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U.S. Bureau of Mines

Cooperative Research Opportunities

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Abstract: The research and development programs of the United States Bureau of Mines (USBM) offer many opportunities for cooperation with the private sector, academia, and other government agencies. The booklet outlines potential cooperative opportunities cataloged by the Office of Technology Transfer under the subheadings of environmental technology; minerals and materials science; and health, safety and mining technology.

PURPOSE

The purpose of this publication is to highlight U.S. Bureau of Mines (USBM) research projects for which cooperators are being sought. The USBM welcomes industry, trade groups, professional organizations, academia, and other agencies and institutions to explore the possibilities for collaborative work in advancing these projects, or in proposing new ventures.

Office of Technology Transfer

SP 03-95

INTRODUCTION

The U.S. Bureau of Mines (USBM) helps ensure that America has an adequate supply of fuel and nonfuel minerals to meet national defense and economic needs. This mission is accomplished through research in minimizing the environmental, safety, and health costs of mineral extraction and processing; developing new materials and processes for the mining, minerals, and other industries; and acquiring and analyzing minerals data.

The USBM maintains research centers across America, each specializing in certain aspects of the mining and minerals sectors. The vast array of expertise, facilities, and equipment makes the USBM the premier research agency for mining and minerals technology. In sharing the benefits of this research with the American public and industry, the USBM supports an effective technology transfer program. Enhancing the Nation's competitiveness and the American people's quality of life requires applying these technologies commercially. Recent legislation reflecting this attitude streamlined the legal, institutional, and bureaucratic barriers that have hampered private and public sector cooperation.

The research and development programs of the USBM offer many opportunities for cooperation with the private sector, academia, and other government agencies. Cooperation is sought for all aspects of research, from the inception of a project to the marketing of a finished product or process. The USBM recognizes proprietary rights and can provide exclusive licenses and other incentives and opportunities to cooperators. Although there is a required format for cooperative research and development agreements (CRADAs), the specifics of each agreement vary; collaborators are free to negotiate an arrangement best suited to their own interests, needs, and resources.

This booklet outlines potential cooperative opportunities cataloged by the Office of Technology Transfer. This list is in no way comprehensive, and will continue to expand as new opportunities are identified.

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New Technology for Plugging Abandoned Mines

Abandoned mine shafts are a hazard to people and wildlife. Techniques previously used to plug old mine shafts vary in effectiveness and cost. Fences and grates are cheap but easily vandalized, and high-density concrete plugs are expensive and require strong support systems inside the shaft. The USBM is investigating a low-cost alternative that provides a long-term and effective method for plugging abandoned mine shafts.

The USBM is using lightweight foam concrete, used for years in the construction industry, to seal old shafts. Foam concrete costs less than standard concrete because it substitutes air for the rock aggregate. Foam concrete can be pumped over long distances to shafts where access is limited. This technology was successfully demonstrated in sealing a 300-foot-deep mine shaft in West Virginia, and the project was cited as one of the year's outstanding reclamation efforts by the Office of Surface Mining Reclamation and Enforcement. USBM researchers are experimenting with reusable inflatable forms to support the foam concrete until it sets.

Cooperative Opportunity

The USBM is looking for cooperators to assist in demonstrating and advancing this technology.

Contact

William Lutzens, Group Supervisor, 303-236-0777; or Guy Johnson, Technology Transfer Officer, 303-236-0777; Denver Research Center, Building 20, Denver Federal Center, Denver, Colorado 80225-0086.

Environmental Geophysics for Mine Reclamation

Characterization of minerals-related hazardous waste sites by determining subsurface structural and geologic conditions is a valuable asset in environmental protection. The USBM is developing a geophysical system that defines pre-mining topography, identifies subsurface features, interprets underground structures, and delineates ground water movement in relation to mine waste sites.

Electrical resistivity, electromagnetic conductivity, spontaneous potential, and seismic reflection and refraction are being investigated for use in site characterization. A ground penetrating radar (GPR) system has been developed and is undergoing testing.

Cooperative Opportunity

Cooperators could further research in this area by contributing toward the further development of the techniques and providing test sites.

Contact

J.J. Snodgrass, Principal Investigator, 303-236-0777; or Guy Johnson, Technology Transfer Officer, 303-236-0777; Denver Research Center, Building 20, Denver Federal Center, Denver, Colorado 80225-0086.

Predictive Chemical Model for Acid Mine Drainage

Acid mine drainage (AMD) presents a difficult and costly reclamation problem in many active and abandoned mine sites. Current and future mining operations may generate acid drainage for years or decades after the mines cease operations. One method of addressing this problem is to develop predictive techniques and methodologies to assess the potential of new mining ventures to generate acid waters. Effective techniques for predicting the potential of new mining ventures to form AMD that enable planning for waste disposal during the permitting and operation of new mining ventures would avoid repeating mistakes that led to past acid drainage problems.

The USBM is developing techniques to predict the potential for AMD from waste rock using information collected during exploration and development activities. This predictive model will be used in preplanning site placement and treatment of waste rock during the planning and permitting stages.

Cooperative Opportunity

Further validating the model using various waste rock types, preferably through the construction and monitoring of test piles containing several hundred tons of waste rock. Assist in validating the effectiveness of methods developed to control AMD by testing them at operating sites.

Contact

William White, Principal Investigator, 801-584-4132; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Immobilized Extractant Technology for Waste Water Treatment Anion Removal

Acid mine drainage (AMD) presents a difficult and costly reclamation problem in many active and abandoned mine sites. The problem is made even more complex by the presence of difficult-to-remove anions in the contaminated waters. Immobilized extractants could effectively remove ions from mining and mineral processing waste waters. This would be a low-maintenance treatment process providing a cost-effective solution for remedying contaminated waters by eliminating anions such as arsenic, selenium, sulfate, phosphate, and nitrate from AMD and other waste streams.

Porous polymeric beads have been developed that contain peat moss and other materials for the remediation of heavy metal cations in AMD and other waters. Current research efforts are focusing on remedying waters with anionic contaminants.

Cooperative Opportunity

Providing field sites for testing newly developed materials for removing arsenic, selenium, sulfate, phosphate, and nitrate. Assist in scaling up production of the newly developed anionic extractants.

Contact

Alan Isaacson, Principal Investigator, 801-584-4163; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Biological Arsenic Remediation: Arsenic Precipitation From Waste Waters

Arsenic is listed as a major contaminant at about 150 sites on the National Priority List and is probably the most common inorganic hazardous-waste contaminant in the western part of our country. Both solid wastes and associated seepage waters require treatment to remove arsenic. This research centers on a bacterial treatment system for removing arsenic from contaminated solutions with the advantage over the commonly used ferric arsenic precipitation circuit of significantly reducing the volumes of sludge generated.

This project uses anaerobic sulfate-reducing bacteria to produce sulfides that are in turn used to precipitate the arsenic as an insoluble arsenic sulfide complex. This precipitate is removed by conventional solid-liquid separation techniques. This biotechnology recently has been tested in the field with arsenic concentrations reduced from 14 mg/L in the feed to less than 0.5 mg/L in the treated water.

Cooperative Opportunity

Field testing, assisting in enhancing the microorganisms, and marketing of the technology.

Contact

Alan Isaacson, Principal Investigator, 801-584-4163; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Biological Cyanide Detoxification: Decommissioning Precious Metals Heap Leaching Facilities

The Western United States has become one of the world's largest gold fields. To process the low-grade ores, heap leaching has become the predominant recovery method using cyanide solutions to dissolve the gold from these ores. When a heap leach operation is closed, the cyanide used in gold recovery becomes a reclamation problem. Biological cyanide oxidation technology shows promise for economically destroying cyanide in process solutions, waste waters, and spent heaps, eliminating the need for toxic or corrosive oxidizers.

This system oxidizes cyanide by activating natural populations of cyanide-oxidizing bacteria. This technology has been used to treat numerous process solutions, and in laboratory testing it has oxidized cyanide from as high as 170 mg/L down to 0.1 mg/L in less than 2 hours. This system will be used to treat cyanide-contaminated process solutions, waste waters, and possibly spent heaps during decommissioning of heap leach facilities.

Cooperative Opportunity

Onsite demonstrations at heap leach operations, assisting in enhancing the microorganisms and enzymes, and marketing of the technology.

Contact

Rick Lien, Principal Investigator, 801-584-4106; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Biological Reduction of Selenium: Bioremediation of Process and Waste Waters

Selenium contamination has been found in at least six western states and has been identified in mine drainage, mineral-processing waste systems, and agricultural runoff where selenium occurs naturally. This threat could be remedied by a biological technique that removes selenium from process solutions and waste waters to the point of meeting the stringent selenium discharge requirements, eliminating a major contaminant blocking mine closure and discharge or reuse of contaminated waters.

This selenium-reduction technique uses biostimulation of indigenous selenium-reducing bacteria and/or bioaugmentation (introduction of bacteria with known selenium-reducing abilities) to remove selenium economically from volumes of waste waters. This biotechnology uses simple bioreactors consisting of bacterial films on solid surfaces (sand and carbon) or bacteria immobilized in "gel beads." Laboratory testing of numerous process solutions containing from less than 1.0 to 30.0 mg/L selenium has produced effluents ranging from 0.02 to 1.2 mg/L selenium.

Cooperative Opportunity

Field testing, improving the bead design, improving the bioreactor design, enhancing the microorganisms and enzymes, and marketing of the technology.

Contact

Jack Adams, Group Supervisor, 801-584-4148; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Selective Metal Recovery From Mine Drainage Using Biogenic Hydrogen Sulfide

Hydrogen sulfide (H_2S), generated by bacteria acting on waste organic materials and the sulfate in mine water, can be used to recover metals from contaminated waste streams as sulfide concentrates. This application can lead to a treatment method for metal mine effluents that will rival the cost and convenience of conventional lime treatment, provide better effluent water quality, result in less expensive sludge disposal, and allow for the selective recovery of metals.

