Minerals yearbook: Metals and minerals 1980. Year 1980, Volume 1 1980

Bureau of Mines
Washington, D. C.: Bureau of Mines : United States Government Printing Office, 1980

Minerals Yearbook

1980

Volume I

METALS AND MINERALS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • James G. Watt, Secretary

BUREAU OF MINES • Robert C. Horton, Director

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, and park and recreation areas, and for the wise use of all those resources. The Department also has a major responsibility for American Indian reservation communities and for the people who live in Island Territories under U.S. administration.

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1981

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Foreword

Through the Minerals Yearbook and its predecessor volumes, the Federal Government has reported annually on mineral industry activities since 1882. This edition discusses the performance of the worldwide mineral industry during 1980 and provides background information to assist in interpreting developments during the year being reviewed. Content of the individual volumes follows:

Volume I, Metals and Minerals, contains chapters on virtually all metallic and nonmetallic mineral commodities important to the U.S. economy. In addition, it includes a chapter on mining and quarrying trends.

Volume II, Area Reports: Domestic, contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. This volume also has a statistical summary.

Volume III, Area Reports: International, contains the latest available mineral data on more than 130 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy.

The Bureau of Mines continually strives to improve the value of its publications to its users. Therefore, the constructive comments and suggestions of readers of the Yearbook will be welcomed.

Robert C. Horton, *Director*

Acknowledgments

Volume I, Metals and Minerals, of the Minerals Yearbook presents data on approximately 90 nonfuel mineral commodities that were obtained as a result of the mineral information gathering activities of the Bureau of Mines.

The collection, compilation, and analysis of data on the domestic minerals industries were performed by the staffs of the Sections of Ferrous Metals, Nonferrous Metals, and Nonmetallic Minerals, Division of Production/Consumption Data Collection and Interpretation. Statistical data were compiled from information supplied by mineral producers, processors, and users in response to production and consumption canvasses, and their voluntary response is gratefully appreciated. The information obtained from individual firms by means of confidential surveys has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonproprietary sources or when permission of the companies has been granted. Other material appearing in this volume was obtained from the trade and technical press, industry contacts, and numerous other sources.

Statistics on world production and foreign country trade were compiled in the Branch of Foreign Data. U.S. foreign trade data were obtained from reports of the Bureau of the Census, U.S. Department of Commerce. World production and international trade data came from numerous sources, including reports from the Foreign Service, U.S. Department of State.

The Branch of Publication Support Services, Division of Publication, provided general guidance on the preparation and coordination of the chapters in this volume and reviewed the manuscripts to insure statistical consistency among the tables, figures, and text, between this volume and other volumes, and between this edition and those of former years.

Acknowledgment is also particularly made of the splendid cooperation of the business press, trade associations, scientific journals, international organizations, and other Federal agencies that supplied information.

The Bureau of Mines has been assisted in collecting mine production data and supporting information by numerous cooperating State agencies. These organizations are listed in the acknowledgments to Volume II.

Albert E. Schreck, *Chief, Division of Publication*

Contents

Mining and Quarrying Trends in the Metal and Nonmetal Industries

By Franklin D. Cooper[1]

This chapter includes tables for 1979 that were not available in time for publication in the 1978-79 Minerals Yearbook, but it does not include corresponding tables for 1980.

The value of raw nonfuel mineral output in 1980 was estimated at $24.8 billion, 3.5% above the 1979 value. Of the 21 metal commodities produced, quantitative output increased for 11 and decreased for 10. The values for 10 metals were up, 10 were down, and 1 was unchanged. Among the 47 nonmetallic commodities produced, 14 showed quantitative increases, 32 declined, and 1 was unchanged. In terms of value, 32 nonmetallics increased, and 15 declined.

Delays caused by environmentalists and doubts about future nuclear power growth following the Three Mile Island mishap slowed the uranium boom as many mines closed, prices fell, and problems of radioactive tailings treatment and water supplies continued.

