MINERALS IN 1992

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Office of Public Information

34 MINERALS* IDENTIFIED AS HIGHLY IMPORTANT TO THE ECONOMY OR DEFENSE OF THE UNITED STATES

Aluminum	Graphite	Potash
Antimony	Hafnium	Rare Earths
Asbestos	Iron	Silver
Barite	Lead	Sulfur
Beryllium	Lithium	Tantalum
Chromium	Magnesium	Thorium
Cobalt	Manganese	Tin
Columbium	Mercury	Titanium
Copper	Molybdenum	Tungsten
Fluorspar	Nickel	Zinc
Gold	Phosphate	Zirconium
	Platinum	

*Because of their importance to the U.S. economy, iron ore and iron and steel are treated as separate items in this publication. Also, it should be noted that 2 of the 34 minerals—asbestos and thorium—are now felt to present such major health and/or environmental problems that their use has substantially declined.

INTRODUCTION

Although most Americans give little thought to them, minerals are vital to our way of life. It takes about 10 tons of nonfuel minerals for every man, woman, and child in the United States every year just to maintain our current standard of living. That works out to more than 2-1/2 billion tons of mineral raw materials every year, plus the fuels we individually consume and the vastly greater quantities of fuel industry consumes on our behalf.

Our need for minerals begins with the most basic requirement for life—food. Minerals are essential to the many activities involved in putting food on our tables. Fertilizers made from potash, phosphate rock, sulfur, and nitrogen help plants grow. Farmers use metal tractors and combines to plant and harvest crops. They ship fruit, vegetables, grain, and livestock to market in trucks, railroad cars, and airplanes—all made of metal. Food processors use metal machines and equipment; they package food in metal cans and other containers made from or with metals.

It can be argued that our society is too consumption oriented, but even if we cut back on consumption we would still require vast quantities of minerals. A typical house, for example, is made of minerals from its concrete foundation to the asphalt shingles on its roof; its interior plumbing and wiring are made from minerals, as are the windows. Minerals used for outside walls range from the clay used to make brick to the aluminum used to make siding; even plastic siding ultimately comes from minerals. The paint that decorates and protects the house is manufactured with mineral fillers and pigments from minerals obtained by mining.

Turning to clothing, all textiles not made of natural fibers come from minerals. Although these mineral-based fabrics are a relatively recent development, they have revolutionized the clothing industry with their variety and are so easy to care for that most households no longer schedule weekly sessions with ironing boards and irons. The technology of clothing manufacture has depended on minerals for centuries—ever since the bone needle was replaced by metal.

In an industrialized nation, minerals are involved in nearly every job. The machines used in factories, plants, mills, and refineries are made from steel and other metals; whatever these machines and the workers who operate them are manufacturing is almost certainly made at least partly of minerals. Office workers use minerals in less obvious but equally vital ways; it takes 42 minerals, for example, to make a telephone handset. The computers that increasingly share our office space are made of minerals, as are more traditional office machines like calculators and typewriters. Even the paper used in an office is made using mineral (clay) fillers, as was the paper on which this book was printed.

And here is where a major problem arises. Unlike food and forest resources, which can be renewed in a year or a few decades, our mineral resources are finite. Endowed with outstanding mineral resources to start out with, the United States has been drawing on them for several centuries in the eastern part of the country and for well over a century in most of the rest of the Nation. Many eastern deposits are long since mined out; elsewhere, ores containing less than 1 percent metal must be mined to meet our ever-increasing needs. And there are some minerals, unimportant in earlier days of simpler technology but deemed vital to us now, that have never been found in significant quantities on the North American continent.

As this problem became apparent in the years following World War II, a group of 34 minerals were identified as highly important to the economy or defense of the United States. In some cases, such as copper and iron, the United States still produces massive supplies of these minerals but from increasingly depleted ores; in others, such as chromium and platinum, the United States relies heavily on imports, sometimes from sources that for political or geographic reasons cannot be regarded as secure. Although petroleum supply problems are not considered here, they give a vivid example of how the U.S. economy can be affected by disruptions in its mineral supply.

In the following pages, we profile the 34 minerals, giving general information about each commodity, followed by a review of events affecting it in recent months. For updates on any of these minerals, contact the Bureau of Mines commodity specialist listed at the end of each profile.

ALUMINUM

One of the leading materials used by modern society, aluminum has been available in large quantities for only about 100 years. Before that, it was so rare that it was considered a semiprecious metal, sometimes selling for more than silver. In 1884 a pyramid of ornamental aluminum was used to cap the newly finished Washington Monument in our Nation's capital.

Scientists suspected that aluminum had vast commercial potential, however, and within the next few years the Bayer and Hall-Heroult processes made this potential a reality. The Bayer process enabled bauxite, the aluminum raw material, to be converted into the intermediate stage of alumina, and the Hall-Heroult process allowed the production of the actual aluminum metal.

Aluminum is important to the transportation industry because of its use in airplanes and automobiles, but its leading use today is actually for containers and packaging—and beverage cans account for the vast majority of use in this area. Over half of these cans are being recycled, and in States with recycling laws about 90 percent of them are recycled.

Why is this recycling so important? One main reason is that the United States has very limited supplies of bauxite, the basic raw material for aluminum production. We import both bauxite and the intermediate alumina from a number of countries; our chief suppliers are Australia, Brazil, Guinea, Jamaica, and Suriname.

Another important reason for recycling aluminum is that producing the original aluminum requires substantial electricity, which has been becoming more expensive in recent years. Recycling aluminum saves about 95 percent of the energy needed to produce new metal from bauxite. Ironically, aluminum itself has important electrical uses; for example, aluminum cable with steel reinforcing has displaced copper for high-capacity transmission lines.

Second only to iron in world metal consumption, aluminum is used in building our homes and in the appliances we use in them. It is vital in aerospace and aircraft uses because of its relatively light weight compared with its strength, and with each passing year more aluminum is used in cars. Because of these needs, our country is the world's leading producer of aluminum metal, even though we have to import the raw material we need for this production.

Industry Highlights in 1991

Despite a decline in aluminum ingot prices, domestic primary production continued to increase, reaching its highest level since 1984. Most domestic primary aluminum smelters operated near or above their annual rated capacity levels throughout the year. U.S. imports of aluminum ingot, scrap, and semifabricated products decreased slightly. Total exports continued their upward trend.

In midyear, the Defence Logistics Agency received the first shipment of aluminum metal from a contract awarded in 1990 to upgrade metal-grade bauxite ore in the National Defense Stockpile to aluminum metal ingot. The contract, which called for the conversion of 243,852 tons of bauxite ore to 55,157 tons of aluminum ingots, was expected to be completed by September 1992.

The price of primary aluminum ingot fluctuated during the year but followed a general downward trend. In January, the average monthly spot price for primary ingot quoted by Metals Week was 68.6 cents per pound. By August, the price had dropped to 57.7 cents per pound, its lowest level since January 1987. Prices on the Commodity Exchange and the London Metal Exchange (LME) followed the trend of U.S. spot prices. Prices in the aluminum scrap markets paralleled the general trend of primary ingot prices. Buying prices for used beverage can (UBC) scrap fluctuated but also followed a general downward trend, from 49 cents per pound in January to 37 cents per pound by August.

World demand for aluminum leveled off in 1991. Primary aluminum stock levels on the LME rose dramatically; the rise was attributed to both a slowdown in the growth of aluminum demand and the appearance on world markets of larger-than-normal amounts of aluminum metal from the former U.S.S.R. Increased stock levels and the decline in prices caused many companies to begin to reevaluate the status of their higher cost aluminum reduction facilities around the world.

For further information on aluminum, contact Patricia A. Plunkert, 202/501-9419.

ANTIMONY

The word "antimony" comes from two Greek words (anti plus monos) that mean "a metal seldom found alone."

Although this name originally referred to antimony's origin—it usually occurs in combination with other metals, such as copper, lead, silver, and zinc—it is also true of its modern uses. As a metal it is used as an alloy with other metals; as a compound, it is likewise used in combination with other materials.

The most important use of antimony today is as a flame retardant in the textile and plastics industries. This is a fairly recent development; only a few years ago, leading uses included starting-lighting-ignition batteries and type metal. Although some antimony is still used for these purposes, technology has changed and reduced its use. For example, the use in batteries is essentially as an alloy of lead, but today's low-maintenance batteries use less or no antimony alloy. In printing, the use of lead type metal has declined as electronic composition has spectacularly increased, and with the decline has come a drop in the amount of antimony used as an alloy.

There are a number of minor uses—minor because they consume less antimony, not necessarily because they are unimportant—including specialty glasses, ammunition, corrosion-resistant pumps and pipes, roofing sheets, solder, cable sheaths, and antifriction bearings. Here again the antimony is used in combination with other substances to achieve specific results; for example, it is a decoloriser in the glass used in television screens and fluorescent tubes.

Because the United States has only limited resources of antimony, it is considered a strategic and critical mineral—one that is essential to our economy or defense and that is unavailable in adequate quantity from reliable and secure suppliers. The world's main resources of antimony are in China, Bolivia, Mexico, the Republic of South Africa, and the former U.S.S.R. Currently China is our chief supplier.

Industry Highlights in 1991

Antimony production from domestic source materials was largely derived from recycling of lead-antimony batteries in 1991. Recycling plus U.S. mine output supplied less than 50 percent of the estimated domestic demand. Total imports of antimony metals increased 17 percent from those of 1990.

On April 25, a coalition of five U.S. antimony trioxide producers and/or manufacturers of antimony trioxide-based products filed an antidumping petition with the International Trade Commission (ITC) and the U.S. Department of Commerce (DOC), charging China with unfair trade practices. On June 5, the

ITC's preliminary investigation determined that there was a reasonable indication of material injury or threatened material injury to the domestic antimony trioxide refining industry as a result of Chinese refined antimony trioxide imports. On October 3, DOC announced its preliminary determination that all Chinese antimony trioxide entering the United States should be assessed a dumping margin of 3.18 percent.

Bolivia and China again attempted to control the prices of antimony. An agreement between these two countries had been signed on January 7, 1989, but in May 1990 Bolivian officials withdrew their participation in the joint Bolivian-Chinese quarterly producer price control. The agreement failed to achieve its objective of coordinating the policies on antimony production and trade between the two countries. The New York estimated antimony dealer price for 1991 was about 13 percent less than in 1990. The decline of the price of antimony, for the third consecutive year, was attributed to the flooding of the international antimony metal market with antimony products from China at prices below that at which other world producers could compete.

Environmental and ecological problems associated with the treatment of antimony metal and ores were minimal because emissions and effluents were controlled at the processing plants.

For further information on antimony, contact Thomas O. Llewellyn, 202/501-9395.

More than 20 countries mine asbestos. Canada and the former U.S.S.R. are the leading producers with over 75 percent of the world's production. The United States accounts for less than 1 percent of world production and is dependent on imports to meet over 90 percent of the domestic demand.

Chrysotile is the most common variety of asbestos used in the United States. The properties that make chrysotile useful are its high strength, good chemical and thermal stability, high flexibility, low electrical conductivity, and large surface area. The major domestic end uses for chrysotile asbestos include brakes, clutches, pipe, and roof coatings. Minor end uses include gaskets, packing, insulating paper, plastics, and textiles. Small amounts of other types of asbestos, crocidolite and amosite, are used domestically in asbestos-cement pipe and insulation board.

Concern over possible health risks and environmental and liability issues have resulted in a dramatic decline in the domestic use of asbestos in recent years and in the enactment of a regulation that phases out the use of asbestos in most products by 1996. In response to these developments, product manufacturers gradually have been replacing asbestos with substitute materials (carbon fibers, glass wool, metal fibers, nonasbestiform minerals, organic fibers, and refractory fibers), redesigning old products to eliminate the need for asbestos, or designing new products that require neither asbestos nor asbestos substitutes.

Industry Highlights in 1991

Although domestic production increased from that of 1990, imports and exports decreased 18 and 21 percent, respectively, and apparent consumption decreased 21 percent. Approximately 98 percent of the asbestos consumed in the United States was chrysotile. Canada remained the largest supplier of asbestos for U.S. consumption.

On October 23, the 5th U.S. Circuit Court of Appeals overturned an Environmental Protection Agency (EPA) regulation that banned the use of asbestos in most products by 1997. The court ruled that EPA did not take into account the health risks posed by asbestos substitutes, the high costs of banning the use of asbestos, and improved working conditions achieved using currently available technology.

The Health Effects Institute—Asbestos Research concluded that airborne asbestos concentrations in well-maintained buildings containing asbestos-containing material are unlikely to be greater than airborne asbestos concentrations outside the building, that radon and tobacco smoke pose a greater lifetime cancer risk to occupants than asbestos-containing material, and that arbitrary removal of asbestos-containing materials from well-maintained buildings probably is not justified.

A new international group, the International Fibre Safety Group, was formed to promote the safe use of asbestos and other industrial fibers in accordance with the International Labor Organization guidelines. The group is made up of representatives from eight major asbestos-producing and asbestos-consuming countries.

EPA issued drinking water standards for 33 contaminants, including asbestos, on January 30. The rule established a maximum contaminant level of 7 million fibers (greater than 10 micrometers in length) per liter of water. The standards go into effect in 1992.

For further information on asbestos, contact Robert L. Virta, 202/501-9384.

BARITE

Although seldom encountered directly except in its hospital use for barium X-rays, barite plays an important part in obtaining every gallon of gasoline we use in driving and every gallon of oil or cubic foot of gas we use for fuel.

In drilling the wells that reach the oil and gas upon which all modern economies depend, barite weights the drilling muds that transport drill cuttings to the surface, control formation pressures, maintain borehole stability, protect producing zones, and cool and lubricate the bit and drill string. The principal function of the barite is to suppress high formation pressures and prevent blowouts. The deeper the hole, the more barite is needed as a percentage of the total mud mix; in 1989, over 35 pounds of barite was used per foot of hole.

Use in drilling is by far the leading use for barite, and the barite industry is highly dependent on developments in the petroleum industry. After attaining alltime peaks when petroleum prices were high and drilling was active in the early 1980's, the industry suffered a severe setback when petroleum prices and drilling activity declined later in the decade.

Although very minor compared to the volume used in drilling mud, some of barite's uses in more refined forms are quite interesting or important. In painting automobiles, barite is used as a filler for the primer coat, contributing to the gloss of the top coat. In carpet backing it deadens sound; in polyurethane foam furniture, it improves recoil properties. Its use in medicine has already been noted, and there are a host of other specialized applications, including recovering sugar from molasses by the barium saccharate process.

Barite is mined in more than 50 countries; because it is a low-priced commodity (the average price is about $35 per ton), the cost of transporting it to the drilling sites is a major factor in determining the source of supply. For example, Ireland exports large tonnages of barite to the United Kingdom for use in the North Sea oilfields. Currently the United States imports about 70 percent of the barite it uses; China, India, and Morocco are our major suppliers.

Once the world's largest producer of barite, the United States remains its leading consumer. Nevada is the leading producing State; one reason so much of the barite the United States uses is imported is that the shipping rate from foreign suppliers to ports servicing the oil drillers on the gulf coast is often less than the rate by rail to this area from suppliers in Nevada.