Indigenous sulfate-reducing bacteria are used to generate H_2S gas in an anaerobic bioreactor containing sulfate-rich mine water and inexpensive, degradable organic matter such as food processing wastes or primary sewage sludge. As H_2S is formed, it is sparged from the bioreactor by an inert carrier gas. When this gas comes in contact with metal contaminants in a mine effluent, the heavy metals precipitate as relatively insoluble sulfides. Since pH exerts a strong influence on the extent of dissolved H_2S dissociation and metal sulfide solubilities vary widely, these properties can be manipulated to precipitate selected metal sulfide concentrates.

Cooperative Opportunity

General assistance in furthering the research and development of this technology.

Contact

Rick Hammack, 412-892-6585; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Lead Electrowinning From Scrap

The secondary-lead industry is the Nation's largest lead producer, and more than 90 percent of the metal supplied to secondary smelters is from scrap lead-acid batteries. Enforcement of emission and ambient air standards for lead and sulfur oxide fumes has contributed to the serious decline in the number of secondary smelters, from over 100 in 1978 to about 15 in 1993. The USBM developed and patented an electrolytic method for recycling lead from scrap batteries that eliminates the toxic emissions associated with pyrometallurgical smelting.

This method for recovering lead from scrap by electrowinning uses small amounts of phosphorous in the electrolyte to prevent formation of toxic lead oxide emissions.

Cooperative Opportunity

Assistance in building a pilot demonstration unit and long-term testing of the process.

Contact

Vernon Miller; or Jim Stephenson, Technology Transfer Officer; Rolla Research Center, 1300 Bishops Avenue, Rolla, Missouri 65401, 314-364-3169.

Treatment of Lead-Bearing Waste

One major environmental challenge is the clean up of lead from past industrial operations and waste sites. This requires developing treatment methods for removing lead from lead-bearing wastes such as soils, fumes, residues, and sludges.

Laboratory-scale tests using fluosilicic acid have been completed. The process consists of carbonating the waste, leaching with acid to solubilize the lead compound, electrowinning to recover the lead, after-acid additions to bring the concentration back to the working level, and recycling the acid for further leaching. Soil decontamination by direct electrowinning has been successful in tests, and a scaled-up slurry electrowinning cell is being designed.

Cooperative Opportunity

Assistance in advancing the technology and participating in its demonstration.

Contact

A.Y. Lee; A.M. Wethington; or Jim Stephenson, Technology Transfer Officer; Rolla Research Center, 1300 Bishop Avenue, Rolla, Missouri 65401, 314-364-3169.

Lead Removal From Contaminated National Defense Sites

Small arms firing ranges have been identified as sources for toxic metal pollution. The U.S. Navy and Marine Corps control approximately 245 active outdoor small-arms firing ranges. Because of the inevitable buildup of bullets, these ranges are source areas for metal contamination, which may be dispersed into the environment along various pathways including surface water runoff, ground water, and airborne dust. The toxic metals present in the soil may pose a hazard to humans, wildlife, and plants. A process for removing heavy metals from small-arms firing range soils would be very beneficial.

The process includes a gravity circuit that removes 95 percent of the metal, a heap leach circuit that extracts the lead smeared on the course soil grains, and a fine particle leach and classification circuit that produces cleaned fines and a low-grade metal fraction for recycling. A pilot-scale mobile remediation plant was operated in 1993 at Camp Pendleton, CA, and Quantico Marine Base, Va. Results demonstrated the successful application of this technology and will be used to develop scale-up data.

Cooperative Opportunity

Provide sites to demonstrate and further develop the technology.

Contact

Jerold Johnson, Principal Investigator, 801-584-4157; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Immobilized Extractant Technology for Waste Water Treatment: Cation Removal

Acid mine drainage presents a difficult and costly reclamation problem for many active and abandoned mine sites. The predominant contamination problem is heavy metals in the contaminated waters. The objective of this project was to develop immobilized extractants that effectively remove cations from mining and mineral processing waste waters. The development of low-maintenance treatment processes may provide a cost-effective solution for remediation of contaminated waters by removing cations, such as cadmium, lead, copper, and zinc from acid mine drainage and other waste streams.

Research has resulted in the commercialized use of USBM-developed bead technology to remove metals from waste waters. The technology has been patented as U.S. Patent No. 5,279,745, and licensed to Harrison Western Environmental Services Inc., and ATA Technologies, Inc. The beads are commercially in use by ASARCO at the Globe Superfund Site in Denver, CO.

Cooperative Opportunity

Cooperators were successful in enabling demonstration and transfer of this technology to industry.

Contact

Tom Jeffers, Research Supervisor, 801-584-4164; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Sediments Remediation

An interagency effort, involving several Federal, State, and local agencies and organizations, to evaluate the physical and chemical nature of contaminated Great Lakes and Chicago River sediment with respect to its effects on potential river use, and to develop mineral-processing pretreatment processes to decrease remediation costs. The research objective is to pretreat sediments and soils using mineral-processing techniques to decrease overall remediation costs. Low-cost, high-efficiency mineral-processing procedures could reduce remediation costs by orders of magnitude for some remediation scenarios by concentrating pollution, decreasing the amount of material requiring destruction or stabilization treatments.

Applying mineral-processing techniques is being evaluated to concentrate contamination into smaller volumes for final remediation. Pretreatment methods, which are environmentally and economically acceptable, are being developed for river, harbor, and lake sediments with heavy metals and organic contamination.

Cooperative Opportunity

State and Federal agencies, harbor authorities, public-interest groups, and vendors of process technology for waste treatment could enhance development of this technology.

Contact

Jim Allen, Principal Investigator, 801-524-4147; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Midnite Mine: Rock Reactivity

The Midnite Mine, an abandoned uranium mine, could threaten Roosevelt Reservoir, an important water resource on the Columbia River. Proper assessment of remediation scenarios requires determining whether materials to be used as fill or cover have the potential to generate acidic or metal-laden effluents when contacted with rain and ground water. Environmentally acceptable reclamation of the Midnite Mine is needed, as well as other metal-bearing sulfide deposits. In addition, methods to test rock reactivity are applicable to predevelopment testing to determine acid-generation potential of sulfidic materials. These evaluations are required to obtain mine development permits.

Accelerated weathering tests, as well as geochemical modeling, are being implemented to predict the quality of effluents resulting from rock types and mineral contacting with runoff and ground water at the mine site.

Cooperative Opportunity

Land-managing agencies, mining companies, public-interest groups, and vendors of process technology for reclamation could enhance development of this technology.

Contact

Kenneth Gritton, Group Supervisor, 801-524-4170; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Waste Minimization in the Copper Industry

The American copper industry generates 600 million tons of mining and mineral processing waste each year. Changes in operating conditions and unit operations could eliminate the generation of a portion of this waste along with the associated environmental consequences. The USBM is researching environmentally and economically acceptable methods for eliminating wastes generated by the copper industry.

Tests have determined control and remedial procedures for copper waste materials resulting from acid-plant blowdown, waste water treatment sludge, and copper refinery liquid wastes. Current focus is on the in situ treatment of heaps and waste dumps to prevent groundwater contamination.

Cooperative Opportunity

Primary and secondary metal producers, including smelters, refineries, leaching facilities, wire-rod mills, and vendors of process technology for waste treatment could enhance development of this technology.

Contact

Kenneth Gritton, Group Supervisor, 801-524-4170; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Stabilization of Mining and Processing Wastes

Solid wastes constitute a major disposal and stabilization problem for the mining, mineral processing, and metallurgical industries. Large quantities of mining and processing wastes have been disposed of or abandoned with inadequate safety measures to prevent environmental pollution. The objective of this research is to develop chemical, physical, or physicochemical methods for stabilizing and containing hazardous wastes. This will lower the cost of waste disposal, reduce the amount of land used for containment, and better safeguard the quality of the environment.

Two portland-cement-based containment media were developed that successfully stabilized wastes with high arsenic content and met the Environmental Protection Agency Toxicity Characteristic Leaching Procedure.

Cooperative Opportunity

The USBM is interested in finding cooperators to optimize the process and to provide access to facilities and wastes.

Contact

Patrick Brown, 205-759-9400; or Eddie Martin, Technology Transfer Officer, 205-759-9408; Tuscaloosa Research Center, University of Alabama, P.O. Box L, Tuscaloosa, Alabama 35486-9777.

Hydrologic Control of Mine Tailing Drainage

The flow of water through mine workings, waste piles, and tailings impoundments has resulted in degradation of many ground water sites. The USBM is working on an integrated approach to controlling contaminant transport in ground water near mines and mine-related waste sites through the application of injected barrier technology.

Research involves clay grout, physical control measures to prevent recharge water from reaching contaminant sources or to contain previously polluted water. The application of this injected clay barrier technology involves the field application of several geotechnical site characterization elements in determining placement of the barrier.

Cooperative Opportunity

General and technical support in developing this technology for control of water in and around mines, and field testing of selected control techniques.

Contact

F.R. Biggs; or Mike Jenkins, Technology Transfer Officer; Spokane Research Center, East 315 Montgomery Avenue, Spokane, Washington 99207, 509-484-1610.

Closure Methods for Metallurgical Processing

Over the years the mining industry has created enormous waste sites, many of which are heap leaching sites, that pose a threat to the environment because they contain soluble toxic chemicals and heavy metals. It is estimated that complete remediation of these sites could cost billions of dollars. This research will lead to remediation technology for operators to prevent past and future inactive heap, dump, and in situ leaching sites from becoming environmental problems.

Of interest in this project are the leaching systems for copper, and gold and silver, with primary emphasis on the latter, which uses cyanide as a lixiviant. This effort will determine the fate of residual cyanide and noxious heavy metals; assess water rinsing as a method for removing these contaminants; develop a mathematical model for predicting cyanide rinsing; and generate technical data that can be used by regulators to draft sound and reasonable closure regulations.

Cooperative Opportunity

Working jointly (1) to compile a data base for verifying the rinsing model, (2) to study natural degradation (without rinsing) in a heap leach site, and (3) to determine the effects of applying dilute rinse effluents from a heap leach facility to a suite of natural soil samples.