Some of the domestic mineral industries' concerns were their high production costs, which for copper, as an example, were reportedly 15% to 50% higher than costs for equivalent production in foreign countries; the cost of enforcement of the Mine and Safety Health Act of 1977, which, for example, cost AMAX Inc. $7.5 million annually in the firm's two molybdenum mines;[2] the inapplicability to hard-rock minerals of the mining practices and procedures specified for coal mining in the 1977 Surface Mining Control and Reclamation Act; the Nation's growing dependence on foreign strategic minerals; the need for investment money; and the lack of Government support to encourage competitiveness with foreign producers.

Exploration.—Significant discoveries in 1980, according to their principal metal values, were silver, eight; gold and uranium, five each; gold-silver, four; copper-zinc, lead-zinc-silver, copper-molybdenum, and molybdenum, two each; and one each for gold-copper, silver-copper, copper and lead-zinc. States in which these discoveries were made were Idaho, six; Nevada, Utah, and Wyoming, four each; Colorado and Nevada, three each; California and New Mexico, two each; and Maine, Montana, Oregon, Texas, Wisconsin, and Washington, one each.

According to the Department of Energy (DOE), the U.S. uranium industry reduced its exploration expenditures to $314 million, the first decrease since 1973. DOE placed on open file a report, GJBX-244 (80), covering 6,184 line miles of helicopter, aerial, geophysical, and radiometric surveys of the Ely and Lund National Topographic Map Series Quadrangles in Nevada, as part of the National Uranium Resource Evaluation program of DOE's Grand Junction, Colo., office.

Techniques introduced for use in exploration included continuous sampling by dual-tube drilling using reverse circulation; a new detector that electrically measures the increase in resistance of a thin gold film after absorption of mercury vapor in soil as a guide to sulfide mineralization at depth; hydraulic instead of mechanical drives on diamond drilling equipment; and the combination of percussive drilling to determine rock relationships based on the one-dimensional wave theory.

Patents issued in 1980 relating to uranium exploration included U.S. 4,186,303 and Canadian 1,079,412 for a method to prevent thoron-derived alpha particles from reaching an alpha particle detector; U.S. 4,209,694 for a method to expose a borehole to neutron activation analyses; Canadian 1,078,533 for a method based on polonium content in uranium ore at considerable depth; and Canadian 1,079,411 for subsurface uranium ore deposits using pairs of phosphor-containing dosimeters placed underground in a grid pattern and capable of storing the energy of alpha particles.

Development.—Significant development projects by 20 mining companies in 1980, ranging from overburden stripping to tunneling, according to their related principal metal values, were gold, eight; copper, three; silver, three; and gold-silver, lead, lead-zinc, lead-silver-zinc, molybdenum, phosphate, and uranium, one each. The number of development projects by States were Nevada, five; Arizona and Colorado, four each; Idaho, three; California, Missouri, and New Mexico, two each; and Wyoming, one. Jersey Miniere Zinc Co. suspended development of a zinc mine in Tennessee. Big-hole drilling provided with a reverse fluid-air assist system for cuttings removal was used in the development of a shaft system for Conoco's Crownpoint uranium mine in New Mexico. The shaft system was planned to have three holes ranging from 14 to 18 feet in diameter extending to a 2,230-foot depth.

Legislation and Government Programs.—The Secretary of the Interior on February 11, 1980, signed an order setting aside for 20 years 40 million acres of Alaskan lands as wildlife refuges and natural resource areas. This action brought to 96 million acres of lands in Alaska where development was banned.

The President on October 21, 1980, signed the National Materials and Mineral Policy Research and Development Act of 1980. This act called for actions to improve the capacity of the Bureau of Mines to assess international mineral supplies, to increase mining and metallurgical research by the Bureau in critical and strategic minerals, and to make available analyses of mineral data for use in Federal land use decision making.

The Bureau of Land Management announced on November 14, 1980, the release of 150 million acres of public lands from further wilderness review, although 24 million additional acres will receive more study.

On November 6, 1980, the Department of the Interior opened 16.6 million acres in nine Western States for exploration of energy resources, potash, and phosphate.

On December 2, 1980, the President signed a compromise bill putting 104.3 additional million acres of Alaskan lands into protected conservation areas, of which 57.0 million acres were classed as wilderness.

The President signed two bills on December 22, 1980, designating 611,000 acres in New Mexico and 1.4 million acres in Colorado as wilderness areas. A total of 594,530 acres in these States were to be studied for further planning. During the study period, grazing, oil and gas exploration, and development will be permitted in accordance with existing law.