Industry Highlights in 1991

The demand for barite remained about the same as in 1990; a slight increase resulted from steady petroleum prices at a level that encouraged oil and gas drilling in the United States. The longer term trend in barite prices has been to drift downwards from 1982 to 1987 and to stay at the 1987 level in terms of constant dollars. This corresponds to the decline of drilling rigs from nearly 5,000 U.S. rigs in 1982 to the 850 to 1,100 range in 1987 and to fewer than 900 in the autumn of 1991.

Imports for consumption of lower cost foreign barite continued to exceed domestic production. Major sources of imported barite were China, India, and Mexico. One factor allowing the lower cost of foreign barite is the cheaper (per ton-mile) cost of ocean transportation as compared to rail transportation from Georgia and Missouri to the end-use regions. Nevada mines, crushers, and grinders are competitive in the California market.

The principal environmental impact of chemically inert barite is the land disturbance normally associated with mining. Mud pits at petroleum drilling sites that contain some barite are treated differently according to chemical content other than barite. The mud in the pits may be dewatered and covered, dewatered and spread over the ground, or transported to special waste-handling facilities.

For further information on barite, contact Jim Searls, 202/501-9407.

BERYLLIUM

In only 65 years beryllium has become an important industrial metal. Its high strength, light weight, and high thermal conductivity make it important in both defense and commercial applications.

In contrast to many other "high tech" metals, the United States has a good supply of the basic beryllium ores, largely in Utah; it currently meets most of its needs without imports and could meet all of them from domestic material if it had to. The principal foreign producers are Brazil, China, and the former U.S.S.R.

About two-thirds of the beryllium we use is alloyed with copper for electrical, electronic, and aerospace applications. One important use is for connectors, switches, springs, and relays in computers. Unalloyed beryllium metal is also used in the space program, especially for heat shields.

Although beryllium is an important metal, the quantities needed are comparatively small, and so is the number of people involved in producing it. In 1985, for example, about 80 people mined all our beryllium, and about 850 were involved in processing and handling it. Both operations present health hazards, but harmful effects, such as the lung disease berylliosis, can be prevented by keeping workplaces clean and requiring the workers to take appropriate precautions.

Because of beryllium's relatively high cost and possible health problems, it is used only when there is a clear technical and economic advantage over other materials. On the other hand, using substitutes for beryllium in most of its applications usually results in substantial loss of performance.

Among the newer specialized applications for beryllium and its alloys are sensors for automobile airbags and a new means of determining wear that will save the automobile industry thousands of hours in testing time. Less technical new applications for beryllium-copper alloys are in golf clubs and as molds for manufacturing plastic bottles.

Industry Highlights in 1991

Although the general economic downturn was reflected in an overall decline in domestic beryllium consumption, not all end-use markets were affected. A continued downturn in computer applications, which began in 1989, resulted in weak demand for traditional beryllium-copper alloys in this end use, particularly scrap and plate. However, uses for Alloy 174, a lower cost beryllium-copper alloy, in automotive electronics, appliances, and computers continued to grow. Demand for beryllium oxide ceramics in automotive electronics dropped significantly because of low automobile production rates. This drop in demand was somewhat offset by increased beryllium oxide ceramic usage in telecommunications and laser components.

New products, such as beryllium-aluminum alloys, were developed for the aerospace and commercial markets. Beryllium and beryllium alloys were used in new applications in the energy field, ranging from oilfield components to experimental fusion reactors.

Beryllium oxide ceramics use in defense applications has declined significantly, beginning in 1989 when the U.S. Department of Defense (DOD) indicated concern about potential health hazards of these components. In 1991, DOD recognized that health hazards were present during the manufacturing process, but that the finished products were safe when handled as a solid form.

The Defense Logistics Agency extended its contract with a domestic firm to purchase an additional 43,000 pounds of vacuum hot-pressed beryllium billets for the National Defense Stockpile (NDS) by yearend 1993. This extension brought the total quantity purchased to 134,000 pounds, worth about $38 million. Billet will be produced by upgrading some of the beryl in the NDS.

For further information on beryllium, contact Deborah Kramer, 202/501-9394.

CHROMIUM

Chromium is vital for making stainless steel and superalloys. Stainless steel, by far the largest use for chromium, is critical throughout civilian and military industries. Superalloys are essential in the production of high-performance military jet engines. Because of these uses, chromium is a strategic and critical material, a secure supply of which is essential to our economic and military security.

Since chromium is not produced in the United States, or even in North America, we must import all of what we use, except for some that is already available in stainless steel scrap. By far the leading source of these imports is the Republic of South Africa; other suppliers include Turkey and Zimbabwe. Since chromium is vital to all industrialized economies, the United States must compete with Japan and Western Europe, especially Germany, for chromium from only a few major chromium-producing countries, which are located in the Eastern Hemisphere.

Even in chromium's lesser uses, such as chromium chemicals, substituting other materials for it either increases cost or impairs performance. Developing technologies that use materials that are both chromium-free and do not depend on chromium for their manufacture would take years to accomplish and require investment unjustified under current conditions of abundant supply. As over 99 percent of these long-term resources are concentrated in southern Africa, secure access to this material is a vital concern of industrialized nations throughout the world.

Industry Highlights in 1991

Reduced demand for ferrochromium, reflecting decreased stainless steel production, and increased supply of ferrochromium, due to producer expansions and new plant construction, resulted in excess ferrochromium. World ferrochromium production capacity increased in 1989 and 1990. Despite strong demand for ferrochromium for production of stainless steel, excess production capacity and reduced demand for durable and capital goods resulted in declining ferrochromium prices. World ferrochromium production was reduced by idling some furnaces.

Although Western World stainless steel production appeared to be recovering moderately, weakening in the United States but recovering moderately in Western Europe and strongly in Japan, apparent consumption decreased 6 percent compared with that of 1990. Chromium demand changes reflect consumption changes or anticipated changes in the steel industry, the major consumer of chromium. It was estimated that in 1992, U.S. apparent consumption of chromium would be about 400,000 tons, and domestic mine production of chromium ore would be zero or negligible. Domestic deposits are small or of low grade.

Chromium releases into the environment continued to be regulated by the Environmental Protection Agency; workplace exposure is regulated by the Occupational Safety and Health Administration.

For further information on chromium, contact John Papp, 202/501-9438.

COBALT

The largest single use of cobalt is in superalloys, which are used primarily in aircraft turbine engines. Other uses of cobalt include driers for paints and inks, cutting tools and wear-resistant materials, permanent magnets, catalysts in the oil and chemical industries, inorganic pigments in glass and ceramics, and adhesives for enamel coatings on steel and for steel-to-rubber bonds in radial tires.

Cobalt is considered a strategic and critical metal because of its many industrial and defense-related uses, and because the United States is highly dependent on imports for its supply. The United States is the world's largest consumer, using about one-third of world supply each year. There is no domestic production, so demand is met primarily from imports, except for small amounts from the recycling of superalloy scrap and other cobalt-containing materials. To ensure an adequate supply in case of a national emergency, cobalt metal is included in the National Defense Stockpile.

Cobalt is almost always produced as a byproduct of other, more abundant metals. More than half of the world's copper supply is mined and refined as a byproduct of the copper industries in Zaire and Zambia. Cobalt production in most other countries is a byproduct of nickel mining or refining. Over 90 percent of the world's refined cobalt is supplied by six countries, listed in order of production: Zaire, the former U.S.S.R., Zambia, Canada, Norway, and Finland.

Large resources of cobalt exist on the ocean floor in the form of manganese nodules and cobalt-rich crusts. Both types of deposits contain manganese, nickel, copper, and cobalt. These are potential sources of cobalt for the future.

Industry Highlights in 1991

U.S. demand for cobalt was slightly weaker than in 1990. The producer price of $11 per pound was maintained during the year. Free market prices remained above the producer price, initially because of increases that occurred during 1990. After gradually dropping from approximately $15.50 per pound in January to below $13 per pound in late July, they increased sharply during the last week of September, following reports of unrest in Zaire, the world's largest cobalt-producing country. Prices in early October exceeded $19 per pound, the highest they had been in a decade. On October 10, Zaire and Zambia, the world's largest cobalt producers, announced a 1992 producer price of $13 per pound, to be effective for 6 months, beginning January 1, 1992. The price was to be reviewed in June and could be changed at that time.

It was estimated that domestic mine production would be zero in 1992 and that U.S. apparent consumption would be about 7,300 tons.

For further information on cobalt, contact Kim Shedd, 202/501-9420.

COLUMBIUM

Columbium (also known as niobium) is a refractory metal that conducts heat and electricity relatively well and is characterized by a high melting point, resistance to corrosion, and ease of fabrication. Columbium is used mostly as an alloying element in steels and in superalloys.

Columbium's importance dates from the 1930's, when metallurgists began using it in the form of ferrocolumbium in steelmaking and as columbium carbide in the production of high-speed cutting tools. Its use in jet engines followed, and as the century wore on, other significant applications were discovered, including use in pipeline steels for transporting oil and gas, especially in cold climates, and in structural steels. Additionally, superconducting magnets for the planned Superconducting Super Collider (particle accelerator), to be built in Texas, will use about 1 million pounds of a 50-50 columbium-titanium alloy. Acceptable substitutes are available for some columbium applications, but in most cases they are less satisfactory. Currently in the United States construction accounts for almost one-half of columbium usage, followed by transportation, machinery, and the oil and gas industries.

There has been no significant mining of columbium in the United States since the 1950's. Domestic resources are too low in grade and/or mineralogically complex to be commercially recoverable. Thus, the United States is 100 percent import dependent for all of its columbium raw material supply. Columbium availability in the United States is dependent on Brazil, which accounts for about 80 percent of world columbium reserves, and Canada. Columbium imports from Brazil, mainly in upgraded forms, satisfy over one-half of the total annual U.S. columbium demand.

Industry Highlights in 1991

First-half-year overall reported consumption of columbium was down 8 percent from that of 1990. Consumption by the steelmaking industry dropped 13 percent, reflecting a corresponding 13-percent decline in raw steel production. Consumption in all reported steel end-use categories fell significantly except for high-strength, low-alloy steels, in which it increased by 12 percent. For the same period, demand for columbium in superalloys rose 10 percent, with the portion used in the form of nickel columbium rising by over 30 percent. First-half-year imports of both columbium concentrates and columbium oxide were virtually unchanged. Imports of ferrocolumbium increased 40 percent and exceeded by 20 percent the amount of ferrocolumbium reportedly consumed. Brazil accounted for all ferrocolumbium imports.

The Metals Week published price for columbite ore, quoted since July 1989 at $3 to $3.50 per pound of contained columbium and tantalum pentoxides, was suspended in February. The Metal Bulletin published price for columbite ore continued at a range of $2.60 to $3.05 per pound of contained columbium and tantalum pentoxides. In the fourth quarter, the published price for steelmaking-grade ferrocolumbium was $6.58 per pound of contained columbium, and the published prices for high-purity ferrocolumbium and nickel columbium were $18.50 and $20.50 per pound of contained columbium, respectively. The published price for columbium oxide was $8.17 per pound of oxide, and published prices for columbium metal ranged from $30 to $50 per pound.

It was estimated that in 1992 domestic columbium mine production would be negligible and that U.S. apparent consumption would be about 7.5 million pounds. The majority of total U.S. demand will continue to be supplied by columbium imports in both ore and upgraded forms.

For further information on columbium, contact Larry Cunningham, 202/501-9443.

COPPER

Copper has been used for over 6,000 years; alloyed with tin, it gave rise to the bronze age of human history. Although the initial use of copper was probably for tools, weapons, and ornaments, by far the largest use today is in electrical applications.

Copper ranks third in the amount of metal consumed each year throughout the world, following iron and steel, collectively, and aluminum. At least four physiochemical properties, singly or in combination, account for the widespread use of copper and its alloys. Foremost among these is electrical conductivity. Among the electrically conductive metals, copper is second in conductivity only to silver. Electrical uses, which account for about 70 percent of copper demand, include electrical power transmission, motors and generators, housing and industrial wiring, automotive and appliance wiring, telecommunications, electronic circuit boards, specialized electronic equipment, and numerous other electrical and electronic applications.

The chemical stability and workability of copper are among the reasons that copper and its alloys have been extensively used in tubing and valves for systems carrying potable water, salt water, and other aqueous fluids. Because of its good thermal conductivity, which again is second only to that of silver, copper and its alloys are extensively used as materials of construction for heat exchangers used in motor vehicles, refrigeration and air conditioning units, and many other applications. Because of its resistance to salt, copper is widely used in marine environments and automotive brake components.

Copper is also widely used, for other reasons than its electrical conductivity, in industrial machinery and transportation equipment. Because of its aesthetic appeal and its resistance to weathering, it is used in construction for roofing, flashing, decorative hardware, and guttering and downspouts. Miscellaneous uses of copper include ammunition, industrial and agricultural chemicals, pigments, fine instruments and watches, jewelry, cooking utensils, decorative items, and coinage.

Chile is the leading world mine producer of copper, followed closely by the United States. Combined, they account for about one-third of world production. The United States is the leading world producer of refined copper. The principal copper-mining States, in descending order, are Arizona, New Mexico, Utah, Michigan, and Montana. The U.S. copper industry underwent significant restructuring following a downturn during the early 1980's. U.S. producers have been able to significantly reduce costs, increase production, and improve their overall competitive position with respect to other world copper producers.

About 80 percent of domestic copper mine production and 60 percent of world mine production is from open pits. Open pit mining of relatively shallow deposits allows for large-scale bulk mining methods that make copper recovery from low-grade ores economically feasible. Relatively low-grade porphyry deposits of copper sulfides account for most domestic and world copper production. Copper is also recovered from massive sulfide and stratabound deposits by open pit and underground methods.

Following blasting, sulfide ores are crushed and ground to liberate the copper minerals, treated by froth flotation to separate or concentrate the copper minerals, smelted to liberate copper from the iron and sulfur, and electrolytically refined to remove impurities. Oxidized ore may be processed by leaching and solvent extraction-electrowinning technology. Byproduct recovery of gold, silver, molybdenum, and sulfur plays an important role in the economic recovery of copper from many domestic deposits.

In the United States more than 2 million metric tons of copper per year is consumed at about 20 wire-rod mills, 40 primary brass mills, and more than 1,000 foundries, chemical plants, and miscellaneous manufacturers. Copper recovered from the recycling of scrap or secondary copper materials is an important part of domestic supply. Old or obsolete scrap accounts for about 25 percent of domestic demand.

U.S. reserves of copper are adequate to meet projected cumulative domestic demand for at least 25 years. However, owing to limited smelter capacity, foreign ownership of some domestic mine production, and other economic operating factors, the United States is a net importer of refined copper and net exporter of copper in concentrates.

Industry Highlights in 1991

Increased world availability of concentrates caused a smelter bottleneck by midyear, resulting both in higher smelting and refinery charges and in refined copper supply constraints. Disruptions to mine supply continued throughout the year, including strikes and mine accidents, and at yearend, civil unrest in Zaire. Even so, largely owing to increased output at several mines in the United States and Chile, copper concentrates were expected to remain surplus to available smelter capacity for some time. In addition to expansions at existing smelters, plans for at least 10 new smelters were under consideration, totaling about 1.5 million tons of new copper capacity.