Contact

Sandra McGill, 702-334-6665; or Jack Walkiewicz, 702-334-6648; Reno Research Center, 1605 Evans Avenue, Reno, Nevada 89512.

Contaminant Fate

Many environmental factors influence the behavior of contaminants in flow systems. A complete understanding of geologic, hydrologic, and chemical relationships are needed to develop guidelines and mine waste management practices. The objective of this research is to determine the influence of site-specific variables on the migration of contaminants from metal and nonmetal mine waste disposal sites.

The USBM is investigating mine waste disposal sites to develop an evaluation system for remedial actions. Geochemical and numerical models are evaluated to determine capabilities for handling hydrologic and geochemical complexities common to mine waste sites. Testing proceeds on conceptual models of the mechanisms controlling contaminant migration in different flow systems.

Cooperative Opportunity

Share resources for site investigation and remediation feasibility studies in the Coeur d'Alene River Basin.

Contact

A.J. Paulson; or Mike Jenkins, Technology Transfer Officer; Spokane Research Center, East 315 Montgomery Avenue, Spokane, Washington 99207.

Environmental Remediation Using Western Wetlands

Past mining practices in the western U.S. have disturbed the landscape causing the production of acid mine drainage (AMD), which has the potential to release metals into aquatic ecosystems. AMD and soluble metals have detrimental effects on aquatic and riparian ecosystems. Constructed wetlands used to mitigate AMD in the eastern coal fields have been quite successful. However, the effectiveness of constructed wetland technology in treating AMD in the Western United States has been less successful, with numerous reported failures due to differences in climate, geology, hydrology, vegetation, and topography. Technology for low-maintenance remediation of historical mining problems is frequently unavailable due to the remoteness and inaccessabilty of sites, the continued need for chemical remediation, and the lack of responsible parties to pay for continued chemical remediation. As a result, a significant research effort is needed to identify and evaluate low-maintenance and passive AMD treatment options such as wetlands.

The USBM research centers on studying natural western wetlands receiving AMD, identifying the wetland processes responsible for removal of the metals, and applying the knowledge to constructing wetlands for treating AMD problems in the Western United States.

Cooperative Opportunity

Cooperators are needed to (1) identify and provide wetlands for detailed monitoring and evaluation, and (2) provide sites for constructing wetlands using performance data obtained from studying natural wetlands.

Contact

Richard R. Corwin, Principal Investigator, 801-584-4185; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Fine Particle Dewatering Technology for Pollution Prevention and Resource Waste Recovery

Fine grain waste slurries resulting from mining or mineral processing often settle slowly and require large impoundment storage capacity. Dewatering can result in less need for impoundment storage, recover potentially marketable products, and eliminate groundwater pollution from leaking impoundments.

Polymers are used to flocculate particles that are then passed over a static screen for dewatering and thickening. Research has been completed and the technology is ready for transfer to practical use.

Cooperative Opportunity

A crushed stone operation is constructing a dewatering plant based on this technology. Other cooperators are encouraged to apply this technology.

Contact

Ronald Church, 205-759-9446; Bernard Scheiner, 205-759-9434; or Eddie Martin, Technology Transfer Officer, 205-759-9408; Tuscaloosa Research Center, University of Alabama, P.O. Box L, Tuscaloosa, Alabama 35486-9777.

Adaptive Computer Technology Process Control (Fuzzy Logic) for the Minerals Industry

Fuzzy logic, a tool incorporating abstract concepts into rule-based systems, interacts with the problem environment through the rule and message system by receiving information about the condition of the environment and taking action based on its rule set. Applying artificial intelligence techniques to process dynamics will benefit several industries. The objective of this research is developing a system that combines the adaptive capabilities of learning classifier systems with the reasoning capabilities of fuzzy logic systems to solve difficult process control problems.

The USBM has developed a fuzzy classifier system for controlling a mathematical model of a pH titration system. Demonstrated at the bench scale, the USBM may apply the technology to a wide variety of physical systems. Work is in progress to apply this technology to a column flotation system, a chemical production system, and helicopter flight controls.

Cooperative Opportunity

The USBM is seeking cooperation from operators interested in advanced process control.

Contact

Charles Karr, Principal Investigator, 205-759-9478; or Eddie Martin, Technology Transfer Officer, 205-759-9408; Tuscaloosa Research Center, University of Alabama, P.O. Box L, Tuscaloosa, Alabama 35486-9777.

Selective Recovery of Heavy Metals From Process Water Using Immobilized Metalloproteins

Metalloproteins are soluble proteins that selectively bind heavy metals in aqueous solution in basic pH and selectively release the bound metals in acidic pH. When chemically bound to a support material and poured into a column, the immobilized metalloproteins can be used to remove heavy metal contaminants from wastewater with the added benefit of recovering the metals for reuse. The USBM is developing an inexpensive metalloprotein and support-material combination capable of the selective recovery of heavy metals from process streams and wastewaters.

The USBM has developed a bench-scale system for removing heavy metals (including transition, lanthanide, and actinide metals) from wastewater using proteins that are available from laboratory suppliers. Continuous operations have demonstrated that the supported proteins are extremely stable. Subject to operating conditions, including the type of protein used, almost any combination of metals can be separated and concentrated.

Cooperative Opportunity

The USBM is seeking cooperation in the development of technology to produce large quantities of metalloproteins, especially transferrin, cheaply.

Contact

Ross Spears, Principal Investigator, 205-759-9405; or Eddie Martin, Technology Transfer Officer, 205-759-9408; Tuscaloosa Research Center, University of Alabama, P.O. Box L, Tuscaloosa, Alabama 35486-9777.

Metal Extraction From Dilute Solutions With Emulsion Membranes

Acid mine drainage and industrial waste waters often contain dilute concentrations of metals. This process economically recovers metals from dilute solutions and can be used as environmental clean up technology or for recovering metal values from dilute heap-leach and dump-leach solutions.

A precommercial demonstration unit (PDU) is undergoing tests. The mobile PDU uses a liquid emulsion membrane (LEM) that combines the extraction and stripping steps in recovering metals from solutions. The LEM technique fits directly between existing leaching operations and electrowinning.

Cooperative Opportunity

Providing access to field sites with different parameters for further testing. Technical and other support in advancing this research.

Contact

G.L. Hundely, 503-967-5944; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Purification of Aluminum Scrap

Secondary aluminum smelters remove impurities from aluminum scrap by chlorination, but an alternative method that is environmentally safer has obvious merits. The USBM is investigating a cost effective and environmentally acceptable method for purifying aluminum scrap that recovers metallic magnesium and zinc as added value products.

Vacuum distillation is being investigated for separating magnesium, zinc, lithium, and hydrogen from aluminum scrap. Bench-scale tests showed rapid and efficient removal of these elements through this method. A vacuum distillation apparatus has been constructed and is being tested to simulate an industrial operation.

Cooperative Opportunity

Providing technical, financial, and general support in furthering the development of this technology.

Contact

Andrea Clark, 702-334-6667; or Technology Transfer Officers, Sandy McGill, 702-334-6665, and Jack Walkiewicz, 702-334-6648; Reno Research Center, 1605 Evans Avenue, Reno, Nevada 89512.

Sorting and Recycling Household Batteries

An estimated 1.6 billion batteries are used each year in the United States, and the disposal of the heavy metals in batteries is a major concern. The USBM is developing a way to separate and recycle spent household batteries.

At this point, only silver oxide, mercury, and nickel-cadmium batteries contain enough valuable elements for economical recycling. The USBM is investigating current and proposed systems for separating and recycling spent batteries.

Cooperative Opportunity

Research is in an initial stage and all types of assistance would be helpful in furthering its development.

Contact

Chris Beyke, Principal Investigator, 801-584-4188; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Removal of Copper and Tin From Ferrous Scrap

The recovery of metals from secondary resources and scrap increases the supply of those metals and enhances recycling efforts. A method of selectively chlorinating and removing copper and tin impurities from ferrous scrap would improve the quality of the scrap, and subsequently the quality of steel produced.

Research with an oxidation-chlorination apparatus chlorinates copper in the presence of iron and removes the copper as a gas phase copper chloride. Proof-of-concept has been confirmed with bench-scale experimentation, and future research will focus on testing larger sample sizes of shredded automobile scrap metal.

Cooperative Opportunity

Participation in this research by ferrous scrap recyclers, steel mills, academies, and members of the copper and tin industry would be welcome. Cooperation could be in the form of parallel experimentation, industrial-scale experimentation, acting as advisory committee members, and/or providing research funding.

Contact

Alan D. Hartman, 503-967-5958; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Anode Reactions That Decrease Electrowinning Energy

Electrowinning is widely used to produce metals, but the technique is energy intensive, which significantly increases the cost of production. This is particularly true in copper electrowinning in which a high-voltage reaction that involves the decomposition of water occurs at the anode. The replacement of this reaction with a less energy consuming reaction represents one of the possibilities for improving the energy efficiency of the process. Such a reaction is the ferrous-ferric and sulfur dioxide reaction, which has the potential to reduce anode energy consumption by 50 percent and of improving the working environment of the electrowinning tankhouse by eliminating acid misting.

Researchers are testing the ferrous-ferric and sulfur dioxide reaction as an alternative to the water decomposition reaction at the anode as a means of conserving energy during copper electrowinning. The alternate anode reaction is being tested at operating conditions used by industry in an electrowinning cell of commercial scale.

Cooperative Opportunity

Technical and general support applicable to electrolytic production of copper as well as cobalt, nickel, zinc, etc.

Contact

Kenneth Lei, 702-334-6683; or Technology Transfer Officers, Sandy McGill, 702-334-6665, and Jack Walkiewicz, 702-334-6648; Reno Research Center, 1605 Evans Avenue, Reno, Nevada 89512.

Recycling of Used Oil Filters

Over 400 million used automotive oil filters in the United States are discarded each year containing an estimated 90 million liters of used oil and 170 metric tons of steel. Ninety percent of discarded oil filters end up in landfills. Motor oil and toxic compounds are capable of leaching from the oil filters into ground and surface water supplies. The USBM is working to identify and evaluate current recycling systems and to develop an environmentally and economically acceptable means for recovering and/or reusing oil filters.

