaluated for use in permanent magnets in lieu of Sm-Co alloys. Magnets were fabricated by powder metallurgy techniques that consisted of arc melting the metals, crushing and grinding the resultant alloy, aligning and compacting the powder, and sintering the green compacts. A cerium-free synthetic mischmetal consisting of La-Pr-Nd was developed that had substantially better magnetic properties than natural mischmetal when alloyed with cobalt, copper, and magnesium.

OP 86–83. Synthetic Construction Aggregate Developed From Phosphate Fertilizer Waste, by Alexander May, John W. Sweeney, and James R. Cobble. Pres. at SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, Oct. 19–21, 1983, SME preprint 83–300, 15 pp. In its role of providing technology to promote the efficient use of minerals and mineral process waste, the U.S. Bureau of Mines conducted research at its Tuscaloosa (AL) Research Center to identify and develop high-volume uses for phosphogypsum. Mixtures containing a maximum of 5 pct phosphogypsum, 6 to 10 pct lime, and the remainder fly ash had compressive strengths as high as 4,800 psi. The effects of the amounts of phosphogypsum, lime, and fly ash were investigated. Also, the effects of fly ash to lime ratios were studied.

OP 87–83. Compact Unit Collects Mine and Mill Dust, by Jon Sandstedt and Steven Page. Min. Equip. Int., v. 7, No. 10, pp. 40, 41–44. Wet collectors and water spray systems usually provide adequate dust control for underground and surface

applications at low cost. However, there are applications where water usage cannot be tolerated because of availability, disposal, or material handling problems. In trona mines, for example, water mixes with trona dust to form a cement-like material that is difficult to remove. This report describes a dry dust collector, developed under a Bureau of Mines contract, that has the dry fabric filtration advantages of (1) high efficiency, (2) easy material handling, and (3) all temperature operation, while minimizing the usual disadvantages of frequent maintenance and large size.

OP 88–83. Effect of Microorganisms on In Situ Uranium Mining, by Marylynn V. Yates, James A. Brierley, Corale L. Brierley, and Steven Follin. Appl. Environ. Microbiol., v. 46, No. 4, October 1983, pp. 779–784. The extraction of some metal values, e.g., uranium or copper, may be accomplished by using solutions to remove metals from ore bodies without practicing conventional mining. This process is referred to as in situ leaching and has been used industrially to recover uranium. The growth of microbial populations during in situ leaching is believed to be one of the causes of flow path plugging in the ore body, which results in decreased uranium production. Leach solution and solid samples from well casings and submersible pumps were collected from an in situ mining operation experiencing plugging problems. *Bacillus* sp., *Micrococcus* sp., pseudomonads, and xanthomonads were isolated from these samples on concentrations of 10^5 colony-forming units per milliliter. A mixed culture of these organisms was inoculated into a uranium core specimen in the laboratory to assess the role of microbes in the plugging problem. A one-third decrease in permeability was effected in 16 days. Hydrogen peroxide killed the microorganisms in the core and alleviated the plugging problems. Periodically injecting hydrogen peroxide into the ore body through the production wells may reduce microbial plugging problems.

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OP 1–84. The Present State of Dust Control in United States Coal Mines, by John A. Breslin. Conf. on Health in Mines, Luxembourg, May 30–31, 1983. Comm. Eur. Communities Rep. 2359, 1983, pp. 13–17. This paper presents the current status of respirable dust control in coal mines in the United States. Federal regulations, average dust concentrations in the mines, current control problems, and dust control research of the Bureau of Mines are discussed.

OP 2–84. Recovery of Platinum-Group Metals and Gold From Electronic Scrap, by H. E. Hilliard and B. W. Dunning, Jr. Paper in The Platinum Group Metals—An In Depth View of the Industry (1983 Int. Precious Met. Seminar, Williamsburg, VA, Apr. 10–13, 1983). Int. Precious Met. Inst., 1983, pp. 129–142. The Bureau of Mines, in cooperation with the National Association of Recycling Industries (NARI) and the Defense Property Disposal Service, studied recycling problems associated with recovering precious metals from electronic scrap. Specific problems encountered by NARI members included the recovery of platinum-group metals (PGM) from electronic reed switches and telephone relays. The Bureau investigated hydrometallurgical techniques as possible alternatives to pyrometallurgical processes for recovering PGM. In addition, both scrap sources (switches and relays) required some mechanical upgrading to produce fine-particle concentrates ideally suited to hydrometallurgical processing.

OP 3–84. A Low-Cost, Low-Maintenance Treatment System for Acid Mine Drainage Using Sphagnum Moss and Limestone, by Robert L. P. Kleinmann, Thomas O. Tiernan, Joseph G. Solch, and Richard L. Harris. Proc. 1983. Symp. on Surface Mining, Hydrology, Sedimentology and Reclamation, Lexington, KY, Nov. 27-Dec. 2, 1983, pp. 241–245. Acid seeps that continue after reclamation obligate mine operators to long-term water treatment. To provide a low-cost, low-maintenance alternative, the Bureau of Mines investigated the feasibility of establishing a sphagnum moss bog as a self-perpetuating treatment system. The moss removes iron by cation exchange, oxidation of Fe^{2+}, and precipitation of iron hydroxides and sulfides. Acidity is then neutralized with limestone that, because of the iron removal step, does not become armored.

OP 4–84. Analysis of Recent Mine Blasting Accidents, by Dennis V. D'Andrea and Larry R. Fletcher. Paper in Proceedings of the Ninth Conference on Explosives and Blasting Technique (Annu. Meeting, Dallas, TX, Jan. 31-Feb. 4, 1983). Soc. Explos. Eng., v. 9, 1983, pp. 105–122. To determine the most frequent causes of accidents in mine blasting, the Bureau of Mines analyzed blasting accident data obtained from the Mine Safety and Health Administration, U.S. Department of Labor. Accident totals from 1971 through 1981 are tabulated for metal-nonmetal and coal mines both surface and underground. In the past 11 yr (1971–81 inclusive) there has been an annual average of 9 fatal and 121 nonfatal blasting accident victims. Underground mining averaged 6 fatal and 93 nonfatal injuries each year. Abstracts from 369 accidents that occurred from 1978 through 1981 were examined to determine accident causes. Most accidents occurred during scheduled blasting, and failure of the blast area security system was the leading cause. Blast area security problems were failure to clear the blast zone, failure of personnel to follow instructions, inadequate guarding, and failure to retreat to a safe location or take adequate cover. Other common causes include premature blasts, excessive flyrock, fumes, and misfires. The blaster was the miner most frequently injured in these accidents. Examples of typical blasting accidents are presented.

OP 5–84. A Study of Misfires in Mining, by Larry R. Fletcher and Dennis V. D'Andrea. Paper in Proceedings of the Ninth Conference on Explosives and Blasting Technique (Annu. Meeting, Dallas, TX, Jan. 31-Feb. 4, 1983). Soc. Explos. Eng., v. 9, 1983, pp. 123–132. A misfire results when explosives fail to detonate as planned during a mine blast. Accidental detonation of misfires is a frequent cause of personal injury, equipment damage, and lost production. In an effort to minimize these problems, the Bureau of Mines investigated the causes of misfires, methods for detecting misfires, and procedures for

their disposal. During this investigation, input was obtained from explosives suppliers, mining companies, blasting contractors, blasting consultants, and governmental agencies. Additional data were obtained through detailed analyses of blasting accidents involving misfires. The greatest number of misfire accidents are caused by drilling into bootlegs in underground metal and nonmetal mines. Improper disposing of misfires is the second most frequent accident category, and some accidents are due to impact initiation of explosives in the muck. Misfires are usually caused by misunderstanding, improper use, or some failure of the initiation system. Other causes are cutoffs, insufficient firing current, inadequate priming, improper explosive storage, and damage to the initiation system. Visual inspection is still the only available method for detecting misfires. Disposal of misfires in underground mines is generally by refiring; at surface mines, they are usually dug out during the mucking operation. Extreme care must be exercised when digging out misfires.

OP 6–84. Mining, by Barry W. Klein, Phillip N. Yasnowsky, and Annette Graham. Ch. 16 in U.S. Industrial Outlook 1984, Dep. Commerce, 24th ed., Jan. 1984, pp. 16-1—16-6. The mineral industry was expected to have begun its recovery by yearend 1983, and mining production is expected to show a moderate gain in 1984. This predicted increase is a result of the strong economy anticipated for 1984. The industries this chapter covers are mine ores of such metals as copper, iron, gold, silver, and zinc (SIC 10) and nonmetallic minerals such as stone, sand and gravel, clays, phosphate rock, salt, sulfur, and potash, but excluding fuels (SIC 14).

OP 7–84. Electrochemical Flotation of Sulfides: Chalcocite-Ethylxanthate Interactions, by P. E. Richardson, J. V. Stout III, C. L. Proctor, and G. W. Walker. Int. J. Miner. Process., Elsevier Science Publishers B.V., Amsterdam, the Netherlands, v. 12, 1984, pp. 73–93. This paper discusses part of a U.S. Bureau of Mines research effort to use electrochemical techniques to control sulfide flotation with the aim of developing new methods to process low-grade, complex domestic ores. The interactions between chalcocite and ethylxanthate (EtX^-) have been studied in an electrochemical-microflotation cell containing a packed bed of the mineral as a working electrode. Spectrophotometric and electrochemical techniques have shown that in the potential range −0.7 to 0 V (SCE) at a pH of 9.2 there are at least four distinct reactions: (1) a reaction of EtX^- to form ethylperxanthate at reducing potentials near −0.5 V; (2) a reaction of EtX^- with soluble Cu(II) at the open circuit potential (—0.028 V); (3) an exchange reaction whereby EtX^- displaces an oxidation product; and (4) a charge transfer oxidation reaction. The exchange and charge transfer oxidation reactions occur over the same potential range (−0.5 to −0.1 V) and are both believed to produce cuprous xanthate and possibly cupric xanthate as an adsorbed hydrophobic species. Xanthate adsorbed as − 0.1 V can be desorbed as the ethylxanthate ion at more negative potentials. The flotation response of chalcocite is also shown to parallel closely the adsorption of EtX^- by reactions 3 and 4 and the reduction of the adsorbed product during cathodic decreases in potential.

OP 8–84. Rapid Identification and Sorting of Scrap Metals, by W. D. Riley, R. E. Brown, and D. M. Soboroff. Pres. at 4th Recycling World Congr., New Orleans, LA, Apr. 6–9, 1982; pub. in Conserv. Recycling, v. 6, No. 4, 1983, pp. 181–192. The Bureau of Mines, U.S. Department of the Interior, is conducting research on methods for the rapid identification and sorting of mixed metal scrap so that domestic scrap resources can be utilized more fully. Initial studies include a technical assessment of available identification methods and of their current or potential use for various scrap sorting problems. Methods investigated were thermoelectric, spectroscopic, and X-ray measurements. A survey of these techniques is presented, with data showing applications to specific scrap identification systems.

OP 9–84. Measuring In-Seam Coal Cutting Forces, by Wallace W. Roepke and James C. Church. Min. Eng., v. 35, No. 9, Sept. 1983, pp. 1281–1286. The U.S. Bureau of Mines developed a portable in-seam tester for direct in situ measurement of coal cutting forces. Since manufacturers and operators currently have no method available for evaluating the cutting characteristics of a coal seam in situ, the device is expected to provide the additional engineering data needed to optimize the equipment-seam match. It may also help develop the next generation of mining machines.

OP 10–84. Reducing Dust Through Deep Cutting, by Robert L. Schmidt. World Min. Equip., v. 7, No. 12, Dec. 1983, pp. 17–18. This paper briefly reviews the history of research on machine parameters for dust reduction in the United Kingdom and the United States over the past 25 years. The most significant variables were found to be cut depth and bit speed. Recent, full-scale research shows dust reduction over 60 pct on drum miners and longwall shearers through parameter control.

OP 11–84. Electrochemical Flotation of Sulfides: Reactions of Chalcocite in Aqueous Solution, by G. W. Walker, J. V. Stout III, and P. E. Richardson. Pres. at 56th Colloid and Surface Symp., Blacksburg, VA, June 13–16, 1982; pub. in Int. J. Miner. Process., Elsevier Science Publishers B.V., Amsterdam, the Netherlands, v. 12, 1984, pp. 55–72. This paper discusses the first phase of a U.S. Bureau of Mines study to use electrochemical techniques to control sulfide flotation with the aim of developing new methods to recover minerals from progressively lower grade, more complex ores. It has been established that (1) under slow potentiodynamic sweeps or potentiostatic conditions, the current-voltage characteristics of chalcocite bed electrodes are essentially the same as those of single electrodes; (2) reactions in the chalcocite-0.5M borate system can be studied quantitatively using a combination of spectrophotometric and electrochemical techniques; and (3) the reactions can be correlated with the collectorless flotation response. A microflotation-electrochemical cell, utilizing a packed bed of conducting sulfide mineral particles as the working electrode, was used to obtain correlations between the electrochemical reactions occurring on the bed and flotation response. Continuous analysis of the electrolyte by fast-scan ultraviolet spectrometry was used to monitor solution chemistry.

OP 12–84. Research by the Bureau of Mines on Underground Support Systems, by D. D. Bolstad. Paper in CNCRM Symp. on Underground Support Systems, Sudbury, Ontario, Canada, Sept. 19-21, 1983, 12 pp. The U.S. Department of the Interior's Bu-

reau of Mines performs research in mining health and safety and productivity as one of its primary functions. Ground support research in these areas ranges from defining geomechanical phenomena to evaluating prototype support systems. This paper provides a limited review of current programs.

OP 13–84. Aluminum Chloride Leaching of Calcined Kaolin Clay, by P. R. Bremner, L. J. Nicks, and D. J. Bauer. Pres. at Metall. Soc. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26-Mar. 1, 1984. TMS Paper Selection A84–47, 1984, 11 pp. As part of a program to devise alternative technologies for producing alumina from domestic resources, the Bureau of Mines investigated the leaching of calcined kaolin clay to form basic aluminum chloride solutions. Bench-scale experiments were conducted for single-stage batch leaching with $AlCl_3$ solution and three-stage countercurrent leaching with substoichiometric HCl. Variable conditions of clay calcination and leaching were studied to determine their effects on aluminum extraction and pregnant liquor composition.

OP 14–84. Mercury. Oversupply Weakens Price, by Linda C. Carrico and James B. Hedrick. Eng. and Min. J., v. 185, No. 3, Mar. 1984, pp. 100–101. World mine production was essentially the same in 1983 as in 1982. U.S. mine production and secondary industrial production satisfied about 78% of total U.S. demand. Spain continued to be the leading supplier of foreign mercury to the United States. Mercury prices declined on a world basis in 1983 in response to an oversupply of material.

OP 15–84. How Gassy Noncoal Mines Can Simulate Methane Flow, by A. B. Cecala, R. H. Grau, and E. D. Thimons. Eng. and Min. J., v. 185, No. 2, Feb. 1984, pp. 51–53. The Bureau of Mines has successfully tested a method to simulate methane gas flows from face areas through the returns of noncoal mines. This technique involves releasing a small quantity of tracer gas at a working area and sampling for that gas downstream in the return airways. By measuring the reduction in the tracer gas concentration, a reduction for any face released volume of methane gas can be calculated. This information is useful in selecting locations for methane monitors and in deciding the necessity for permissible equipment in the returns.

OP 16–84. Recovery of Gold and Silver From Ores by Hydrometallurgical Processing, by J. A. Eisele, A. F. Colombo, and G. E. McClelland. Paper in Precious Metals: Mining, Extraction, and Processing, ed. by V. Kydryk, D. A. Corrigan, and W. W. Liang (Proc. AIME-IPMI Int. Symp. on Precious Metals, Los Angeles, CA, Feb. 27–29, 1984). Metall. Soc. AIME, 1984, pp. 387–395. The Bureau of Mines has played an important role in the revival of precious-metal mining underway in the Western United States. During the past 30 yr, many techniques used by industry to recover gold and silver were pioneered and developed by the Bureau. In 1952, technology was developed to strip gold from granular activated carbon and allow the carbon to be reused. In 1969, the heap-leaching concept was applied to low-grade gold and silver ores and mine wastes. Heap leaching in conjunction with carbon adsorption-desorption permits very low value material to be economically processed. In 1970, an oxidation treatment based on hypochlorite was developed to increase the recovery of gold from carbonaceous gold ores by cyanidation. In the early 1950's, attempts were made to employ carbon-in-pulp technology to recover gold from ores, but the fixed price of gold and increasing operational costs made the process unprofitable. The Bureau and Homestake Mining Co. jointly operated a carbon-in-pulp pilot plant, and the technology was used in full-scale production at the Homestake Mine in 1972. In 1973, a pressure-stripping method, which decreased the time needed for the stripping step, was developed to desorb gold and silver from carbon. An alcohol desorption method, developed in 1976, also decreased the carbon stripping time. These stripping methods are in commercial use. In 1979, an agglomeration pretreatment was developed that permitted clayey precious-metal ores to be heap-leached. Agglomeration-heap-leaching technology is being used by at least 30 operations, several of them major gold and silver mines. Almost all precious-metal-mining companies use at least one of the above techniques in production facilities.

OP 17–84. Perspective on Chromium From the U.S. Bureau of Mines, by Ralph C. Kirby and John F. Papp. Chromium Rev., v. 1, No. 1, Apr. 1983, pp. 6–7. The importance of chromium is demonstrated by its inclusion in the Strategic Materials Stockpile maintained by the Federal Government for the protection of national security. The stockpile contains about a 3-yr supply of chromium-containing materials at current consumption rates and is to be used to fill national security needs in the event of a supply shortage. The Bureau of Mines, among others, is researching ways that might allow the United States to become less dependent upon chromium. The research is aimed at the development of processes that would permit the use of low-grade domestic ore, the recycling of chromium-containing materials, the production of more chromium-efficient materials, and the identification of alternatives to chromium-containing materials.

OP 18–84. Recycling and Metal Recovery Technology for Stainless Steel Pickling Liquors, by J. B. Stephenson, J. C. Hogan, and R. S. Kaplan. Pres. at AIChE Meeting, Denver, CO, Aug. 28–31, 1983; pub. in Environ. Prog., v. 3, No. 1, Feb. 1984, pp. 50–53. Most stainless steels require a final treatment in nitric and/or hydrofluoric acid pickling baths for the removal of oxide scales formed during processing to final gauge and shape. These pickling baths become ineffective as their metal content increases. The baths appear to be particularly sensitive to the concentration of iron. Conventional operating procedures call for the replacement and disposal of the spent acids. The high cost of waste acid disposal and the loss of the valuable nickel and chromium they contain are important considerations. This review covers recovery and recycling processes for spent nitric and hydrofluoric acid pickle liquors generated during the production of stainless steels.