The United States and some European countries continued to show signs of economic malaise. As a result, U.S. copper consumption was lower than in 1990. U.S. exports of concentrates, refined copper, and semifabricates continued to increase. U.S. net imports of brass mill semifabricates decreased for the seventh consecutive year. It was estimated that U.S. apparent consumption of copper would exceed 2.1 million tons in 1992, and that domestic mine production would exceed 1.6 million tons.

For further information on copper, contact Janice Jolly, 202/501-9414, and Daniel Edelstein, 202/501-9415.

FLUORSPAR

Although fluorspar is not a household word like aluminum and steel, it is used in producing both these metals. In making steel, it helps remove sulfur and phosphorus from the molten metal and improves its qualities in other ways. In making aluminum, it is reacted with sulfuric acid to produce hydrogen fluoride, which is used to make aluminum fluoride and synthetic cryolite; 50 to 60 pounds of fluorspar in these forms is needed to make each ton of aluminum we produce.

Although fluorspar reserves exist in the United States, we import most of what we use. Because of higher production and transportation costs, it is more economic for U.S. industry to secure the fluorspar it needs from foreign sources. The majority of this imported material comes from Mexico, China, and the Republic of South Africa. Most of the limited domestic production comes from Illinois.

Fluorspar is marketed in three principal grades: Acid, ceramic, and metallurgical. Most of the acid-grade material is converted to hydrofluoric acid by the chemical industry; this material has diverse uses, including the manufacture of fluorochemicals, glass and metal processing, and the manufacture of high-octane fuel for aircraft and automobiles. The largest chemical use is for the production of chlorofluorocarbons (CFC's), which is now restricted to help protect the ozone layer.

Uses for ceramic-grade material range from making various kinds of glass and enamel to welding rod coatings and fiberglass insulation. As its name implies, metallurgical-grade material is used in a number of metal industries; by far the largest use is in making iron and steel, where up to 20 pounds per ton of molten metal may be used.

Industry Highlights in 1991

On March 6, the Environmental Protection Agency published temporary regulations to implement the 1991 limits on the production and consumption of ozone-depleting chemicals required by section 604 of the Clean Air Act Amendments of 1990. The regulations were in effect only during 1991 and were to be replaced by regulations proposed on September 30, 1991, that were to take effect January 1, 1992. The purpose of the regulations was to implement the Montreal Protocol on Substances That Deplete the Ozone Layer and appropriate sections of the Clean Air Act Amendments. The protocol and the amendments impose limits on the production and consumption of certain ozone-depleting chemicals according to specified schedules. The protocol also requires each nation that becomes a party to the agreement to impose certain restrictions on trade in ozone-depleting substances with non-parties.

For further information on fluorspar, contact Michael Miller, 202/501-9409.

GOLD

Gold has been a standard of value through most of human history, sometimes with the value of currency officially linked to it, sometimes simply because it was the material of which precious objects were made. When Pizarro conquered Peru, he held the Inca emperor hostage until enough gold could be raised to fill a 17- by 22-foot room to a height of 9 feet from the floor. Before all the gold could be collected, the Spaniards became impatient to divide it up, and for this and various political reasons, the hostage was brutally dispatched. The episode illustrates how cultures have universally viewed gold as the ultimate substance of value, seemingly arriving independently at an appreciation of its beauty, durability, and worth.

Why gold became so highly and widely esteemed can now only be conjectured. A relatively rare metal, it does not tarnish or corrode in use, so that its inherent beauty remains unimpaired. It is easy to work with and has a bright, pleasing color. All of this made it a "natural" for jewelry, its oldest and by far its largest use, both historically and in the present day. Its high price today is not solely due to its desirability, however—gold is expensive to find and to mine, and a major portion of the per-ounce cost is traceable directly to the cost of production.

Gold is useful as well as beautiful and valuable. In today's high-tech economy, it performs critical functions in computers, communications equipment, spacecraft, and jet aircraft engines; and in our daily lives it is widely used in dentistry for inlays, crowns, and bridges.

Despite these important uses, the major demand for gold remains for its use in jewelry and for investment in the forms of bullion and gold coins, and about a third of all the gold that has been mined throughout history is in government vaults in various countries, such as America's Fort Knox.

Gold discoveries have occasioned some spectacular gold rushes and have expedited if not altered the course of history. In particular, the gold rush of 1849, which followed the discovery of gold at Sutter's Mill in California in 1848, led to the opening to settlement of vast regions of the Western United States. Similarly, the quest for gold has also led explorers to remote regions of the Earth where exploration for other, less valuable minerals could not be justified but where their serendipitous discovery as a byproduct of exploration for gold has contributed to meeting the needs of society. Today's major sources of gold are South Africa, the former U.S.S.R., the United States, Australia, Canada, and Brazil, and although a new gold rush may be unlikely, who can say one is impossible?

Although the United States has not used gold as actual currency for many years, it started producing legal tender American Eagle coins, all of which are made of newly mined U.S. gold, in October 1986; so popular did the new coins prove with collectors, speculators, and citizens who simply wanted a gold coin that the first offering of 558,000 ounces sold out in 2 days. More coins were produced, and sales of the Eagles, which come in l/10-, l/4-, l/2-, and l-ounce sizes, have remained brisk. Other U.S. issues have included coins commemorating the bicentennial of the U.S. Constitution in 1987 and the bicentennial of the U.S. Congress in 1989.

Industry Highlights in 1991

For the second consecutive year, the United States was the world's second largest gold-producing nation, after the Republic of South Africa; for nearly 50 years the U.S.S.R. had been the world's second largest producer.

The dominant gold-producing States were Nevada and California, with about 75 percent of the U.S. total. Some new gold mine development activity was postponed pending higher prices. U.S. gold exploration activity continued to moderate, and the focus of many U.S. companies began to shift to other nations, especially toward Latin America. In July, the President lifted economic sanctions against the Republic of South Africa, thereby allowing the resumption of imports and sales of gold Krugerrand coins in the United States. It was estimated that domestic mine production of gold would be about 315 metric tons in 1992.

The Engelhard Industries/London daily final price of gold ranged from a high of $404 per ounce at the beginning of the war in the Persian Gulf in mid-January to a low of $345 per ounce in mid-September, its lowest level in over 5 years. Uncertainty arising from the continuing turmoil in the former U.S.S.R. and reports regarding the size of Soviet bullion reserves led to a post-September rally that drove the price over $360 per ounce. The volume of gold futures traded on the Nation's exchanges declined substantially from that of 1990, owing in part to apparent investor disinterest.

Environmental pollution abatement continued to be of concern to domestic gold producers, especially in Alaska, where there are many small placer mines. Provision for reclamation of mined land is an integral part of an increasing number of gold mine plans.

For further information on gold, contact John Lucas, 202/501-9417.

GRAPHITE

Graphite, a soft crystalline form of carbon, has been called plumbago and black lead. Although most of us meet a little graphite every day—every time we use a so-called lead pencil—steel mills and iron and steel foundries account for about 70 percent of overall use.

The United States produces and uses much more synthetic graphite than natural graphite. In a recent year, we used about 35,000 tons of natural graphite—most of which was imported—for refractories, brake linings, foundries, and other uses. In contrast, almost 276,000 short tons of synthetic graphite was produced for use in anodes; cloth and fibers; crucibles, vessels, and refractories; electric motor brushes and machined shapes; electrodes; and other graphite articles. This synthetic graphite is largely made from petroleum coke, coal tar pitch binder, and a little petroleum-base oil.

Natural graphite comes in three principal forms—amorphous, lump, and crystalline flake; actually all graphite is crystalline, but in the type called amorphous the crystals are so fine that they can only be seen with a microscope. All crystalline lump graphite comes from Sri Lanka, formerly known as the island of Ceylon; the island nation of Madagascar has the world's largest known resource of flake graphite. China is the world's leading producer of amorphous graphite and is the second largest source of U.S. graphite imports, following Mexico.

Industry Highlights in 1991

Availability of graphite was more than satisfactory during 1991. Demand was met largely by imports of flake from Brazil, China, and Madagascar; lump and chip from Sri Lanka; and amorphous from China and Mexico. Imports of all kinds of graphite were down 42 percent from those of 1990. Exports, although relatively small, were up substantially.

For further information on graphite, contact Harold Taylor, 202/501-9754.

HAFNIUM AND ZIRCONIUM

Hafnium and zirconium occur together in nature, but in very different proportions: I part of hafnium to 50 parts of zirconium is the usual ratio. Zirconium is the more widely used of the two; the principal use for hafnium is for control rods in nuclear-powered submarines.

The two elements must be separated for nuclear applications—production of hafnium originated when it had to be removed from zirconium to purify the latter for use in nuclear reactors—but are not separated for most other uses. Over 95 percent of zirconium uses are industrial rather than nuclear and include foundry sands, refractories, ceramics, abrasives, chemicals, and metallurgical applications as alloys. The foundry uses are by far the greatest; in them, the mineral form, zircon, is used as facings on foundry molds to increase resistance to metal penetration and to give the castings a uniform finish.

Both hafnium and zirconium are extracted from zircon, which in turn is a byproduct of mining ilmenite and rutile, the source minerals for titanium. In the United States, zircon is mined primarily from placer deposits in Florida; the major foreign sources are Australia and the Republic of South Africa.

The Bureau of Mines played an important role in developing the way to produce high-purity zirconium and hafnium. Its Kroll process was adopted by private industry in 1953 and led to the production of large quantities of zirconium in both high-purity and commercial grades.

Hafnium Industry Highlights in 1991

Hafnium production continued to be low, primarily owing to weak demand for nuclear-grade (hafnium-free) zirconium metal. Existing stocks of hafnium oxide continued to increase because consumption generally failed to keep pace with the supply produced through the production of zirconium for the nuclear industry.

Zirconium Industry Highlights in 1991

Pilot plant trials, close-spaced drilling, and crop testing to determine soil reclamation all were activities associated with the development of several promising deposits in Virginia and North Carolina; initial production could begin by 1995. A new zirconia production facility was brought on-line by an established producer in New York.

Although mine production was weak and near 1990 levels, domestic mines did not undergo rotating closures as occurred with some Australian mines. Waning prices and production were mostly attributable to the world economy, although the situation was exacerbated by new capacity that came on-stream during a period of record high prices and dwindling demand.

For further information on hafnium and zirconium, contact David A. Templeton, 202/501-9391.

IRON ORE

Iron ore is probably the single most important nonfuel mineral. As the source of primary iron, it is essential to the iron and steel industries and thus to modern industry itself. Although not one of the largest world producers of iron ore, the United States produces enough to meet about 80 percent of its needs, importing much of the rest of its requirements from Canada and Brazil.

Many of the iron deposits mined today were formed between 2 and 3 billion years ago during Precambrian time. These Precambrian deposits, known as banded iron formations, occur in some of the oldest rocks recognized by geology. Most iron mines are enormous open pit operations, both because so much iron ore is needed and because it is more economic to mine iron on a large scale. Because the richer U.S. deposits of iron ore were mined out between 1900 and 1950, we must now mine low-grade ore called taconite. About 3.1 tons of crude taconite must be mined for every ton of usable ore produced. When the nonore waste rock and overburden are considered, the proportion rises to 5:1.

After the taconite ore has been mined, it must be crushed and beneficiated to increase its iron content and reduce the content of impurities. Limestone and other fluxes are frequently added to meet the needs of particular consumers. In the United States, the powdery iron ore concentrate is then agglomerated into hard, marble-sized pellets and shipped to the steelworks. At the steelworks the pellets are charged into giant blast furnaces that produce the actual molten metal. The molten iron then goes to another part of the steelworks, where it is blown with oxygen to make steel and cast into steel slabs.

Transportation is a major factor in the iron ore industry. Transportation costs account for between 20 and 40 percent of the delivered cost of the ore at consuming plants. In the United States, transportation is complicated by the fact that the vast majority of U.S. iron ore output comes from Minnesota and Michigan and is shipped by vessel on the Great Lakes. Because of dangerous pack ice formation on the lakes in January and February, the ore can only be shipped 9 months of the year.

Since 1986, following two major recessions in the steel industry, the U.S. iron ore industry has undergone major restructuring to lower operating costs and improve competitiveness. By 1989, the U.S. industry consisted of 20 open pit mines and 1 underground operation; 99 percent of U.S. output came from just 10 of the mines.

Industry Highlights in 1991

World production of iron ore continued to decline from the 1989 record high of 926 million tons because of adverse events in the former U.S.S.R., North America, and Liberia. In 1990 blast furnace production of hot metal and pig iron dropped 4 percent to 527 million tons because of cutbacks in Brazil, the U.S.S.R., North America, and the Federal Republic of Germany; a similar decrease was expected for 1991. Competition between ore producers remained intense, and several smaller mines with marginal ore grades were in a precarious financial position.

The largest mines (those with production capacities greater than 10 million tons per year) continued to expand because of the advantages of economy of scale. This trend showed no signs of abating, with the giant Carajas project in Brazil increasing capacity to 35 million tons per year. The Brazilians also made improvements at several mines and pelletizing plants in the Iron Ore Quadrangle of Minas Gerais. Railroads and marine terminals were upgraded in both regions. Brazil produced 154 million tons of usable ore in 1990 and exported 114 million tons, setting new records in both cases. Early projections indicate that the corresponding 1991 figures will be even higher. Australia, the second largest exporter after Brazil, also reported record production in 1990 and was expected to bring another two mines in the Pilbara Region on-stream between 1992 and 1994. Operations at the huge Mount Whaleback complex have been fully restored, following the collapse of a pit wall in 1989.

Iron ore suppliers gained price increases of 6 to 10 percent from Japanese steelmakers during annual contract negotiations at the beginning of 1991. These price hikes were less dramatic than those of 1990, but 1991 was the third consecutive year that suppliers have gotten increases. Prices were also up in Western Europe, but the hikes were smaller in several cases.

In early 1991 the first new iron mine in Minnesota in more than 10 years was opened in the central part of the Mesabi Range. Taconite from the new mine was trucked about 6 miles to an existing pelletizing complex. The U.S. iron ore industry continued to be affected by the weak demand for steel caused by a soft economy. Financial problems at one Canadian steelworks resulted in a sharp drop in U.S. pellet exports and created problems for one of two pelletizing complexes in Michigan.

An increasing number of North American steelworks were using fluxed pellets. This newer, more easily reducible type of pellet is created by adding limestone and/or dolomite to the iron ore concentrate during the balling stage. Fluxed pellets accounted for 39 percent of total U.S. production in 1990 and were expected to account for almost half of the 1991 output. Environmental concerns continued to include reclamation of process water and solid waste, reduction of dust and noise, and control of ground shock from blasting. Technological research focused on improving the quality of fluxed pellets, direct steelmaking, direct reduction of pellets using solid fuels, substitution of organic binders for bentonite, and reduction of fuel costs.

For further information on iron ore, contact Bill Kirk, 202/501-9430.

IRON AND STEEL

Iron and its alloy steel are vital to the United States for both national security and economic well-being. As we will see, the origins of steel are well known, but the use of iron at least for ornaments goes back at least 6,000 years, before the development of written records. The first iron to be used probably came from meteorites; later, some prehistoric fire built over an iron ore deposit probably led to the concept of smelting and thus in time to modern industrial society. The historic period known as the iron age began around 1200 B.C.