Research encompasses several activities. Collecting data on the available processing methods and uses of oil filters. Evaluating the various recycling methods for both oil recovery and scrap preparation by crushing, draining, and cleaning the filters. Melting the filters to study the effects of the various processes on the different metallurgical factors such as metallic yield, steel and slag chemistry, flue dust composition, and energy requirements. Results of studies will be used to improve the design of oil filters to optimize recycling.

Cooperative Opportunity

Assisting in full-scale test work, and evaluating and testing alternative designs and construction materials to enhance recyclability.

Contact

K.D. Peaslee; or Jim Stephenson, Technology Transfer Officer; Rolla Research Center, 1300 Bishop Avenue, Rolla, Missouri 65401, 314-364-3169.

Sensor Development for Smart Ropes and Cables

Wire ropes and cables are used extensively for industrial and structural applications, and during the course of normal use they can fail because of fatigue, wear, and corrosion. The USBM is working to develop and incorporate smart systems into wire ropes and cables that will detect, evaluate, and warn of imminent failure, and that will possibly take corrective action to minimize catastrophic effects.

The initial effort has focused on the construction and testing of the appropriate sensors to detect strain and compression. Some of these sensors are based on polymer composites and exhibit changes in their electrical properties. Other sensors are based on optical fibers that are also used to model rope and cables.

Cooperative Opportunity

Assist in the development and field testing of the smart systems.

Contact

D.M. Price; G.L. Horter; or Jim Stephenson, Technology Transfer Officer; Rolla Research Center, 1300 Bishop Avenue, Rolla, Missouri 65401, 314-364-3169.

Use of Polyethylene Oxide to Enhance Rock Fragmentation and Extend Drill Bit Life

Drilling, grinding, and other fragmentation processes are some of the major high-cost elements of a mining and exploration program. Methods that could decrease those costs while concurrently improving productivity would benefit the mining industry. The use of polyethylene oxide (PEO) as a drilling fluid additive improves both drill bit life and penetration rates for enhanced drilling, cutting, and fragmentation technology.

The USBM is investigating the use of chemical additives to increase the productivity of domestic mining and related operations by improving the performance of rock drilling, tunneling, cutting, and similar operations. Success using PEO as a drilling fluid additive was proven during extensive laboratory test, and subsequent filed tests, on hard rock such as taconite and quartzite schists and softer coal measure rocks resulting in increased penetration rates and extended bit life.

Cooperative Opportunity

Developing the optimum conditions for using PEO as a drilling fluid incorporating such components as PEO concentration, drill bit composition and design, drilling rotational speed and thrust, and fluid flow rate in controlled field tests to demonstrate enhanced penetration rates and extended equipment life.

Contact

Dr. John Pahlman, 612-725-4629; Pamela Watson, 612-725-4714; Patrick Tuzinski, 612-725-4633; or Steve Swan, Technology Transfer Officer, 612-725-4576; Twin Cities Research Center, 5629 Minnehaha Avenue South, Minneapolis, Minnesota 55417.

Lightweight Titanium-Ceramic Composites

New technology and applications require advanced materials with enhanced properties. Lightweight titanium-ceramic composites would fulfill some of these needs by providing additional strength, greater durability, and higher temperature service.

Research involves determining the effects of processing time, temperature, and pressure on composite properties; mechanical and ballistic tests to evaluate parameter effects; microstructure and interface gradient analyses; production of self-sustaining, high temperature synthesis laminar composites; exploring characteristics in welding titanium to intermetallic composites; and producing automotive parts from titanium intermetallics.

Cooperative Opportunity

Providing input for new applications of titanium composites and assisting in further development of this technology.

Contact

G.T. Fisher, 503-967-5863; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Monitor and/or Alarm Systems for Structural Members in Mines or Infrastructure Applications

Mine and infrastructure structures endure a great amount of strain, leading to structural damage or failure. Smart structural materials, such as transformation induced plasticity (TRIP) steel, would be valuable in assessing damage, monitoring stress, and providing advanced notice of impending failure in mine structures or infrastructure applications such as bridges.

Research efforts center on developing steel composites that exhibit TRIP characteristics at the onset of deformation, a means of gauging changes in the steel, and designing a detector and monitor system.

Cooperative Opportunity

Industries that supply structural materials for mining systems or that have an interest in monitoring stress on bridges or other infrastructure applications could cooperate in a number of ways.

Contact

J.S. Dunning, 503-967-5876; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Synthesis and Joining of Advanced Materials

By utilizing advanced processing methods and improved intermetallic, metal, and composite materials; low-cost, domestically available resources can be used to satisfy newly emerging high-technology materials applications. This requires synthesizing advanced intermetallic, layered composites or functionally gradient materials and rapid-solidification joining of dissimilar metals, offering unlimited opportunities for developing new materials with greater strength, wear resistance, and oxidation resistance.

Evaluations continue on applying the Engel-Brewer Theory to predicting the physical properties of metal alloys and intermetallics, and on work optimizing the processing parameters leading to advanced intermetallic-metal and intermetallic-ceramic composites and functionally gradient materials. Also, demonstrations of rapid solidification and dissimilar metal joining and improvements in the properties of iron aluminides.

Cooperative Opportunity

The USBM is seeking cooperators with knowledge, interest, and/or expertise in layered composites, intermetallics, rapid solidification, and dissimilar metal joining.

Contact

A. Petty, 503-967-5878; R. Wilson, 503-967-5869; D. Alman, 503-967-5885; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Identification, Characterization, and Recycling of Advanced Materials and Alloys

The United States relies on other countries to supply a large portion of strategic and critical metals. In many cases recycling is the only economically viable means to reduce this dependency. The most critical step in metal recycling is identifying and sorting the mixed materials into groups of alloys that can be melted and processed. The introduction of new materials, such as fiber-reinforced alloys and coated materials, further complicates recycling efforts. This research seeks to identify and recover metal values from advanced materials such as fiber-reinforced metallic alloys, dispersion-strengthened alloys, and aluminum-lithium alloys.

Experiments will concentrate on developing a means for determining techniques for identifying new materials. Once reliable identification methods have been developed, proper recycling techniques for the segregated material will be devised. A method to recover pure lithium from lithium-aluminum alloys has been patented. Additional research is being conducted on removing copper from steels and recycling advanced materials.

Cooperative Opportunity

The USBM is seeking cooperation with secondary resource companies, advanced materials users, and the aluminum industry.

Contact

Bill Riley, 503-967-5851; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Rapid Analysis and Control of Industrial Process Streams

To improve the efficiency of industrial processes in the minerals industry, the USBM is developing methods for rapid on-line analysis. Analytical results then can be used to control process streams. Successful on-line analytical procedures have the potential to reduce drastically the cost of monitoring metallurgical extraction processes and to improve significantly the efficiency of industrial mineral processing technology.

Specific areas of research include development of rapid analysis procedures that are readily integrated into metallurgical process control schemes, and development of methods to control metallurgical processes using the values obtained from on-line analysis.

Cooperative Opportunity

The USBM is seeking cooperators in the minerals industry with on-line analytical problems and those who would like their instrumentation equipment tested for metallurgical applications.

Contact

Donna Harbuck, Group Supervisor, 801-584-4146; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

In Situ Leaching of Land-Based Phosphorites

Survival of the domestic phosphate industry will depend on the successful mining of unconventional phosphorites such as deep body ores. In situ mining of phosphate deposits could prove to be an effective, environmentally acceptable method for phosphate recovery. To ensure that the United States has a consistent supply of phosphates into the next century, the USBM is investigating in situ leaching and subsequent recovery of land-based phosphorites.

Efforts include determining the effect of pressure on leaching reactions, developing technology to remove impurities from the pregnant leach liquor, and producing a salable phosphate product meeting industry specifications.

Cooperative Opportunity

Providing access to phosphate ore deposits that are suitable for in situ processing.

Contact

Donna Harbuck, Group Supervisor, 801-584-4146; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Engineering Processes for Improved Rare Metal Byproduct Recovery

Advanced materials and processes require rare metals. The objective of this research is recovering rare metals from mining and metallurgical processing wastes, and developing engineering processes to recover rare metals in stream as byproducts.

Current efforts include producing rhenium from molybdenum concentrates, scandium and other rare earths from zirconium chlorinator residues, and lithium from magnesium operations.

Cooperative Opportunity

The USBM is seeking industrial mineral processors with the potential for rare metal recovery from their ores or residues.

Contact

Donna Harbuck, Group Supervisor, 801-584-4146; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Steel Plant Sludge Dewatering

The steel industry produces an estimated 1.3 million tons of sludge from off-gas scrubbing each year. Most of this material is not recycled. Dewatering steel sludge will permit recycling of the approximately $50 million in iron metal values annually contained in sludge. Successful reclamation of the sludges will result in reduced landfilling of sludges, reducing the associated environmental liabilities.

The USBM is investigating innovative technology to reduce the moisture in steel mill sludges to 12 percent by weight. This moisture level is optimal for pelletizing the solids without dusting. Solvent extraction of the water with acetone, freeze conditioning of the sludge before filtration, and surfactant-assisted steam pressure filtration all have shown promise for reaching the targeted moisture level.

Cooperative Opportunity

Evaluating the technology in pilot testing, and performing engineering and cost evaluations following pilot testing.

Contact

William Tolley, Group Supervisor, 801-584-4150; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Critical Metals Recovery From Advanced Material Scrap

Advanced materials are being developed and used in an increasing number of high-technology applications. Wastes generated from the production and fabrication of advanced materials vary widely in composition, and many contain valuable and/or strategic metals. Such wastes also may contain components that render safe disposal difficult and costly. The USBM is developing technology for recovering and recycling critical metals from advanced material scrap.

Research includes identifying present sources generating advanced material scrap, obtaining materials, and developing methods that will either remove impurities and facilitate advanced material reuse or that will recover the individual components of the advanced materials.

Cooperative Opportunity

Parnerships are available for metal salt producers, alloy and metal producers, and manufacturers of batteries, magnets, and other advanced devices.