OP 19–84. Applications for Turbomachinery in the Deep Mining Industry, by Robert Torbin and Edward Thimons. Turbomachinery Int., v. 24, No. 9, Nov.–Dec. 1983, pp. 23–26. As mines descend to greater depths in search of minerals, higher temperatures and humidities are encountered associated with the heat released from off the surrounding rock. These conditions make a comfortable working environment difficult and expensive to maintain. To overcome this condition, large quantities of water must be carried down long vertical pipelines to be used for refrigeration and personnel cooling. The cost associated with providing this cooling is rising, and creates financial hardships on the mining opera-

tion, especially in times of unstable mineral prices. To help deal with this problem, the U.S. Bureau of Mines has awarded a contract to Foster-Miller, Inc., of Waltham, MA, to investigate and evaluate commercially available means of energy recovery for the deep mining industry.

OP 20–84. A Multistep Shear Test for Bond Strength of Claddings, by Robert Blickensderfer and J. Michael Burrus. J. Test. and Eval., v. 12, No. 1, Jan. 1984, pp. 3–12. A test for determining the bonding shear strength of a clad metal and the fixture for performing the test are described. The test specimen, which is relatively easy to machine, has approximately nine shear steps ranging in depth from shallower than the cladding to deeper than the cladding. Thus, at least one of the shear lips gives the shear strength very near the interface between the cladding and the base metal. Test results on a variety of bimetals are presented. Results are compared with ASTM Specification for Corrosion-Resisting Chromium Steel Clad Plate, Sheet, and Strip (A 264) criteria. This work was conducted by the Bureau of Mines, U.S. Department of the Interior, as a part of its effort to develop vacuum-rolled claddings to conserve strategic materials.

OP 21–84. Recovery of Cobalt and Nickel From Lead Smelter Matte, by Robert M. Doerr, R. B. Prater, Jr., and E. R. Cole. Pres. at Metall. Soc. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 1, 1984. Metall. Soc. AIME paper selection A84–59, 1984, 19 pp. Research to find basic technology for Co and Ni recovery is part of an overall effort by the Bureau of Mines to help reduce import vulnerability by enhancing the Nation's ability to produce critical and strategic minerals from domestic resources. The Missouri lead ores mined annually contain sufficient Co to provide about 25 pct of current national demand, if all of it could be recovered. About 5 pct of that Co reports to the Pb-smelter mattes, along with quantities of As, Ni, Pb, Ag, and Cu. Not only is this a loss of Co, but it makes the matte unsuitable for environmentally acceptable Cu recovery techniques. This paper describes the basis for selective oxidative (MnO_2-H_2SO_4) leaching of the matte, followed by selective recovery of salable or usable products of Cu, Co, Ni, and Mn from the resulting leach liquor.

OP 22–84. Preparation of Tungsten Carbide by Gas Sparging Tungstate Melts, by J. M. Gomes, A. E. Raddatz, and T. G. Carnahan. Pres. at Metall. Soc. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 1, 1984. Metall. Soc. AIME paper selection A84–48, 1984, 12 pp. The Bureau of Mines is investigating a novel method for the separation of tungsten carbide from concentrates. The method eliminates several steps in the conventional method. Wolframite or scheelite is decomposed in a two-phase chloride-silicate melt. Tungsten is concentrated in the chloride phase as sodium tungstate, and the iron, manganese, or calcium oxides are retained in the silicate phase. After separating the phases, the molten chloride-tungstate phase is sparged with hydrocarbon gas and yields tungsten monocarbide. The paper discusses bench-scale research that delineates operating variables.

OP 23–84. Continuous Miner Dust Collector Proves Worth at Eastover, by G. J. Hundman, P. Disney, and E. F. Divers. Coal Min. and Process., v. 20, No. 2, Feb. 1983, pp. 46–48. An improved dust collector system, mounted in a continuous miner boom, has improved face ventilation and dust removal from both blowing and exhaust face ventilation air. The scrubber system is designed for low coal seams, compatibility with a 10-ft line curtain, high reliability, and low maintenance. It consists of two (twin) scrubbers, each mounted in the forward inby end of the boom. The twin-scrubber system delivers a total of 5,000 cfm, with one scrubber mounted on each side of the continuous miner's auger support frame. Each scrubber consists of a 2,500-cfm centrifugal fan, direct-driven at 4,000 rpm by a hydraulic motor; a flooded stainless steel wire mesh scrubber panel, 14- by 16- by ¼-in thick; water sprays (two on each scrubber at 2.5 gpm at 150 psig); a water-droplet eliminator; and associated ductwork. Air intakes are located within 6 ft of the coal face and are designed to reduce clogging during the mining cycle. All components except the exhaust duct are fabricated from heavy-gauge steel.

OP 24–84. Control and Distribution of Face Air by Water Sprays on Mining Machines, by F. N. Kissell and T. Muldoon. Proc. Australas. Inst. Min. and Metall.-Illawarra Branch Symp. on Ventilation of Coal Mines, Wollongong, NSW, Australia, May 10–13, 1983, pp. 18–1—18–10. It has been recognized for some time that a water spray in a tube can act to move air through that tube. However, it is a more recent notion that a series of spray nozzles arranged in a logical fashion can be used to modify the airflow pattern on a mining machine to achieve a desired ventilation effect. The first development in this regard, the spray fan, was successful in quickly controlling airflow. This success led to other applications. The intent of this paper is to provide an update on those items that are familiar and to discuss, in some detail, the results that have recently been obtained.

OP 25–84. How U.S. Longwalls are Achieving the 2.0 mg Standard—Past Trends and Future Technology, by Fred Kissell, Robert Nesbit, and Jonathan Kelly. Proc. Symp. on Dust Suppression in Mines, Luxembourg, May 30–31, 1983. Comm. Eur. Communities Doc. No. 2363/83, May 1983, pp. 75–87. In July-August 1982, the average respirable dust "designated occupation" sample from U.S. double-drum shearer longwall faces was 1.7 mg/m^3, and the trend has been more faces coming into compliance with the 2.0-mg/m^3 standard. A key reason for lower measured dust levels in U.S. mines is occupational sampling, and this has also permitted both researchers and mine operators to test and utilize a wider variety of approaches in lowering the dust breathed by mine workers. An important element of the Bureau's research program is to forecast prospective reductions in dust levels due to the various "dust avoidance" techniques permitted by occupational sampling. Reductions in dust have been forecasted for the following specific items, both alone and in reasonable combination: (1) unidirectional cutting, (2) homotropal ventilation, (3) use of one drum only for a portion of the mining cycle, (4) shearer equipped with asymmetrical drums or proportioned waterflow to drums, and (5) shearer remote control by radio or umbilical cord.

OP 26–84. Longwall Lighting, by W. H. Lewis, J. Peay, J. C. Yingling, and George R. Bockosh. J. Mine Vent. Soc. S. Afr., v. 37, No. 1, Jan. 1984, pp. 1–8. The introduction of lighting systems into underground coal mines in the United States has been a controversial issue. Longwall lighting, however, has received widespread management and

miner acceptance with tangible benefits being realized in both safety and production. Based on the experience that longwall operators have had with their lighting systems, the following general conclusions seem appropriate: (1) A wide selection of lighting equipment and suppliers exists. (2) Intrinsically safe fluorescent systems are more widely used. (3) The majority of operators reported that maintenance requirements are low or moderate with only a few experiencing major maintenance problems. (4) The biggest maintenance problem has been damage to the system power cables. This paper describes the present state of the art and status of longwall lighting in the United States. Specific subtopics discussed are as follows: review of MSHA lighting regulations and requirements for longwalls, overview of available lighting hardware, installation procedures and costs, and analysis of installations to date.

OP 27–84. Corrosion Properties of Amorphous Iron-Zirconium Films in 1*N* Sulfuric Acid, by L. D. McCormick, N. S. Wheeler, C. R. Molock, and C. L. Chien. J. Electrochem. Soc., v. 131, No. 3, Mar. 1984, pp. 530–534. Amorphous iron-zirconium alloys, ranging in composition from $Fe_{90}Zr_{10}$ to $Fe_{33}Zr_{67}$, have been studied by anodic polarization and passivation decay in 1*N* sulfuric acid. The results showed a compositional enhancement of corrosion resistance with increasing zirconium concentration. Auger electron spectroscopy indicated that exposure to the sulfuric acid solution enhances the surface zirconium concentration with respect to the bulk of the exposed alloy and also with respect to the as-deposited surface composition. X-ray photoemission spectroscopy shows that the passive film is a mixture of zirconium oxides and hydroxides and iron oxides and hydroxides.

OP 28–84. Continuous Ferric Chloride Leaching of Galena, by J. E. Murphy, B. R. Eichbaum, and J. A. Eisele. Pres. at Soc. Min. Eng.-AIME Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 1, 1984. Soc. Min. Eng. AIME preprint 84–124, 1984, 5 pp. The Bureau of Mines demonstrated ferric chloride leaching of galena concentrate on a continuous bench-scale basis. Leaching was performed at 95° C and with a contact time of 15 min. The ferric chloride leaching solution was continuously fed to a leaching tank at a constant rate for periods up to 45 h. In each test a constant redox potential was maintained in the slurry exiting the leaching tank by controlling the concentrate feed rate. In the 45-h test, lead extraction exceeded 99.5 pct, and the lead chloride produced was 99.97 pct pure.

OP 29–84. Ten Ways To Reduce Longwall Dust, by George E. Niewiadomski, Robert A. Jankowski, and Fred N. Kissell. Min. Cong. J., v. 8, No. 8, Aug. 1982, pp. 10–14. The need to improve productivity and to meet the growing demand for coal has prompted the coal industry to shift to greater utilization of longwall mining. Although longwall mining offers many advantages, there is a severe problem in the control of respirable dust and in the ability to comply with the 2-mg/m^3 Federal dust standard. The Bureau of Mines has been aggressively seeking solutions to the problem for several years and has successfully demonstrated cost-effective engineering controls that are available for immediate application. In cooperation with MSHA and the mining industry, the Bureau continues to assist the industry in implementing currently available techniques to reduce the dust exposure of all longwall face workers. Although substantial progress has been achieved, because of the complex and interactive factors involved, not all of these improved techniques are applicable on every longwall installation. Physical characteristics on each panel directly impact the dust control requirements to be implemented. In addition, many new procedures have been developed but not evaluated under the diverse conditions encountered throughout the industry. In response, the Bureau has undertaken a major joint effort with industry to identify and document technology that may eliminate the longwall dust problem. This will be accomplished through the most extensive systematic in-mine evaluation of the effectiveness of available and promising longwall dust control techniques ever attempted.

OP 30–84. Tafel Constants and Changes in Hydrogen Coverage During Corrosion of Fe18Cr, by Murray Rosen and Jonathan G. Harris. J. Electrochem. Soc., v. 130, No. 12, Dec. 1983, pp. 2329–2334. Cathodic tafel constants associated with the hydrogen reaction at Fe18Cr in H_2-saturated 1*N*H_2SO_4 were determined by computer analysis of the potential decay following current interruption at fixed starting potentials positive to the corrosion potential. The values of $b = -2.3\ RT/\alpha F$ were evaluated from the general current-interruptive equation, $E = E_i + b \log [1 + t/\tau]$, from its linear log form, and from a modification of the general equation that was derived to analyze multiple tafel regions. For starting potentials of 0, —0.05, —0.075, and —0.2V (RHE), the number of tafel regions was 3, 3, 2, and 1, respectively. The amount of hydrogen associated with the electrode at the fixed potentials and during decay was determined from anodic charging pulses. Results indicated that the bonding strength between metal sites and hydrogen varies with decay and starting potential. The first tafel region from 0, —0.05, and —0.075V was under combination control, $2H \rightarrow H_2$. The decay from —0.2V was controlled by the electrochemical-desorption step, $H^+ + e + H \rightarrow H_2$.

OP 31–84. Face Ventilation Analysis by Probability Plotting of Transformed Methane Concentration Data, by W. E. Schroeder and Fred N. Kissell. J. Mine Vent. Soc. S. Afr., v. 36, No. 11, Nov. 1983, pp. 109–117, and No. 12, Dec. 1983, pp. 126–130. Analysis of environmental data is never straightforward, and methane emission data from underground coal mines are no exception. In the United States, considerable effort has been expended by the U.S. Department of the Interior, Bureau of Mines, to develop ventilation devices that dilute methane at coal mine working faces. Careful analysis is required to measure the effectiveness of those devices. The most prevalent underground coal mining method in the United States is by continuous mining machine. Research showed that methane emissions during operation of this machine occur as a series of peaks and that concentration peak values will fit a normal or log-normal distribution. It appeared that normal distributions were obtained when the emitted methane was vigorously mixed into the incoming fresh air stream and log-normal distributions were obtained when mixing was less vigorous. The purpose of this paper is to explore that finding in greater detail, as well as to assess the benefits gained by transforming concentration data; that is, correcting measured raw values for the effects of variables that could not be controlled during testing.

OP 32–84. Parachute-Type Stoppings—USBM Develops Different Designs for Day-to-Day and Emergency Ventilation Control, by Edward D. Thimons and Fred N. Kissell. Eng. and Min. J., Feb. 1979, pp. 91–94. A parachute-type stopping intended for changing the course of mine ventilation air during mine emergencies has been designed and tested. Some production uses are also visualized for metal mines. Preliminary tests in the laboratory and underground indicate that the parachute stopping is a workable concept, but further developmental research is required.

OP 33–84. USBM Develops Damage-Resistant Brattice, by Edward D. Thimons and Fred N. Kissell. Eng. and Min. J., Sept. 1978, pp. 204–208. The Bureau of Mines has developed a damage-resistant brattice, intended for use as a stopping in locations where blast damage to stoppings is a problem, the roof is relatively flat, and the differential pressure across the stopping is not high. Damage-resistant brattices consist of a series of vertically hung brattice panels joined to each other by Velcro connections that improve the airtightness of the brattice. When the brattice is subjected to strong blast forces, the Velcro connections peel apart, allowing the panels to open without incurring damage. The Velcro connections can then be resealed in a matter of minutes. A preliminary test in the Bureau's Safety Research Mine and subsequent long-term testing at the White Pine copper mine in Michigan and the Retsof salt mine in New York show that damage-resistant brattices withstand blasting better than conventional stoppings, while still performing as efficient air barriers when the Velcro connections are sealed.

OP 34–84. Using Sulphur Hexafluoride Tracer Gas for Mine Ventilation Analysis, by E. D. Thimons and F. N. Kissell. Paper in Proc. Int. Mine Ventilation Cong., Johannesburg, Republic of South Africa, Sept. 15–19, 1975. J. Mine Vent. Soc. S. Afr., Marshalltown, Repub. S. Afr., 1975, pp. 97–102. Mine ventilation systems are generally very complex, and many aspects of a mine ventilation network can be studied by conventional anemometer and smoke-cloud techniques. However, problems such as recirculation of return into intake air, leakage from adjacent mines, lost intake air, and unknown transit flow times through stoped areas call for new ways of analyzing airflow underground. Use of sulfur hexafluoride as a tracer gas can be an effective means of analyzing these ventilation problems. The Bureau of Mines is concerned with finding solutions to these problems in conjunction with its ventilation programs. Studies have been conducted by the Bureau in several mines in order to show the value of the sulfur hexafluoride tracer gas.

OP 35–84. Current Status of R&D on Alumina From Domestic Nonbauxitic Resources, by James A. Barclay. Ch. 9 in Proceedings of the 1984 Bauxite Symposium (Los Angeles, CA, Feb. 26-Mar. 1, 1984, ed. by L. Jacob, Jr.) Soc. Min. Eng. AIME, New York, Mar. 1984, pp. 165-199. Results of investigations over approximately 10 yr by the Bureau of Mines and others on technology for recovering cell-grade alumina from domestic nonbauxitic resources such as clay, anorthosite, alunite, dawsonitic oil shale, coal ash, and coal shale are reviewed. It is concluded that, although many innovative techniques have evolved from this effort and have been shown to be technically feasible, energy and economic considerations will prevent any of the processes from competing with the Bayer process under normal conditions. Based on the Bureau's experience, some variation of clay-HCl leaching, HCl gas sparging crystallization has the greatest potential as an alternative to the Bayer-bauxite process.

OP 36–84. Mid-Continent Has Early Success With the Longest Longwall Face Ever Operated in the US, by Bradley J. Bourquin and Jasinder S. Jaspal. Min. Eng., Jan. 1984, pp. 48–52. Operation of the first longwall panel to be mined under a cooperative agreement between the U.S. Bureau of Mines and Mid-Continent Resources at the Dutch Creek No. 1 Mine is underway. The 800-ft-wide longwall face, which is part of a multilift longwall demonstration, is extracting a 10-ft-high top lift from a 28-ft-thick coal horizon in an area of the property where the Coal Basin A and Coal Basin B beds have come together to form one seam. This face, the longest ever operated in the United States, is being worked on an advancing longwall system. From the first month of operation the performance of the longwall face has yielded high productivity and safety, which should be of interest to coal producers in the United States.

OP 37–84. Electromagnetic Detection of Trapped Miners, by J. Durkin. IEEE Commun. Mag., v. 22, No. 2, Feb. 1984, pp. 37–46. The Bureau of Mines conducted field studies in coal mines throughout the United States to determine the effectiveness of electromagnetic techniques in locating miners trapped underground following a mine accident. Data from these tests were used to generate models of expected signal and noise distributions as found above these mines. These distributions have aided in placing the expected performance of a through-the-earth electromagnetic communications technique into a probabilistic framework. Results show that at a 10% false-alarm rate, the expected probability of detecting a miner's signal from a depth of 1,000 ft is 54%; at 500 ft it is 95%. These depths exceed the actual depths of 90% and 50%, respectively, of U.S. coal mines. Sensitivity studies showed that at a depth of 1,000 ft, the probability of detection will improve approximately 2% for each decibel of increase in signal-to-noise ratio.

OP 38–84. Hydrolysis of Inorganic Iron(III) Salts, by Charles M. Flynn, Jr. Chem. Rev., v. 84, No. 1, 1984, pp. 31–41. The scope of this review includes studies on the hydrolysis and precipitation of Fe(III) from aqueous solutions of its inorganic salts, chiefly the nitrate, perchlorate, chloride, and sulfate. After a survey of structural and thermodynamic properties of the relevant Fe(III) species, this review examines the reactions of hydrolysis and precipitation in aqueous Fe(III) solutions. These reactions, most of which occur slowly, include the formation, aging, and agglomeration of a red cationic hydrolytic polymer. The constitution of the slowly precipitated hydrous oxide products is also examined. For comparison, the constitution and aging of rapidly precipitated hydrous iron(III) oxides is briefly surveyed. Techniques employed in the study of Fe(III) hydrolysis and precipitation include pH measurement, visible and infrared spectroscopy, ultracentrifugation, electron microscopy, and X-ray diffraction. Electrokinetic properties and thermal dehydration of precipitated iron oxides are not considered. Iron(III) oxides, hydrous oxides, or related compounds formed via oxidation of elemental iron or iron(II) compounds, or via other redox reactions, are not considered.