A little steel was made by local ironmakers even in ancient times, but large quantities could not be made until the 19th century, when the Bessemer process for making steel by blowing air through large tonnages of molten pig iron to remove excess carbon and other elements was introduced. The new industry grew rapidly; much of the 19th century development that laid the foundation of our modern industrial world was based on Bessemer steel. Since then, new steelmaking processes have been introduced; today much U.S. steel is produced by an Austrian process introduced in the 1950's. This process is known as the Linz-Donawitz (L-D) process in Europe and as the basic oxygen process in the United States. As its name implies, the process uses pure oxygen, which is injected into the molten metal to remove excess carbon, silicon, and other elements. Almost all pig iron produced in the United States is delivered while it is still liquid to steelmaking furnaces located at the same site for refining into raw steel. Another important ingredient in the furnace charges is scrap. This is almost always the only material charged in electric arc furnaces. Typically used to produce stainless and special alloy steels, these furnaces nowadays also make much ordinary steel, in "minimills."

Most Americans are aware of the erratic fortunes of the U.S. steel industry in recent years. Production of iron and steel in the industrialized countries increased steadily after World War II until 1974. Because the world steel industry was operating at capacity, additional facilities were being built to meet the expected growing demand. The sharp rise of petroleum prices and the following economic disturbances resulted in much slower growth in demand than had been anticipated, and within the next few years steel companies throughout the world suffered massive financial losses. The loss figure for the United States for 1982-86 alone was about $12 billion.

The U.S. steel industry benefited from this crisis in many ways, however. Despite the losses, almost $18 billion was spent on development and modernization during the 1980's, and the work force required per product ton was cut by nearly 50 percent. These changes left the U.S. industry better able to compete with foreign producers, which typically had more modern facilities, and in the case of developing countries such advantages as lower labor, raw material, and/or pollution control costs.

An interesting figure showing the importance of steel to modern industrial society comes from the United Nations. In less developed countries, per capita consumption of raw steel is about 40 pounds. In Japan, Canada, the United States, and some European countries, it is over l,200 pounds. Construction and transportation are the leading uses.

Another interesting statistic is that about 90 percent of all metal consumed in the United States is iron and steel. The bulk of the steel we use is made in the United States; Indiana is the leading producer, followed by Ohio and Pennsylvania.

Industry Highlights in 1991

1991 was not an eventful year for the iron and steel industry. No ownership changes took place in the primary steel sector, and no major developments were announced. The industry suffered from very weak markets, possibly due to uncertainty created by the war in the Persian Gulf. Also, a large amount of steel was produced in the last quarter of 1990 in the expectation of an imminent upturn, resulting in an overhang of stocks at the beginning of 1991 and a drastic fall in production. Capacity utilization dropped to between 62 and 69 percent in February and stayed below 75 percent for the remainder of the year. As a result, steel production dropped by 12 percent compared with that of 1990; shipments dropped less (7 percent) because of shipments from industry stocks. Shipments to the main markets (service centers, automotive producers, and construction) were 12 to 18 percent off their previous levels. Because of severe price cutting, most integrated steel companies and some minimills showed losses. The average list or nominal prices rose toward yearend from $523 to $544 per ton; however, discounts often exceeded 20 percent, occasionally reaching 30 percent for some stainless and alloy steel grades in common sections. Only toward yearend did some firming of prices for oil country goods and cans and other containers become apparent.

The only bright spot in the picture was exports, which rose by more than 40 percent, owing to active search for export markets by all producers, integrated as well as minimills. Prices for exports, however, were often even lower than prices at home.

Minimills took another part of the integrated major producers' market when two companies started to roll wide-flange beams, causing two of the three integrated mills producing these sections to leave this business. The success of the thin-slab flat products technology was convincingly demonstrated in that the first such plant operated at about 90 percent of capacity and, according to its owners, at a profit; a second such plant is being constructed by the same company.

For further information on iron and steel, contact Gerald Houck, 202/501-9439.

LEAD

Lead is one of the oldest metals used by man—some historians have theorized that the downfall of the Roman Empire was expedited by the debilitating effects on its citizens of drinking water carried in lead pipes. It is the most corrosion resistant of the common metals; buildings built in Europe four centuries ago still stand under their original lead roofs.

Today's major use of lead is in lead-acid storage batteries. The electrical systems of vehicles, ships, and aircraft depend on such batteries for startup, and in some cases batteries provide the actual motive power. Other batteries provide standby electrical power for emergencies, and very large lead-acid systems are designed to provide "peaking" power in such applications as commercial power networks and subway systems. An increasing use is in the uninterruptible power supply systems necessary for voltage control and emergency power in critical computer storage systems. Lead in gasoline, once the second largest use of lead in the United States, has been virtually phased out to eliminate the health hazard it was found to present.

Nontransportation uses for lead include increasing use for soundproofing in office buildings, schools, and hotels. It is widely used in hospitals to block x-ray and gamma radiation, and is employed to shield against nuclear radiation both in permanent installations and when nuclear material is being transported.

A major problem with lead in some uses is its toxicity since accumulation of even minute quantities in the aqueous system of the body can cause permanent brain damage and/or central nervous system disability, liver and kidney damage, and even death. Even the use of lead shot for hunting geese, ducks, and other migratory waterfowl is declining because of lead's toxic effect on the marine-life chain.

Besides being a major user of lead, the United States is a major mine producer and by far the world's leading metal producer.

Missouri is by far the main producing State. Because of the great number of scrap batteries that become available each year, recycled lead supplies over 60 percent of our annual demand. The leading foreign mine producers, with output about equal to that of the United States, are Australia and the former U.S.S.R. The leading foreign metal producers are the former U.S.S.R., the United Kingdom, the Federal Republic of Germany, and Japan. These countries, together with the United States, account for about half of the world's refined lead production.

Lead's toxicity presents problems in producing it as well as in using it, and emissions from lead smelters and refineries are closely regulated, as are worker blood-lead levels and in-plant permissible exposure limits in all lead and lead oxide producing, lead-acid battery manufacturing, and other lead products plants. This adds to the cost of producing lead but is necessary to protect both the general public health and the health of lead industry workers.

Industry Highlights in 1991

After considerable growth in domestic refinery production and consumption during 1987-89 and a leveling in 1990, all sectors reflected the general recession in 1991 as the United States continued to be nearly self-sufficient in lead. Although at least one small secondary plant permanently closed, a medium-sized smelter opened in Texas and the Nation's top primary producer started up a large secondary plant in Missouri. Since there was a net gain in secondary capacity, utilization in that sector dropped to about 82 percent. Although both new Alaska mines reached capacity, several Idaho silver-lead-zinc mines and two Missouri lead mines closed, owing to submarginal prices. World demand dropped for the second year in a row, to about 5.8 million tons, compared with the record of about 6.1 million tons set in 1989.

Lead prices during 1991 were relatively stable but considerably lower than in 1990.

Domestic mine production of lead in 1992 was expected to be about the same as in 1991, with continued high exports from Alaska. The U.S. secondary plants were expected to continue producing at high levels as individual States continue to enact battery disposal or mandatory recycling laws. Future growth in lead demand is contingent on the development of cost-competitive electric vehicles for general and new industrial uses, power supply load-leveling systems, and expanded use of uninterruptible power supply batteries, especially for networked computer systems of all capacities.

In April, U.S. lead producers, including battery manufacturers, were included in the Environmental Protection Agency's (EPA) voluntary "33-50" program to reduce industrial emissions one-third by 1992 and one-half by 1995. In May, EPA made the final determination not to regulate primary lead smelter slags as hazardous waste, and tentatively proposed to handle them in conjunction with mining wastes in a later ruling. A regulatory negotiating committee established by EPA to write a battery recycling rule was terminated in September after 9 months because no justifiable risks or benefits could be determined. However, Congress included legislative directions to this end in various pending Resource Conservation and Recovery Act amendments, along with other lead process waste and secondary lead product content issues. EPA also undertook comprehensive reviews of the ambient air lead standard for smelters and new source performance standards for secondary plants during 1991; both rules were expected to be promulgated in late 1992. By yearend 37 States had passed battery disposal or mandatory recycling laws, and similar actions had been initiated in 6 others.

For further information on lead, contact William Woodbury, 202/501-9444.

LITHIUM

The United States leads the world in both production and consumption of lithium. A major deposit of spodumene, the raw material for lithium, in North Carolina is the main source of U.S. output.

Except for batteries, a relatively new use, most lithium uses are unfamiliar to the general public because they occur in the course of producing other mineral products, and it is the final product that is generally thought of. A major use of lithium is in producing aluminum—lithium compounds are added to the cryolite bath in aluminum potlines to lower operating temperatures and increase the electrical conductivity of the bath. Use of the lithium allows the potline operator more flexibility to either increase production, reduce power consumption, or increase current efficiency.

Another important use of lithium is in making glass and ceramics, especially pyroceramics (thermal-shock-resistant cookware). Added to the other materials being used, it reduces melting temperatures, improves other physical properties, and replaces toxic compounds, which must be eliminated from cookware and tableware. Other uses in this area include picture tubes for black and white television.

A third important area is the manufacture of multipurpose greases. Greases made with lithium work well under a wide range of temperatures and are used extensively in military, industrial, automotive, aircraft, and marine applications.

Although lithium has been used to make aluminum for years, a new use in this area has emerged; aluminum-lithium alloys have been developed for use in aircraft. The use of the new alloys can make the airplanes lighter, resulting in a substantial savings in fuel.

Industry Highlights in 1991

In 1990, a U.S. lithium producer reached an agreement with the Government of Bolivia to develop a lithium brine operation in the Bolivian Andes at the Salar de Uyuni. Following political pressure in Bolivia, the Government canceled the contract and sent out a request for international bids.

In 1991, the U.S. company once again entered a bid to develop Uyuni, while also pursuing the development of another brine deposit at the Salar de Hombre Muerto in Argentina. Following the new bids in Bolivia, the Government agent recommended that the contract to develop Uyuni be granted to the same U.S. company after renegotiation.

The Salar de Uyuni is the largest identified lithium resource in the world. The Argentine deposit is not believed to be nearly as large, although exploration has not been completed.

There is little question that the U.S. company will eventually develop a brine deposit; the question is which deposit it will become permanently involved with.

For further information on lithium, contact Joyce Ober, 202/501-9406.

MAGNESIUM AND ITS COMPOUNDS

Magnesium is fairly unusual among mineral materials in that we obtain our supply of it both from such ores as magnesite and dolomite and from seawater and brines. More of it is used as various compounds than as metal.

The chief user of magnesium compounds is the iron and steel industry as a refractory; such refractories are used to line the equipment used to make these metals. As metal, the leading use is as an alloy with aluminum, in applications ranging from beverage cans to aircraft.

There are many additional uses of both compounds and metal. Magnesium compounds find uses in animal feed, cement, rubber, fertilizers, paper manufacture, insulation, and medicine. Cows can develop a fatal illness if they do not get enough magnesium in their diet, so magnesium compounds are added to their feed. The cement floors of industrial buildings often contain magnesium compounds, and they are used as stabilizers and vulcanizing agents in making rubber.

In addition to its use as an alloy with aluminum, magnesium metal is being increasingly used in the automobile industry and in manufacturing communications equipment, computers, machinery, and sports equipment. Use in many of these areas is expanding, following the recent development of high-purity magnesium alloys that have better resistance to corrosion than the less pure alloys. Advantages gained by using magnesium in some of these applications include built-in shielding against electromagnetic interference (for computers), ability to maintain precision tolerances, more effective heat dissipation, and high strength-to-weight ratio. Compared with aluminum, specific magnesium components are about one-third lighter, which is important in automobile components. By decreasing a car's weight, gas mileage can be improved.

Industry Highlights in 1991—Magnesium

U.S. production of primary magnesium declined as producers reduced inventory levels and faced competition from imports. Nevertheless, magnesium continued to make inroads into automotive applications because of a potential increase in the Corporate Average Fuel Economy Standards. In some automotive applications, magnesium was specified for engine components, seat supports, and steering columns.

Although U.S. inventories of magnesium declined, world inventories increased, prompting some cutbacks in production. In Canada, a 12,500-ton-per-year magnesium plant, which opened in 1990, closed in early 1991 because of technical problems and high operating costs. The operator was seeking a buyer for the plant. A Norwegian magnesium producer closed 10,000 tons of annual capacity and planned to modernize the closed portion of the plant, which could take 1 to 2 years. In Yugoslavia, overall magnesium production was lowered by 15 to 20 percent until 1992 because of rising inventories; production at Haley, Ontario, Canada, was reduced for the same reason.

Despite these closures, development of two proposed magnesium plants was accelerated. One firm in Australia planned to construct a pilot plant by early 1992 to recover magnesium from a magnesite deposit in Queensland. Successful pilot plant operations were expected to lead to the construction of a 60,000-ton-per-year primary magnesium plant by the late 1990's. A 50,000-ton-per-year plant to recover magnesium from asbestos tailings was planned for construction in Canada by 1996.

In May, the Environmental Protection Agency made a final determination that waste water from magnesium processing at a plant in Utah would not be regulated under subtitle C of the Resource Conservation and Recovery Act. It was expected that this waste would be regulated under subtitle D, which covers nonhazardous wastes from mining. The International Trade Administration began an antidumping duty investigation regarding imports of magnesium and magnesium alloys from Canada. One U.S. producer filed a petition alleging that a Canadian firm sold material in Canada at less than the company's cost of production.

Industry Highlights in 1991—Magnesium Compounds

A new magnesite mine opened in Australia, with a capacity of 2.5 million tons per year of magnesite. Output from this mine was expected to supply a new 150,000-ton-per-year dead-burned-magnesia facility, scheduled to open in early 1992. In Canada, a fused-magnesia plant was scheduled to double its capacity to 28,000 tons per year by adding two additional furnaces.

Czechoslovakia planned to reduce magnesite production by 25 percent by 2000 in an effort to upgrade the quality of the magnesite clinker by reducing the iron content. In India, a 30,000-ton-per-year dead-burned-magnesia plant was scheduled to be constructed by 1993.

A U.S. magnesia producer developed a product designed to treat industrial wastewater discharge. In a clarifier, the new product reduces heavy metal concentrations and neutralizes acid, with a smaller sludge volume and reduced costs.

For further information on magnesium and magnesium compounds, contact Deborah Kramer, 202/501-9394.

MANGANESE

Manganese is a brittle metal which, by itself, has no significant use. It is, however, essential to iron and steel production and therefore is a key ingredient for the industrial base that supports modern society.

Originally used to control oxygen and sulfur impurities when the Bessemer process for making steel was introduced in the 19th century, manganese was later found to increase the strength, hardness, toughness, and hardenability of steel and to inhibit the formation of grain boundary carbides, which would otherwise make the steel brittle. It has, in fact, survived the Bessemer process it was originally associated with, which has given way to more modern processes for making steel.

The United States must import its entire supply of manganese ore and most of its supply of manganese ferroalloys. In the late 1980's, the main suppliers to the United States were the Republic of South Africa, Gabon, and France. Domestic resources of ore exist, but not of a type that would support production at a price competitive with that of imported ore. Most other industrial countries are also dependent on imports for their ore supply, with the notable exception of the former U.S.S.R. World land resources of manganese, the greatest concentrations of which are in the Republic of South Africa and the former U.S.S.R., are large in comparison with world demand.