Underground Mining.—Technological developments fostered better mining methods and equipment having higher productivity.

The shift to hydraulic-powered drilling equipment continued because of its better economics and improved productivity. Hard-rock drills featured hydraulic power resulting in the doubling of the penetration rate while using a third of the customary energy. The Bureau of Mines developed a percussion drill having a 95-decibel maximum noise level by positioning knitted metal disks above the bit of the drill. The United Kingdom's National Coal Board developed the safe use of liquid nitrogen as a power source for underground pneumatic tools.

St. Joe Minerals Co. and The Pettibone Co. developed new equipment for loading explosives in a single setup in a typical 18- by 33-foot face. Hercules Inc. offered an explosive, which remained inert until detonated, using a gaseous mixture to activate caps in a hole-to-hole hookup. The Bureau of Mines developed prototype low-voltage electric blasting caps that contained no primary explosive.

Reportedly, 290 raise drilling machines were available in 1980 for use in 25 countries. These machines had hydraulic, a.c., or d.c. drive systems and many could drill holes at angles ranging from 20° to 90°. The main horsepower for the majority of the machines ranged from 56 to 112, and their pilot thrust ranged from 74,900 to 349,600 pounds.

The American Borate Co. reported good performance by hard-rock continuous miners in cutting rock having a 16,000-pound-per-square-inch unconfined maximum compressive strength in cut-and-fill slot stoping.

Vertical crater retreat stoping proved successful in the Homestake gold mine in South Dakota, when drilling 6.5-inch-diameter holes from a topsill to an undercut on the level below. The holes were loaded from above with a predetermined weight of explosives. Horizontal slices up to 14 feet thick were then blasted into the undercut from which broken ore was removed through drawpoints.

Eagle Crusher Co., Galion, Ohio, announced its model M44 portable crusher, which can handle 30-inch chunks under an 11-foot-high roof.

A Bureau of Mines contract with the Colorado School of Mines for improving hoisting technology comprised a computer simulation program and its testing on a skip in an operating mine. Redmark Engineering Inc. set a record by pneumatically hoisting 200 tons[3] per hour of 2.5-inch cuttings from a shaft boring machine through a 16-inch pipeline from a vertical depth of 1,260 feet.

The Lockerby Mine of Falconbridge Nickel Mines Ltd., Ontario, Canada, used remote control load-haul-dump units, which reportedly reduced the costs and time required for mine development, employee exposure to potential hazards, and stoping costs. In transporting ore at Newmont's Magma Copper Co.'s San Manuel Mine, Swedish designed, ASEA hinged bottom dump cars, in comparison with rotary-dump cars, were dumped faster, had less operating and maintenance expenses, required no dump operator, had less spillage during faster loading, and were cleaned more easily.

Booz Allen & Hamilton, under DOE contract, developed microcomputer-controlled locomotives for automated underground rail haulage. The designers estimate that reduced manpower, repairs, and derailments will reduce haulage costs by 50%.

The Bureau of Mines developed a new steel-fiber-reinforced (SFR) concrete material for roof support, which was estimated to have a 3-to-1 cost advantage compared with steel support. Homestake Mining Co. successfully used a cable bolting system to convert a timbered stope to an open cut-and-fill stope. The system allowed larger panels to be mined, reduced hanging wall dilution in a large, deep, open stope, and permitted reinforcing of pillars along haulageways. A ground support system, comprising 8 two-piece, wide flange steel sets, when tested in a grizzly drift in Magma Copper Co.'s San Manuel Mine, indicated a longer life compared with typical monolithic concrete.

The Bureau by contracted or in-house work was active in the following:

Issued a five-volume guide relating to the use of resin-grouted roof bolts; sponsored a high-speed, water-jet-augmented small drill to speed the drilling of roof bolt holes while reducing the quantity of resins used to anchor the bolts; contracted for the design of a mobile, high-rise work platform with built-in temporary roof support; developed a method for dewatering and consolidating underground accumulations of slimes by application of direct electric current, which proved to be practical, efficient, and economical in Climax Molybdenum Co.'s Henderson Mine. By grant G0274006, funded a study to develop an early high-strength, hydraulic backfill having no more than 5% reduction of initial in-place thickness; as a result, four methods when tested in combination increased the strength of hydraulic backfills. Developed personal and minewide radiation warning systems; developed a portable underground crusher for low-headroom room-and-pillar mines, and formulated inorganic grouts for mine roof bolting, 50 cartridges of which were to be evaluated under British mine conditions; and awarded a contract to Engineers International Inc. to test large-diameter vane-axial fans under laboratory and field conditions in several mines.