Contact

Jane Lyman, Principal Investigator, 801-584-4151; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Separation and Recovery of Heavy Rare-Earth Elements

With new applications and rising demand for rare-earth elements, the USBM has sought more efficient methods for separating rare earths. Current technology requires several weeks to separate a specific rare-earth product. Greater flexibility and efficiency in separation is needed. The USBM is developing the technology for separating specific rare-earth products to the point that it can be commercially viable.

The USBM recently developed improved ion-exchange technology for separating the heavier rare-earth elements. The rate of production is about 10 times faster than earlier ion-exchange systems. This offers the potential for separating all the rare earths from samarium to lutetium in a batch operation with a low amount of solution recycling.

Cooperative Opportunity

The USBM is seeking cooperators with rare-earth production capability who are interested in participating in scale up, cost evaluation, and process demonstration.

Contact

Allan Petersen, Supervisor, 801-584-4145; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Synthetic Rutile From Hard-Rock Ilmenite

Hard-rock ilmenite has not been a competitive source of feed material for titanium production. Hard rock ilmenite is quite refractory and typically contains large amounts of iron, magnesium, and calcium impurities. The USBM is developing synthetic rutile technology for commercial application.

The process under development is for production of synthetic rutile from domestic ilmenite concentrates. Typical product would contain less than 2 percent FeO, and less than 1 percent combined MgO-CaO. Process fines, normally rejected by other synthetic rutile producers, can be accommodated. A method of sintering fine grained TiO_2 to yield a product that is durable enough to be used as feed in fluid-bed chlorination is also under development.

Cooperative Opportunity

Assess synthetic rutile production economics, evaluate technology for chemical regeneration and waste disposal, and assess the chemical and physical properties of the sintered products.

Contact

Allan Petersen, Supervisor, 801-584-4145; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Recovery of Zirconium and Yttrium From New Mexico Eudialyte

Eudialyte is an acid-soluble silicate mineral, containing zirconium and rare-earth elements (principally yttrium). The Pajarito deposit on the Mescalero Apache Reservation in New Mexico contains eudialyte. The objective is to increase the domestic supply of zirconium, yttrium, and associated rare-earth elements, and to minimize silicon dissolution during mineral leaching operations.

Low-acid process technology has been identified for dissolving zirconium and yttrium from eudialyte. Soluble silicon was converted to a solid form. Current studies focus on maximizing metal dissolution and recovering the metal values from solution by precipitation techniques.

Cooperative Opportunity

The USBM is seeking two types of cooperators: (1) those interested in processing eudialyte and related acid-soluble minerals, and (2) those interested in minimizing silicon dissolution to avoid associated environmental or chemical-processing problems.

Contact

Allan Petersen, Supervisor, 801-584-4145; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Column Flotation of Resinite From Coal

Resinite is a naturally occurring coal constituent that currently is not being recovered, although it is potentially worth much more than the coal. Flotation is effective in recovering the resin. Column flotation, a recent advance over conventional flotation technology, has been shown to increase grade and recovery in many applications. Research is needed to accomplish more efficient concentration of resinite from domestic coal resources through column flotation, combined with advanced process control and improved on-line sensors.

Efforts are focused on applying improved process control technologies to column flotation in order to produce high-quality, value-added resinite products from coal. Sensing devices are under development that will enable on-line analysis of resinite grade, and control of the pulp potential of the coal slurry.

Cooperative Opportunity

General and technical assistance in advancing resin recovery methods and sensor technology for on-line analysis of resin, including field testing.

Contact

William Hirt, Group Supervisor, 801-524-4147; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Double Membrane Electrolytic Cell Technology

Electrolytic cell technology is used in the recycling, primary metals, and chemical industries. The USBM has developed a novel Double Membrane Electrolytic Cell (DMEC). The DMEC offers some unique features over conventional electrolytic cell technology: essentially no impurity transport between anolytes and catholytes, production of ultra-high-purity cathode products, operation at relatively high-current densities, and operation at relatively competitive energy consumption rates.

Researchers are investigating the feasibility of using DMEC technology in a variety of applications.

Cooperative Opportunity

The USBM is seeking cooperators interested in further refining DMEC technology and in investigating new and diverse applications for this technology.

Contact

Lorin Redden, Group Supervisor, 801-524-4143; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Lixiviants for In Situ Leaching of Copper Sulfides

As domestic copper oxide and near-surface copper sulfide ores are depleted, the need to exploit deeply buried deposits and other uneconomical deposits will increase. However, high labor and energy costs, coupled with increasing environmental constraints, preclude the use of conventional mining techniques. In situ leaching has been identified as a candidate technology for exploiting these otherwise uneconomical copper sulfide deposits. In situ leaching encompasses the philosophy of selectively leaching the mineral value from the deposit without significantly degrading the environment or endangering the health and safety of workers.

The concept of in situ leaching of copper oxides is well established, and considerable experience with solution delivery and recovery has been documented. The primary obstacle regarding in situ leaching of sulfide deposits is selection of suitable lixiviants. The USBM is evaluating lixiviants for in situ leaching of chalcopyrite and related copper sulfides.

Cooperative Opportunity

The USBM is seeking cooperators interested in providing resources to support laboratory research as well as facilities and other appropriate resources for field experimentation.

Contact

Lorin Redden, Group Supervisor, 801-524-4143; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Offshore Phosphate Mining and Mineral Processing

A vast phosphate resource is off the east coast of the United States, extending from North Carolina to Florida within the U.S. Exclusive Economic Zone. Just one area off North Carolina, at Oslow Bay, contains enough phosphate to produce up to 20.7 billion tons of phosphate concentrate grading about 30 percent P_2O_5. Research efforts center on developing an environmentally sound technology to recover offshore phosphate that provides an alternative supply to counterbalance declining, domestic-onshore phosphate reserves as mines are worked out.

This research will encompass development of an integrated total extraction system for offshore phosphate production. The system includes submarine mining, lifting systems to transport ore and/or concentrates to the surface, at-sea mineral processing, and submarine tailings disposal.

Cooperative Opportunity

Opportunities exist for joint research in developing integrated mining and processing system for offshore phosphate. Areas for participation include sample acquisition, providing historical data on any previous industrial experience with offshore phosphates, process design and evaluation, and providing technical advice.

Contact

William Hirt, Group Supervisor, 801-524-4174; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

U.S. Bureau of Mines/Industry Flotation

Recent innovative USBM developments in flotation sensors, control, and equipment have been integrated into a single pilot circuit in order to evaluate the technologies under real-time continuous testing utilizing actual plant environmental operating conditions. The technologies will allow flotation mills to react more swiftly to changes in ore grade and composition and to adjust flotation parameters for maximum product grade and recoveries. Higher recoveries can extend mine life and reduce energy costs and reagent consumption.

The USBM-developed flotation technologies, including column flotation, on-line self-cleaning redox sensors, optical sensors for froth analysis, advanced adaptive control programming, and a new rapid flotation device are being integrated into a single pilot plant system. The system will be operated at a commercial flotation concentrator in order to refine and evaluate the technologies.

Cooperative Opportunity

Conducting on-site pilot plant testing at commercial flotation concentrators. This will allow participants to acquire early access to these technologies applied to their specific ores of interest.

Contact

William Hirt, Group Supervisor, 801-524-4174; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Recovery of Fine Particles With Immiscible Liquids

The selective separation of fine particles containing valuable minerals is a severe problem for the minerals industry. Large quantities of fine particles are being discarded because they cannot be processed effectively. New technologies are needed in order to avoid these mineral losses by separating minerals with immiscible liquids, providing a way to recover high-value fine mineral particles selectively.

Recovering fine particles with immiscible liquids is similar to solvent extraction. The significant difference between these processes is that minerals particles are recovered instead of soluble ions. The research is investigating the fundamental and applied aspects of the separation process. Mineral components present in a binary mixture of minerals with a mean particle diameter of 3 micrometers have been separated selectively. Additional research on cobalt-rich ferromanganese crust shows that the process has potential to work on finely ground material.

Cooperative Opportunity

Progressive mineral processing companies with particle processing problems could cooperate by providing samples and directional input or by joining in accelerated research and pilot-scale testing.

Contact

William Hirt, Group Supervisor, 801-524-4174; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Microwave-Assisted Comminution

Crushing and grinding of ores is essential in most mineral processing operations to liberate the mineral or metal values for subsequent beneficiation. Comminution is typically the most energy-intensive step in the mineral liberation process. It has been shown for the copper and iron ore industries that crushing and grinding account for about 25 percent of the total energy consumption. Novel comminution technology will result in greater selectivity in crushing and grinding to enhance liberation at a coarser grind size, reduce production of slimes in grinding, and reduce overall energy consumption in the comminution process.

Microwave heating of ores induces thermomechanical stressing in rock. Pioneering tests indicate measurable improvements in controlled grinding tests following microwave pretreatment.

Cooperative Opportunity

Designing and constructing optimized equipment, pilot testing the equipment to assess improved liberation, and evaluating energy utilization.

Contact

Bill Tolley, Group Supervisor, 801-524-4150; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Surface Chemistry of Oxidized Mineral Flotation

Flotation is used industrially to concentrate a wide variety of valuable minerals selectively, including cobalt, copper, iron, lead, nickel, and zinc. Controlling the selectivity of the flotation process is critical to the economic processing of low-grade and complex ores. As current ores are depleted and more complex sulfide ores are milled, more sophisticated technology must become available to separate the desired values. The objective of this research is greater reliability of instrumentation to measure oxidation potential in flotation circuits, improving the efficiency of flotation. This will yield a better understanding of flotation chemistry resulting in more efficient use of expensive flotation reagents and reducing flotation mill tailings.

Fundamental flotation studies are producing improved rejection of iron in copper flotation, especially in oxidized sulfide ores. Success in this area is leading to similar research leading toward improved rejection of siliceous gangue in both sulfide and oxide flotation.

Cooperative Opportunity

Pilot testing redox sensing electrodes, and laboratory and pilot-scale research to refine concepts in redox control of flotation circuits.