An extensive new source of manganese in time to come may be crust and nodule deposits found in various parts of the oceans. Their commercial utilization faces significant legal and technical obstacles. These marine deposits are of interest for their contents not only of manganese but also of minerals such as nickel, cobalt, and copper.

Industry Highlights in 1991

The rapid escalation of ore prices of 1988-90 was arrested, and the price declined slightly from that of 1990. A main reason for the halt apparently was a decline in imports by China and the Eastern European countries. This, coupled with an easing of overall output by the world's steelmakers, led to production cutbacks at major manganese mines. Consequently, world ore production was projected as the lowest since 1983. Nevertheless, developments were reported that had potential for leading to modest amounts of new production from Western Australia, Burkina Faso, Ghana, and Vanuatu. Negative trends in manganese ferroalloys were manifested by shutdowns of several large foreign smelters and decreasing U.S. prices.

For 1992 it was estimated that U.S. apparent consumption of manganese would be 675,000 tons, content basis.

For further information on manganese, contact Thomas Jones, 202/501-9428.

MERCURY

Mercury is one of the few metals that are liquid at room temperature. It does not become solid until a temperature of -38.87 °C. For this reason it is packaged in cast iron, wrought iron, or spun steel containers, and the basic unit for reporting statistics about it is a flask containing 76 pounds of mercury.

Minor uses of mercury were made in ancient times, and consumption increased considerably in the 16th century, following development of the Patio process, in which mercury was used in the recovery of silver. The primary use of mercury today is in batteries; mercury cell batteries have long shelf life, stable operating voltage, compact size, high performance, large discharge capacity per unit volume, and a wide range of operating temperatures—all critical to many industrial, military, and aerospace applications. Civilian uses of these batteries include portable radios, cameras, fire and smoke detectors, and hearing aids. Perhaps the best known traditional use of mercury is in thermometers, which rely on its normally liquid state for their accuracy.

Mercury is toxic and can be fatal to humans, animals, and plants. Mercury poisoning can occur in mining and recovery, in the manufacture and use of mercury products, from industrial waste discharge, and by concentration in the human food chain. Various traditional uses have been eliminated or sharply reduced for reasons traceable to mercury's toxicity; these include use in the pulp and paper industry, gold amalgamation, and antifouling paint.

The United States has some mercury supplies but has been a net importer of mercury metal for many years. Foreign operations have lower production costs, partly because of the different nature of the deposits. U.S. deposits are smaller and lower in grade of ore than foreign ones, ruling out the use of large-scale development, mining, and metallurgical techniques, which tend to lower mining and processing costs. Even the economics of transportation favor the foreign producers, whose output reaches Eastern U.S. consumers by low-cost water transportation rather than traveling more expensively by land. The major foreign producers are currently the former U.S.S.R., Spain, and Algeria, with Spain being a leading U.S. supplier.

Industry Highlights in 1991

Domestic mercury demand continued to decline, falling to about one-quarter of the 1988 figure. Analysts attributed the lower demand to increased regulations affecting the use of mercury as well as its handling and disposal and to technological advances that have reduced the amount of mercury used in some products. Reflecting the declining demand, the price declined to less than $100 per flask in 1991.

Of concern was the large quantity of mercury held by the Federal Government. At the current rate of demand of about 500 metric tons per year, the Government holds enough excess mercury to supply total domestic demand for nearly 11 years. Part of the Government, although constrained to avoid unduly disrupting the shrinking mercury market, is attempting to dispose of the excess material; these sales regain some of the tax money spent over the years to purchase and store the mercury, as well as providing funds to purchase material currently judged to be needed for national defense purposes. However, another part of the Government, concerned about the potential health and environmental problems associated with mercury, is proposing increasingly stringent regulations to control the metal's use and ultimate disposition.

For further information on mercury, contact Robert Reese, Jr., 202/501-9413.

MOLYBDENUM

Molybdenum is used as an alloy in making steels, cast irons, and superalloys. It improves these materials in a number of ways, including making them stronger and tougher and more resistant to wear and corrosion. Because of its association with the iron and steel industry, which accounts for about 75 percent of molybdenum consumption, the amount of molybdenum produced and used varies with activity in that vital industrial sector.

The United States is self-sufficient in molybdenum, with about 45 percent of overall world production; the other major producers are Canada, Chile, and the former U.S.S.R. The United States exports molybdenum to other industrial nations, such as those in Western Europe and Japan.

Although the mineral molybdenite, from which molybdenum is obtained, was probably known in ancient times, there was no significant use of molybdenum until World War I, when it was substituted for tungsten in high-speed steels and used as an alloying element for other steels in military armaments. By the mid-1920's its peacetime use as an alloy was well established, and in the years since then research has considerably expanded the range of materials in which it is an important alloy.

Turning to the other 25 percent of the molybdenum we use, some is used as a metal in its own right, especially in applications requiring materials that can be used under extremely high temperatures. Molybdenum disulfide is used as a lubricant; it performs well under severe temperature and pressure conditions. Other major uses are as catalysts, notably in petroleum refining, and as pigments in dyes, inks, and paints.

Industry Highlights in 1991

U.S. mine output of molybdenum decreased 3 percent compared with that of 1990. Reported consumption decreased about 7 percent, exports decreased about 3 percent, and U.S. producer inventories decreased 4 percent compared with those of 1990. A molybdenum mine, Cyprus Tonopah, Tonopah, NV, closed down, as did a molybdenum roaster in Washington, PA.

It was estimated that domestic mine production of molybdenum would be 60,000 metric tons in 1992 and that U.S. reported consumption would be 17,000 metric tons.

The domestic price for technical-grade molybdic oxide averaged $7.39 per kilogram of contained molybdenum. Mine capacity utilization was 80 percent.

For further information on molybdenum, contact John W. Blossom, 202/501-9435.

NICKEL

Familiar to every American as the name of a medium-size coin bearing the profile of Thomas Jefferson, nickel is vital to the stainless steel industry and has played a key role in the development of the aerospace industry. Its importance in these areas is as an alloy—both as a constituent of stainless steel, the largest use, and in combinations where nickel is the major component. In chemical and petroleum processing equipment, for example, some of the alloys are 95 percent nickel.

Among the qualities nickel brings to the final material are strength and ability to resist corrosion. The so-called superalloys typically contain slightly over 50 percent nickel, which enables them to withstand the high-temperature and corrosive conditions found in the gas turbine engines for which they were originally developed.

Because nickel is not currently mined in the United States, we must import our supplies of this essential material. Fortunately, Canada is our major supplier.

Because of the close linkage with the steel industry, demand for nickel varies substantially from year to year, depending on overall activity in this vital area. It has also been noted that nickel is consumed primarily in major goods and equipment and that consumers tend to delay purchases of these items when the economy is depressed, thus making nickel demand sensitive to the general business cycle.

Industry Highlights in 1991

Domestic primary nickel consumption was down from that of 1990, primarily due to a decline in stainless steel production. It was estimated that 1992 domestic mine production of nickel would be 8,400 tons and that U.S. apparent consumption would be about 160,000 tons.

The London Metal Exchange cash price for nickel rose and remained at relatively high levels in the first half of the year, reflecting stronger than expected demand from the stainless steel sector. The second half of the year saw prices fall, rally briefly, and then fall once more as demand from the stainless steel industry declined. The drop in demand for primary nickel was compounded by unusually large exports of nickel from the former U.S.S.R. to the West and ample supplies of inexpensive nickel-bearing scrap.

A number of nickel production projects began or gathered momentum in 1991, primarily in Australia.

For further information about nickel, contact Peter Kuck, 202/501-9436.

PHOSPHATE ROCK

Phosphorus is a fertilizer that aids root activity, maturing, and ripening of plants; without enough phosphorus, yields drop and resistance to disease is reduced. Phosphate rock, mainly from Florida, is the chief source of our phosphorus; most commercial phosphate rock deposits are classified as marine phosphorite deposits and are believed to have formed in basins located in warm climates and areas of upwelling water in previous geologic eras.

Because the phosphate mineral itself is very insoluble, the phosphate rock is usually treated with sulfuric acid to produce wet-process phosphoric acid. This in turn is used to make monoammonium and diammonium phosphate fertilizers and liquid mixed fertilizers. Other processing variations are used to produce superphosphoric acid and the various grades of superphosphates.

Partly because of their regional concentration, the Florida phosphate rock mining and processing operations are carefully monitored to minimize environmental damage. Nevertheless, the use of phosphorus fertilizer is vital, to improve crop yields in a hungry world and because animals and people who eat plants grown with too little phosphorus may be affected by the phosphorus deficiency.

Industry Highlights in 1991

Phosphate rock production was approximately the same as in 1990. Strong demand from major importing countries such as China and India for diammonium phosphate provided the markets for the high production level. Planned phosphate rock production was achieved, indicating a close supply-demand balance during 1991.

In May, the Environmental Protection Agency (EPA) determined that the regulation of phosphogypsum under the Resource Conservation and Recovery Act was too inflexible and costly, selecting the more flexible regulatory provisions of the Toxic Substances Control Act instead.

The Food, Agriculture, Conservation and Trade Act of 1990 was signed into law in November 1990. The 1990 farm bill achieved the $13 billion reduction in agricultural outlays prescribed by the 1990 Budget Reconciliation Act for 1991-95. It reduced agricultural outlays by making program payments on fewer acres. The bill retained annual acreage reduction programs but modified the method used to determine set-asides.

The two remaining Tennessee phosphate rock companies closed their mines and electric furnaces. Production costs in Tennessee were not competitive with those in the Western States or with the cost of purified wet-process phosphoric acid.

For further information on phosphate rock, contact William Stowasser, 202/501-9408.

PLATINUM-GROUP METALS

The platinum group comprises six closely related metals—platinum, palladium, rhodium, ruthenium, iridium, and osmium—which commonly occur together in nature and are among the scarcest of the metallic elements. Along with gold and silver, they are known as precious metals.

The use of platinum began in the New World: The Spanish conquistadors found South American Indians of the Choco region of Colombia had platinum jewelry, worked from metal collected from placer deposits—that is, metal that had washed out of the locations in which it had originally formed and been found in downstream locations. By the mid-nineteenth century, it had been determined by European scientists that there were six platinum-group metals (PGM's), rather than a single metal as originally believed.

Worldwide, the amount of platinum used in jewelry approximately equals the amount of platinum used in automobile catalysts (autocatalysts), slightly more than one-third of world demand. In the United States, however, over 95 percent of PGM use is by industry—as catalysts in the automotive, chemical, and petroleum refining industries, and as corrosion-resistant materials in the chemical, electrical, glass, and dental-medical industries. Probably the most familiar use is in the automotive industry, where platinum, palladium, and rhodium are used in catalysts to reduce the emission of carbon monoxide, nitrogen oxides, and hydrocarbons from automobiles and light-duty trucks. In addition, platinum oxygen sensors are used to regulate the air-fuel mixture used by the engine.

Despite platinum's New World origins, the bulk of today's PGM production is from the Republic of South Africa and the former U.S.S.R. Nearly all current production is from lode deposits in which the PGM's originally occur—often associated with nickel and copper—rather than the placer deposits from which the early PGM's were obtained. Because the United States imports essentially all the new PGM's it uses, our supply is vulnerable to disruption by the actions of foreign governments, and the U.S. Department of State has certified PGM's as strategic minerals essential for the economy or defense of the United States that are unavailable in adequate supply from reliable and secure suppliers. Considerable emphasis has therefore been placed upon recycling PGM's, and mining of platinum and palladium has recently commenced in Montana.

Industry Highlights in 1991

The price of platinum declined sharply following a series of announcements that various companies had developed less expensive substitutes for PGM's used in autocatalysts. Two Japanese automobile companies announced new palladium-only catalysts, a South African firm announced a manganese-based autocatalyst, and a researcher in the Netherlands claimed development of a catalyst based on copper and chromium. In addition, a U.S. oil company developed a reformulated gasoline aimed at reducing platinum loadings in autocatalysts; the new gasoline is considerably more expensive to produce than conventional fuel and will not be produced unless there are adequate economic or legislative incentives to do so.

Precious metal companies that produce PGM-based autocatalysts have claimed that the newly developed autocatalysts cannot meet the durability requirements for U.S. autocatalysts, which currently are required to operate for 100,000 miles. There is skepticism about whether the new autocatalysts can withstand the effects of trace quantities of lead found in gasoline.

Because of the weak prices for platinum and palladium, a U.S. producer in Montana postponed expansion plans that would have doubled ore production to 2,000 short tons per day.

As the economy of the former U.S.S.R. deteriorated, that country's exports of platinum and rhodium to the West rose dramatically. Exports of platinum rose 27 percent in 1990, and final figures for 1991 were expected to show a further rise. In May, the U.S.S.R. reportedly shipped a large quantity of rhodium to Switzerland to be used as collateral against foreign exchange loans.

The U.S. Bureau of Mines investigated the recovery of PGM's from used autocatalysts by leaching with sodium cyanide solutions at high temperatures, achieving recovery rates of 85 to 90 percent.

For further information on platinum-group metals, contact J. Roger Loebenstein, 202/501-9416.

POTASH

The term "potash" includes several water-soluble compounds that provide potassium, which is crucial to life on earth. Potassium is part of the essential electrolytes of living tissue and is central to the neurological systems of animals. Potassium is found in many industrial and medical products but is employed primarily as a fertilizer for crops.

As a fertilizer, potash aids in the synthesis of starch, sugar, and amino acids in all plants. It also stiffens the straw in cereal plants and promotes root growth. Like nitrogen and phosphorus, it is an essential plant nutrient for which there is no substitute. In contrast to nitrogen, where our imports are small, and phosphorus, where we are a net exporter, we import the bulk of our potash needs, largely from Canada. Domestically produced potash comes largely from New Mexico.

Both here and abroad, most potash reserves occur in underground salt beds formed during previous geologic periods by the evaporation of shallow ancient sea embayments. Some potash is produced from brines that do not flow to the sea, such as the Dead Sea between Israel and Jordan and the Great Salt Lake in Utah.

The former U.S.S.R. and Canada are the leading potash producers, supplying about 60 percent of the world's total output. The former U.S.S.R. and the United States are the largest consumers, using about 40 percent of the world's total.

Industry Highlights in 1991

The world's potash producers stayed in overcapacity; several producers produced at partial capacity to maintain prices. The Canadian potash industry operated at about 65 percent of capacity. In the United States, the Corn Belt and Lake States received about the same amount of potash as in the 1989 and 1990 spring seasons. Abundant world supplies of soybeans and corn did not encourage heavy planting. After the spring planting season, crop conditions in the former U.S.S.R. and the anticipation of exports to that country encouraged a stronger fall application of potash in anticipation of 1992. The Department of Agriculture reduced the corn Acreage Reduction Program to 5 percent, which led to increased application of potash in the fall. One Carlsbad, NM, potash mine was for sale at yearend.

It was estimated that domestic mine production would be 1.8 million tons in 1992 and that U.S. apparent consumption would be 5.4 million tons.

For further information on potash, contact James Searls, 202/501-9407.