OP 39–84. Recovery and Recycling of Chromium-Bearing Solutions, by L. C. George, N. L. Rogers, and Glenn L. Horter. Paper in Proc. of the 29th Natl. Soc. for the Advancement of Mater. and Process Eng. (SAMPE) Symp. (Reno, NV, Apr. 3–5, 1984). V. 29, Apr. 1984, pp. 853–858. Bell Helicopter Textron, Inc., under a cooperative agreement with the Bureau of Mines, evaluated technology for the regeneration of waste chromic acid devised by the Bureau. Laboratory and pilot studies were performed to determine the applicability of electrolytic membrane cell technology to Bell's process stream for the surface preparation of aluminum alloy components. The study revealed that the technology reduced chemical cost by regenerating chromic acid for reuse, reduced waste treatment costs, and reduced hazardous waste disposal costs. Bell has installed a regeneration unit based on the Bureau-developed technology in its Hurst, TX, plant.

OP 40–84. America's Dependence on Strategic Minerals, by V. Anthony Cammarota, Jr. Pres. at Conf. on Strategic Minerals and International Economic Assistance, Wilmington, DE, Dec. 8–10, 1982. Ch. 22 in American Strategic Minerals, Crane, Russak & Co., Inc., New York, 1984, pp. 29–57. This paper illustrates the degree of U.S. dependence on domestically produced and imported strategic materials, the source of imports on a geographical basis, and the trends that may be foreseen for the remainder of this decade in terms of the future supply of these materials. Strategic materials were defined and 20 were selected for an examination of recent trends in import dependence and the outlook for a reversal in the trend. For the minerals and metals for which the United States is over 75 pct dependent, the major source countries are oftentimes the Republic of South Africa, the U.S.S.R., and the developing countries of Africa, Asia, and South America. Based on reserves and resource estimates, it appears that these countries will continue to be major suppliers of strategic materials for the foreseeable future.

OP 41–84. Separation and Recovery of Cobalt From Copper Leach Solutions, by T. H. Jeffers. Pres. at Metall. Soc. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984. Metall. Soc. AIME paper selection A84–21, 1984, 8 pp. The Bureau of Mines developed a procedure using a chelating ion-exchange resin to successfully extract cobalt from a pH copper-processing solution containing only 30 mg/L cobalt. Cyclic tests with the commercial resin XFS-4195 in 4-ft-high by 1-in-diam columns gave an average cobalt extraction of 95 pct when 65 bed volumes of solution were processed at a flow rate of 4 gpm/ft^2. Elution of the cobalt using a 50-g/L sulfuric acid solution yielded an eluate containing 0.5 g/L cobalt. Nickel, copper, iron, zinc, and aluminum were coextracted with the cobalt and also appeared in the eluate. Selective elution of the loaded resin and solvent extraction procedures using di-2-ethylhexyl phosphoric acid and Cyanex 272 removed the impurities and produced a cobalt sulfate solution containing 25 g/L cobalt.

OP 42–84. Gaseous Corrosion of Metals in a 60% H_2O, 40% HCl Environment, by J. P. Carter, B. S. Covino, Jr., T. J. Driscoll, W. D. Riley, and M. Rosen. Corrosion, v. 40, No. 5, May 1984, pp. 205–214. Laboratory tests were conducted on iron, nickel, titanium, and cobalt base alloys and zirconium 702, primarily at temperatures of 95° to 400° C for exposure periods of 15 days in a 60 vol % H_2O, 40 vol % HCl gaseous mixture. The alloys were also exposed for a period of 66 days. Field tests were conducted in a rotary calciner and a fluidized bed decomposer using the more corrosion-resistant alloys from the laboratory tests. For the laboratory tests, titanium and cobalt base alloys showed the lowest corrosion rates at 140° to 380° C, and the Ti-0.2Pd alloy exhibited the lowest corrosion rates at 95° to 140° C. The conditions for field tests were found to be less severe than for the laboratory tests, resulting in lower corrosion rates. Element profiles obtained with auger electron spectroscopy indicated that the most prevalent corrosion-resistance process for most nickel base alloys was gaseous oxidation involving O_2. The major process opposing this was HCl attack, which resulted in thinning of the oxide portion of the film and the formation of nickel chloride. Titanium buildup at the film-metal interface of Rene 41 samples helped give Rene 41 an extremely low rate of corrosion.

OP 43–84. Magnesium Oxide for Improved Heavy Metals Removal, by J. E. Schiller and S. E. Khalafalla. Min. Eng., Feb. 1984, pp. 171–173. To improve technology for treating process water, U.S. Bureau of Mines research has shown that magnesium oxide (MgO) has many advantages over lime or caustic soda for precipitating heavy metals. Sludge produced by MgO occupies only 0.2 to 0.3 times as much volume as the precipitate made using a soluble base. While a settled, lime-formed precipitate is easily resuspended, the MgO-metal hydroxide sludge becomes cemented together on standing. Settling of the metal hydroxides from a dilute suspension is more complete than precipitates formed with other bases. Virtually any metal that can be precipitated by raising the pH can be treated using MgO. A threefold to fourfold stoichiometric excess of solid reagent is added. The mixture is reacted for 5 to 10 min. Polymer is added, and settling or filtration completes the process. Because of the greater cost of MgO compared with lime, large-scale practice of this technology will probably be limited to water containing 50 mg/L or less of dissolved metals. For such dilute solutions, chemicals are not a large fraction of total treatment costs, so more desirable sludge properties might justify higher chemical expenses. While the MgO process is technically suitable for widespread application, the extent to which it is adopted will probably be determined by a trade-off between the greater cost of MgO compared with lime and the superior properties of the precipitates and their corresponding ultimate disposal costs.

OP 44–84. An Approach to Air Quality Control for Diesel Mucking in Underground Mines, by George H. Schnakenberg, Jr. Pres. at Annu. Am. Conf. Ind. Hyg., Philadelphia, PA, May 22–27, 1983. Am. Ind. Hyg. Assoc., v. 8, 1984, pp. 107–117. The Bureau of Mines, in its pursuit of methods to improve the quality of the underground workplace, has funded studies on the behavior of diesel exhaust components in deadened drifts. Real-time and time-integrated measurements of CO_2, CO, NO, and NO_2 and gravimetric measurements of particulates analyzed for hydrogen, carbon, and the nitrogen fraction were performed in several mines and under controlled conditions in a test drift. The relationship among the contaminants was examined in light of the fact that the CO_2 concentrations found are only the result of the amount of fuel burned and the exhaust dilution of background CO_2 is subtracted out. Although the engine operates over several modes for

a given production activity, the ratio of each of the other exhaust-contaminant concentrations to the CO_2 concentration was found to be relatively constant for a given engine in a given activity. The fact that the relationship is constant can be exploited in that CO_2 levels alone can be used to give a measure of the level of diesel exhaust air quality. Furthermore, time-weighted averages of the other contaminants (CO, NO, NO_2, particulate) and CO_2, or direct tailpipe measurements with the engine suitably loaded, can be made and the ratios compared with previous data. Changes in the ratio indicate changes in engine and/or exhaust control systems, and maintenance may be indicated; changes in the ambient CO_2 level reflect changes in ventilation. The measurement technology and a graphical approach for this method are presented as well.

OP 45–84. Application of Cross-Measure Borehole Technology to Retreat Longwalls in the United States, by J. Cervik, F. E. McCall, and A. A. Campoli. Paper in Proc. 20th Int. Conf. on Safety in Mines Research Institutes, Sheffield, United Kingdom, Oct. 3–7, 1983, 13 pp. Prior to 1970, ventilation was the primary method of controlling methane in gobs. Mining regulations require that the methane concentration in the entries adjacent to the gob be 2 vol pct or less. As mining depth increased, gassier coalbeds and surrounding strata were encountered, and acceptable methane levels in the entries adjacent to the gob could not be maintained by ventilation alone. Consequently, surface gob boreholes were introduced as an auxiliary gob gas control method. Surface gob boreholes cannot always be drilled because mining may be under populated areas, topography may be too severe, or access to private property may be denied. The cross-measure borehole technique, which is used in the United Kingdom and Europe, appears to be an alternative method of controlling gob gas. This paper describes joint efforts by the Bureau of Mines and the mining industry to adapt cross-measure borehole technology to multiple-entry retreat longwall mining in the United States.

OP 46–84. Chlorate Oxidation—An Alternative Anode Reaction in Electrowinning, by G. R. Smith and W. R. Thompson. Paper in Anodes for Electrowinning, ed. by D. J. Robinson and S. E. James (Metall. Soc. AIME Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984). Metall Soc. AIME reprint, 1984, 12 pp. Electrolysis studies by the Bureau of Mines have demonstrated that zinc or copper electrowinning can be combined with the electrochemical production of sodium perchlorate to achieve a significant decrease in the use of electrolysis energy. Current efficiencies exceeding 90 pct were obtained for each half-cell reaction, using current densities and temperatures in the ranges typically employed for the respective electrowinning and electrochemical reactions. The cationic permselective membrane separating the two half-cells exhibited a high efficiency, allowing less than 4 pct of the anolyte and catholyte to interdiffuse during electrolysis.

OP 47–84. Mercury Removal From Gold Cyanide Leach Solution, by W. L. Staker, W. W. Simpson, and R. G. Sandberg. Miner. and Metall. Process., May 1984, pp. 56–61. The Bureau of Mines investigated selective extraction of Au and Ag from a low-grade Au ore containing Hg. Gold and silver were extracted from the ore in cyanide slurries, and Hg extraction was suppressed with sodium or calcium sulfide. Maximum Au extraction and minimum Hg extraction were obtained using solutions containing 0.34 lb NaCN/ton of solution. Increasing the cyanide concentration increased Hg extraction without increasing Au extraction. Mercury extraction from the ore was suppressed with 0.5 to 2.9 lb CaS/lb Hg in the ore. Gold-to-mercury ratios of 100:1 to 400:1 were obtained in the leach solution and on the activated carbon in a carbon-in-pulp circuit.

OP 48–84. Bureau of Mines Respirable Dust Measurement and Monitoring Program, by K. L. Williams and G. H. Schnakenberg, Jr. Ch. 9 in Aerosols in the Mining and Industrial Work Environment. Ann Arbor Sci., Ann Arbor, MI, v. 1, 1984, pp. 99–107. This chapter reviews current projects and discusses the future direction of the Bureau of Mines respirable dust measurement and monitoring program. Projects presently underway include the development of a mining machine-mounted respirable dust monitor based on light scattering; the development of direct-indicating personal dust exposure monitors, one using light scattering and the other using a tapered element oscillating microbalance technique; a feasibility study of a light reflectance technique for measuring the mass of dust deposited on a filter; an in-house evaluation of various existing dust monitors; and two projects related to the determination of the quartz content of dust samples. The technical aspects of the various developments are not discussed in detail; rather, the philosophy and rationale behind the development or investigation are explained. Also, the chapter points out the need for and nature of a planned respirable coal mine dust monitoring strategy study.

OP 49–84. Evaluation of Surface Deformation Characteristics Over Longwall Panels in the Northern Appalachian Coalfield, by Vladimir Adamek and Paul W. Jeran. Paper in Proc. Soc. Min. Eng. AIME 1st Int. Conf. on State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, Honolulu, HI, Sept. 5–9, 1982, pp. 183–198. Characteristics of surface deformations—i.e., subsidence, inclination, curvature, and horizontal strains—are evaluated, based on information obtained by direct field measurements over three longwall panels in the northern Appalachian coalfield. Surface deformations were precomputed using Bals' and Knothe's theories. The results were compared with Bureau of Mines field data to evaluate the applicability of the two theories to U.S. mining conditions. Measured horizontal movements and the resulting horizontal strains differ as much as 300 pct from precomputed values. Topography has no detectable effect on vertical movements but appears to have substantial effect on the development of horizontal strains. The horizontal deformations computed from field measurements generally exceed the limits used in other countries to protect surface structures.

OP 50–84. Evaluation of Existing Predictive Methods for Mine Subsidence in the U.S., by Vladimir Adamek and Paul W. Jeran. Paper in Workshop on Surface Subsidence Due to Underground Mining (sponsored by West Virginia University, Morgantown, WV, Nov. 30–Dec. 2, 1981). West Virginia University, Morgantown, WV, Mar. 1982, pp. 88–98. Two existing predictive methods were chosen for evaluation; an influence function (Bals' theory) and a profile function (hyperbolic). These were applied to several field-measured subsidence profiles over U.S. coal mines. The effect of homogeneous

versus nonhomogeneous overburden on surface subsidence is demonstrated and the utilization of Bals' theory as a subsidence predictive method for both types of overburden is examined. The major factor affecting subsidence profile characteristics is the migration of the inflection point toward the centerline of the longwall panel. A computer program was written to aid in the analysis.

OP 51–84. An Investigation Into the Effects of a Retreating Longwall on a Three-Entry Gateroad System, by Richard A. Allwes, Jeffrey M. Listak, and Gregory J. Chekan. Paper in Proc. Soc. Min. Eng. AIME 112th Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983, pp. 95–112. This paper presents the final results of an in-mine study conducted by the Bureau of Mines on a three-entry gateroad system utilizing the stiff-yield pillar design concept. The analyses of roof-to-floor convergence and roof-bolt loading of headgate systems and tailgate chain pillar stresses are presented in detail as the longwall panels were mined. Stress distribution within pillars, relative stress changes between yield and abutment pillars, and the histories of pillar stress, roof-to-floor convergence, and roof-bolt loading as a function of longwall movement are discussed.

OP 52–84. In-Mine Assessment of a Longwall Entry System, by D. R. Babich, R. A. Allwes, and L. V. Wade. Paper in Proc. Soc. Min. Eng. AIME 1st Int. Conf. on State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, Honolulu, HI, Sept. 5–9, 1982, pp. 97–105. The design of a longwall entry system is discussed in this Bureau of Mines paper. This is done primarily through the results of an in-mine case study made of two sets of longwall entries utilizing the stiff-yield pillar design concept. The rock mechanics instrumentation plan used in the case study is shown, including a description of the instrumentation layout and the types of instruments used. The analysis of the stress changes in the abutment and yield pillars is presented in detail as the longwall panels were mined. Conclusions concerning when the pillar first started to experience significant stress, pillar stress history as the longwall face approached and moved past the pillars, stress distribution within the pillars, and relative stress changes between yield and abutment pillars are discussed. The paper concludes with a discussion of the redistribution of stress in the vicinity of the longwall panel.

OP 53–84. The Minerals Availability Program of the U.S. Bureau of Mines—Purpose, Progress and Methodology, by Harold J. Bennett and Robert L. Davidoff. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984, Soc. Min. Eng. AIME preprint 84–112, 11 pp. The Minerals Availability Program is a Bureau of Mines program to systematically measure and classify identified worldwide nonfuel mineral resources according to their respective extraction technology, economics, and commercial availability. The program is designed to identify, collect, compile, and evaluate information on worldwide active mines as well as on developed and explored mineral deposits, and on mineral processing plants. Objectives are to classify domestic and foreign resources, to identify by cost evaluations resources that are reserves, and to prepare analyses of the availability of these resources for 34 commodities and secondary minerals. Availability analyses consider such factors as geographic location, the type of producible material, the technology and time required to produce a marketable product, and the productive capacity and unit cost for each deposit. These factors, reflected in the aggregated tabular and graphical data in the study for each commodity, are developed for consideration in the formulation of both domestic and foreign mineral policy. To date, the data have been collected for the 34 commodities; expected first cycle completion date for all 34 is early 1986. Raw and aggregated data are available to the public in the form of computer-generated listings, tapes, and maps as well as in published reports. Also, systems developed to assist in performing the engineering and economic analyses are available.

OP 54–84. Tungsten—Can the Market Economy Countries Hold Their Own? by Donald I. Bleiwas, Ronald J. Hurdlebrink, and Terry F. Anstett. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb 26–Mar. 2, 1984, Soc. Min. Eng. AIME preprint 84–111, 15 pp. The U.S. Bureau of Mines evaluated the potential availability of tungsten from 57 tungsten mines and deposits in 19 market economy countries. The 38 properties that were producing at the time the study was performed contained approximately 375,000 tons of WO_3 (tungsten trioxide). The total estimated recoverable resource from all properties studied, both producers and nonproducers, was 1.2 million tons of WO_3 (demonstrated level). Approximately 143,000 tons of WO_3 is recoverable from producing properties with costs at or below January 1983 market price. The study indicates that by 1990 production from currently operating mines in market economy countries will decrease as their demonstrated resources become exhausted. Some of this potential decline may be offset by lower than anticipated levels of market demand, discoveries of additional resources at producing mines, development of other known deposits, and/or discoveries of new deposits. Development of new tungsten resources will likely result in costs higher than exist at currently producing properties. China has been steadily increasing production and export of tungsten in various forms and currently supplies about 25 pct of U.S. imports. China's tungsten mines are large, high-grade operations capable of producing at relatively low cost. These factors, coupled with China's apparent need for foreign exchange, could lead to further expansions of production and exports from China, with a consequent increased dependence by market economy countries on China for tungsten requirements and a threat to the survival of the market economy countries' tungsten industries.

OP 55–84. U.S. Bureau of Mines Rock Bolting Research, by D. D. Bolstad, J. R. M. Hill, and J. M. Karhnak. Paper in Rock Bolting, Theory and Application in Mining and Underground Construction, ed. by O. Stephansson (Proc. Int. Symp. on Rock Bolting, Abisko, Sweden, Aug. 28–Sept. 2, 1983). A. A. Balkema Publ., Rotterdam, Netherlands, 1983, pp. 313–320. U.S. Bureau of Mines research is developing technology that can lead to reduced accidents from roof falls in underground mining operations. Research efforts have focused on the development of systems to install rock reinforcements remotely, and on studies to define the interaction mechanics between rock mass and support systems. Remote manual roof bolters, a fiberglass epoxy-resin pumpable roof-bolting system, and automated bolter modules, all of which utilize flexible shaft drills and bolt benders-inserters, are

being developed. These systems provide remote longer-than-seam-height drilling and bolting capabilities. Systems are also being developed to grout rock bolts remotely in mine roof through application of a slurry injection system using low-cost, fast-setting gypsum cement. A device to evaluate the bond quality of full-column grouted bolts nondestructively is also under development. A full-scale geotechnical model of a coal mine entry, in correlation with finite-element analysis, is being used by the Bureau for research in the area of roof-bolt support interaction mechanics.

OP 56–84. Induction Time Studies of Fe18Cr and 430 SS Under Open Circuit Conditions in Chloride-Containing Sulfuric Acid, by B. S. Covino, Jr., and M. Rosen. Corrosion, v. 40, No. 4, Apr. 1984, pp. 140–146. In order to promote the effective and efficient application of corrosion-resistant metals and alloys in mineral-processing environments, the Bureau of Mines has characterized the effect of aggressive ions on the corrosion and passive behavior of two stainless steels, Fe18Cr and AISI 430 SS. Samples prepassivated in oxygen saturated 1*N* H_2SO_4 at 0.6 V normal hydrogen electrode and then released to open circuit and aged for times ranging from 10 to 80,000 min (55 days) were subsequently exposed to chloride ion concentrations ranging from 5 to 44 parts per thousand. Susceptibility to chloride ion attack was determined as a function of time in solution, chloride ion concentration, and open circuit potentials at the time chloride was added by measuring the amount of time required for a sample to begin corroding after adding the chloride ion.