Contact

Bill Tolley, Group Supervisor, 801-524-4150; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Optical Sensors for Metallurgical Processes

Process control is one of the most rapidly advancing areas of modern mineral processing. Appropriate process control can significantly increase metallurgical efficiencies by extracting valuable materials more completely. Optical sensors are inexpensive and non-intrusive, and can collect real-time data. The research objective is to improve the sensors used to monitor metallurgical processes and the process control leading to grade and recovery of beneficiation processes. This will maximize mineral usage and improve rejection of unwanted or toxic components of ores.

Use of optical sensors is progressing as a means of quickly assessing flotation. Composition of the float product is determined continuously from the color of the float product. Currently, the optical sensor is used as an adjunct to conventional chemical analyses to determine beneficiation performance more rapidly. Further improvements include the use of fiber optics to view multiple flotation steps simultaneously.

Cooperative Opportunity

Flotation plant operators at iron ore and base metal sulfide mills could assist in developing this technology, along with manufacturers of flotation equipment, process control systems, and electronic equipment vendors.

Contact

Bill Tolley, Group Supervisor, 801-524-4150; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Self-Cleaning Redox Sensors

Redox sensors monitor the reduction-oxidation (redox) potential, an important operating parameter for flotation. During use, sensors commonly become coated with a calcareous scale which fouls the electrode, produces inaccurate measurements, and leads to unreliable control. Cleaning a conventional sensor requires physically removing it from the circuit. This causes high maintenance and lengthy down time for the process control system. Greater reliability and extended service life of redox sensors will improve process control and hence product grade and recovery in the harsh mineral processing environment. Additional benefits include reduced environmental impact of mining by maximizing metals recovery from minerals and reducing waste.

Electrolytically cleaning and conditioning the sensor in place is a novel method developed by the USBM to remove the scale and return the electrode to useful service within about 10 minutes. This is accomplished by periodically applying a small electric current similar to that in a "bug zapper."

Cooperative Opportunity

Opportunities are sought with flotation plant operators at iron ore and base metal sulfide mills, and manufacturers of flotation equipment and process control systems.

Contact

Bill Tolley, Group Supervisor, 801-584-4150; or Paulette Lym, Technology Transfer Officer, 801-584-4152; Salt Lake City Research Center, 729 Arapeen Drive, Salt Lake City, Utah 84108.

Thiosulfate leaching as an Alternative to Cyanide Leaching

Cyanide is the standard leaching process for extracting precious metals. However, cyanide does not work effectively on all types of ores, and environmental concerns are also limiting its use. This indicates a need to develop other extraction methods. The objective of this research is to develop and apply thiosulfate leaching technology to the recovery of precious metals from low-grade refractory or oxidized gold ores.

Thiosulfate leaching of carbonaceous and sulfidic refractory gold ores is being evaluated in bottle roll and column tests. Because of the nature of these materials, precious metals can be recovered directly from carbonaceous ores, while the sulfidic ores require a pre-oxidation leach. Pre-oxidation is being investigated in basic solutions to enhance the conditions for thiosulfate leaching.

Cooperative Opportunity

Assistance in developing and demonstrating the technology on a pilot heap scale.

Contact

K.P.V. Lei, Group Supervisor, 702-334-6683; or Technology Transfer Officers, Sandy McGill, 702-334-6665, and Jack Walkiewicz, 702-334-6648; Reno Research Center, 1605 Evans Avenue, Reno, Nevada 89512.

Nitrogen Alloying of Iron-Based Alloy Powders

Advanced materials used in demanding industrial and technical applications require enhanced strength, durability, and service temperature. Nitrogen alloying to supplement or replace carbon in conventional steels can provide these improved properties. Infusing nitrogen into metallic alloys increases tensile strength, creep and fatigue resistance, service temperature, and corrosion resistance.

The USBM is investigating several aspects of nitrogen alloying. Nitrogen can be infused into liquid alloys during powder production by inert gas or centrifugal atomization, by post-processing powders in the solid state through high-pressure and high-temperature infusion, and by mechanical alloying. Additional research is optimizing the nitrogen concentrations and processing parameters.

Cooperative Opportunity

General and technical assistance in advancing this technology.

Contact

John Dunning, 503-967-5876; or Richard Walters, Technology Transfer Officer, 503-967-5873; Albany Research Center, 1450 Queen Avenue SW, Albany, Oregon 97321.

Evaluation of Roof Support Performance In High Stress Environments

A number of mines in the United States experience varying degrees of roof control problems becuase of the effects of horizontal stress. One method of controlling these often difficult roof conditions is optimizing the performance of the roof support system.

The USBM is researching the performance of various types of roof supports in differing rock geologies and horizontal stress intensities.

Cooperative Opportunity

Cooperation is available to those interested in evaluating existing or novel roof support or roof support products in a high stress environment.

Contact

Thomas Mucho, 412-892-6558; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.

Magnetic Levitation Using Permanent Magnets

A permanent magnet-based magnetic levitation (maglev) transport system would enhance the safety and productivity of underground mining and materials handling. The USBM has developed maglev technology that allows for noncontact, frictionless conveyance of a levitated body within a dedicated transit corridor.

The maglev technology uses permanent magnets for suspension, combined with an electronic position control system for noncontact levitation. The matrix of neodymium-iron-boron magnets is contained in the levitated body and the ceramic magnet matrix lines the bottom of the transit corridor; the orientation of the magnets causes the two matrices to repel each other. The electronic position control system on the levitated body overcomes the inherent instability of the repelling matrices. The USBM has incorporated this technology into a pneumatic freight pipeline system to move bulk materials, and has made patent submittals on the maglev transport system and the electronic positioning system.

Cooperative Opportunity

A facilitated technological collaboration to further develop the maglev system.

Contact

Kanaan Hanna, Group Supervisor, 303-236-0777; or Guy Johnson, Technology Transfer Officer, 303-236-0777; Denver Research Center, Building 20, Denver Federal Center, Denver, Colorado 80225-0086.

Drill-Split Fragmentation for Primary Removal of Rocks

Mechanical excavation and fragmentation of rock or engineered products has many valuable applications. Suitable nonexplosive techniques have limited effectiveness, especially when used in primary fragmentation. The goal of this research is producing a practical alternative to explosive fragmentation that is safe, automatable, and simple to operate.

The USBM has demonstrated the ability of drill-split techniques to excavate concrete, and sedimentary and igneous rocks. The technique uses a special splitter to load the rock both radially and axially. The radial-axial splitter anchors itself within a predrilled hole by applying a radial load. Once anchored the tool applies an axial load to the end of the hole, resulting in the excavation of rock from the host that has the appearance of pulling a plug. Two productive sizes of radial-axial splitters have been successfully demonstrated, proving that the technology can be engineered to meet the requirements of a wide variety of jobs. The full potential of the drill-split technology can only be realized through the development of systems and procedures for the variety of applicable excavation projects.

Cooperative Opportunity

The USBM is seeking cooperators interested in developing commercial drill-split technology for the mining and civil construction industries.

Contact

Sterling Anderson, 612-725-4564; John Pahlman, 612-725-4629; or Steve Swan, Technology Transfer Officer, 612-725-4576; Twin Cities Research Center, 5629 Minnehaha Avenue S., Minneapolis, MN 55417.

Coal Mine Roof Rating

Knowledge of the structural competence of coal mine roof is necessary in a number of mining applications. Included in these are roof bolt selection, stable gate road design, and roof fall analysis.

The USBM Coal Mine Roof Rating (CMRR) is an easy and inexpensive method of assessing the roof strength and assigning it a relative value. The CMRR considers roof parameters such as bedding cohesion, spacing, and persistence, as well as the existence of strong bed, and uniaxial compressive strength to compute an engineering value.

Cooperative Opportunity

The USBM will engage in cooperative research with anyone needing to test the above applications of the CMRR or to develop and test new applications.

Contact

Gregory Molinda, 412-892-6890; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.

Subsidence Upgrade of Residential Structures

Subsidence damage to residential structures is an escalating concern to longwall coal mine operators and homeowners. The differential and erratic movement of the ground during the longwall subsidence event damages structures by over stressing their physical members and by titling them to unacceptable levels. As a result of increasing public awareness of subsidence damage and the formation of public interest groups to prevent longwall mining, innovative subsidence-damage mitigation techniques need to be developed for longwall mining to maintain its growth.

The USBM is conducting a progressive research program to develop subsidence upgrade designs for existing residential structures, methods of mechanically isolating residential foundations from ground movements, and means for releveling structures following a subsidence event. The USBM has demonstrated the feasibility and positive benefits of posttensioning masonry walls. Posttensioning foundations with tendons serves to repair wall already damaged by normal settlement and also significantly increases their strength in resisting subsidence damage.

Cooperative Opportunity

Assistance in advancing the developed technology through field demonstrations.

Contact

Richard Allwes, 412-892-6889; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.

Remote Reset Systems for Continuous Miner Machines Used in Extended Cuts

The popularity of extended cut mining is increasing in U.S. coal mines. This method uses remote-controlled continuous miners to drive entries inby permanently supported roof. A particular problem area in this method is power interruption to the continuous miner. Mine workers are tempted to dart under unsupported roof to reset circuit breakers on the machine. The USBM has developed two systems for remotely resetting circuit breakers.

The mechanical and the electrohydraulic systems allow for installation on most brands of remotely controlled continuous miners employed in extended cuts. Both systems have been tested successfully.

Cooperative Opportunity

The USBM is seeking cooperators to assist in further research and development of this technology.

Contact

August Kwitowski, 412-892-6474; Albert Brautigam, 412-892-6470; or Jacquie Jansky, Technology transfer Officer, 412-892-6615; Pittsburgh Research Center, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236.

Stope Leaching

Transporting ore to the surface for leaching can be costly and lead to surface disturbances and other adverse environmental effects. Surface methods also restrict leaching to higher grade ores, limiting production. Researchers at the USBM are working to modify conventional mining practices to reduce significantly the amount of material brought to the surface from underground mines, or to "re-mine" existing surface mine dumps by backfilling empty underground stopes. Through this method low-grade reserves would also become more economical to mine and process.