RARE EARTHS

The rare earths are a group of 17 chemical elements comprised of scandium, yttrium, and the lanthanides: cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, promethium, samarium, terbium, thulium, and ytterbium. The chief uses of the rare-earth elements are in petroleum fluid cracking catalysts, metallurgical additives and alloys, ceramics and polishing compounds, permanent magnets, and phosphors in products ranging from television sets to fluorescent tubes. "High-tech" uses include laser crystals and high-temperature superconductors. Although some applications demand a specific element, most rare earths presently used by industry are consumed as mixed compounds containing several rare-earth elements. However, demand is shifting to the use of individual rare earths. The special term "mischmetal" denotes a mixture of rare-earth elements in metallic form.

Most of the rare-earth elements are recovered from the minerals monazite and bastnasite. Lesser quantities of rare earths are recovered from the mineral xenotime, an important source of yttrium. The principal domestic source of the rare-earth elements is a bastnasite deposit at Mountain Pass, CA. Other U.S. output comes from byproduct monazite production in Florida and byproduct monazite and xenotime production in North Carolina.

Industry Highlights in 1991

Overall demand for rare earths decreased slightly as the domestic economy experienced a recession. Demand, however, remained steady for rare earths used in permanent magnets and in catalytic converters. In Japan, increased rare-earth demand was the result of initial commercial production of rechargeable rare-earth-nickel hydride batteries.

Several heavy-mineral sands deposits in the Eastern United States continued to be studied. Deposits in Virginia and North Carolina have proceeded through the pilot plant stage; one operation in Virginia is at the permitting stage.

A major domestic rare-earth producer was offered for sale by its parent company. The sale was tied to molybdenum operations in New Mexico and Pennsylvania and to foreign interests in a columbium mine.

Low-cost rare-earth products from China continued to make the international markets extremely competitive. Prices for rare earths, including scandium and yttrium, have dropped significantly since the Chinese entered the market. As a result of the increased availability of low-cost products, rare-earth-processing facilities in several countries remained closed.

For further information on the rare-earth elements, contact James Hedrick, 202/501-9412.

SILVER

The use of silver, largely for jewelry and utensils, reaches back beyond written records; in historic times it became the standard in monetary systems such as that of the Roman Empire. It remained the standard for most currencies for over a thousand years, but after supplies became more plentiful, most countries abandoned it as a standard for their currencies in favor of the rarer gold. Like gold, silver has the "mystique" of a metal whose value is inherent rather than necessarily based on its actual uses; consider the esteem in which silver tableware is held, compared with the equally beautiful and more practical stainless steel.

Silver has a host of practical uses, however, especially in industrialized countries, where nondecorative uses outweigh its use for jewelry and sterlingware. The most important use is in photographic materials: It is used in the manufacture of film, photographic paper, photocopying paper, x-ray film, photo-offset printing plates, and other light-sensitive products. Photographic materials are produced by depositing thin layers of silver salts, gelatin, and dyes onto a support material. Silver salts, while not extremely sensitive to light when first exposed to illumination, produce a greatly intensified image after exposure when treated with photographic developers. The developer reduces a portion of each silver salt grain to metallic silver, depending on the intensity of the light to which the grain was exposed. The resulting black metallic silver forms a negative image of the original object.

Silver is also used in electrical and electronic products, such as switching devices and specialized batteries for defense and space applications. Small silver-zinc batteries are used commercially in calculators and hearing aids. Other uses are found in the refrigeration and air conditioning industry and in such diverse applications as mirrors and medicines. U.S. coins in general circulation no longer contain much silver because as silver prices increased, the value of the silver in the coins exceeded their face value and the Treasury withdrew them. Silver coins are still minted to commemorate special events such as the Olympics, but such coins are normally sold to collectors and never actually used as money.

Mexico is the world's leading silver producer; in fact, it was the opening of silver mines in Mexico and other New World countries in colonial times that caused the change from silver to gold as the general monetary standard as the new supplies of silver flooded the market. Other important suppliers include Peru, the United States, the former U.S.S.R., and Canada. Silver is also recovered from scrap sources such as electronic scrap and old photographic films. When silver prices are high, coins, jewelry, and sterlingware become additional sources of supply to the extent that the higher prices lead their owners to sell them as scrap silver.

Industry Highlights in 1991

Based on preliminary data, U.S. silver production declined for the first time in 6 years. Domestic production was adversely impacted by the closure or curtailment of operations at a number of mines, especially in the Coeur d'Alene area of Idaho. Mining activity was reduced in response to the continued buildup of reported silver stocks, and to the declining silver price, which fell to its lowest level in nearly two decades. Over the past few years, U.S. silver production has continued to increase despite declining prices, owing primarily to the opening of new mines and increased byproduct silver production from copper, gold, lead, and zinc mines. However, it appears that in 1991 the recovery of byproduct silver was unable to compensate for the lower production from primary silver mines.

The Federal Government completed the disposal of that part of Department of the Treasury silver required by Public Law 100-440, the Treasury and Postal Service Appropriations Bill. Approximately 78 metric tons of silver was sold during fiscal year (FY) 1991, bringing the total quantity of silver sold during FY 1989-91 to 233 metric tons. The Government continued to dispose of the silver held in the National Defense Stockpile, using it for the production of commemorative coins and the Eagle silver bullion coins.

In 1991, the average silver price decreased for the fourth consecutive year. Throughout the first 9 months, the daily price ranged between $3 and $5 per troy ounce. Analysts attributed the silver price weakness to lack of investor demand for the metal, combined with the U.S. economic recession and the resulting negative implications for industrial demand.

For further information on silver, contact Robert Reese, Jr., 202/501-9413.

SULFUR

Sulfur, known as "brimstone," the stone that burns, has been utilized by humanity for thousands of years. It became an important mineral commodity after the invention of gunpowder, of which it is an essential ingredient. Since then it has found many more productive uses; in fact, most industrial products require sulfur in one form or another at some stage of their manufacture.

The United States is the world's foremost producer and consumer of sulfur. Part of our production is obtained directly from sulfur deposits using the Frasch process, which involves introducing very hot water to melt the sulfur underground and then bringing it to the surface as a liquid. More of our sulfur is recovered during the refining of petroleum and the processing of "sour" natural gas. Together, Louisiana and Texas produce over half of our sulfur output.

An important, but not major, source of sulfur is the byproduct sulfuric acid captured at operations smelting ores to produce nonferrous metals. Annually, this acid contains over 1 million tons of sulfur that could have been released to the atmosphere, possibly hurting the environment, if it had not been collected at the smelters. Unfortunately, many of the smelters are so far from areas where sulfuric acid is consumed that the value of the acid is offset by transportation costs.

Most sulfur is used to make sulfuric acid. Although sulfur is not in itself a major fertilizer, the manufacture of phosphate fertilizer is by far the largest use of sulfuric acid. Phosphate fertilizers, together with nitrogen and potassium, are vital to the health and growth of plants. Minor quantities of sulfur or sulfuric acid are used in almost every other industry, including some that are also sources of sulfur, such as copper metal production and petroleum refining.

Industry Highlights in 1991

Domestic Frasch production decreased significantly owing to the closings of two operations in Louisiana. Both mines, closed because of decreased production due to depletion of resources, were owned by the same company. This company has a new project under construction in the Gulf of Mexico which will produce both recovered and Frasch sulfur in conjunction with oil and gas production. Production from this site should replace the production lost at the other mines. When completed, the new operation will be the largest structure in the Gulf.

North American sulfur prices presented an unusual situation. Worldwide sulfur production appeared to be lower than in 1990, with little change in demand; this should indicate that prices would remain strong, but the opposite was true—prices fell throughout the second half of the year. U.S. producers reduced prices to compete with Canadian producers and maintain market share. Canadian producers who recover sulfur from oil and gas decreased prices to overcome a cash shortfall caused by low natural gas prices and to build market share. Prices seemed to have stabilized by yearend.

The occupation of Kuwait by Iraq and the subsequent Gulf War disrupted sulfur production in the region. Political and economic upheavals in Eastern Europe and the former U.S.S.R. curtailed or slowed sulfur production in these countries.

It was estimated that 1992 domestic sulfur production would be 11 million tons and that U.S. apparent consumption would be 12.5 million tons.

For further information on sulfur, contact Joyce Ober, 202/501-9406.

TANTALUM

Tantalum is a refractory metal that is easily fabricated, has a high melting point, is highly resistant to corrosion by acids, and is a good conductor of heat and electricity. Discovered in 1802, tantalum's first commercial use occurred a century later as filament material in light bulbs. Tantalum capacitors were perfected in 1940, and the consumption of tantalum increased sharply owing to military applications during World War II.

Currently the major use for tantalum, around 60 percent in the form of tantalum metal powder, is in the production of electronic components, mainly tantalum capacitors. Applications for tantalum capacitors include computers, communication systems, and instruments and controls for various military systems. The tantalum capacitor exhibits reliable performance and combines compactness and high efficiency with good shelf life. Alloyed with other metals, tantalum is also used in making carbide tools for metalworking equipment, in chemical processing equipment, and in the production of superalloys for jet components. Substitutes exist for tantalum but are made at either a performance or economic penalty.

There has been no significant mining of tantalum in the United States since the 1950's. Most domestic resources of tantalum are low in grade and are not currently commercially recoverable. Consequently, the United States is highly import dependent for its tantalum raw material supply. Australia is the leading world producer, followed by Brazil and Canada.

Industry Highlights in 1991

Overall demand for tantalum was down from that of 1990. First half-year U.S. sales of tantalum capacitors were up slightly. However, the amount of tantalum capacitor-grade powder consumed was on the decline, owing to the continued use of higher capacitance tantalum powders. Imports for consumption of tantalum mineral concentrates declined to the lowest level since 1987. The published spot price for tantalite ore began the year at $31 to $35 per pound of contained pentoxide, fell to $29 to $33 by midyear, and was quoted at $27.50 to $29 in the fourth quarter. Industry sources indicated that tantalum mill products sold at an average of $170 per pound, depending on specification, and that tantalum capacitor-grade powder sold at an average of $145 per pound.

It was estimated that domestic mine production would be small in 1992 and that U.S. apparent consumption would continue to be less than 1 million pounds.

For further information on tantalum, contact Larry Cunningham, 202/501-9443.

THORIUM

Named after Thor, the Scandinavian god of thunder and lightning, thorium is a naturally radioactive element that is widely distributed in the Earth's crust. It can be used as a fuel in the generation of nuclear energy; however, reactor technology has evolved along different lines, and only one U.S. reactor uses thorium.

Before electrification, thorium could be found in almost every home. It was used to make the mantles used in gaslights and in kerosene and oil lamps. Today, thorium's use in lighting survives in the lanterns used by campers.

There are a number of industrial uses for thorium, although its radioactivity limits its use to areas where there are no satisfactory substitutes. It is used in making various refractories and in high-strength, high-temperature ceramics, where its very high melting point (3,300 °C) gives it an advantage. It is alloyed with magnesium for use where light weight and strength are important. Thoriated tungsten welding electrodes are used where the quality of the welds is vital.

Thorium is recovered as a byproduct of recovering the rare-earth elements from monazite. Much more could be recovered if demand increased; however, most thorium produced is discarded. Some excess thorium is stored in containers at processing facilities, but most is shipped to approved radioactive disposal sites.

Industry Highlights in 1991

The oversupply of thorium continued to grow as domestic consumption remained less than 100 metric tons per year. An overall decline in thorium's nonenergy uses was forecast.

Thorium's natural radioactivity is a significant problem for the industry. Costs associated with handling, storing, and disposing of thorium have continued to increase, and compliance with environmental regulations has become increasingly difficult. In addition, public concerns and potential liabilities resulting from thorium's natural radioactivity have impacted its use. Continuing the trend, several companies announced plans to decrease or cease use of thorium-bearing materials. A principal alloy producer in the United Kingdom announced it would phase out production of magnesium-thorium alloys over the next 5 years, while a domestic rare-earth processor switched feed material to eliminate generating thorium-containing residues.

For further information on thorium, contact James Hedrick, 202/501-9412.

TIN

Tin was one of the earliest metals known; combined with copper it was used in bronze implements as early as 3500 B.C. The search for tin led explorers from the Eastern Mediterranean to the edges of the known world, though exactly how the Phoenicians learned of the tin deposits of ancient Britain will probably remain a mystery forever.

Today tin is still usually used alloyed with another metal or coated upon another metal; in the latter case, it sometimes gives its name to the end product, as in "tin cans." A major use is as solder, for which it is alloyed with lead. Tinplate coating on steel is another major use, though one that has declined since aluminum entered the container market. There are numerous uses that, while they represent only a minor percentage of overall tin consumption, are in themselves important; for example, in aircraft tin is used in bearing alloys and in high-impact alloys in landing-gear assemblies. The alloy pewter is actually nearly all tin, with minor amounts of copper and antimony added to harden it.

Although virtually every continent has an important tin-mining country, tin is a relatively scarce element; there are about 2 parts per million (ppm) of it in the Earth's crust, compared with 63 ppm for copper, 12 ppm for lead, and 94 ppm for zinc. The only important source is the mineral cassiterite, most often from placer deposits formed when the comparatively heavy cassiterite is left concentrated after lighter rock materials are eroded away. Currently the major producing countries are Brazil, Malaysia, Indonesia, and China; U.S. mine production of tin is negligible. Accordingly, although we recycle a considerable quantity of tin and tin alloy scrap, we import tin to fill about 75 percent of our needs, mainly from the leading producers mentioned above.

Industry Highlights in 1991

The price of tin remained low by historical standards, and the world tin oversupply persisted at about 40,000 tons. Numerous tin mines and smelters ceased production as their operations were made unprofitable by continuing low tin prices. Tin mines closed in Canada, Malaysia, and the United Kingdom. Tin smelters closed in Singapore and the United Kingdom.

Domestic recycling efforts, directed at used tin cans, continued to increase. Many municipalities installed voluntary or mandatory recycling programs for households and businesses. Some of the recovered cans were detinned, but most were baled and sold (often on a diluted basis) to foundries, minimills, and large integrated steel plants, thus helping to meet the domestic shortage of suitable steel scrap.

For further information on tin, contact James Carlin, 202/501-9411.

TITANIUM

Titanium was discovered in 1790, but little use was made of it until the 20th century. Today titanium dioxide is the major white pigment, far exceeding the production of all other white pigments combined, and titanium metal plays a major role in the aircraft industry.

Titanium dioxide pigment is also by far the largest use of titanium. The pigment is used in making paint, but also in making plastics and paper, including photographic papers, paper boxes that require a light-colored, high-gloss coating, and practically all printing paper except newsprint.

The Bureau of Mines developed the large-scale production of titanium metal during World War II, and commercial production began shortly after the war. Today most of the titanium metal produced is used by the aircraft industry for both military and commercial planes—about 6 percent of the weight of a large airliner consists of titanium.

Most of the titanium we use comes from a mineral called ilmenite; rutile is another source. There is some domestic production of both minerals, but the bulk of our supply is imported, Australia being the major supplier in both cases. Because of the importance of titanium and the distant location of our supplies of the raw materials necessary to produce it, recent legislation has emphasized the development of a reliable domestic supply of ilmenite. Currently this material is produced from three heavy mineral sand deposits in Florida, and experimental quantities are being produced from a sand and gravel operation in California.