OP 57–84. Effect of Atmospheric Moisture on the Deterioration of Coal Mine Roof Shales, by R. A. Cummings, M. M. Singh, and N. N. Moebs. Min. Eng., v. 35, No. 3, Mar. 1983, pp. 243–245. Disintegration of the immediate shale roof in coal mines interferes with ventilation, production, and safety. The effect is seasonal and correlates with high levels of moisture in the intake ventilation air. Disintegration, although not completely understood, is caused by shale dilation and weakening upon exposure to atmospheric moisture. Fluctuating moisture conditions are particularly deleterious, but may be at least partially controlled by tempering the air before it is brought to the working place. This paper discusses a 2-year program that was conducted on behalf of the Bureau of Mines to study the deterioration problem in mines.

OP 58–84. A Computer-Implemented Data Base for Coalbed Methane Resource Characterization and Research, by William Patrick Diamond, David Michael Hyman, and John Charles LaScola. J. Petrol. Technol., v. 36, No. 5, May 1984, pp. 846–848. The Bureau of Mines has obtained gas content data on more than 1,500 coal samples from approximately 250 coalbeds in 17 States. A computer-implemented coalbed methane data base was established to respond more efficiently to health, safety, and mine-planning related data requests from the coal industry and to the resource characterization needs of those interested in using coalbed methane. The system also will be used for coalbed methane research, including multivariate statistical analysis of the physical, chemical, and geologic province factors influencing the methane generation and storage capacity of coal, with the ultimate goal of developing an indirect method of estimating the gas content of coalbeds.

OP 59–84. The Impact of Diminishing Rutile Resources on Titanium Production and Costs, by Richard J. Fantel, David A. Buckingham, and Daniel E. Sullivan. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984, Soc. Min. Eng. AIME preprint 84–109, 11 pp. This paper addresses the impact of declining world rutile resources upon the production of titanium products and their associated costs. Titanium is used primarily for the production of pigments; in its metal form it is considered a strategic and critical material to the U.S. defense and aerospace industries. There are two major mineral sources for titanium: ilmenite and rutile. Both these mineral types can be used to produce titanium pigments. Only high-grade titanium concentrates, such as rutile, high-grade ilmenite, and synthetic rutile (which is produced through further processing of ilmenite), can be used in the production of titanium metal. This paper draws upon the data and analyses of a recent Bureau of Mines Minerals Availability Program appraisal that evaluated the international availability of titanium from market economy countries. The paper will show that production from economic rutile mines will decline sometime after the turn of the century and that rutile shortages could be alleviated by production from other high-grade titanium resources such as higher cost rutile deposits and anatase deposits, or through an increase in world synthetic rutile capacity.

OP 60–84. Quartz Crystal, by J. E. Ferrell. Min. Eng., v. 36, No. 5, May 1984, pp. 528–529. The industrial quartz crystal industry rebounded sharply during the second half of 1983. Estimated domestic mine production of lasca, the mineral feedstock material used for growing cultured quartz crystal, increased fourfold during the year. The recovery in the cultured quartz industry was due to a turnaround in the automotive industry, which uses quartz crystal in its microprocessors, and increased quartz sales for microprocessors in computer hardware, videocassette recorders, and cordless telephones. In 1983, cultured quartz crystal was produced by seven companies in five States. About 32 companies in 11 States consumed quartz crystal to produce crystal units for various electronic and optical products.

OP 61–84. Strontium, by J. E. Ferrell. Min. Eng., v. 36, No. 5, May 1984, p. 531. The U.S. strontium industry experienced a major shakeup during 1983 when the leading domestic producer of strontium chemicals announced plans to close its plants. Changes also occurred in the world marketplace as Japan surpassed the United States as the leading consumer of strontium compounds. Neither the United States or Japan mine celestite, the commercial strontium mineral form. Mexico supplies most of the U.S. celestite demand, while Spain satisfies most of the Japanese demand. Primary strontium compounds were used primarily in glass manufacture for television picture tubes, and to a lesser extent in pyrotechnics and signals, ferrite permanent magnets, pigments and fillers, and electrolytic production of zinc.

OP 62–84. Longwall Dust Control, a Perspective View of How U.S. Mine Operators Are Coping With the Problem, by Robert A. Jankowski and John A. Organiscak. Paper in Proc. Eur. Econ. Communities Conf. on Longwall Dust Control, Luxembourg, May 30–31, 1983, Doc. No. 2365/83, pp. 103–124. The

Bureau of Mines recently completed a survey of six U.S. longwall operations that show a consistent record of compliance with Federal dust standards and six operations experiencing the greatest difficulty maintaining compliance levels. The selection of the six "cleanest" longwall double-drum shearers was based on mine operator and MSHA compliance records. A list of 10 longwall double-drum shearers experiencing the most difficulty with compliance was also obtained from MSHA. During the surveys, 4 of the 10 operations implemented improved dust controls that substantially lowered dust levels; thus the results discussed in this report are from the six U.S. longwall faces still having the greatest difficulty complying with the Federal dust standards. The objective of the surveys was to (1) identify the dust control techniques that were most effective, (2) determine whether existing technology was capable of controlling dust from the major longwall dust sources, and (3) identify the areas where existing technology was not adequate. This information would permit mine operators to select the most appropriate techniques to control longwall dust levels and provide additional direction to research efforts designed to develop control technology for specific problem areas.

OP 63–84. Improved Face Ventilation Lowers Longwall Dust Levels, by Robert A. Jankowski and Fred N. Kissell. Paper in Proc. Soc. Min. Eng. AIME 112th Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983. Soc. Min. Eng. AIME preprint 83–171, 7 pp.; paper in Trans. Soc. Min. Eng. AIME, v. 274, 1984, pp. 2024–2028. The Bureau of Mines, in close cooperation with the mining industry, has recently established several improved face ventilation techniques for longwall mining systems. These include coursing the primary face intake from tailgate to headgate, installing curtains at the intake end of the longwall face, and identifying improved techniques for measuring face ventilation parameters on longwall sections. Application of these techniques throughout the mining industry should reduce the health hazard associated with excessive exposure to respirable dust.

OP 64–84. Soda Ash by D. S. Kostick. Min. Eng., v. 36, No. 5, May 1984, pp. 530–531. Domestic production of natural and synthetic soda ash increased because of the 48% rise in exports, mainly to Asia and South America. Several proposed international soda ash projects were announced that could influence the size of the future U.S. export market. Domestic apparent consumption of soda ash increased slightly as demand improved for soda ash in soap and detergents, pulp and paper, and chemicals. The growing market displacement of glass containers, the largest end use of soda ash, by polyethylene terephthalate bottles continued to severely affect domestic soda ash sales.

OP 65–84. The Competitive Position of Nickel-Cobalt and Copper-Cobalt Deposits in Canada, Zambia, Zaire, and the Pacific Islands, by James F. Lemons, Jr. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984, Soc. Min. Eng. AIME preprint 84–107, 13 pp. The potential production of cobalt from nickel sulfide deposits in Canada, from nickel laterite deposits in the Pacific Islands, and from the copper deposits in Zaire and Zambia will be a function of the cost of recovery of the primary nickel and copper products. This cost of production varies significantly for these deposits and is related to the differences in the cost of labor, energy, and supplies; to production technology; and to the grade and recovery of nickel, copper, and cobalt. This Bureau of Mines paper investigates these cost and technology differences as they relate to the cost competitiveness of the deposits in Canada, Zambia, Zaire, and the Pacific Islands.

OP 66–84. Use Lower Shearer Drum Speeds To Achieve Deeper Coal Cutting, by Jonathan Ludlow and Robert A. Jankowski. Min. Eng., v. 36, No. 3, Mar. 1984, pp. 251–255. A longwall operator can make few changes to increase output, significantly reduce respirable dust, and decrease power consumption. Reducing drum speed, and thereby cutting with increased pick penetration, is one. This article defines the benefits of deep cutting in terms of reduced dust production and power consumption. It also identifies the practical aspects of high pick penetration in terms of shearer performance and coal loading.

OP 67–84. Bromine, by P. A. Lyday. Min. Eng., v. 36, No. 5, May 1984, pp. 508–509. A 1983 review of changes in the bromine industry during the year. The review included changes in Government environmental and trade programs that affected the industry. The domestic and overseas industry was included in the review, which also contained an outlook section projecting future changes.

OP 68–84. Iodine, by P. A. Lyday. Min. Eng., v. 36, No. 5, May 1984, pp. 518–519. A 1983 review of changes in the iodine industry during the year. The review included changes in Government stockpiles, imports, and the domestic and foreign industry. The development of new capacity in the United States and existing capacity in Japan was included. An outlook section projected future changes.

OP 69–84. Hazardous Roof Structures in Appalachian Coal Mines, by Noel N. Moebs and John L. Ellenberger. Ch. 2 in Ground Control in Room-and-Pillar Mining, ed. by Y. P. Chugh (Proc. Polish-American Conf. on Ground Control in Room-and-Pillar Mining, Soc. Min. Eng. AIME, Carbondale, IL, Aug. 6–8, 1980). Soc. Min. Eng. AIME, 1982, pp. 9–16. Geologic structures in mine roof rock contribute to many roof falls in Appalachian coal mines. These structures include paleochannels, scours, pinch-outs, slickensides, clay veins, and cravasse splays consisting of thinly interlaminated sandstone and shale. These structures often can be identified during, and sometimes before, development and mine projections can be revised to reduce the adverse effects of discontinuities in roof structure. Large areas of roof consisting of laminated sandstones or incompetent strata generally can be delineated from exploratory drill-hole data and the need for supplementary support can be anticipated. Because an accurate description of roof geology also provides some indication of optimum length and type of roof bolts that should be installed, this Bureau of Mines paper describes the hazardous roof structures most commonly encountered in the Appalachian coal region.

OP 70–84. Are Charge Materials Affecting Casting Quality? by R. H. Nafziger, R. F. Farrell, and J. E. Brynildson. Mod. Cast., v. 74, No. 5, May 1984, pp. 23–26. The foundry industry has expressed concern regarding the quality of scrap used

to prepare iron castings owing to the growth of alloy steel production and its influence on tramp element levels when recycled. Reliable and current information is unavailable on the amount of tramp elements contained in iron castings produced over a significant period of time. Accordingly, the Bureau of Mines is analyzing over 50 cast iron samples from participating foundries throughout the United States on a quarterly basis under a Memorandum of Agreement between the Bureau and the American Foundrymen's Society. A direct-reading spectrograph and atomic absorption techniques provide the determination of 28 elements on each sample. The objective is to determine if the level of tramp elements in charge materials is changing over a period of time. Results to date indicate that the type of furnace used and the geographic location and size of the foundry did not significantly affect casting compositions. Owing to the variability of charge materials used, correlation of the analyses with charge compositions was unsuccessful. The data obtained thus far represent insufficient time to justify a statistical evaluation of possible trends.

OP 71–84. Longwall Dust Control Research, by George E. Niewiadomski and Robert A. Jankowski. Paper in Proc. 12th Annu. Inst. on Coal Mining Health, Safety and Research, Blacksburg, VA, Aug. 24–26, 1981, pp. 79–92. The Bureau of Mines has been active in respirable dust research since passage of the Federal Coal Mine Health and Safety Act of 1969. Until several years ago, the main thrust of the research program was on the development and new and improved dust control technologies to reduce the miners' exposure to respirable dust in mines employing conventional and continuous mining methods. As a result of the efforts of the Bureau, the Mine Safety and Health Administration (MSHA), and the coal mining industry, significant progress has been achieved in lowering the dust levels in these mines from over 5 mg/m³ in 1969 to less than 2 mg/m³ today. This is reflected in the number of citations issued by MSHA in recent years. Based on inspection data, at least 95 pct of all conventional and continuous mining sections are currently in compliance at any given time.

OP 72–84. Taking the Dust Out of Longwalls, by George E. Niewiadomski, Robert A. Jankowski, and Fred N. Kissell. Min. Equip. Int., v. 6, No. 12, Dec. 1982, pp. 25–28. Longwall mining offers many advantages, but controlling respirable dust can be difficult especially at mines using double-drum shearers. However, the Bureau of Mines, in cooperation with the mining industry, has developed and tested cost-effective solutions—including improved ventilation, better uses of water, and improved machine design—that are currently in use. This paper discusses those solutions and some cases where the solutions do not apply.

OP 73–84. Unconventional Uses of Geotechnical Tools for Impoundment Seepage Investigations, by Steven E. Follin, George L. Chedsey, and Andrew Mac G. Robertson. Paper in Sixth Symposium on Uranium Mill Tailings Management, Fort Collins, CO, Feb. 1–3, 1984, pp. 615–626. Proper design of dewatering or seepage control systems for existing waste impoundments requires reliable estimates of soil parameters, knowledge of pore pressure distribution, and good information about the layering present. As part of a program to improve the effectiveness of dewatering systems used in the mining industry, the Bureau of Mines sponsored field tests of two recently developed instruments, the piezocone penetrometer and the Delft 66-mm continuous sampler. These tools, developed for other applications in which soft soils are encountered, were used to obtain soil and hydrologic information at an active uranium tailings impoundment. This paper describes the equipment, its operation, the fieldwork performed, and the results obtained.

OP 74–84. Direct Flotation of Potash From Insoluble Slime-Bearing Sylvinite and Carnallite Ores, by D. G. Foot, Jr., and J. L. Huiatt. Trans. Soc. Min. Eng. AIME, v. 272, May 1983, pp. 1974–1978. The Bureau of Mines devised a direct flotation method for treating low-grade carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$) and sylvinite (a mixture of KCl and NaCl) ores characterized by a high content of water-insoluble impurities. The procedure consists of flocculation-depression of the insoluble slimes; decomposition leach (carnallite only); potash rougher, cleaner, and recleaner flotation; and final product leaching. The technique eliminates the necessity of removing the water-insoluble slimes by mechanical or flotation desliming. Laboratory results demonstrated that the direct flotation procedure, when compared with conventional techniques, yielded equivalent or improved flotation results with equal or less reagent consumptions. The direct flotation method recovered 81.6% of the solid phase KCl from carnallite ore and 79.7% of the KCl from sylvinite ore in final products containing 60.5% and 60.9% K_2O, respectively. A flowsheet incorporating the described flotation procedure is presented.

OP 75–84. Black Sand Survey Along the Pacific Coast, by John Gomes. Paper in Fifth Annual Conference on Alaskan Placer Mining (sponsored by the Univ. of AK, Fairbanks, AK, Mar. 30–31, 1983), comp. and ed. by B. W. Campbell, J. Madonna, and M. S. Husted. Miner. Ind. Res. Lab. Rep. No. 68, 1983, pp. 49–52. The Bureau of Mines investigated the occurrence and recovery of byproduct gold and heavy minerals from west coast sand and gravel operations. Heavy mineral (black sand) concentrates were prepared from sand samples from 150 locations. Magnetite, ilmenite, zircon, chromite, rutile, radioactive minerals, platinum-group minerals, and gold were identified in many of the concentrates. Individual magnetite, ilmenite, zircon, chromite, rutile, thoria, platinum-group minerals, and gold products were prepared from selected concentrates. Low- and high-intensity magnetic, electrostatic, flotation, and amalgamation techniques were used to beneficiate the black sands.

OP 76–84. Heap Leaching of Gold Ores, by John Gomes. Paper in Fifth Annual Conference on Alaskan Placer Mining (sponsored by the Univ. of AK, Fairbanks, AK, Mar. 30–31, 1983), comp. and ed. by B. W. Campbell, J. Madonna, and M. S. Husted. Miner. Ind. Res. Lab. Rep. No. 68, 1983, pp. 80–83. During the 1970's, the Bureau of Mines investigated a particle agglomeration technique for improving the flow of leaching solution through heaps of clayey or crushed, low-grade gold-silver ores, wastes, and tailings. This technology has been adopted on a broad scale by the precious-metals-processing industry. This report presents information on five commercial operations that have benefited from agglomeration technology and that represent a cross section of current heap leaching practice. The technology is cost effective because of decreased leach times and improved precious metal recoveries.

OP 77–84. Cast-On Surfacing of Polystyrene Pattern Castings, by J. S. Hansen. Paper in Am. Foundrymen's Soc. 87th Annu. Meeting, Des Plaines, IL, Apr. 10–15, 1983. AFS Trans., v. 91, 1983, pp. 65–70. In support of its objective to decrease the use of critical materials through conservation and wear reduction, the Bureau of Mines investigated a hardsurfacing technique for use in mining and metallurgical processing equipment that confines alloy additions to wear-prone surfaces only and improves wear resistance. In the technique, powdered, wear-resistant material is pasted on a polystyrene pattern and transferred to a casting surface at the time of pouring. Vacuum is applied to a special casting flask to eliminate gas, maintain shape, and promote intimate contact between the powder and liquid metal. Three examples are cited in which high-carbon ferrochrome was applied as a surfacing material to AISI 1030 steel castings. Ferrochrome paste with less than 0.5% polyvinyl acetate or cellulose binder resulted in hardsurfaces with few inclusions, few shrinkage voids, and no gas porosity. The hardsurfaces, containing $M_{23}C_6$ carbides, were fused and metallurgically bonded to the castings. A heat-treated ferrochrome-surfaced casting performed 27% better than water-quenched (Rc 62) AISI 1060 steel in a test for low-stress abrasive wear. Work is continuing to improve process variables and to evaluate alternate hardsurfacing materials.

OP 78–84. Anticipating Facies-Related Coal Mining Problems in Hartshorne Formation, Arkoma Basin, by David W. Houseknecht and Anthony T. Iannacchione. Am. Assoc. Petrol. Geol. Bull., v. 66, No. 7, July 1982, pp. 923–930. The close relationship observed between sedimentary facies and potential coal mining problems within the Hartshorne Formation of the Arkoma Basin provides the basis for anticipating where mining problems may jeopardize safe and economical coal production in undeveloped parts of the basin. Deltaic facies within the Hartshorne include distributary-channel sandstones and interdistributary-bay shales, siltstones, and sandstones. A thick, linear, distributary-channel sandstone is closely related to several potential mining problems: (1) both underlying and overlying coalbeds are locally thin and discontinuous along the trend of the sandstone, (2) coal quality decreases significantly adjacent to the sandstone (decrease in free swelling index and increase in sulfur), (3) the sandstone is a natural gas reservoir that may emit gas into adjacent coal mines, and (4) geologic factors favoring unstable roof conditions and coalbed rolls are locally associated with the sandstone. In contrast, interdistributary-bay deposits, because of relative homogeneity and lateral persistence, do not present potential facies-related problems. Basinwide availability of geophysical logs from gas wells makes facies mapping and delineation of potential problem areas a straightforward procedure that must be integrated into formulation of exploration strategy, evaluation of reserves, and mine planning if Hartshorne coal resources are to be safely and economically exploited.