Surface Mining.—Scaled-up operations using large equipment were the continuing trend during 1980 although smaller self-loading scrapers were taking over on many small earthmoving jobs. With the rapid rise in diesel fuel costs, alternative haulage systems were reexamined, and conveyors and other continuous systems were chosen instead of truck and rail haulage for some operations. Reportedly, the 3-cent-per-kilowatt-hour cost of electricity in 1975-79 averaged 4 cents in 1980, while diesel oil at 41 cents per gallon in 1977 cost over $1.00. Recent studies showed that, on the average, the operating costs to move 11,000 tons of overburden per day was 46 cents per ton using a front-end loader and truck haulback procedure and 34 cents using an electric shovel and truck haulback procedure. The cost advantage shown by the use of electric power was expected to widen as diesel fuel costs continued to rise at a rate exceeding that of electricity.

Many operators chose mine expansions rather than developing costly new sites. Technical innovations for improving the productivity of rotary drills, power shovels, and trucks were sparse in 1980. Price competitiveness among equipment manufacturers appeared to be the primary deterrent because options offered on basic equipment priced the equipment out of the market.

Mine planning and maintenance programs received more attention as operators became more aware of the benefits of computer use.

Komatsu Ltd., of Japan, developed unmanned haulage trucks equipped with electromechanical systems controlling steering, speed, dump, and safety devices. Electromagnetic wave signals from transmitters sited along the haulage road controlled each truck. The loading operator had a transmitter for starting and stopping the trucks.

The Bureau of Mines contracted with R. A. Hanson Co., Inc., to fabricate and test a conveying system for handling lump ore of 60-inch maximum size at capacities of 2,500 to 3,500 cubic yards per hour using 400- to 600-foot-per-minute belt speeds. The R. A. Hanson Co., Inc., also developed a mobile belt conveyor capable of moving as fast as 12 feet per minute on crawler tracks. Mobile crushers teamed with belt conveyors proved to be less sensitive to the rising costs of fuel, equipment, and labor. Marion Power Shovel Co. announced its cross pit conveyor to transport broken overburden and to prebench for draglines and other primary excavators. The conveyor, with a discharge reach of 550 to 700 feet, was designed to handle 4,000 to 6,000 tons per hour. It used a 50- to 70-foot-diameter tub for support and could rotate 360°. Despite recent consideration given to shiftable conveyors, trucks continued to remain the most convenient way to move overburden.

Liebherr-America, Inc., offered a guaranteed availability plan (GAP) and a 40% credit on any component replacement on its largest model R-991 hydraulic excavator. International Harvester Co. developed its new 600 Series of hydraulic excavators in both wheeled and tracked versions while Liebherr-America, Inc., offered its R-942 hydraulic excavator featuring a monoblock gooseneck boom as standard equipment. Distinct advantages offered by hydraulic excavators were simplicity of control, compactness, extra power when needed in breakout operations, simplified maintenance, elimination of danger from cables and complex systems of wheels and pulleys, versatility, and ease of transport between job sites.

Southwest Research Institute, under a Bureau of Mines contract, developed an indicator showing the bulldozer operator the amount of work being done. Big Bud Tractor introduced its model 525/84 wheel dozer having 525 horsepower and a 17-foot blade, which resulted in 20% to 25% greater productivity.

New elevating scrapers introduced included Caterpillar Tractor Co.'s model 639D having a 34-cubic-yard heaped capacity and 700 flywheel horsepower, and John Deere's model 862 having 16-cubic-yard capacity, 141 horsepower, and a microprocessor-controlled automatic transmission.

Champion Road Machinery International Corp. announced its model 100T earthmoving system primarily for use in open pit and strip mines. The 101-ton, 700-horsepower unit has a 24- by 5-foot blade and a 50-foot turning radius.