Industry Highlights in 1991

Declines in military aircraft buildup, reduction of customers' inventories, and the economic recession contributed to a significant decline in domestic titanium sponge demand. One U.S. producer in Ohio announced plans to close its 11,000-ton-per-year sponge production plants permanently. A Soviet sponge plant reportedly closed 20,000 tons per year of capacity late in the year.

U.S. TiO_2 pigment demand increased about 2 percent in 1991, despite the worldwide recession. New pigment production came on-stream in Saudi Arabia and the United States. Chloride-process projects that were scheduled to begin operation in 1992 include 54,000 tons of annual capacity in Australia, 20,000 tons in Mexico, and 50,000 tons in Malaysia. The former U.S.S.R. announced that it would add an additional 75,000 tons of annual capacity to two of its sulfate-process plants.

Increased environmental regulations, particularly in Europe, affected many sulfate process TiO_2 pigment plants. Many producers that previously had dumped waste acid into the sea invested in acid-recycling or neutralization equipment, which would allow the waste acid to be reused and eliminate acid discharges to the sea.

Other producers have replaced sulfate-process plants with chloride-process plants, which are considered to be less environmentally damaging.

For further information on titanium, contact Joe Gambogi, 202/501-9390.

TUNGSTEN

Tungsten is found in virtually every home—it is used to make the filaments and electrodes that provide light in lightbulbs and fluorescent lighting tubes. The major uses are industrial, however; metalworking equipment and mining, oil and gas drilling, and construction machinery and equipment consume over two-thirds of the tungsten we use.

Among the reasons for tungsten's importance in these end-use sectors are its high melting point and its tensile strength at high temperatures; it surpasses all other metals in both these areas. It is also very hard; cemented tungsten carbide is the primary cutting-tool-insert material in use today. Tungsten is also an important strategic material necessary for defense purposes. Heavy metal alloys containing over 90 percent tungsten are used in several types of small-diameter projectiles for penetrating armor plate. Significant quantities of tungsten are thus stored in the National Defense Stockpile.

Tungsten has "high-tech" applications as well; although most of them are in the metallurgical field, one interesting development is the use of tungsten in genetic engineering. Microscopic heavy tungsten spheres laden with genes are propelled through the cell walls of plants, where alteration of the cells to improve crop yields then begins. The aerospace industry also makes extensive use of tungsten metal and tungsten-containing superalloys.

Most of the tungsten we use is imported; China is our major supplier, producing from the world's greatest tungsten reserves at a cheaper price than can be achieved in most other countries, partly owing to China's extremely low labor costs.

Industry Highlights in 1991

Domestic demand for tungsten products remained stable during the first three quarters of 1991 in spite of the relatively weak U.S. economy. Consumption of tungsten carbide powder and ferrotungsten was down slightly, while consumption of tungsten metal powder and scrap was up slightly, compared with the same period in 1990. U.S. trade statistics through June indicated that imports of tungsten materials from the People's Republic of China (PRC) continued to represent about 59 percent of all tungsten imports. About 78 percent of the PRC's share of these imports was in the form of ore concentrate.

On September 20, the International Trade Administration (ITA), U.S. Department of Commerce, issued its final determination in an antidumping suit filed against the PRC concerning imports of tungsten ore concentrates. The ITA concluded that "tungsten ore concentrates from the PRC are being, or are likely to be, sold in the United States at less than fair value" and ruled that a tariff of 151 percent should be levied on the weighted average price of the imported concentrates. Accordingly, the U.S. Customs Service was directed to suspend liquidation (delay final import processing) of all entries of tungsten ore concentrates from the PRC until a cash deposit was received or a bond was posted equivalent to the determined tariff. The ITA's findings were reported to the International Trade Commission for its final determination on whether an industry is materially injured or is threatened by material injury as a result of these imports.

The Orderly Marketing Agreement (OMA), limiting U.S. imports of ammonium paratungstate and tungstic acid from the PRC since October 1, 1987, was allowed to expire on September 30. The Government decision was made following final discussions and a subsequent vote by an interagency trade policy review group. Prior to the decision, U.S. Government and industry officials discussed what trade control measures might be necessary upon reaching the expiration date of the OMA. Among the measures considered but not pursued were the extension of the OMA or the initiation of an investigation toward arriving at a new agreement with the PRC covering additional tungsten products.

The Australian Bureau of Mineral Resources reported a significant decline in tungsten reserves and a corresponding reclassification to what would be considered reserve base status.

For further information on tungsten, contact Gerald Smith, 202/501-9431.

ZINC

Zinc is the fourth most widely used industrial metal, following iron, aluminum, and copper. Its use reaches back to ancient times—it occurs in bronze artifacts made 5,000 years ago and has been used as a component of brass for more than 2,000 years.

Often we use zinc without knowing we are using it. For example, a roof we think of as a tin roof is more likely to be made of steel sheet galvanized with zinc to prevent corrosion. Components of automobiles that we normally never see are similarly galvanized, likewise to prevent corrosion. The galvanizing itself can be done either by immersing clean steel or iron in a bath of molten zinc or electrolytically by electrodeposition of zinc in solution on steel or iron.

Largely because of its use for galvanizing, the major end uses of zinc are in construction, including such diverse forms as industrial plants, farm structures, bridges, roads, and residential and commercial buildings. The transportation industry, especially the automotive sector, is the second largest consumer, where zinc is used in grilles, handles and locks, mechanical and electrical components, body and hardware trim, and instrument and lighting fixtures—all in addition to corrosion protection. And while use in the first category is decreasing as cars become smaller, use in the second is increasing as consumers demand more corrosion protection.

The U.S. zinc industry got underway in 1860, and from 1901 through 1971 the United States was the largest zinc metal producer in the world. Later the lead passed to the former U.S.S.R., with Japan and Canada in second and third place respectively. Canada has led in mine production of zinc for many years, and over half of our zinc imports originate there, some being supplied in unprocessed form and some as metal. Domestically, the bulk of our zinc mine output originates in Alaska; other zinc-producing States include Missouri, New York, and Tennessee. Currently we import about 60 percent of the zinc we consume, but as with various other metal commodities, this is essentially because the imported material is cheaper rather than because our own reserves are exhausted.

Industry Highlights in 1991

Zinc production in Alaska raised U.S. output to its highest level since 1965 despite the closure of five mines in the Western States. Mines closed in Idaho, Montana, Nevada, and New Mexico mainly owing to low metal prices. Despite the mine production increase, U.S. self-sufficiency in refined primary zinc production did not improve, nor was it expected to do so in the next decade, owing to a lack of domestic primary smelting capacity. Alaska's two mines accounted for about half of the U.S. total output; however, all of the zinc concentrate produced was exported and was scheduled to be exported in future years also. In 1990 the United States became a major world exporter of zinc concentrates, a situation that is expected to continue. Ironically, the United States is the world's largest importer of refined zinc, a situation that is also expected to continue, though at a lesser rate because of increasing domestic zinc recycle.

The recovery of zinc from steelmaking electric arc furnace (EAF) dusts increased from virtually none a decade ago to about 75,000 tons. The impetus for EAF dust recycle was Environmental Protection Agency regulations requiring the thermal treatment of EAF dusts containing more than 15 percent zinc before they can be disposed of. The increased use of galvanized steel in recent years in automobiles, appliances, etc., suggests that larger amounts of zinc will be recoverable from EAF dusts in future years.

The slump in the U.S. economy reduced domestic zinc consumption by more than 10 percent from that of 1990. Metal consumption was at its lowest level since 1982, a recession year. All use sectors declined. Despite the consumption decline, zinc smelter production increased slightly, owing mainly to higher metal production from secondary source materials. As a consequence of higher production and reduced consumption, domestic imports of metal and other zinc materials fell sharply from 1990 levels.

The International Lead and Zinc Study Group forecast in October that production of both concentrate and metal will substantially exceed demand in 1992, suggesting continued downward pressure on zinc prices.

Environmental concerns in the zinc-processing sector were more associated with coproduct and byproduct elements, such as lead, cadmium, and sulfur, than with zinc. Zinc slag from primary smelting was 1 of 20 mineral processing wastes exempted from subtitle C hazardous waste regulations in the Resource Conservation and Recovery Act.

For further information on zinc, contact James Jolly, 202/501-9422.

For Zirconium coverage, see Hafnium and Zirconium, page 24.

Photograph on page 57 shows one of the basic mining operations that make possible both America's minerals-based daily way of life and such technical triumphs as the country's outreach to other worlds (p. 58).

MINERALS AND THE ENVIRONMENT

The basis of the way of life that most Americans enjoy and that citizens of many other countries aspire to is minerals, both the fuel minerals that provide energy for our industries and personal uses and the nonfuel minerals that provide the raw materials for almost everything else.

Before these minerals can be used, they must be extracted from the rocks in which they occur, processed in various ways, and shipped to the places where they will be used. All three stages can cause environmental disruption and/or damage, which can range from fairly minor disturbance at a local quarry to the world-famous devastation following the grounding of the Exxon *Valdez*. This has been true throughout the history of mineral extraction, but has become a more acute problem as cumulative disruption to the world's environment (from many other sources in addition to mining) has increased, as awareness of present and potential environmental problems has mounted, and as the scale of humanity's extractive efforts has increased in size.

In the earlier days of U.S. mining, little care was taken for the environmental results of extracting minerals, partly out of ignorance about the long-term consequences of environmental damage and partly because of the different morality with regard to environmental issues that existed at that time. Today, all this has changed, partly due to State and Federal regulation and partly because no responsible representative of the mineral industry wants to permanently damage an environment we all must share. For example, although over 7,000 miles of U.S. rivers and streams are adversely affected by coal mine drainage, most of this drainage comes from mines that have been abandoned for many years. For over a decade, active mines have been required to chemically treat their effluent waters, at a cost of over $l million a day. Such efforts are by no means confined to coal—across the country mining and mineral processing industries of every nature are expending enormous sums on environmental controls.

Assisting in these efforts has been Government research such as that conducted by the U.S. Bureau of Mines. One Bureau effort that has achieved both national and international recognition is water treatment, using wetlands constructed especially for that purpose on the mine property. In the wetlands, metals are removed from the water, and acidity is neutralized by biological activity. Bacteria living in the wetlands help cleanse the water by oxidizing iron and manganese and by reducing sulfates. About 400 of these wetlands have been built at mine sites in the United States, and others are being built in foreign countries. In these cases, solving the potential environmental problem created by mining actually enhances the overall environment.

The Bureau has also been helping Minnesota's iron industry to revegetate its disposal areas, which are enormous since processing taconite, the ore now used by the U.S. iron industry, produces over 70 million tons of tailings annually, and these tailings are deposited in impoundment areas that can cover 10 square miles.

Once these disposal areas are filled with tailings, State environmental regulations require that they be covered by vegetation to prevent water and wind erosion, but the required revegetation has been difficult to achieve in some areas. Special treatment of the tailings is needed to build up the soil qualities and provide an acceptable host for vegetation. The Bureau of Mines, in cooperation with local mining companies, State agencies, and the University of Minnesota, is conducting research to determine ideal combinations of vegetation and soil to produce a permanent vegetative cover and stabilize the surface of the coarse tailings areas.

As long as we continue needing minerals, which will be as long as human life as we now know it survives, environmental problems will probably arise. But with increasing awareness in this area, many of these problems can be mitigated or avoided, and with increased research and appropriate expenditures, most of those that cannot be avoided can be resolved.

MINERALS AND LAND USE PLANNING

Any major industry has some effect on the environment, and most major human activities require the use of land. Mining—the process by which we obtain the minerals we so badly need to sustain our industrial society—adds the complication that it can only be done in areas where mineral deposits exist. In some cases these areas are so remote that there are few competing uses for the land, but in others major problems can arise.

The quarrying industry that produces the crushed stone, sand, and gravel we need to build our homes and highways is an example of the problems that can occur in this area. For the construction materials to be obtained economically, shipping costs must be kept low, which means that using sources of the materials that are close to the construction sites is desirable. However, with increasing urbanization, the development of such sites meets with increasing opposition from local residents and zoning authorities because of the dust, noise, and traffic that quarry operations tend to generate. In some cases, towns and cities spread before potential quarry sites have been developed, so that the minerals they contain are never recovered.

Although land use planning by both mining firms and public agencies cannot keep all such problems from arising, a constructive approach in this area can forestall many of them and help ensure that our supplies of minerals are economically recovered.

In most cases, two land use changes must be considered—the change from the existing situation to mining, and the return of the land after mining to its original or some other desirable use. In making the first change, provision should be made for the second phase; also, the actual extent of disturbance can usually be minimized by careful planning, and this will in turn reduce the cost of restoration.

However disruptive active mining may be in a given area, it creates jobs, pays taxes, and above all provides us with the minerals we vitally need. Today's mine operators recognize restoration costs as part of the cost of doing business, and are happy to work with local, State, and/or Federal authorities in developing plans for the optimum use of land after the minerals they seek have been recovered.

MINERALS AND RECYCLING

Recycling has become a household word in recent years as cities throughout the country pursue this alternative to increasingly difficult disposal of their wastes by landfill. It is something the mineral industry has been doing for years.

The aluminum industry, for example, recycles over half the beverage cans it produces; in States with recycling laws, about 90 percent of them are recycled. Nationwide, this adds up to about 50 billion cans per year. Recycling the cans doesn't just save space in landfills—it reduces our need for imported raw materials and cuts back on a major energy use. As explained in the aluminum section of this book, the bauxite and alumina our aluminum industry uses are almost all imported; when recycled material is used, these imports are reduced—and recycling saves about 95 percent of the energy needed to produce new metal from bauxite. This reduces both the aluminum industry's costs and the amount of fuel our society needs to produce the energy.

Traditional backbone of U.S. industry, the iron and steel makers are also major recyclers. Although by no means all the steel we use is recycled, the metal is 100 percent recyclable, and the steel industry is the single largest U.S. recycler, recycling twice as much material as all other industries combined. To the industry, this makes simple economic sense: A ton of steel recycled in 1990, according to an industry spokesperson, saved 2,500 pounds of iron ore and 1,000 pounds of coal, plus limestone and energy commodities and costs. And when it comes to cans, one U.S. steelmaker is experimenting with a system in which cans are inserted into "reverse-vending" machines, which pay the customers a penny for each can inserted. The cans are returned to company mills for recycling.

The Bureau of Mines has been a major contributor to recycling research and at one point even ran a model plant in which municipal trash was sorted into its various components, an essential first step for recycling it. More high-tech Bureau research in this area has involved the recovery of metals from various processes and products so that they can be reused. Metals so recovered have ranged from the silver in photographic wastes to the lead in automobile batteries.

As our resources become increasingly depleted and landfill and energy costs mount, recycling will become increasingly vital to our industries and overall way of life.

MINERALS AND HIGH-TECH MATERIALS

Until the dawn of the "space age," most products were made of so-called traditional materials, although some of these materials, such as aluminum and stainless steel, were themselves fairly recent developments. In the last 30 years, however, a whole new class of materials has come into being, including plastics, new types of metals, ceramics, and combinations thereof.

Dreamed up by scientists, designed with computers, and fabricated by robots, these materials have already contributed to advances in electronics, medicine, nuclear energy, and aerospace technology. They are now finding uses in more general products, ranging from automobiles to sports equipment.