The USBM is researching the control of leaching solutions, as well as developing economical leaching solutions that are environmentally compatible. Progress has been made on using sodium thiosulfate for leaching gold from refractory carbonaceous ores, leaching copper from chalcopyrite ores with ferric chloride solution, and preleaching oxidation treatment of various minerals with biological agents.

Cooperative Opportunity

The USBM is seeking cooperators to assist in further research and development of this technology.

Contact

Carl Schmuck, Principal Investigator, 303-236-0777; or Guy Johnson, Technology Transfer Officer, 303-236-0777; Denver Research Center, Building 20, Denver Federal Center, Denver, Colorado 80225-0086.

Polysulfide Solutions for In Situ Precious Metals Extraction

In situ mining of ore is hampered by concerns over the effect of lixiviants on groundwater and reactive gangue minerals. This research is seeking an effective and environmentally safe lixiviant for in situ mining that is nontoxic and operates at a neutral pH level.

The USBM recently conducted experiments that delineated high gold solubilities in very dilute, aqueous sulfur-bearing solutions at elevated temperatures and pressures. The ionic forms of the sulfur in these aqueous solutions for transporting gold are polysulfides. The solubility of gold in polysulfide solutions is comparable to the solubility of gold in cyanide. This new precious metals lixiviant is nontoxic and operates best at neutral pH levels. A variety of cheap and widely available chemical reagents can be used to generate the lixiviant. Polysulfide leaching tests are being conducted on a wide variety of ores.

Cooperative Opportunity

The USBM is seeking cooperators who may be interested in developing full-scale in situ and other types of hydrometallurgical extraction systems based on this lixiviant system.

Contact

Jon Ahlness, 612-725-4673; Dusty Earley, 612-725-4687; or Steve Swan, Technology Transfer Officer, 612-725-4576; Twin Cities Research Center, 5629 Minnehaha Avenue, S., Minneapolis, Minnesota 55417.

Development and Testing of Compact Service Hoist

Technologies are being studied that will increase the safety and productivity of underground metal-nonmetal mines. One specific area of interest involves improvements to miner and material transport. This objective could be reached by installing and testing a compact service hoist developed by the USBM.

A compact service hoist has been developed for underground mines to improve the transport of miners and materials to stopes or between levels. The hoist has been surface tested and is ready for underground installation and testing. The hoist system consists of a self-contained hoisting mechanism attached to a 1,000-pound-capacity cage. The hoist uses wire-rope traction climbers to climb two wire ropes suspended in the raise. The system is designed to operate in inclined or vertical raises 4-foot in diameter and up to 400 feet long.

<u>Cooperative Opportunity</u>

General and technical support in installing and maintaining the system for field testing.

<u>Contact</u>

Todd Ruff, Principal Investigator; or Mike Jenkins, Technology Transfer Officer; Spokane Research Center, East 315 Montgomery Avenue, Spokane, Washington 99207, 509-484-1610.

Grippers for Robots Inspecting Hazardous Waste Sites

Objects of varying size and shape become contaminated at hazardous waste sites. Grippers suitable for manipulating irregularly shaped objects are required for sampling and removal procedures. The USBM is working to develop grippers for robots inspecting hazardous wastes sites suitable for manipulating irregularly shaped objects.

Formulation of the design requirements for the grippers is underway. Once the design requirements have been established, development of the first generation of gripper designs will begin. Prototyping, testing, and refinements on the final design will follow.

<u>Cooperative Opportunity</u>

The USBM is seeking cooperators interested in the design, development, and testing of grippers for robots inspecting hazardous waste sites.

<u>Contact</u>

Grant King, Mechanical Engineer; or Mike Jenkins, Technology Transfer Officer; Spokane Research Center, E. 315 Montgomery Avenue, Spokane, Washington 99207, 509-484-1610.

Ground-Penetrating Radar

Mining health, safety, and productivity can be increased by improving the seam-tracking capability of mining equipment. A coal interface detector (CID) system would locate the coal seam boundary relative to the cutting machine.

Research is proceeding on a spatial-domain radar system that can measure the thickness of coal or any other nonmetallic material. The system can measure the thickness of multi-layer strata. Further work on a three-dimensional imaging system will solve the general problem of "seeing" into the earth. The system also has nonmining applications as a survey tool.

Cooperative Opportunity

Providing funds for the development of the three-dimensional radar system for applications-oriented evaluations.

Contact

Robert L. Chufo, 412-892-6886; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Optical Float Dust Deposition Meter

Accumulations of combustible dust generated during industrial extraction, processing, transportation, and storage activities pose a serious explosion hazard. It is important to develop a method for continuously and automatically measuring the depth of accumulations of airborne particulate material, providing an alarm and/or enabling automatic corrective measures.

Prior work has demonstrated that the top layer of a stratified structure of two optically dissimilar particulate materials could be determined (to within an accuracy of 50 microns) by measuring the optical reflectivity of the layer surface.

Cooperative Opportunity

Prototyping, beta testing, manufacturing, and marketing of the meter. The USBM holds a patent on this meter.

Contact

Robert Cortese, 412-892-6487; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Biological Methane Production From Coal

New discoveries in the field of anaerobic microbiology prompted a successful search for microorganisms that can produce methane from bituminous coal. This technology offers a method to access the energy content of inaccessible coal such as in abandoned mines, thin seams, and deep seams or seams being used for coalbed methane production. This technology offers environmental benefits by producing the methane in situ, without the mining and waste disposal needs of conventional coal utilization.

The USBM has demonstrated microbial production of methane from bituminous coals in the laboratory. Extrapolation of the methane production data indicate similar gas production volumes as might be found in an economically viable coalbed-methane gas well. Ongoing bench-scale tests continue to support the smaller scale laboratory results.

Cooperative Opportunity

Cooperative research to demonstrate the feasibility of the technology. Demonstration will include participation in pilot-scale studies and full-scale testing of the concept.

Contact

Jon C. Volkwein, 412-892-6689; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Submicron Particulate Detector

An ability to detect minute particulate levels enhances the capabilities of fire detection systems. The USBM has developed and patented a novel fire-detection sensor that is sensitive to particulates at the submicrometer level and at very low concentration levels. This technology has many potential nonmining uses, including clean-room monitoring and other atmosphere-detection operations.

Cooperative Opportunity

Producing, marketing, and/or funding is needed to complete the transfer of this technology to commercial use.

Contact

Charles D. Litton, 412-892-6752; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Diesel-Discriminating Fire Sensor

Traditional product-of-combustion, fire-detection techniques are ineffective in environments using engines producing diesel particulates and combustion gases. The USBM has developed a technique that determines if the particulates are from a fire or diesel engine exhaust.

Cooperative Opportunity

Producing and marketing this technology.

Contact

Charles D. Litton, 412-892-6752; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Remote Methane Detector

Methane gas accumulations are a serious mining hazard. Many situations exist in underground mines where there is a need to measure methane at remote, safe distances. The USBM has identified a means to remotely measure methane gas accumulations using optical remote sensing technology.

Cooperative Opportunity

Producing and marketing the remote methane detector.

Contact

Charles D. Litton, 412-892-6752; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Optical Rock Dust Meter

Federal regulations require underground coal mines to maintain a minimum concentration of pulverized limestone (rock dust) in the mine corridors to prevent mine dust explosions. The USBM has constructed a hand-held meter to measure optically the rock dust concentration in coal-dust and rock-dust mixtures to ensure a nonexplosive environment. This instrument will yield the immediate measure on rock-dust content, avoiding the present procedures of sending samples to federal laboratories for chemical analysis. This unit also has been successfully applied to other binary particulate mixtures in which the two components have different optical reflectivities.

Cooperative Opportunity

Prototyping, beta testing, manufacturing, and marketing of this patented technology.

Contact

Carrie Lucci, 412-892-4308; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

A Cable Handling Unit for an Extended-Cut Mining Machine

Productivity in underground mines depends on the continuous operation of continuous mining machines. This function is impeded by electric cables and water hoses needed to operate the mining machine. Cable handlers help alleviate the problem, but they are limited because they must remain under supported roof. This project entails developing a practical method for automating the cable-handling process in extending and retracting cables and utility hoses on mining equipment.

Research efforts would involve machine design and thermodynamic analysis, development of a prototype, and establishment of design parameters.

Cooperative Opportunity

The USBM is interested in working with cooperators with the ability to perform finite element thermodynamic analysis and to design and prototype mine-duty machines.

Contact

James Cawley, 412-892-6654; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Intrinsic Safety of Fiber-Optic Systems Using Solid-State Lasers

Recent advances in solid-state laser technology provide a practical way to transmit high optical power densities through fiber-optic cables. Under certain conditions the optical power densities of laser systems may be sufficient to ignite explosive atmospheres, but these conditions are not well understood. There are no current standards or guidelines concerning the safe use of fiber-optic cables in explosive atmospheres. Comprehensive research is needed that provides the necessary scientific data base to understand fully the safe use of fiber-optic cables.

The USBM has the equipment needed for establishing the safety guidelines; high-powered lasers, fiber-optic coupling devices, explosion chambers, explosive gas and dust mixing systems, optical power meters, time domain reflectometers, and data acquisition and computer systems.

Cooperative Opportunity

Assisting in developing the needed data base and the appropriate fiber-optic systems.

Contact

Thomas Dubaniewicz, 412-892-6596; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Prediction of the Effects of High-Extraction Mining on the Local Hydrological Regime

Concern for loss or diminution of the ground water system is an environmental focal point in the United States. Recently, attention has converged on mine operators using high-extraction mining systems, namely the longwall method. It is believed that the concern stems from the fact that the entire overburden rock mass, above the longwall panel, responds in some degree to the subjacent excavation. Furthermore, the subsequent effects on the ground water system over the extraction area are relatively unknown. Accurate prediction methods would enable mine operators to minimize or eliminate the impact of mining on the hydrological system.

The USBM is conducting a comprehensive program of research to provide much needed data. The program calls for basic hydrological field studies integrated with fundamental subsidence studies. To date, results have been obtained on the timing, onset, magnitude, and duration of change in shallow water wells, but little information has been collected on surface water. Furthermore, much work is needed on the development of predictive capabilities.