OP 79–84. Roundrobin Investigation of Respirable Quartz Dust, by Charles Huggins. Paper in Proceedings of the Symposium on Control of Respirable Coal Mine Dust (cosponsored by MSHA and labor and management of the coal industry), ed. by J. A. Barrett, M. Jacobson, W. H. Sutherland, G. R. Tinney, and P. M. Turcie, Beckley, WV, Oct. 4–6, 1983, pp. 287–296. Five interagency roundrobin investigations were run by five laboratories in order to examine the analysis of quartz in coal dust by infrared spectroscopy and X-ray diffraction. The objective was to obtain consistent results from all laboratories. Three reference quartz standards were used during the investigations, and minus 5-μm Minusil was chosen as the preferred standard by four of the five laboratories. Quartz particle size distribution measurements were made by scanning electron and transmission electron microscopy on the reference standards. The results of the final roundrobin show that consistent values can be obtained from different laboratories using the same standard and similar techniques.

OP 80–84. Modify Spray Heads To Reduce the Dust Rollback on Miners, by Natesa I. Jayaraman, Fred N. Kissell, and W. E. Schroeder. Coal Age, v. 89, No. 6, June 1984, pp. 56–57. The Bureau of Mines recently developed a water spray system that reduces dust levels at the continuous miner operator position, particularly in mines where respirable dust standards are more stringent because of silica in the coal. The purpose is to reduce dust rollback caused by the dense dust at the cutter head spreading back over the operator's cab. This article describes the three factors that promote dust rollback and the features in the new design of the spray system that improve the dust conditions. The design features include (1) a moderate spray pressure of 100 psi at the nozzles, (2) arrangement of top and side sprays for low reach, and (3) use of underboom sprays for increasing the dust knockdown efficiency. The degree of improvement effected by the new system depends on the degree of present exposure of the operator. In recent trials, the new system reduced dust levels by 40 pct.

OP 81–84. Dust Control Systems, by Fred N. Kissell. Paper in Proceedings of the Eleventh Annual Institute on Coal Mining Health, Safety and Research (cosponsored by VA Polytech. Inst. & State Univ., MSHA, and BuMines), ed. by M. Karmis, J. A. Lamonica, J. L. Patrick, and J. R. Lucas, Blacksburg, VA, Aug. 26–28, 1981, pp. 62–83. An overview of the Bureau of Mines Respirable Dust Control Program is presented. Completed and ongoing developments in the areas of dust generation, ventilation, scrubbers, personal protection, and instrumentation are discussed. The program is implemented through in-house and contract projects that are conducted at the Bureau's Pittsburgh Research Center and the Twin Cities Research Center.

OP 82–84. Mining-Induced Stress Measurement With Hydraulic Borehole Pressure Cells, by Paul H. Lu. Paper in Proceedings of the 25th U.S. Symposium on Rock Mechanics, Evanston, IL, June 25–27, 1984. Soc. Min. Eng. AIME, ch. 22, 1984, pp. 204–211. This paper proposes an unconventional, simple, and practical method of measuring mining-induced ground stresses with hydraulic borehole pressure cells. The method is a direct ground stress measuring technique. It does not require the value of deformation modulus for back-calculation of stresses; instead, it directly measures the ground stress in situ. The applicability and practicality of the technique are shown by two case studies. The technique may be applied to monitoring a stress buildup that may lead to mine roof failure or to rock and coal outbursts.

OP 83–84. Reducing Longwall Tailgate Workers' Dust Exposure Utilizing Water-Powered Scrubbers, by

John A. Organiscak, Jon C. Volkwein, and Robert A. Jankowski. Paper in Proc. Soc. Min. Eng. AIME Fall Meeting, Salt Lake City, UT, Oct. 19–21, 1983, pp. 113–118. The Bureau of Mines evaluated a new dust control technique for longwall personnel required to work at the tailgate end of the face. This technique utilizes a water-powered scrubber to clean a portion of the face air, which is discharged behind a brattice partition at the working area. Laboratory simulation of this system in a wind tunnel resulted in average efficiencies greater than 70 pct with system efficiency directly related to scrubber quantity. Underground evaluations indicated a similar direct relationship between scrubber quantity and system efficiency. Gravimetric measurements of respirable dust made during these underground evaluations resulted in average protection efficiencies ranging from 30.7 to 42.5 pct with increasing scrubber air quantity.

OP 84–84. Improving Dust Control on Longwall Shearers, by R. A. Pimentel, R. F. J. Adam, and R. A. Jankowski. Paper in Proc. Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984, pp. 63–82. Many longwall operators experience difficulty complying with the Federal regulation limiting average dust exposure. Others are currently in compliance, but the dust exposure limit keeps them from increasing their production. Spray water is a major means of dust control. Excess water can cause problems in the transportation system and the cleaning plant, and reduces the British thermal unit value of the run-of-mine coal. Thus, the dust exposure per unit of water sprayed must be maximized. This paper discusses underground tests recently completed as part of a Bureau of Mines research program to determine the effects of variations in spray water flow rate, pressure, proportioning, and spray orientation on longwall shearers.

OP 85–84. Clay Dikes in the Lower Kittanning Seam in Northern West Virginia, by John T. Popp and Anthony T. Iannacchione. Pres. at 96th Annu. Meeting, Geol. Soc. Am., Indianapolis, IN, Oct. 31–Nov. 3, 1983. Abstr. With Programs, v. 15, No. 6, Sept. 1983, p. 662. Clay dikes have been mapped in the Lower Kittanning Seam and the strata immediately surrounding the seam in an underground mine in northern West Virginia. Individual clay dikes, ranging in size from a thin film to intrusions several feet wide, have been traced as far as 900 ft laterally within the seam and surrounding strata. The vertical extent of the clay dikes is unknown.

OP 86–84. Fundamental Approaches to Longwall Dust Control, by Steven K. Ruggieri and Robert A. Jankowski. Paper in Soc. Min. Eng. AIME 112th Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983, pp. 3–8; Paper in Proc. Symp. on Control of Respirable Dust, Beckley, WV, Oct. 4–8, 1983, pp. 1–5. The Bureau of Mines is currently assessing the effectiveness of longwall dust control techniques in use today and those proposed for the future. The objective is being achieved through laboratory and field evaluations of dust control practices, using innovative sampling procedures, and state-of-the-art respirable dust monitors and support instrumentation. This makes it possible to quantify the effectiveness or lack of effectiveness of specific techniques. The results will provide the coal industry with the information necessary for proper application of dust control techniques.

OP 87–84. Interpretation of Piezometer Cone Testing of Tailings, by Eben Rust, Dirk van Zyl, and Steven Follin. Paper in Sixth Symposium on Uranium Mill Tailings Management, Fort Collins, CO, Feb. 1–3, 1984, pp. 627–638. The piezocone penetrometer is an in situ testing tool that is particularly useful for the investigation of tailings impoundments. This equipment is ideally suited for testing of tailings since a lightweight pushing frame can be used for advancing the probe. A field testing program was completed at a uranium tailings impoundment in Uravan, CO. This paper describes how the results of piezocone tests are interpreted and demonstrates these methods using the data obtained.

OP 88–84. Bureau of Mines Technology for Dewatering of Phosphatic Clays, by B. J. Scheiner. Paper in Phosphatic Clay Workshop, ed. by S. W. Clark (sponsored by Florida Institute of Phosphate Research and Central Florida Regional Planning Council, Bartow, FL, Apr. 16, 1982). FL Inst. Phosphate Res., No. 02–020–012, 1982, pp. 55–64. The Bureau of Mines has developed a dewatering technique for phosphatic clay waste. The technique consists of treating the clay waste with a flocculant such as polyethylene oxide and dewatering the resulting flocs on a mechanical device such as a rotary screen. In small-scale continuous tests at the Bureau's Tuscaloosa Research Center, clay waste was consolidated from a nominal 4 wt % solids to about 20 wt % solids. Based upon these results, a field test unit was operated at the Estech Corp. Silver City Mine, located near Bartow, FL. The unit is now operating at the Occidental Suwannee River Mine located near White Springs, FL. This report describes the results of field tests conducted to date.

OP 89–84. Mineral Processing Water Treatment Using Magnesium Oxide, by Joseph E. Schiller, Daniel N. Tallman, and Sanaa E. Khalafalla. Environ. Prog., v. 3, No. 2, May 1984, pp. 136–141. This paper describes two applications where magnesium oxide (MgO) can be used to purify process water in two ways: (1) to filter out suspended solids and (2) to precipitate dissolved heavy metals. Granular MgO (periclase mineral) out-performs sand in deep bed filters, since an MgO filter system operates with cycles up to twice as long and gives a cleaner filtrate than a comparable sand filter. To precipitate heavy metals, powdered MgO (magnesia chemical) is used instead of lime or caustic soda. The MgO-formed sludge cements into a solid mass on standing and occupies only about 20 to 30 pct of the volume as the precipitates produced by more soluble bases.

OP 90–84. Use of CO_2 Measurements in Monitoring Air Quality in Dead-End Drifts, by George H. Schnakenberg, Jr., Paul Schaefer, and John H. Johnson. Paper in Mine Ventilation, Third International Congress, Harrogate, England, June 6–13, 1984, pp. 383–389. The U.S. Bureau of Mines, in its pursuit of methods to improve the quality of the underground workplace, has funded studies on the behavior of diesel exhaust components in dead-end drifts. Real-time and time-integrated measurements of CO_2, CO, NO, and NO_2 and gravimetric measurements of particulates analyzed for hydrogen, carbon, and the nitrogen fraction were performed in several mines and under controlled conditions in a test drift. The relationship among the contaminants was examined on the basis that the CO_2 concentrations are only the result of the amount of fuel

burned and the exhaust dilution if background CO_2 is subtracted. Although the engine operates over several modes for a given production activity, the ratio of each of the other exhaust-contaminant concentrations to the CO_2 concentration was found to be relatively constant for a given engine in a given activity. The fact that the relationship is constant can be exploited in that CO_2 levels alone can be used to give a measure of the level of diesel exhaust air quality. Furthermore, time-weighted averages of the other contaminants (CO, NO, NO_2, and particulate) and CO_2, or direct tailpipe measurements with the engine suitably loaded, can be made and the ratios can be compared with previous data. Changes in the ratio indicate changes in engine and/or exhaust control systems, and maintenance may be indicated; changes in the ambient CO_2 level reflect changes in ventilation. The measurement technology and a graphical approach for this method is presented.

OP 91–84. Use of Instantaneous Samplers To Evaluate the Effectiveness of Respirable Dust Control Methods in Underground Mines, by C. D. Taylor, R. A. Jankowski, S. K. Ruggieri, and T. L. Muldoon. Ch. 32 in Aerosols in the Mining and Industrial Work Environments. Volume 2. Characterization, ed. by V. A. Marple and B. Y. H. Liu (Proc. Int. Symp. on Aerosols in the Mining and Industrial Work Environment, Minneapolis, MN, Nov. 1–6, 1981). Ann Arbor Sci., Ann Arbor, MI, 1981, pp. 433–440. Sampling strategies, which can be used in coal mines with GCA RAM (respirable aerosol monitor) instantaneous dust sampling instruments, have been developed to provide information that cannot be obtained with full-shift gravimetric sampling. As part of a Bureau of Mines dust control research contract, GCA RAM instruments were used on one longwall face to determine dust levels when using two different water spray systems. Sampling on the longwall face was conducted adjacent to and upwind of the shearer to estimate the shearer operator's exposure. A stationary face location was also sampled to profile dust levels near the shearer. Results of the sampling were compared to determine the relative dust control effectiveness of each water spray system.

OP 92–84. Issues Affecting U.S. Ferrochromium Import Dependency, by Paul R. Thomas. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984. Soc. Min. Eng. AIME preprint 84–108, 15 pp. This paper addresses two issues affecting the international ferrochromium market as they pertain to the changing pattern of U.S. chromium import dependency. These issues are (1) the long-term ferrochromium production cost differential between the United States and the Republic of South Africa, and (2) the ability of Zimbabwe to expand ferrochromium production and exportation. This paper draws upon the data and analyses of a recent Bureau of Mines Minerals Availability Program appraisal that evaluated the international availability of chromium in the form of chromite and ferrochromium from 10 market economy countries. South African ferrochromium producers are shown to have a long-term production cost advantage over U.S. producers of $0.03 to $0.04 per pound of contained chromium in 1981 dollars. Zimbabwean ferrochromium production and exportation are expected to increase in the future. Major expansions of production capacity will be dependent upon alleviating potentially serious constraints in electric power, rail, and port facilities. In the long term, ferrochromium production costs in Zimbabwe are expected to increase faster than the rate of inflation because as chromite mining from the podiform resources in Zimbabwe increases, production from the Great Dyke resources will increase.

OP 93–84. South African Gold Production: How Much, for How Long and at What Cost, by Paul R. Thomas and Edward H. Boyle, Jr. Pres. at Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26–Mar. 2, 1984. Soc. Min. Eng. AIME preprint 84–110, 11 pp. This paper addresses the long-term cost and availability of primary gold production from the Republic of South Africa. Forty-four major producing or developing operations were evaluated. The analyses present estimates concerning (1) total refined gold potentially available from demonstrated resources, (2) annual production potential into the next century, (3) long-term weighted average total costs for underground mine production and surface waste reprocessing, (4) the expected annual decrease in gold production, and (5) the ability of other market economy countries to compensate for the anticipated decline in South African gold output. This paper draws upon the data and analyses of a recent Bureau of Mines Minerals Availability Program appraisal that evaluated the worldwide availability of gold and silver from primary precious metal operations and as a byproduct of base metal production.

OP 94–84. Controlled Burnout at an Abandoned Coal Mine Fire, by Robert F. Chaiken. Paper in Proceedings of the Eighth Underground Coal Conversion Symposium (sponsored by U.S. Dep. Energy, Keystone, CO, Aug. 15–19, 1982), pp. 511–514. This paper presents a new Bureau of Mines technique called "burnout control" that shows promise for controlling fires in abandoned coal mines and waste banks and also for extracting the thermal energy represented by such "wasted" coals. The technique involves complete combustion of the coal in place while maintaining total control of the resulting heat and fumes. The thermal energy produced and brought to the surface as high-temperature gas can be as much as 20 times the equivalent thermal energy required to operate the burnout control system.

OP 95–84. Economic Benefits From Burnout of Abandoned Coal Mine Fires, by Robert F. Chaiken. Paper in Proceedings of the Ninth Annual Underground Coal Gasification Symposium, ed. by P. R. Wieber, J. W. Martin, and C. W. Byrer (sponsored by U.S. Dep. Energy, Bloomingdale, IL, Aug. 7–10, 1982). U.S. Dep. Energy, Morgantown Energy Technol. Center, Morgantown, WV, DOE/METC/84–7, Dec. 1983, pp. 523–532. Burnout control of abandoned coal mine fires was investigated by the Bureau of Mines to determine the feasibility of completely burning out the coal in situ while maintaining control of the heat and fumes produced. The control process would also enable the thermal energy developed underground to be brought to the surface as high-temperature flue gas suitable for powering an on-site, waste heat, boiler-steam turbine electrical generation plant. Since accelerated coal burning will lead to earlier self-extinguishment of the mine fire after the fuel is totally consumed, burnout control offers a means for eliminating a serious environmental problem while at the same time converting a coal waste to a coal resource. Unlike most conventional methods of extinguishing abandoned coal mine fires (such as excavation and quenching), burnout control through the production and sale of electricity can

lead to net revenues that would make the process economically viable. This paper documents some of the cost factors involved in determining the net revenues from burnout control. Net cash flow analyses indicate the possibility of sufficient rates of return from relatively low capital investment to attract the interest of private investors.

OP 96–84. Burnout Control of Fires in Abandoned Coal Mines and Waste Banks by In Situ Combustion, by R. F. Chaiken, L. E. Dalverny, M. C. Irani, and I. A. Zlochower. Paper in Proceedings of Seventh Underground Coal Conversion Symposium (sponsored by U.S. Dep. Energy, Fallen Leaf Lake, CA, Sept. 8–11, 1982), pp. 380–392. The Bureau of Mines investigated a novel approach to eliminating environmental and public safety hazards that are associated with fires in abandoned coal mines and waste banks which involves the use of in situ combustion technology to accelerate the burning of the wasted coals in place. This technology would be used under exhaust ventilation control conditions that would allow for total management of the hot gases produced. Combustion stoichiometries would be optimized to minimize unburnt combustibles and to maximize the heat content of the gas products, which will be exhausted at one or more fan locations. When necessary, scrubber systems would be employed to remove air pollutants, such as sulfur dioxide; heat utilization systems (process heat, steam, and electricity) would also be employed to offset operational costs. Ultimately, complete burnout would solve the fire and acid water formation problems of the abandoned coal mine or waste bank. Pertinent technical data from the burning of tonnage quantities of coal and coal refuse under simulated in situ conditions are discussed in this paper in terms of burnout control.

OP 97–84. Safeguarding of Blast-Affected Areas, by Dennis V. D'Andrea and Jerry Bennett. Paper in Proc. Soc. Explos. Eng. 10th Annu. Conf. on Explosives and Blasting Techniques, Lake Buena Vista, FL, Jan. 29–Feb. 2, 1984, pp. 100–119. A recent Bureau of Mines analysis has shown that failure of blast area security systems is the major cause of mine blasting accidents. Accidents occur during scheduled blasting because of failure to clear the blast zone, inadequate guarding and failure of personnel to follow instructions, retreat to a safe location, and/or failure to take adequate cover. The high incidence of blast-site security-related accidents could be considerably reduced by increased attention to improving minesite blast-guarding practices. Mining and Marketing Associates, Inc., conducted research under contract to the Bureau of Mines to determine the state-of-the-art of blast area guarding and to recommend safe procedures and areas deserving of future research. This paper is a summary of that research. Case studies of current blast area guarding practices at two surface and three underground mines are presented; practices at these five mines are considered to be much safer than those generally found in the industry. The essential elements of an effective blast-guarding system are outlined, along with recommendations for improving procedures. Although the survey of military and industrial surveillance and detection technology did not reveal any security systems immediately available for transfer to the mining industry, areas with a potential for adaptation were identified.

OP 98–84. Bureau of Mines Recycling Research, by Roger DeCesare. J. Met., July 1984, pp. 44, 143. Three areas of current Bureau of Mines recycling research are summarized in this review article: critical metals recovery from superalloy scrap, utilizing zinc wastes in electrogalvanizing processes, and rapid scrap identification technology. Metals such as cobalt, chromium, and nickel can be recovered from dissolved superalloy scrap if it is made readily leachable by first forming intermetallic compounds with either aluminum or zinc. Zinc-containing furnace dust, currently considered a potetial environmental disposal problem, can be used as a replacement for virgin zinc in electrogalvanizing processes. More scrap metal can be effectively recycled if low-cost identification and sorting methods are developed for scrap processors to use. These projects typify the broad spectrum of recycling research undertaken by the Bureau in its efforts to increase mineral recovery from wastes generated throughout the minerals industry.