Bridger Coal Co. installed a McDonnell-Douglas computerized monitor on a Marion 8200 dragline to print out percent bucket loading, cubic yards stripped in 1 hour, cable loads, bucket position, load, and boom swing angles.

American Hoist & Derrick Co. introduced its new Pow'r-Hoe, Model 480 shovel, which had a patented control circuit that used full engine revolutions per minute to obtain high production rates and a fast cycle time.

Caterpillar Tractor Co. engineers devised "staggered tandem" and "chain" methods to load trucks faster. The methods were most beneficial on 1,000- to 2,000-foot-haul runs because haulage times were not affected. Firestone Electric Wheel Co. offered 15° rims to reduce the high cost of underinflated truck tires. Marsh "Mellow" fabric and rubber springs made by the Firestone Tire and Rubber Co. increased truck availability while virtually eliminating vibration damage and wear on four Dart 3100 dump trucks. An ASEA-designed prototype system was tested on a 170 Unit Rig truck at a Utah copper mine to measure frame stress and to indicate net, gross, front and rear weights. Agril's Tirefiller, a new system introduced to flat-proof tires, comprised two air-driven pumps, a control to synchronize the flows of two liquid polyurethanes, a motionless mixer for blending the two components, and a pressurized pot for supplying cleaning solvent.

Domestic manufacturers were encountering growing competition from foreign-made bulldozers, drills, and hydraulic excavators.

D'Appolonia Consulting Engineers, Inc., refined a concept of explosive casting for which drilling costs reportedly were probably doubled while 40% to 60% of the overburden would be cast onto spoil piles and not require rehandling by shovels or draglines. Difficulties experienced when drilling inclined blastholes may prevent its wide application.

The Bucyrus-Erie Co. stated that the current trend is toward larger blasthole drilling, and in the future, the rotary drill may not dominate the market after research improves alternate types. Currently, 17.5-inch-diameter rotary blasthole drilling is used on a limited basis in taconite partly because drill design is restricted by the upper limits of power, weight, and air capacity. Rotary drilled 12.75-inch-diameter holes were widely used because of factors such as cost, accessibility, and availability.

Driltech, Inc., introduced its Driltech D40K for performing either small test hole drilling or large blasthole drilling. New small-diameter drilling equipment offered included the PaK-TraK Industries, Inc., Complete Rock Drill Swingair featuring a 360° rotary turntable, a high-speed track carrier, a 20-second, one-person steel change, and choice of air or hydraulic power; the crane-mounted Reed Model 2500, for off-the-road use, with top head drive for either rotary or down-hole drilling; MacLean Engineering & Marketing Co.'s self-contained blockhole hydraulic drill mounted on a backhoe for 4.25-inch holes; and Gardner-Denver's SCH 3500A hydraulic drill with capability for 2.5- to 3.5-inch holes to a 60-foot depth. The latter drill was the first one-man, self-contained, hydraulic drill made in the United States.

The Bureau of Mines in three 1-day technology transfer seminars in late 1980 made the first public description of research leading to new recommendations for controlling ground vibrating damage from mine blasting.

Consolidation Placer Dredging Inc. developed the Cleaveland circular jig MK11 for dredges. Advantages offered, by the jig's pulsation and the deceleration of the pulp as it spreads away from the feed point, were the concentration and recovery of the heavier particles in the pulp.

Beneficiation.—Ore processing faced an accelerating upsurge in costs because of environmental and safety regulations, the cost of energy in real money terms, and the necessity to treat lower grade and mineralogically more complex ores. Because crushing and grinding was the most expensive operation, the focus was primarily on scaled-up units, operating controls, mill liner designs, and methods to reduce grinding media consumption.

Battelle Columbus Laboratories proposed a selective flocculation study for recovering coal, copper, and phosphate from tailings dumps. U.S. patent 4,186,083 was issued for an improved flotation collector for use with phosphate rock, barite, fluorspar, scheelite, or iron ores. The collector comprised 70.0% to 99.9% by weight of tall oil fatty acid, and the remainder was an anionic perfluorosulfonate compound.