Cooperative Opportunity

General assistance in advancing this technology through laboratory and field experiments.

Contact

R.J. Matetic, 412-892-6560; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Rugged Emulsion Explosive

Explosive emulsions and water gels have handling and performance advantages over other explosives, but they also are subject to the adverse effects of desensitization from explosives fired in adjacent boreholes. This problem would be solved by creating a rugged emulsion explosive.

The USBM has identified a means to produce a rugged emulsion-based explosive without the deleterious effects of desensitization.

Cooperative Opportunity

Commercial development and marketing of the technology.

Contact

Tom Ruhe, 412-892-6416; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Prediction of Gob Gas

Emission of methane gas is a perpetual problem facing the coal mining industry. Mine operators normally use ventilated air to dilute the gas to a safe concentration. However, when emissions exceed the capacity of the ventilation system, methane drainage techniques are required. Gob gas vent boreholes are used to remove the gas. This technique uses a vertical borehole to drain gas from the rock mass forming the gob zone. Unfortunately, given current technology, it is impossible to predict accurately how the overburden rock mass will be affected by the mining; how much gas in the overburden will migrate to the mine opening; how much gas can be drained efficiently; and the appropriate number of gob vent boreholes to be used.

Cooperative Opportunity

Help in improving the methods for predicting and controlling gob gas through laboratory and field experiments.

Contact

Michael A. Trevits, 412-892-6556; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Subsidence Abatement Investigation Laboratory

Unplanned subsidence is ground movement resulting from the collapse of overlying strata into a mine void because of failure of the mine roof, mine floor, or support pillars. In the case of abandoned mines, this failure may propagate to the surface and can be expressed as depressions, cracks, or sinkholes. The objective of the USBM's Abandoned Mine Land Research Program is to improve subsidence abatement practices, increase the use of sound geotechnical engineering principles during site investigation work and remedial design, and to develop or improve state-of-the-art tools and procedures for subsidence abatement.

The USBM's Subsidence Abatement Investigation Laboratory (SAIL) is quite flexible; it is a surface structure that simulates a mine void. The laboratory structure consists of a three story steel tower with two elevated working platforms. The upper platform is about 11 meters above the simulated mine floor. The laboratory may be configured to a number of different mine conditions. For example, the work platform has been designed to accommodate a pipe up to 25 centimeters in diameter to simulate a borehole. With modification, the mine may be configured to simulate open stopes, tunnels, and to a limited degree, flooded conditions.

Cooperative Opportunity

Assist in advancing the methods for abandoned mine land subsidence abatement. Full-scale cooperative evaluations of new and existing techniques will be performed at the SAIL prior to implementation in the field.

Contact

Michael A. Trevits, 412-892-6556; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Mine Roof Simulator

Advancement in mine roof technology is essential to enhancing the safety and productivity of mining operations. This requires improving the performance testing, design, and utilization of various roof support systems for underground mining.

The USBM's Mine Roof Simulator (MRS) is a unique frame due to its size and loading capabilities. The MRS has 20-foot by 20-foot platens with a maximum vertical opening of 16 feet. It has biaxial loading capabilities with controlled force or displacement in the vertical and one horizontal axes. Maximum loading is 3 million pounds vertically through a 24-inch stroke and 1.6 million pounds horizontally through a 16-inch stroke. Vertical and horizontal loads can be applied independently or simultaneously.

Cooperative Opportunity

Cooperation is available to anyone who needs a large load frame for concept development or proof testing. Developing novel roof support systems will capitalize on USBM expertise in this area.

Contact

Thomas Barczak, 412-892-6557; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Selective Borehole Slurry Mining

In order for the U.S. mining industry to remain viable, technology must advance to a point where the environmental impacts of mining are reduced. Advancements in detecting ore in situ are needed to facilitate selective mining techniques.

The USBM is researching various methods to determine ore in situ for selective borehole slurry mining.

Cooperative Opportunity

Assistance in advancing the art of determining ore in situ by providing site access and/or sharing equipment.

Contact

Roy H. Grau, 412-892-6562; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Cryogenic Slurry Injection to Control Subsurface Fires

Fires in coal waste banks and on abandoned lands pose serious safety and environmental hazards. In 1989, 225 surface fires and 99 underground mine fires were listed. The fires affected an area of over 7,000 acres and required an excess of $780 million in reclamation costs. There are few effective methods for extinguishing subsurface fires. Removing the large volumes of heat necessary to extinguish such fires requires delivering a heat transfer medium. Needed is an effective heat transfer method to extinguish waste bank and other subsurface fires.

The USBM has developed a cryogenic heat transfer method to extinguish waste bank fires. This prototype, producing and injecting a slurry of liquid nitrogen and granular carbon dioxide, has been tested. The cryogenic slurry has a low temperature (-180 degrees Celsius) and changes in state from the solid or liquid to the gas phase. This phase change produces a 500-fold increase in volume, creating a cold pressure wave that produces an inert atmosphere and forces fumes from the combustion zone.

Cooperative Opportunity

Providing access to a burning waste-bank site for a full-scale test and funding to cover the cost of the cryogenic fluids. Assistance from cooperators with experience with cryogenic fluids for the scale up of the prototype equipment.

Contact

Ann G. Kim, 412-892-6724; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Improvement of the Retirement Criteria for Wire Hoist Ropes

The regulations for retiring wire ropes have essentially been unchanged since their inception in 1915. The Mine Safety and Health Administration requested that the USBM provide research support for improving and updating the criteria. By developing accurate data on the effect of wear and bending fatigue on wire rope life, more precise regulations governing retirement criteria can be formulated. This will result in greater safety and avoid premature retirement of hoist ropes. New and optimized rope constructions may also result.

Because one of the primary modes of wire rope degradation is fatigue from bending on sheaves and drums, the USBM has set up a laboratory with a machine designed to cause fatigue damage in varying degrees in a long sample of wire rope. A large tensile and axial fatigue testing machine is used to break ropes from the bending fatigue machine and ropes obtained from mine hoists. Highly competent metallographic analysis is also available.

Cooperative Opportunity

Sharing data on degradation, and providing samples and input for program direction.

Contact

Anthony J. Miscoe, 412-892-6463; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Respiratory Protection Equipment

Breathable air cannot be taken for granted in underground mines, especially after a fire or explosion. Self-contained breathing apparatus are necessary in these occasions for evacuation and recovery of the mine. Development of such apparatus will require quantitative evaluation of its performance. Highly specialized equipment is necessary for this evaluation. Small manufacturers with novel ideas for improvements in breathing apparatus may not be able to afford such equipment. The USBM's Respiratory Protective Equipment Testing Lab is working to improve this technology.

The Bureau is interested in furthering the development of respiratory protection equipment to make such equipment smaller, lighter, and less stressful for the user. The laboratory equipment is set up to test closed-circuit breathing apparatus, but can also test open-circuit apparatus.

Cooperative Opportunity

The USBM seeks manufacturers sharing an interest in advancing the technology of self-contained, closed-circuit respiratory protective equipment to make them smaller, lighter, and less stressful to users.

Contact

Nicholas Kyriazi, 412-892-6478; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Synthetic Hoist Ropes

On a comparable strength basis, a synthetic rope is about one-fifth the weight of steel rope, allowing increased production in deep mines. Furthermore, internal corrosion, which is hidden in steel ropes, would not occur in synthetic ropes. Because the light weight of synthetic rope results in less stored strain energy, it has a large safety advantage over wire rope. If it breaks, the free ends recoil with little force, resulting in greatly reduced danger to nearby workers. In addition, its nearly comparable strength will allow larger payloads per trip at the same safety factor, increasing production in deep mines. The light weight also enables faster and safer installation.

This work has been in defining the effects of bending fatigue on the degradation of synthetic ropes; it has also determined that a rope's acoustic response changes as wear increases. Because of the unknowns, the Mine Safety and Health Administration requested the USBM's assistance in determining the bending fatigue strength of various synthetic ropes, methods of termination, and methods for determining a synthetic rope's condition using non-destructive and/or visual means.

Cooperative Opportunity

Supplying rope samples, sharing performance data, and providing program input.

Contact

William M. McKewan, 412-892-6642; or Jacquie Jansky, Technology Transfer Officer, 412-892-6615; Pittsburgh Research Center, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, Pennsylvania 15236.

Coal Air-Lift Hydrohoist

Underground coal transportation systems, such as conveyor belts, rail haulage, shuttle cars, and chain conveyors, have inherent safety hazards and production limits. The goal of this work is a coal air-lift hydrohoist for lifting run-of-mine coal to the surface, thus eliminating underground belt and rail haulage.

This work is based on the concept that low-cost vertical flow can be created by injecting compressed air microbubbles into one column of a two-column, U-shaped hydraulic loop. Bench-scale and pilot-scale models have been tested, including a 165-foot-high model designed to hoist 27 tons of coal during a 15-minute test run.

Cooperative Opportunity

General and technical assistance in advancing the technology, and assistance in proving its feasibility.

Contact

Philip Lindahl, 303-236-0777; or Guy Johnson, Technology Transfer Officer, 303-236-0777 Denver Research Center, Building 20, Denver Federal Center, Denver, Coloràdo 80225-0086.

Control Systems for Drilling

Ground failures and roof falls are the most severe safety hazards that miners encounter in underground mining. Safety would be enhanced by removing workers from the face. This would be achieved by using advanced controls for roof support systems, removing personnel from hazardous operations, and operator-assisted remote controls to operate these systems.

Efforts center on developing drill vibration techniques to identify hazardous roof strata remotely. Additional efforts include developing an underground coal mine roof bolter drill control system to be used for the vibration study.

Cooperative Opportunity

General and technical assistance in developing this technology.

Contact

T.L. Nichols; G.G. Miller; W.L. Howie; or Mike Jenkins, Technology Transfer Officer; Spokane Research Center, East 315 Montgomery Avenue, Spokane, Washington 99207, 509-484-1610.