OP 99–84. Maintain Filters To Control Roof Dust, by Edward Divers and John McClelland. Coal Age, v. 89, No. 8, Aug. 1984, pp. 141–142. Although the roof strata of many underground coal mines contains well over 50% silica, the exposure of roof bolter operators to excessive levels of respirable silica can be controlled readily and inexpensively by taking a few simple maintenance procedures. The primary areas for concern are dust in the blower exhaust and dust escaping the collar of the drill hole. Mine operators can provide adequate protection from dust during roof drilling by using good-quality filter cartridges and replacing them as they become clogged or damaged, flushing the collector system, and checking periodically for system leaks and overloaded filters. This paper discusses the areas for concern and some methods that can be utilized to alleviate the problems.

OP 100–84. Reducing Oxidation of Pyrite Through Selective Reclamation Practices, by Patricia M. Erickson, Robert L. P. Kleinmann, and Peter S. A. Campion. Paper in 1982 Symposium on Surface Mining Hydolrogy, Sedimentology and Reclamation, Lexington, KY, Dec. 5–10, 1982, pp. 97–102. Reclamation efforts concentrating on establishing vegetation frequently fail to control discharge of acid mine water from surface mines and coal refuse areas. A proposed method of combining control of acid drainage and establishment of vegetation is to use the plant-soil zone to produce a low-oxygen environment in the underlying pyritic material. Oxygen consumption by plant roots, soil biota and organic material decay, and oxygen diffusion barriers formed by fine-grained material provide potential means of limiting the oxygen available for pyrite oxidation. Detailed studies of field relationships among pyrite oxidation, reclamation treatments, and subsurface oxygen profiles were conducted at an experimental refuse area and an abandoned surface mine. Preliminary results from unreclaimed refuse areas indicated that significant oxygen concentrations were limited to the uppermost meter of material. A shallow, near-surface oxygenated zone was also found at the experimental refuse area in plots subjected to various reclamation treatments. Soil moisture sample pH values from the plots were generally consistent with pyrite oxidation being limited to the oxygenated zone. The effects of 13 reclamation treatments on subsurface oxygen and water quality profiles were investigated.

OP 101–84. Hydrogeochemistry of a Large Mine Pool, by Patricia M. Erickson, Robert L. P. Kleinmann, Emanuel T. Posluszny, and Patricia J. Leonard-Mayer. Paper in Proc. 1st Int. Mine Water Congr., Budapest, Hungary, Apr. 19–23, 1982, pp. 27–42. Flooded mine workings underlie approximately 17,500 ha of the northern anthracite field in northeastern Pennsylvania. The U.S. Bureau of Mines is examining the hydrology and geochemistry of this large mine pool complex in order to identify flow patterns, sources of acid mine drainage, and chemical stratification. Fluid resistivity, temperature, pH, and oxidation reduction potential are being measured with down-hole instruments in 12 mine shafts open to depths down to 460 m. Samples collected at various depths are being analyzed for concentrations of total and ferrous iron, sulfate, manganese, aluminum, pH, alkalinity or acidity, and fecal coliform bacteria. Water flowing from the mine pool remains heavily contaminated by acid mine drainage more than 30 yr after the pool started to form. One goal of this study is to determine if pyrite oxidation is still adding to the pollutant load or if previously oxidized products are being flushed from the pool. A preliminary survey of water quality at depth suggests that changes in chemical parameters within the pool are closely related to the mined-out coal seams. Generally, water quality was found to decrease gradually with depth and to change sharply at the elevation of mined-out beds. The results of this study will provide better understanding of flow and geochemical processes in the mine pool. Consequently, the effects of rehabilitation plans, such as changing the mine pool elevation or reducing surface infiltration, can be evaluated more objectively.

OP 102–84. Dust Control in Longwall Shearer Faces Through Air Movement by Water Sprays, by Natesa I. Jayaraman and Fred N. Kissell. Ch. 14 in Longwall-Shortwall Mining, State of the Art, ed. by R. V. Ramani. Soc. Min. Eng. AIME, New York, 1981, pp. 115–120. This paper describes a Bureau of Mines research project that resulted in a simple procedure for reducing the dust exposure of longwall shearer operators. The project involved researching and testing a water spray and passive shield system to hold dust against the face and away from the shearer operators. The system is known as the Shearer-Clearer.

OP 103–84. Recent Experience With the Spray Fan, by Fred N. Kissell, William Schroeder, Steven Ruggieri, and Stanley Hoover. Paper in Proc. Soc. Min. Eng. AIME, Int. Mine Ventilation Congr., Reno, NV, Nov. 4–8, 1979, pp. 685–690. Methods were developed under a Bureau of Mines contract to increase the amount of fresh air that reaches the front of a continuous-mining machine, with emphasis on removing methane buildups that occur at the cutterhead. Using a full-scale plywood mockup of a coal mine working face area, the study showed that in many instances only about 20 pct of the fresh air heading towards an exhaust brattice or tubing actually gets to within 1 ft (0.3 m) of the face. Enhancing and moving forward the natural airflow pattern will provide more air at the face, which can be accomplished by taking advantage of the air-moving abilities of the conventional water spray. It was discovered that if all the water sprays on the machine were realigned, then ventilation efficiencies of 70 pct or more were achieved regularly. This meant that if 9,000 cfm (4.2 m^3/s) was entering the brattice, at least 6,300 cfm (3.0 m^3/s) of this was reaching to within 1 ft (0.3 m) of the face. The water spray realignment consists of placing a few nozzles on the side of the machine opposite the curtain and tilting the front sprays slightly toward the curtain side. Two underground tests and two independent laboratory tests of the water "spray fan" have been completed. In general, they have confirmed the performance of the spray fan system, but they also have provided useful information as to its difficulties and limitations.

OP 104–84. Bactericidal Control of Acid Problems in Surface Mines and Coal Refuse, by Robert L. P. Kleinmann. Paper in Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, KP, Dec. 1–5, 1980, pp. 333–337. A bacterium *Thiobacillus ferroxidans,* accelerates acidification of pyritic material and significantly increases the eventual level of acid production by catalyzing pyrite oxidation in the zone of aeration. Bactericides can be effective in reducing acid formation if added to infiltrating precipitation. However, the bactericidal treatment must be repeated frequently to prevent repopulation. To accomplish this at low cost, the Bureau of Mines developed a controlled release technique involving diffusion and dissolution of anionic detergents from pellets of an elastomeric matrix. Release is expected to continue for approximately 5 yr after application of the pellets. The technique was tested in the laboratory, on small coal refuse piles in central Pennsylvania, and on hydrologically isolated sections of an abandoned surface mine in northern West Virginia. Detergent concentrations of approximately 25 ppm in the pyritic material delayed or prevented acidification of coal refuse and reduced acidity of drainage from acid-producing material by 50% to 95%.

OP 105–84. Control of Acid Mine Drainage Using Anionic Surfactants, by Robert L. P. Kleinmann and Patricia M. Erickson. Paper in Proc. 1st Int. Mine Water Congr., Budapest, Hungary, Apr. 19–23, 1982, pp. 51–63. Acid drainage from abandoned coal mines pollutes thousands of kilometers of streams in the Eastern United States and causes the coal mining industry of the area to spend millions of dollars annually to prevent further degradation of local waterways. To control the formation of acid drainage at its source, the U.S. Bureau of Mines investigated the role of iron-oxidizing bacteria in the oxidation of pyrite. It was determined that inexpensive bactericides can be used to control the rate of pyrite oxidation and thereby reduce the acidity of drainage. At concentrations of 25 mg/L or greater, certain biodegradable anionic surfactants, such as sodium lauryl sulfate, kill the acidophilic iron-oxidizing bacteria in the pyritic material. To prevent repopulation, the surfactant was incorporated into rubber pellets, from which the surfactant is gradually released over time. After an initial application of surfactant solution, these pellets were placed so as to intercept and treat infiltrating rainwater on a surface mine or refuse pile. The rubber formulation can be adjusted to modify the duration of release; results of laboratory studies were used to optimize both phases of the treatment process. The technique was tested in small-scale laboratory and field experiments. Treatment resulted in titratable acidities that were 75 pct lower than those of controls in laboratory simulations, 67 pct lower when one of two 25-metric-ton coal refuse piles was treated, and 95 pct lower when a test was

conducted on isolated sections of an acid-producing surface mine. Large-scale field tests were conducted at surface mines and coal refuse piles in Ohio, West Virginia, and Pennsylvania to provide information on adsorption of the surfactant by fine-grained particles and to determine if downstream concentrations of surfactant pose a potential environmental problem. Preliminary results indicated surfactant concentrations of the effluent of 0.1 mg/L or less, well within the World Health Organization's suggested stream concentrations of less than 1.0 mg/L.

OP 106–84. Field Evaluation of a Bactericidal Treatment To Control Acid Drainage, by Robert L. P. Kleinmann and Patricia M. Erickson. Paper in Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, KY, Dec. 7-11, 1981, pp. 325–330. The U.S. Bureau of Mines has demonstrated that inhibition of an iron-oxidizing bacterium, *Thiobacillus ferrooxidans*, slows the rate of pyrite oxidation and thereby reduces acidity in mine drainage from surface mines and coal refuse piles. Long-term inhibition is accomplished at low cost by controlled release of sodium lauryl sulfate (SLS), an anionic surfactant, from rubber pellets. In addition, surfactant solution is applied so as to treat each acre-foot of pyritic material with the equivalent of 7 lb of dry surfactant, excess surfactant must be provided to saturate the adsorption capacity of the material. The surfactant solution reduces subsequent adsorption of the slowly released SLS and provides a rapid reduction in the population of *T. ferrooxidans*. Results of laboratory studies were utilized to optimize both phases of the treatment procedure. Field tests were conducted at inactive, acid-producing surface mines and coal refuse piles at sites in Ohio, Pennsylvania, and West Virginia. It was noted that the effectiveness of the technique required good infiltration of rainfall. Percolation tests at a partially reclaimed site in West Virginia indicated that overburden that had been impacted may be too impermeable for the surfactant to infiltrate to the pyritic material. In contract, 50- to 95-pct reductions in acidity were observed in previous small-scale tests at more permeable sites.

OP 107–84. Full-Scale Field Trials of a Bactericidal Treatment To Control Acid Mine Drainage, by Robert L. P. Kleinmann and Patricia M. Erickson. Pres. at Annu. Meeting, Geol. Soc. Am., New Orleans, LA, Oct. 18–21, 1982. Abstr. With Programs, v. 14, No. 7, pp. 531–532; paper in 1982 Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, KY, Dec. 8–10, 1982, pp. 617–622. Sodium lauryl sulfate (SLS) is one of several anionic detergents known to be effective in inhibiting the iron-oxidizing bacterium, *Thiobacillus ferrooxidans*. Since *T. ferrooxidans* plays a critical role in determining the rate of pyrite oxidation, the Bureau of Mines investigated the use of SLS as a method to control the formation of acid mine drainage. In previously reported pilot-scale tests, the detergent successfully controlled *T. ferrooxidans* and thereby reduced acid production 60 to 90 pct. During 1982, the Bureau conducted five full-scale field trials at active and abandoned surface mines and coal refuse piles. The first of these tests was at a 10-acre inactive refuse pile near Beckley, WV. After a 3-month lag period, average acidity decreased from 900 mg/L to 350 mg/L and iron decreased from over 100 mg/L to 2 mg/L. An 8-acre active section of a large refuse pile was treated similarly; acidity and sulfate decreased from over 4,000 mg/L to less than 100 mg/L and iron decreased from 1,000 mg/L to 2 mg/L or less. At both sites, a single application was effective for about 4 months. Other field tests have been conducted at active and abandoned surface mines in Ohio and West Virginia.

OP 108–84. Reclamation and the Control of Acid Mine Drainage, by Robert L. P. Kleinmann and Patricia M. Erickson. Ch. 18 in Papers Presented Before the Abandoned Mine Reclamation Symposium, ed. by N. Smeck and P. Sutton (sponsored by All Ohio Chap., Soil Conserv. Soc. Am., St. Clairsville, OH, Nov. 3–5, 1982). OH State Univ., St. Clairsville, OH, 1982, pp. 18–1—18–12. The Bureau of Mines is currently evaluating reclamation practices in terms of their effect on acid production. Site-related factors, identified prior to reclamation, appear to be critical in abatement of acid production. Recent developments in acid mine drainage control, such as the use of soluble alkaline materials and the application of anionic surfactants to inhibit iron-oxidizing bacteria, are currently in use at active mining operations and are potentially applicable to abandoned mine lands. In addition, the possibility of using vegetation, mulches, and soil amendments to limit the oxygen diffusion into pyritic material is currently being investigated for potential long-term control of acid mine drainage.

OP 109–84. Delineation of Zones of Acid Mine Drainage Using Surface Geophysics, by Kenneth J. Ladwig. Paper in 1982 Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, KY, Dec. 5–10, 1982, pp. 279–287. Electromagnetic (EM) induction terrain conductivity surveys were conducted at three reclaimed surface mines in Pennsylvania to evaluate potential applications of the technique in acid mine drainage (AMD) control. At a 6-ha (15-acre) reclaimed strip mine with a perennial acidic seep issuing from the base of the spoil backfill, 2 days of EM surveying defined the locations of two pockets of acid-producing preparation plant refuse buried in the spoil and yielded information on the probable flow of ground water from the acid source to the seep. At an 8-ha (20-acre) reclaimed surface mine with acid discharges from subdrains and an intermittent seep, less than 2 days of EM surveying established the approximate positions of the buried high and low walls, defined probable flow paths to the drain outlets, and located a potential zone of ground water storage within the spoil contributing to the acidic seep. At a 15-ha (37-acre) reclaimed mountaintop removal mine with two large areas of perennial acidic seeps, 3 days of EM surveying located zones of stored water within the spoil and probable flow to the seepage areas. The results of these studies indicate that the high conductivity associated with AMD and AMD sources is a good target for electrical detection. The ease of field operations and clearly defined electrical anomalies associated with AMD and AMD sources distinguish EM as a potentially valuable tool in preliminary site characterization at acid-producing reclaimed surface mines.

OP 110–84. Electromagnetic Induction Methods for Monitoring Acid Mine Drainage, by Kenneth J. Ladwig. Ground Water Monit. Rev., v. 3, No. 1, 1983, pp. 46–51. In the past 15 yr, surface geophysical methods have found an increasing number of applications in ground water contamination monitoring. More recently, electromagnetic (EM) induction methods, long used for mineral exploration, have

been added to the suite of geophysical tools readily adaptable to ground water studies. EM surveys are used to measure terrain conductivity, or inverse resistivity. Field operations with EM methods are fast and simple, providing a rapid means of obtaining good qualitative data on shallow subsurface conductivity distributions. Successful applications of EM surveying have recently been reported for defining landfill leachate plumes and fresh and salt water interfaces. This paper discusses the use of EM methods in reclaimed mining site monitoring for three specific field examples.

OP 111–84. Influence of Passageway Fires on Ventilation Flows, by C. K. Lee, C. C. Hwang, J. M. Singer, and R. F. Chaiken. Ch. 50 in 2nd Mine Ventilation Congress, Reno, NV, Nov. 4–8, 1979. Soc. Min. Eng. AIME, New York, 1980, pp. 448–454. The influence of passageway fires on ventilation flows was investigated in three horizontal fire tunnels: (1) a laboratory-scale fire tunnel network, (2) a small-scale fire-plume tunnel, and (3) a laboratory-scale simulated mine gallery. Wood was used in the first and third tunnels and gas burners were used in the second tunnel to generate passageway fires. Experimental measurements included gas mass flow rate, velocity, temperature, and pressure on the passageways and exhaust fans. The effects of the fires were investigated by comparing the measurements obtained before and during the fires. Results show that a passageway fire essentially increases the flow resistances of the passageways of a tunnel flow network by virtue of volatile fuel mass injection and high combustion temperatures. The ventilation airflow rate is consequently throttled to lower values than that before the fire. At severe throttling, reverse flow occurs. Conditions for reverse flow are characterized by two Froude numbers based on gas velocity and density upstream of the fire and height of the passageway. The Froude numbers and the characteristics of the passageway fire are necessary to analyze mine ventilation-fire interaction and to predict mine ventilation patterns during fires.

OP 112–84. Mine Sealing by Pneumatic Stowing in Ohio, by Slavoljub D. Maksimovic. Ch. 10 in Papers Presented Before the Abandoned Mine Reclamation Symposium, ed. by N. Smeck and P. Sutton (sponsored by All Ohio Chap., Soil Conserv. Soc. Am., St. Clairsville, OH, Nov. 3–5, 1982). OH State Univ., St. Clairsville, OH, 1982, pp. 10-1—10-14. The Bureau of Mines tested a method of constructing mine seals using pneumatic stowing to backfill six abandoned mine openings in Ohio. During the stowing, well-graded aggregate with sufficient fines was ejected from a nozzle at high velocity, creating a high-compaction fill upon impact. The method is safer and faster than conventional methods, it is cost competitive, and it eliminates or reduces the exposure of workers to possible hazards, since they can be kept outside the openings. The technique may be used for sealing abandoned and active mine openings, even in remote locations and during severe weather conditions.

OP 113–84. Ferrous Iron Oxidation by *Thiobacillus Ferrooxidans*: Inhibition With Benzoic Acid, Sorbic Acid, and Sodium Lauryl Sulfate, by Steven J. Onysko, Robert L. P. Kleinmann, and Patricia M. Erickson. Appl. Environ. Microbiol., v. 48, No. 1, July 1984, pp. 229–231. Acid mine drainage is formed by the weathering or oxidation of pyritic material exposed during the mining of coal deposits and is a major water pollution problem in the Appalachian region of the United States. The rate of pyritic material oxidation can be greatly accelerated by certain acidophilic bacteria such as *Thiobacillus ferrooxidans*. These bacteria promote indirect oxidation of pyrite through the catalysis of the oxidation of ferrous iron to ferric iron. These bacteria also may catalyze direct oxidation of pyrite to oxygen. A number of organic compounds, under laboratory conditions, can apparently inhibit both the oxidation of ferrous iron to ferric iron by *T. ferrooxidans*, and the weathering of pyritic material by mixed cultures of acid mine drainage microorganisms. Sodium lauryl sulfate (SLS), an anionic surfactant, has proved effective in this regard. Benzoic acid, sorbic acid, and SLS at low concentrations, each effectively inhibited bacterial oxidation of ferrous iron in batch cultures of *T. ferrooxidans*. The rate of chemical oxidation of ferrous iron in low-pH, sterile batch reactors was not substantially affected at the tested concentrations of any of the compounds.

OP 114–84. General Methods of Primary Dust Control During Cutting, by W. W. Roepke. Min. Eng., v. 36, No. 6, June 1984, pp. 636–644. One phase of Bureau of Mines research deals with reduction of primary respirable dust generated by bit cutting action at a coal seam face. This paper presents a summary of coal cutting technology addressing this problem. All aspects of the cutting system affecting miner health and safety are discussed. Cutting design concepts are considered that minimize dust generation, energy used, and ignitions, while maintaining production. With present equipment, an operator can maintain production and minimize dust energy and ignitions by cutting at maximum depth (maximum sumping or advance rate) at all times, at minimum revolutions per minute with fewest possible bits, and with lowest possible included bit tip angle, i.e., minimum bit wear.