A major advantage of the new materials is that they can be tailor-made for specific applications. Scientists, for example, can combine many different plastics, metals, and ceramics as composites. Producers can customize small batches of material to suit specialty markets. They can create materials, rather than merely alter them. Recent progress in telecommunications and computerization would have been impossible without the development of optical fiber and the silicon chip.

Although these new materials are challenging traditional mineral materials in various uses—for example, the growth of plastics use in the automobile industry is at the expense of the metals that were previously used—they ultimately derive from the earth's original mineral endowment, just as the traditional minerals do.

Most plastics, of course, come from the earth's petroleum and natural gas resources, and more than 60 elements used in other new material applications are derived from mined minerals, often ones that are fairly unfamiliar, such as yttrium and the rare earths, zirconium, hafnium, cadmium, germanium, gallium, indium, thallium, selenium, and tellurium. Some of the elements used in making the new materials, such as the indium needed for lasers and semiconductors, are drawn from limited domestic mineral reserves, or are byproducts of declining metals-production capacity. Thus, the availability of mineral resources and processing facilities can be limiting factors in new material development and application.

At least a dozen of the elements used in making advanced materials are extracted from minerals for which the United States has potential supply problems. In fact, the United States has no reserves of the cesium, osmium, rhodium, rubidium, and ruthenium used in new materials for energy, electronics, and biomedical applications.

Fortunately, relatively small quantities of these critical elements are needed to produce the advanced materials, and the materials are valuable enough that they can create new market incentives for mineral suppliers. In addition, the Government can (and does) stimulate supplies by guaranteeing markets for producers. Under the Defense Production Act of 1950, for example, the Department of Defense has offered U.S. companies guarantees to purchase $8 million worth of high-purity silicon. Other guarantees have been proposed to stimulate production of quartz fiber for missile parts and reinforced aluminum for spacecraft composites.

Additional options to reduce possible supply problems include substitution and recycling. Considerable research in the Bureau of Mines Minerals and Materials Science Program is focused on these latter two alternatives.

FUTURE MINERAL SOURCES

Unlike products that can be grown anew each year, like our food supplies, or within decades, like our forests, minerals have only one harvest, except for those that can be recycled. Once they are out of the ground, they will not be renewed in any humanly conceivable time frame. In the United States most of the high- and medium-grade ores have been mined out, and although we are still a leading producer of many minerals, we are producing them from increasingly poorer ores. Richer ores still exist in other countries, but the demands on them are rising.

At the same time that world mineral resources are becoming depleted, more people are calling on them as populations increase and as their expectations rise. Countries whose mines were once sources of ore for more industrialized nations may want to use their minerals themselves to support their own growing industries—and in any case the supply of minerals ultimately available is definitely finite.

Alaska is an obvious possible source of additional mineral supplies, as is Antarctica, but in both cases the technical difficulties of obtaining the minerals are enormous. With regard to Antarctica, the U.S. Geological Survey has stated that "the total accessible (mineral) endowment could hardly be expected to seriously dent the long range demand for minerals by the world as a whole."

Covering far more of the Earth's surface than is occupied by land, the oceans are already a source of mineral fuels and may in time to come be a source of other minerals. Almost every element has been identified in sea water, but most are present in such small amounts that obtaining them is not now economically feasible. Both economics and technology are problems when it comes to developing the deep-sea deposits of metallic nodules found at various points in the oceans—but as more accessible mineral supplies decline and the costs of exploiting those that remain rise, the economic factor may level out. The development of improved technology for mining such deposits may itself improve the economic picture.

Truly looking toward the future is the prospect of mining in space; for over 20 years the Bureau of Mines has been cooperating with the National Aeronautics and Space Administration (NASA) to develop the technology for mining operations on other plants.

During the Apollo moon program of the 1960's and '70's, the Bureau managed a program for NASA to evaluate basic drilling, fragmentation, materials handling, and sampling technology in space environments. Since 1985, the Bureau has been helping NASA assess the use of existing operational and experimental mining technology in space.

Should the proposed exploration of Mars and outer space from a permanent base on the Moon be under-taken, life-support materials, such as oxygen, water, and fuel, could be mined on the Moon more economically than they could be transported from Earth. To explore the possibilities of such lunar mining, Bureau researchers helped organize a steering Committee on Lunar and Planetary Mining and Construction, consisting of representatives from Government, industry, and academia. The steering committee conducted workshops to discuss and evaluate methods and equipment to operate surface mines on the Moon.

The success of these activities led the Bureau to form its own permanent space mining steering committee. Consisting of representatives from six Bureau Research Centers scattered across the country, this committee will guide future Bureau research and technology development activities for mining and mineral processing in space. It will also be the focal point for future Bureau cooperation with NASA.

MINERALS AND THE GENERAL MINING LAW

Geology and the history of U.S. landownership have combined cause and effect in such a way that many of our unexploited mineral resources are on public lands in the Western States and Alaska. Some 270 million acres of these lands are administered by the Bureau of Land Management, and recovery of most of the minerals on them is governed by the General Mining Law of 1872. At present, there are 1.2 million mining claims for minerals on these lands.

The General Mining Law has served the Nation well; the minerals recovered under its provisions have helped build and sustain the most comfortable society humanity has ever known. Certain features of the law are dated—for example, the fee to patent land is still $2.50 an acre, just what it was in 1872. Also, the patenting process leads to full ownership of the land, and in some cases has been abused in that land so acquired has been used for purposes other than mining. Overall, however, says Bureau of Mines Director T S Ary, the law "has been one of the most incredibly successful laws that we have on our books. It helped settle the West, and it created enormous wealth for our Nation by providing a dynamic, but orderly method to mine orebodies."

The Bureau of Land Management has been working on changing regulations to set consistent policies for bonding of miners and reclamation of mined land, thus answering other criticisms of the law that have surfaced in recent years. This also helps the agency to carry out its responsibilities under the Federal Land Policy and Management Act of 1976, which requires that public lands be managed for a variety of uses, such as forestry, livestock grazing, wildlife habitat, hunting, and camping, as well as mining. The Bureau of Land Management notes that while mining may be the most important activity on a given tract of land at a given time, it will end when the minerals being extracted are depleted. The land can then be reclaimed for other uses.

For further information on the General Mining Law of 1872 and/or on mineral activities on the public lands managed by the Bureau of Land Management, contact agency headquarters:

Bureau of Land Management
U.S. Department of the Interior
1849 C St., NW.
Washington, DC 20240-0001
202/208-5717

MINERALS AND THE BUREAU OF MINES

Founded in 1910 in response to the high accident and death rates then typical of U.S. coal mining, the Bureau of Mines soon acquired additional functions in the areas of research and information and analysis (I&A). Some 60 years later these became its main functions when the direct health and safety activity became a separate agency.

Today the Bureau's primary goal is to help ensure that the Nation has adequate mineral supplies for its security and other needs. Research is conducted to provide improved technology for the extraction, processing, use, and recycling of the Nation's mineral resources at a reasonable cost and without harm to the environment or the workers involved.

Nationwide, nine Research Centers conduct the basic research that private industries tend to avoid until it shows promise of commercial development. Technology developed by the Bureau played a major role in launching the current gold boom in Nevada; today Bureau research is seeking ways to correct the environmental problems this 20th century "gold rush" has fostered. Substantial health and safety research is conducted because the Mine Safety and Health Administration focuses on safety enforcement, relying on the Bureau for research in this area.

In its information and analysis activities, the Bureau collects, compiles, analyzes, and publishes statistical and economic information on all phases of nonfuel mineral resource development, including exploration, production, shipments, demand, stocks, prices, imports, and exports. Special studies are frequently made on subjects of particular national interest, such as the effects of potential economic, technologic, or legal developments on mineral resource availability. Helping the U.S. mineral industry to be competitive in the world market place is a major I&A priority.

Although many I&A activities are conducted at the Bureau's Washington, DC, headquarters, the Bureau has eight Regional Offices of State Activities to monitor mineral activities in each State, a Minerals Availability Field Office, and three Field Operations Centers. The latter assess the mineral resources on public lands in areas that have never been fully explored, mostly in the Western States and Alaska.

Numbering only about 2,500 employees nationwide, the Bureau of Mines makes a massive contribution to the Nation's mineral welfare and thus to the overall welfare of our country and its citizens.

U. S. BUREAU OF MINES LOCATIONS

Headquarters

U.S. Bureau of Mines
810 Seventh Street; NW
Washington, DC 20241
202/501-9649

Field Facilities

Albany Research Center
1450 Queen Avenue, SW
Albany, OR 97321
503/967-5893

Helium Field Operations
1100 South Fillmore
Amarillo, TX 79101
806/376-2602

Alaska Field Operations Center
3301 C Street, Suite 525
Anchorage, AK 99503
907/271-2454

Intermountain Field Operations Center
PO Box 25086
Building 20, Denver Federal Center
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412/892-6601

Reno Research Center
1605 Evans Avenue
Reno, NV 89512
702/784-5261

Rolla Research Center
PO Box 280
1300 Bishop Avenue
Rolla, MO 65401
314/364-3169

Salt Lake City Research Center
729 Arapeen Drive
Salt Lake City, UT 84108
801/524-6100

Spokane Research Center
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Spokane, WA 99207
509/484-1610

Western Field Operations Center
East 360 Third Avenue
Spokane, WA 99202
509/456-7905

Tuscaloosa Research Center
PO Box L
University of Alabama Campus
Tuscaloosa, AL 35486
205/759-9431

Twin Cities Research Center
5629 Minnehaha Avenue South
Minneapolis, MN 55417
612/725-4610

STATE ACTIVITIES OFFICES

Alaska Regional Office of State Activities
PO Box 020550
Juneau, AK 99802-0550
907/364-2111: ALASKA

Denver Regional Office of State Activities
PO Box 25086
Denver Federal Center, Bldg. 20
Denver, CO 80225
303/236-0435: COLORADO, KANSAS, OKLAHOMA, TEXAS

Pittsburgh Regional Office of State Activities
PO Box 18070
Cochrans Mill Road
Pittsburgh, PA 15236
412/892-4423: DELAWARE, KENTUCKY, MARYLAND, OHIO, PENNSYLVANIA, VIRGINIA, WEST VIRGINIA
412/892-4422: MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, RHODE ISLAND, VERMONT

Reno Regional Office of State Activities
1605 Evans Avenue
Reno, NV 89512
702/784-5215: CALIFORNIA, HAWAII, NEVADA

Spokane Regional Office of State Activities
East 360 Third Avenue
Spokane, WA 99502
509/353-2726: IDAHO, MONTANA, OREGON, WASHINGTON, WYOMING

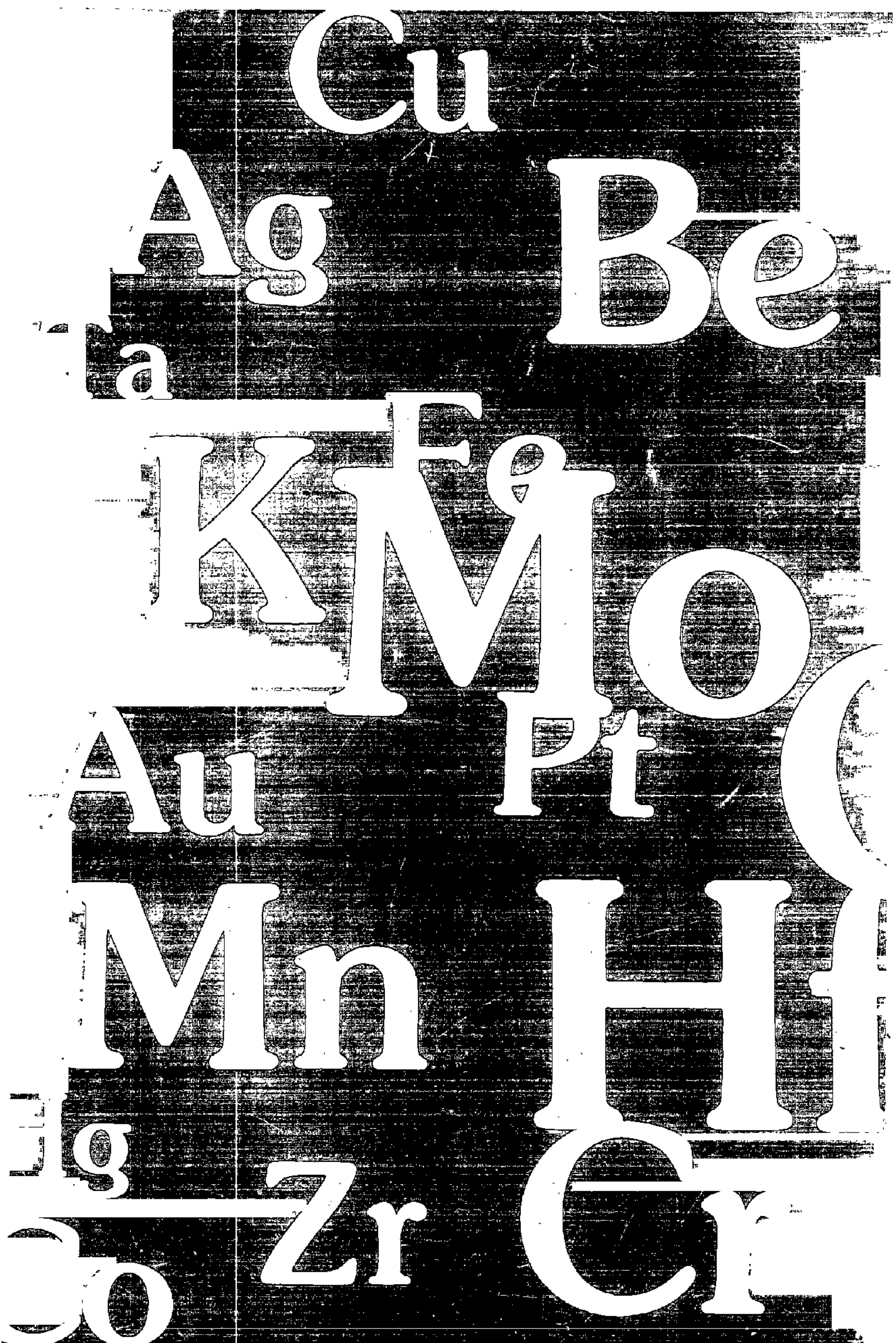
Tucson Regional Office of State Activities
210 East Seventh Street
Tucson, AZ 85705-8454
602/670-5110: ARIZONA, NEW MEXICO, UTAH

Tuscaloosa Regional Office of State Activities
PO Box L
University of Alabama Campus
University, AL 35486
205/759-9465: ALABAMA, ARKANSAS, FLORIDA, LOUISIANA, MISSISSIPPI
205/759-9466: GEORGIA, NORTH CAROLINA, PUERTO RICO,SOUTH CAROLINA, TENNESSEE, VIRGIN ISLANDS

Twin Cities Regional Office of State Activities
5629 Minnehaha Avenue South
Minneapolis, MN 55417
612/725-4534: ILLINOIS, INDIANA, MICHIGAN, MINNESOTA, WISCONSIN
612/725-4536: IOWA, MISSOURI, NEBRASKA, NORTH DAKOTA, SOUTH DAKOTA

TAKE PRIDE IN AMERICA

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