OP 115–84. Insoluble Cross-Linked Starch Xanthate as a Selective Flocculant for Sulfide Minerals, by S. C. Termes, R. L. Wilfong, and P. E. Richardson. Pres. at Soc. Min. Eng. AIME Annu. Meeting, Dallas, TX, Feb. 14–18, 1982. Soc. Min. Eng. AIME Trans., v. 274, 1984, pp. 1971–1977. This paper discusses recent Bureau of Mines research on the selective flocculation of various minerals with insoluble cross-linked starch xanthate (ISX). ISX is insoluble, has a shelf life of more than a year when kept cold, and has a higher molecular weight due to cross-linking than the soluble, noncross-linked starch xanthate used in previous flocculation studies on nonsulfide minerals. ISX readily flocculates a number of sulfide mineral fines, but no siliceous gangue. Floc formation, floc size, and settling rate are dependent on pH. The pH dependence, however, differs for each mineral. Bornite has been selectively flocculated from bornite-quartz mixtures, and the bornite-containing flocs were separated from the unflocculated quartz using decantation and washing procedures.

OP 116–84. Methane Encountered at the Bureau of Mines Oil Shale Shaft, by Robert P. Vinson, Kenneth C. Cox, and Fred N. Kissell. Paper in Proc. 12th Oil Shale Symp., Denver, CO, Apr. 17–20, 1979, pp. 339–842. In studies published in 1975 and 1977, the Bureau of Mines called attention to the possibility that deep oil shale mines would be gassy. The presence of methane gas in mines creates an addi-

tional hazard as well as impacting the economics of mining. In November 1978, a methane ignition occurred in the Bureau of Mines oil shale research shaft in Colorado, which was subsequently classified as gassy by the Mine Safety and Health Administration. In December 1978, a second ignition was followed by a fire that necessitated flooding of the shaft. The present paper briefly reviews the circumstances surrounding those incidents and their implication for methane gas hazards in other oil shale deposits.

OP 117–84. Alloy Plating Using a Particle Occlusion Method, by J. E. Allison, Jr., and G. R. Smith. Paper in 71st Annual Technical Conference, American Electroplaters' Society, SUR/FIN '84, Session K—Alloy Plating I (New York, July 16–19, 1984). Am. Electroplat. Soc., Winter Park, FL, 1984, pp. 1–14. As part of a broad research program on conservation of critical metals, the Bureau of Mines studied a modified aqueous electrodeposition method for preparing stainless steel type alloy coatings. Chromium powder ($\simeq$2 μm) was suspended in an Fe-Ni alloy electroplating bath and occluded in the alloy electrodeposit matrix. The occlusion process was significantly affected by the composition of the electrolyte and the structure and composition of the electrodeposited matrix. A maximum quantity was occluded when the electrodeposited matrix consisted of a crystallographic dual-phase γ(Ni,Fe)-α(Fe,Ni) structure. Up to 21 wt pct Cr was occluded from Cr powder suspensions of 20 vol pct. Heat treatment at 800° to 1,100° C served to homogenize the composite coatings. An interdiffusion region of $\simeq$80 μm was observed at the AISI 1020 substrate–alloy coating interface after heat treatment of a 125-μm-thick composite coating. Martensitic type stainless steel coatings have been produced.

OP 118–84. Oxygen Solubility in Brines, by Stephen D. Cramer. Ind. and Eng. Chem., Process Des. and Dev., v. 23, No. 3, July 1984, pp. 618–620. The solubility of oxygen in water and brines, expressed as the Henry's law constant, is reported for temperatures from 0 to 300° C. A smoothing and interpolation formula based upon a widely used heat capacity equation fit the solubility data well over this temperature range and may be extrapolated to somewhat higher temperatures. The solubility of oxygen in water and brines exposed to air saturated with water vapor is given for temperatures from 0° C to the normal boiling point.

OP 119–84. Solubility of Methane in Brines From 0 to 300° C, by Stephen D. Cramer. Ind. and Eng. Chem., Process Des. and Dev., v. 23, No. 3, July 1984, pp. 533–538. The solubility of methane was measured in brines at temperatures from 0 to 300° C by the technique of gas extraction. Results, expressed in terms of the Henry's law constant, were fit to a smoothing and interpolation formula for subsequent interpretation and analysis. The results can be extrapolated to temperatures above 300° C. The Henry's law constant exhibits maximums in the temperature range 80° to 100° C. Methane is salted out with increased concentration of dissolved salts. The salting-out coefficient is strongly dependent upon temperature. The effect of temperature on solubility in a hypersaline geothermal brine is different from that for the simpler sodium chloride brines owing to the more complex chemistry of the geothermal brine.

OP 120–84. Staged Heap Leaching—Direct Electrowinning, by J. A. Eisele, C. H. Elges, M. D. Wroblewski, and G. E. McClelland. Paper in First International Symposium on Recovery of Precious Metals (sponsored by Int. Symposia on Mining, Reno, NV, June 10–14, 1984). Miller Freeman Publ., San Francisco, CA, 1984, pp. 21–29. The Federal Bureau of Mines, Reno Research Center, is conducting research to develop a staged agglomeration-heap leaching system and to electrowin the dissolved precious metals from the pregnant leaching solution. For direct electrowinning to be successful, the pregnant solutions generated during the initial stages of leaching must be higher grade than obtained by conventional heap leaching. The precious metal concentration of the pregnant solution can be increased by agglomeration pretreatment with cyanide solution that starts the leaching process during the curing period, by leaching with small volumes of solution, and by cycling the leaching solution through more than one heap in a staged manner. The resulting pregnant solution is passed directly through an electrowinning circuit. The barren solution from electrowinning is recycled to the leaching circuit. Bench-scale research on the development of the staged leaching system and on the development of an efficient electrowinning cell is described.

OP 121–84. Improved Sprayfans Provide Ventilation Solutions, by Steven K. Ruggieri, Diane M. Doyle, and John C. Volkwein. Coal Min., v. 21, No. 4, Apr. 1984, pp. 94–96, 98. The Bureau of Mines has refined the original spray-fan system (water sprays that move and direct air) into a simpler and more effective improved spray fan. The system has concentrated sprays at the mine hinge point and increased front spray power and angle to improve the face ventilation of a full-scale laboratory model. Tracer gas testing in the model showed a 40-pct improvement in face ventilation over the original spray-fan system.

OP 122–84. Techniques for Recovering Metal Values From Postflash Geothermal Brines, by L. E. Schultze. Paper in Geothermal Energy: Bet On It!, ed. by R. Wright and R. G. Richards (Geotherm. Resour. Council Annu. Meeting, Reno, NV, Aug. 26–29, 1984). Trans. Geotherm. Resour. Council, Davis, CA, v. 8, Aug. 1984, pp. 159–162. The U.S. Department of the Interior, Bureau of Mines, devised methods for recovering metal values from postflash geothermal brines. A ZnS-PbS concentrate was obtained by treating brine with H_2S and lime. Subsequently iron and manganese were removed by using a lime slurry to adjust the pH of the brine to 8.5. Lithium was precipitated by treating brine with a solution of $AlCl_3$ and adjusting the pH to 7.5 with a lime slurry. The mixed Al-Li precipitate was dissolved with HCl, and the resulting solution was treated with gaseous HCl to separate Li from Al and recover $AlCl_3$ for recycle. The LiCl solution was distilled to recover HCl, and the distillation residue was purified to remove $CaCl_2$. The LiCl product was 99.9 pct pure. The treated brine was acidified to pH 5.5 and returned to the injection well.

OP 123–84. Small Hydropower Development for Mining Industry, by Robert N. Torbin, Steven D. Lautenschlaeger, and Edward D. Thimons. Paper in Water For Resource Development (Am. Soc. Civ. Eng., Hydraulics Div., Conf., Coeur d'Alene, ID, Aug. 14–17, 1984. Am. Soc. Civ. Eng., 1984, pp.

684–688. The high temperatures and humidities encountered in deep mines make a comfortable and healthy work environment difficult and expensive to maintain. Therefore, large refrigeration systems are employed to condition the working air to help control temperature and humidity. The refrigeration systems can be located on the surface or underground on the working levels of the mine. Regardless of location, large quantities of water are required to be brought into the mine to operate these refrigeration systems. The large values of head and flow offer an excellent opportunity for energy recovery due to the large amount of available potential energy. This paper describes a program the Bureau of Mines has undertaken to study the feasibility of recovering this energy.

OP 124–84. Evaluation of Instruments for Monitoring the Effectiveness of Dust Control Techniques, by Kenneth L. Williams. Paper in Proceedings of the Symposium on Control of Respirable Coal Mine Dust (cosponsored by Mine Safety and Health Administration, U.S. Dep. Labor, and labor and management of the coal industry), ed. by J. A. Barrett, M. Jacobson, W. H. Sutherland, G. R. Tinney, and P. M. Turcic, Beckley, WV, Oct. 4–6, 1983, pp. 217–237. The Bureau of Mines is evaluating three dust measuring instruments that could be used to monitor the effectiveness of dust control techniques. The real-time aerosol monitor, a commercially available nephelometer, has been extensively tested and widely used by Bureau research personnel. Another commercially available nephelometer called the MINI-RAM is currently undergoing evaluation by the National Institute for Occupational Safety and Health and the University of Minnesota. The tapered element oscillating microbalance is an experimental prototype that relates the frequency of oscillation of a special tapered element-filter combination to the mass of dust collected on the filter. This presentation includes a description of each instrument, most recent test results, and a brief discussion of potential applications.

OP 125–84. Mineral Industries of China, by E. Chin. Paper in Mining Annual Review, M. West (ed.). The Min. J. Ltd., London, England, reprint, 1984, 4 pp. This paper presents data on the minerals industry of China covering foreign investments; basic tax changes; exploration; and the coal, oil and gas, and iron and steel industries.

OP 126–84. Mineral Industries in the U.S.S.R., by Richard M. Levine. Paper in Mining Annual Review, M. West (ed.). The Min. J. Ltd., London, England, reprint, 1984, 13 pp. This paper presents data on the minerals industry of the U.S.S.R. covering issues and events, mineral industry technology, secondary production, production plans, and foreign trade and assistance.

OP 127–84. In-Line Aeration and Treatment of Acid Mine Drainage, by Terry E. Ackman, Robert L. P. Kleinmann, and Steven J. Onysko. Paper 29 in Symposium on the Reclamation, Treatment and Utilisation of Coal Mining Wastes (Durham, England, Sept. 10–14, 1984). National Coal Board, United Kingdom, Sept. 1984, pp. 29.1–29.12. This report describes a Bureau of Mines designed treatment system, currently in full-scale operation, that has proved to have economic and environmental advantages over conventional treatment. The in-line aeration and treatment system functions in existing acid mine drainage pipelines using the energy of existing mine water discharge pumps. The system offers reduced maintenance, operating, and capital costs as well as improved iron oxidation reaction time.

OP 128–84. Evaluating and Improving Materials for Mineral Processing, by R. Blickensderfer, J. H. Tylczak, B. W. Madsen, and J. S. Hansen. Paper in Int. Conf. on Tribology in Mineral Extraction War on Wear, London, England, Sept. 17–19, 1984. Mech. Eng. Publ. Ltd., London, England, v. 11, No. C347/84, 1984, pp. 15–21. The Bureau of Mines, U.S. Department of the Interior, is actively engaged in the war on wear. The emphasis of its research is on improving the wear resistance of materials that contain strategic and critical metals by applying metallurgical processes such as heat treatment and microstructural control. Another approach is to reduce the amounts of strategic and critical metals in certain alloys while maintaining adequate wear resistance by substituting other metals or by using alternative metallurgical processes. Because the greatest wear losses occur during comminution of ore, materials used in crushing and grinding mills have received much attention. This paper presents research on spalling and abrasion of commercial grinding balls and white cast irons, abrasion resistance of low-alloy steels, cast-on hardsurfacing, slurry wear of materials, and ball mill erosion-corrosion.

OP 129–84. Substitutes for Chromium in Stainless Steels, by John S. Dunning, Max L. Glenn, and Howard W. Leavenworth, Jr. Met. Prog., v. 126, No. 5, Oct. 1984, pp. 19–24. The United States is completely dependent upon foreign sources for chromium, with major reserves concentrated in the Republic of South Africa and Zimbabwe. Although supplies of chromium are said to be sufficient for 600 years, the economic and strategic consequences of a disruption in this supply for a lengthy period could be quite serious. Concern for U.S. dependence on foreign sources for chromium has prompted research by the Bureau of Mines and others that has begun to clarify some options for potential substitution. The focus of this article is on elements that can replace all or part of the chromium in stainless steels.

OP 130–84. A Spray Fan To Deliver More Air to the Coal Face, by Fred Kissell. Paper in Proc. 1978 National Safety Congress, Chicago, IL, Oct. 12–15, 1978, p. 14. The conventional water spray of the sort found on mining machinery is known to move a moderate quantity of air. This research showed that if all of the water sprays on a continuous miner were arranged to act in concert, then a substantial amount of air could be moved to the working face during cutting. The result is a lowering of methane concentrations and greatly reduced probability of face ignitions.

OP 131–84. New Developments in Mine Ventilation, by Fred N. Kissell. Ch. 6 in Underground Mining Methods Handbook, ed. by W. A. Hustrulid. Soc. Min. Eng. AIME, 1982, pp. 1674–1679. Recent developments in mine ventilation are reviewed. For hard-rock mines, the list includes new types of stoppings and a method to easily measure stopping leakage. A tracer gas technique for measuring mine ventilation airflow is also discussed. For coal, items

include improvements in face ventilation, drainage of methane, and forecasting methane emissions.

OP 132–84. Measuring the Methane Content of Coalbeds for Resource Evaluation, by Charles M. McCulloch, Jeffrey R. Levine, Fred N. Kissell, and Maurice Deul. Pres. at Geol. Soc. Am. Annu. Meeting, Salt Lake City, UT, Oct. 20–22, 1975. Abstr. With Programs, 1975, pp. 1194–1195. The methane content of coalbeds can be measured prior to mining by using a simple Bureau of Mines technique called the "direct method." Coal cores from exploration drilling are enclosed in an airtight canister when the core barrel is brought to the surface. Methane emitted into the canister from the coal core is used to calculate coalbed gas content.

OP 133–84. Overview of Bureau of Mines Coal Mine Research, by John N. Murphy. Min. Technol., v. 66, No. 766, Aug. 1984, pp. 259–272. The Bureau of Mines mining research program is divided into two principal problem areas: health and safety and conservation and development; both programs address coal as well as metal and nonmetal problems, but this paper is limited to coal mining activities. The health and safety program addresses problems in underground and surface mines and in surface facilities associated with those mines. The conservation and development program focuses on problems relative to reducing the environmental impact of productivity and resource recovery. The emphasis of this paper is directed toward recent accomplishments that will be available to industry in the near future.

OP 134–84. Chemical and Electrochemical Reactions in the Chalcocite-Xanthate System, by C. S. O'Dell, R. K. Dooley, G. W. Walker, and P. E. Richardson. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods (165th Meeting sponsored by Electrochem. Soc., Cincinnati, OH, May 6–11, 1984). Electrochem. Soc., Inc., Pennington, NJ, v. 84–10, 1984, pp. 81–95. The interactions between chalcocite and ethylxanthate were examined by the Bureau of Mines in an electrochemical-microflotation cell containing a particle bed working electrode. Cyclic voltammetry showed the formation of a chemisorbed product commencing at −0.5 V (saturated calomel electrode) with bulk oxidation products, possibly cuprous xanthate, forming above −0.23 V. Relating the charge passed on a potentiostated mineral bed after addition of xanthate to spectrophotometric changes in xanthate suggests the presence of a fast chemical reaction and a charge transfer reaction. The strong correlation between flotation response and potential indicates that chemisorption of the ethylxanthate produces a hydrophobic layer sufficient for chalcocite flotation.

OP 135–84. Keystone Achieves Positive Dust Control During Dry Drilling, by Steven J. Page and Mark Folk. Eng. and Min. J., v. 185, No. 9, Sept. 1984, pp. 84–85. In conventional room-and-pillar mining, the drilling of mining faces is frequently a severe source of airborne dust. Without the use of effective dust control, instantaneous total dust concentrations occasionally reach or exceed 200 mg/m^3, and the time-weighted average often exceeds the 10-mg/m^3 total dust standard. The control of dust produced by face drilling includes dry collection systems or the following three wet dust suppression systems: external water sprays, water injection through the drill, or foam injection through the drill.

OP 136–84. Correlations Between Measurements With RAM-1 and Gravimetric Samplers on Longwall Shearer Faces, by Steven J. Page and Robert A. Jankowski. Am. Ind. Hyg. Assoc. J., v. 45, No. 9, 1984, pp. 610–616. Simultaneous RAM-1 and gravimetric personal sampler respirable dust measurements were made by the Bureau of Mines at two locations adjacent to a moving shearer on longwall faces. These locations were (1) 4.6 to 6.1 m (15 to 20 ft) on the ventilation intake side of the shearer headgate drum and (2) at the shearer midpoint, between the two operators. Despite the fact that the RAM-1 monitors were laboratory-calibrated to five equivalent readings, underground readings were often lower, particularly at the intake side of the shearer. The RAM-gravimetric ratio of all readings was 0.53 at the intake position and 0.75 at the midpoint position for all data. When only head-to-tail cut passes were analyzed, the RAM-gravimetric ratios were 0.58 at the intake position and 1.00 at the midpoint position. The difference between RAM and gravimetric dust readings is attributed to a combination of factors such as ambient air velocity and cyclone orientation.

OP 137–84. Semiconducting Characteristics of Galena Electrodes, by P. E. Richardson and C. S. O'Dell. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods (165th Meeting sponsored by Electrochem. Soc., Cincinnati, OH, May 6–11, 1984). Electrochem. Soc., Inc., Pennington, NJ, v. 84–10, 1984, pp. 132–151. Electrochemical, interfacial capacitance, and surface photovoltage measurements were used by the Bureau of Mines in a study of oxygen reduction and xanthate chemisorption on in situ cleaved natural and synthetic lead sulfide crystals. Electrodes cleaved in nitrogen sparged 0.1*M* sodium tetraborate assume the flatband potential, V_{fbp}, at the instant of cleavage, and thus the cleavage potential decreases with increasing bulk electron concentration. Highly n-type electrodes have a cleavage potential (V_{fbp}) of $\simeq$ −0.6 V (SCE [saturated calomel electrode]), and highly p-type electrodes have a value of $\simeq$ −0.2 V (SCE). The space charge is readily varied by applied potentials in the range −0.2 to −0.6 V. The effect of the variable space charge layer on oxygen reduction and xanthate chemisorption is discussed.

OP 138–84. Ventilation Monitoring Instrumentation, by George H. Schnakenberg, Jr., and Fred N. Kissell. Ch. 5 in Underground Mining Methods Handbook, ed. by W. A. Hustrulid. Soc. Min. Eng. AIME, 1982, pp. 1669–1678. Currently available ventilation monitoring instrumentation is reviewed. Price and availability are discussed. Guidelines for proper use of the most common air velocity instruments are given, and their performance limitations reviewed. MSHA-approved gas detectors are listed.

OP 139–84. Zinc and Copper Electrowinning Combined With Sodium Perchlorate Production, by G. R. Smith. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods (165th Meeting sponsored by Electrochem. Soc., Cincinnati, OH, May 6–11, 1984). Electrochem. Soc., Inc., Pennington, NJ, v. 84–10, 1984,

pp. 548–561. Electrolysis studies by the Bureau of Mines have demonstrated that zinc and copper electrowinning can be combined with the electrochemical production of sodium perchlorate in a cationic membrane cell to achieve a significant decrease in the use of electrolysis energy. Current efficiencies exceeding 88 and 80 pct were obtained for electrowinning and electrochemical production, respectively, using typical current densities, electrolyte compositions, and electrolysis periods. The cationic membrane effectively separated the two half-cells, allowing as low as 1.5 pct (0.9 g) of the Zn^{2+}, 0.02 pct (0.01 g) of the Cu^{2+}, 0.9 pct (0.25 g) of the ClO_4^-, and 1.0 pct (2.9 g) of the SO_4^{2-}, to interdiffuse during electrolysis.

OP 140–84. Upgrading High-Iron Chromite Concentrates by Carbonyl Processing, by A. Visnapuu and W. M. Dressel. Ch. 16 in Process Mineralogy III. Applications in Metallurgy, Coal, Concrete, Smelting and Exploration, ed. by W. Petruk (Proc. Symp. sponsored by Process Mineral. Comm., SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6–10, 1983). Soc. Min. Eng. AIME, New York, 1984, pp. 259–274. The Bureau of Mines, U.S. Department of the Interior, has upgraded high-iron domestic chromite concentrate to high-chromium concentrate by a laboratory carbonyl process. The chromite concentrate product has a chromium-to-iron ratio in excess of 3:1 compared with the starting concentrate ratio of 1.6:1. The high-iron chromite was first reduced to convert the iron oxides to the metal, and then treated with carbon monoxide at elevated pressures and low temperatures to convert the metallic iron fraction to iron pentacarbonyl. Carbonylation was accelerated by the addition of hydrogen sulfide in small quantities. A constant flow of carbon monoxide swept the iron pentacarbonyl formed in the reactor out through a pressure-reducing valve. The mixture of carbon monoxide and iron pentacarbonyl at atmospheric pressure was then passed through a heated section to decompose the iron pentacarbonyl to carbon monoxide and iron, whereupon the latter plated out on the heated surface. Carbon monoxide pressure, temperature, and promoter trends for enhanced carbonylation are presented.

OP 141–84. Correlation of the Electrosorption of Sulfur and Thiol Collectors With Contact Angle and Flotation, by G. W. Walker, C. P. Walters, and P. E. Richardson. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods (165th Meeting sponsored by Electrochem. Soc., Cincinnati, OH, May 6–11, 1984). Electrochem. Soc., Inc., Pennington, NJ, v. 84–10, 1984, pp. 202–218. The hydrophobic character of a variety of base-metal sulfides was examined in the presence of sodium hydrosulfide and potassium ethylxanthate. The magnitudes of hydrophobicity induced by electrodeposition of sulfur and by electrochemical reaction between the minerals and ethylxanthate were determined by contact angle measurements on polished surfaces and by flotation of mineral particles. During flotation, mineral-reagent interactions were followed by monitoring the solution composition spectrophotometrically. The results show that on gold and chalcopyrite the oxidation of hydrosulfide to sulfur and the oxidation of ethylxanthate to dixanthogen produced hydrophobic surfaces, while on pyrite, sulfur deposition was more effective than dixanthogen in producing a hydrophobic surface. Chalcocite, in contrast to gold, chalcopyrite, and pyrite, was found to react directly with ethylxanthate and hydrosulfide, but only the metal xanthate product was hydrophobic. Covellite, which is a possible product of the reaction between hydrosulfide and chalcocite, did not react with hydrosulfide but behaved more like a catalytic surface for the deposition of sulfur.

OP 142–84. Agglomeration Heap Leaching of Precious Metals, by J. A. Eisele and D. L. Pool. Paper in Leaching. Unit Operations and Processes (14th Annu. Hydrometall. Meeting, Timmins, Ontario, Canada, Oct. 14–17, 1984). CIM Metall. Soc., Timmins, Ontario, Canada, No. 11, 1984, pp. 1–15. The Bureau of Mines developed a particle agglomeration technique to improve the flow of leaching solution through heaps of low-grade gold and silver ores that contain clays. Bench-scale experiments and industrial practice show that the percolation rate of cyanide leaching solution is greatly enhanced by mixing the ore with Portland cement as a binder, moistening the mixture, mechanically tumbling to form agglomerates, and aging before heap building and leaching. A slight modification of the technique allows its application to precious-metal-bearing tailings, which cannot normally be treated by heap leaching because they are too fine.

OP 143–84. Cutting Trials With a Water-Jet-Assisted In-Seam Tester, by Robert J. Evans, Howard J. Handewith, and Michael Hood. Ch. 78 in Rock Mechanics in Productivity, Protection (25th Symp. on Rock Mechanics, Chicago, IL, June 25–27, 1984), pp. 767–773. An in-seam tester, a hydraulically activated single-pick instrument to measure and record pick cutting forces, was designed and fabricated to establish criteria necessary for the design and development of a water-jet-assisted rotary drum cutting system using moderate-pressure jets (3,000 to 10,000 psi). Data are presented for cutting trials in a simulated coal block and underground in the Pittsburgh coal seam for water-jet assist and dry cutting. Data analyses indicate that water-jet assist significantly reduces pick forces.

OP 144–84. Assessment of Environmental Impacts Associated With Phosphogypsum in Florida, by Alexander May and John W. Sweeney. Paper in The Chemistry and Technology of Gypsum, ed. by R. A. Kuntze (Symp. sponsored by ASTM Committee C-11 on Gypsum and Related Building Materials and Systems, Atlanta, GA, Apr. 14–15, 1983). ASTM Spec. Tech. Publ. 861, Oct. 1984, pp. 116–139. In its role to provide technology to prevent or limit adverse environmental impacts associated with mining or minerals processing, the U.S. Bureau of Mines has conducted research at its Tuscaloosa Research Center to assess the environmental impacts of phosphogypsum produced by the Florida phosphate industry. Over the years, stockpiles containing 304 million metric tons of phosphogypsum have accumulated, and the industry continues to generate an additional 30 million metric tons per year. Samples from approximately 300 m of drill core, obtained from 9 stockpiles, were characterized using chemical, X-ray diffraction, emission spectrographic, radiological, and physical means. The data developed indicated that phosphogypsum is not a corrosive or toxic hazardous waste as defined by the Environmental Protective Agency criteria. Radium analyses averaged 21 pCi/g and its content was inversely related to particle sizes. Thirty-nine elements were detected in phosphogypsum; concentrations of these elements did not vary with depth within the stockpiles.

OP 145–84. Evaluation of Radium and Toxic Element Leaching Characteristics of Florida Phosphogypsum Stockpiles, by Alexander May and John W. Sweeney. Paper in The Chemistry and Technology of Gypsum, ed. by R. A. Kuntze (Symp. sponsored by ASTM Committee C-11 on Gypsum and Related Building Materials and Systems, Atlanta, GA, Apr. 14–15, 1983). ASTM Spec. Tech. Publ. 861, Oct. 1984, pp. 140–159. The U.S. Bureau of Mines conducted studies to determine if phosphogypsum, a waste material from the processing of phosphate rock, contains hazardous toxic materials as defined by the Environmental Protection Agency (EPA) and whether leaching of these toxic materials and radium may occur. Samples of the phosphogypsum stockpiled material were evaluated using the EPA extraction procedure, atomic absorption, neutron activation, X-ray diffraction, and chemical and physical means. Radiological tests performed used both the germanium-lithium and emanation methods. The data show that the phosphogypsum stockpiles are not hazardous toxic waste as defined by EPA criteria. Trace elements and radium are not leached from the phosphogypsum stockpiles. Absorption of trace elements and radium by phosphogypsum is the major reason for their not being leached. The standard error of measurement of radium concentrations was 4.7 pCi/g.

OP 146–84. CSM-USBM Rotary Cutting Machine: Research Capabilities and Trials for Improving the Performance of Tunnel, Shaft and Raise Boring Machines, by Levent Ozdemir, Robert J. Evans, Russell J. Miller, and William Sharp. Ch. 7 in 1983 RETC Proceedings, Volume 1 (6th Rapid Excavation and Tunneling Conf., Chicago, IL, June 12–16, 1983). CO School of Mines, Golden, CO, 1983, pp. 106–130. This paper describes the specifications and capabilities of a 6-ft (1.83-m) diameter laboratory rotary cutting machine that was designed and fabricated under a Bureau of Mines contract awarded to the Colorado School of Mines. The machine will be used to carry out research and development programs aimed toward improving the design and operation of mechanical tunnel, shaft, and raise boring equipment.

OP 147–84. Development of a Water Jet Assisted Drag Bit Cutting Head for Coal Measure Rock, by Levent Ozdemir and Robert J. Evans. Ch. 41 in 1983 RETC Proceedings, Volume 2 (6th Rapid Excavation and Tunneling Conf., Chicago, IL, June 12–16, 1983). CO School of Mines, Golden, CO, 1983, pp. 701–718. An ongoing research program at the Colorado School of Mines is investigating the application of low-to-moderate pressure water jets to assist the cutting performance of drag-type cutter bits commonly used on coal mine cutting machinery. The results to date indicate that a water jet directed to impinge the rock in the immediate vicinity of cutter tip can provide significant benefits in terms of reduced cutting forces, prolonged bit life, and less airborne dust, as well as reduced tendency of sparking during cutting. This paper describes the findings of this research effort designed to fully evaluate and optimize the parameters affecting the performance of a combined water-jet-assisted, drag-bit cutting system for coal mine applications.

OP 148–84. Water Jet Coal Cutting: The Resurgence of an Old Technology, by William E. Souder and R. J. Evans. Ch. 42 in 1983 RETC Proceedings, Volume 2 (6th Rapid Excavation and Tunneling Conf., Chicago, IL, June 12–16, 1983). CO School of Mines, Golden, CO, 1983, pp. 719–739. From time to time, major technological innovations arise that alter the time-honored ways of doing things. Such innovations can dramatically benefit society in terms of new products, increased outputs, reduced costs, and general modernizations. However, the advent of these types of technologies is likely to be resisted because of their uncertain potentials, and because they disrupt established routines and industry patterns. This paper reviews the case history of water jet coal cutting, and assesses its potential to become a major innovation within the next decade.

OP 149–84. Some Patterns of Technology Transfer and Utilization in Water Jet Cutting, by William E. Souder and R. J. Evans. Paper in The Second U.S. Water Jet Symposium, ed. by D. A. Summers and F. F. Haston (sponsored by School of Mines & Metallurgy, Univ. MO—Rolla, MO, May 24–26, 1983). Univ. MO—Rolla, MO, 1983, pp. 225–234. From time to time, major technological innovations arise that alter the time-honored ways of doing things. Such innovations can dramatically benefit society in terms of new products, increased outputs, reduced costs, and general modernizations. However, the advent of these types of technologies is likely to be resisted because of their uncertain potentials, and because they disrupt established routines and industry patterns. This paper reviews the case history of water jet coal cutting and assesses its potential to become a major innovation within the next decade.

OP 150–84. Chlorination-Grade Feedstock From Domestic Ilmenite, by John B. Wright, Gerald W. Elger, Jack E. Tress, and Harry E. Bell. Pres. at Soc. Min. Eng. AIME Fall Meeting, Denver, CO, Oct. 24–26, 1984. Soc. Min. Eng. AIME preprint 84–379, 1984, 13 pp. This paper describes laboratory techniques and subsequent results of Bureau of Mines research to produce chlorination-grade feedstock from an abundant, low-grade, domestic, rock ilmenite ore. The research is part of the Bureau effort to devise technology that may help decrease U.S. dependence on imported raw materials. A rock ilmenite containing about 46 wt pct TiO_2 was smelted in an electric arc furnace with coke, woodchips, and Na_2CO_3 to separate most of the iron as pig iron and to form a low-iron, titanium-enriched slag. The slag was ground, pelletized, oxidized, and then sulfated with mixtures of SO_2 and air in a continuous 4.5- to 9.1-kg/h apparatus at 1,023 to 1,223 K. The sulfated slag, containing 60 to 65 pct TiO_2, was reground and leached in water at ambient temperature to decrease the combined levels of the troublesome Ca, Mg, and Mn impurities from 7.0 to 1.7 wt pct. At levels of more than 3 wt pct, these impurities contribute to operating and disposal problems. The final product was upgraded to about 84 wt pct TiO_2. This material potentially is suitable for chlorination in a fluidized-bed reactor. The most favorable results were achieved with leached slag sulfated at a feedrate of 4.5 kg/h and at temperatures of 1,073 to 1,123 K.

OP 151–84. Strategy in Reducing Dust in the Coal Mines of the United States, by John A. Breslin. Paper in VIth International Pneumoconiosis Conference, Bochum, Federal Republic of Germany, Sept. 20–23, 1983. ILO, Washington, DC, v. 3, 1984, pp. 1724–1729. This paper describes the strategy and the technical measures used in the United States to control respirable dust in coal mines. Federal law limits the average respirable dust concentration to

which each coal miner may be exposed to no more than 2.0 mg/m³. The allowable dust limit is reduced if the quartz content of the dust exceeds 5 pct. Dust measurements are made in the mines using personal gravimetric dust samplers worn by the miners. The average dust concentration for continuous mining machine operators was reduced from about 6.5 mg/m³ in 1968 to 1.3 mg/m³ in 1980. This success was due primarily to improvements in face ventilation. In some mines significant dust reductions have been achieved by use of dust collectors mounted on the mining machines. Control of dust is much more difficult for longwall operations, and the Bureau of Mines has conducted extensive research since 1979 to alleviate this problem. Some new techniques have been developed that enable mine operators to comply with the 2.0 mg/m³ dust standard for longwalls. One new technique uses the air entrained by water sprays to divert dust away from the shearer operators and reduces dust exposure by as much as 50 pct. Dust reductions have also been achieved by improvements in longwall face ventilation, more efficient use of water, and modifications in the methods of coal cutting.

OP 152–84. Direct Electrowinning of Gold, by C. H. Elges III, M. D. Wroblewski, and J. A. Eisele. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods. Electrochem. Soc., Pennington, NJ, v. 84–10, 1984, pp. 501–512. Electrowinning gold and silver from cyanide leaching solutions has been utilized by industry for many years. Steel wool cathodes are loaded to high levels with precious metals and fire-refined to produce dore bullion. If the leaching solutions are dilute, the gold and silver are concentrated by adsorption on activated carbon, followed by desorption in order to produce a strong enough solution for electrowinning. The electrowinning cells are operated at about 80° C, which is the solution temperature coming from stripping. The Bureau of Mines is developing an electrowinning cell having improved mass transfer (IMT) characteristics. The gold and silver are deposited onto steel wool cathodes directly from dilute leaching solutions, and the carbon adsorption-desorption step is avoided. An additional benefit is that electrolysis can be done at ambient temperatures and does not require heating large quantities of solution. By fortifying the dilute leaching solution with NaOH and recirculating the electrolyte rapidly within the cathode compartment, better current efficiency and deposition rates were obtained at ambient temperature with the IMT cell than with the conventional Zadra cell.

OP 153–84. Improved Face Ventilation by Spray Jet Systems, by Fred N. Kissell. Paper in Proceedings of the Second Annual Mining Institute 1979 (cosponsored by MSHA and AL Miner. Resour. Inst.), Tuscaloosa, AL, Apr. 11–13, 1979, pp. 1–12. Under a Bureau of Mines contract, methods were developed to increase significantly the amount of fresh air that reaches the front of a continuous mining machine. The emphasis was on removing methane buildups that occur at the cutterhead. Using a full-scale plywood mockup of a coal mine working face area, the study showed that in many instances only about 20 pct of the fresh air heading toward an exhaust brattice or tubing actually gets to within 1 ft of the face. To provide more air at the face, the natural airflow pattern should be enhanced and moved forward. The change in the natural airflow pattern can be accomplished by taking advantage of the air-moving abilities of a conventional water spray. It was discovered that by realigning a few nozzles on the side of the machine opposite the curtain and tilting the front sprays slightly toward the curtain side, the ventilation efficiencies of 70 pct or more were achieved regularly. This meant that if 9,000 cfm of air was entering the brattice, at least 6,300 cfm of the air was reaching to within 1 ft of the face.

OP 154–84. The Advantages of Inhole Motor Drilling, by Stephen J. Kravits, Albert Sainato, and Gerald L. Finfinger. Coal Min., v. 21, No. 11, Nov. 12, 1984, pp. 44–46. The Bureau of Mines pioneered the rotary drilling technology of horizontal boreholes into coal as an effective method of removing methane from coalbeds. To date, more than 10 billion cu ft of methane has been removed, consistently reducing methane emissions at active faces by at least 50%. Although horizontal boreholes have been drilled to depths greater than 2,500 ft, inherent problems have prevented universal acceptance of this technique. This paper presents a discussion on the advantages of inhole motor drilling compared with rotary drilling.

OP 155–84. Leaching Sulfide Minerals by Oxidative Electrolysis in Membrane Cells, by K. P. V. Lei and T. G. Carnahan. Paper in Proceedings of the International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods. Electrochem. Soc., Pennington, NJ, v. 84–10, 1984, pp. 374–390. Sulfide minerals present a significant resource for strategic, precious, and base metals. The Federal Bureau of Mines is investigating an oxidative-electrolysis procedure for leaching sulfide minerals. Leaching of sulfide minerals was performed by electrolysis of sodium chloride solution in cells equipped with ion-selective membranes to separate the anodic and cathodic reactions. The metal sulfide minerals were oxidized by chlorine produced at the anode and converted to soluble metal ions, sulfate ions, and elemental sulfur. Sodium hydroxide was simultaneously generated at the cathode. The objectives of this paper are to discuss the important requirements for developing a membrane electrolysis cell, to review past and current results on the oxidative-electrolysis leaching of sulfide minerals or materials, and to demonstrate the feasibility of incorporating the leaching technique into a viable hydrometallurgical process.

INDEX OF BUREAU OF MINES PUBLICATIONS

ABBREVIATIONS

B	Bulletin
CT	Computer Tape
EPA*	Environmental Protection Agency
FBG*	Florida Bureau of Geology
FIPR*	Florida Institute of Phosphate Research
GS*	Geological Survey
HB	Handbook
IC	Information Circular
MCP	Mineral Commodity Profile
MI	Mineral Issues
MLA	Mineral Land Assessment
MP	Mineral Perspective
MY†	Minerals Yearbook
NCGS*	North Carolina Geological Survey
OFR	Open File Report
OP	Outside Publication
P	Patent
RI	Report of Investigation
SP	Special Publication
TPR	Technical Progress Report

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* Author of chapter.
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* Author of chapter.

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