Joy Manufacturing Co. introduced a horizontal-belt vacuum filter, ranging from 5 to 1,500 square feet of effective filtration area, and capable of a 100-foot-per-minute speed while operating at 25 inches Hg vacuum. Permanently bonded side curbs eliminated friction between the belt and side plates of the frame.

A custom-designed hydroclone system, having four 10-inch-diameter hydroclones from Siveco Inc., was used to recover 5% more sand fines from a screw classifier overflow. Sand and gravel samples from central and southern California were tested by the Bureau of Mines using a spiral concentrator for recovery of heavy-mineral products.

A Purdue University project devised a new concept to broaden the usefulness of high-gradient-magnetic-separation technology to allow its use for normally nonmagnetic materials such as aluminum minerals from domestic sources as alunite, anorthosite, and certain clays and shales.

Black Pine Mining Co. developed and commercially applied an ore sorting system comprising a feeder, scanner, and separator, which resulted in an overall silver recovery of 93%. Tests by Occidental Research Corp., using the patented Oxylene process, indicated the viability of a new induced fluorescent sorting technique for the preconcentration of limestone, coal, and oil shale. The process was based on selective surface chemistry to label either ore or gangue particles with a fluorescent coating detectable with ultraviolet light.

A Swedish-designed, lightweight, 3-by-4-foot Morgensen Sizer, recently introduced into the United States, showed excellent performance at a Virginia limestone operation when fed with 90 tons per hour of wet or dry, hot or cold, 0.5- to 2-inch stone. The

Sizer, having two vertical sides shaped like a skewed rectangle, can operate with either three or five screen decks. Barber Greene Co. introduced its Dyna-Deck screening equipment for separating minus 1-inch, sticky, wet materials such as lime, bank-run sand, coal, or coke. Except for spacing purposes, cross wires were eliminated on the lower deck, thereby increasing the open screening area by 40%. Screen positioning angles ranged from 30° to 50°.

Tailings disposal continued to receive attention as shown by the following items: Reserve Mining Co. stopped dumping 67,000 tons per day of iron ore tailings into Lake Superior March 18, 1980, when a new on-land disposal basin, costing about $250 million, was completed; approval of tailings disposal systems was required before new uranium processing mills could be built in New Mexico; Gulf Mineral Resources Co. proposed a staged-multicell impoundment for tailings from its 4,200-ton-per-day Mount Taylor project in New Mexico; Kennecott Minerals Co. planned to spend $15 million to recover copper from 2,000 acres of tailings near the McGill, Nev., mill; Climax Molybdenum planned to place a 3- to 5-foot-thick rock cover on a tailing site to improve stability and to prevent erosion by wind or rainfall; Environmental Protection Agency (EPA) in April 1980 proposed standards that would require the cleanup of uranium-mill tailings at an estimated $100 million cost over a 7-year period; EG&G Sealol Inc. introduced its Swing Pad Bearing to operate in high-density ore tailings and sludge; Linatex Corp. of America introduced a new separator to provide a much higher density of underflow discharge without loss in recovery efficiency than experienced when using conventional hydroclones.

The Bureau of Mines and Allis Chalmers Corp. reduced by 2 to 7 dbA the noise of ore sizing equipment by replacing conventional steel decks on screens with nonmetallic decks, which however were 1% to 10% less efficient. Other Bureau activities in beneficiation were concerned with the use of magnesium oxide to purify mineral processing water and with the characterization of residual chemicals in mineral process streams to determine their effects on mineral processing and environmental quality.

In Situ Mining and Leaching.—Several recent patents relating to in situ mining included Canadian 1,068,599 and Canadian 1,069,042 for methods to minimize water hammer resulting from the alternative opening or closing of a foot valve or an eductor nozzle. U.S. patent 4,175,490 covers a method to fragmentize an ore zone by detonating explosives beneath the ore to form a free face and a void space. Canadian patent 1,078,599 covers the use of a lixiviant containing sodium hexametaphosphate or sodium pyrophosphate to retard the growth of calcite during the in situ leaching of a uranium ore deposit associated with limestone containing smectite or calcitic clay.

In situ leaching (ISL) of uranium increased significantly. Reportedly, in 1979, about 7.7% of all U.S. yellow cake production came from ISL. Five commercial projects were started in 1980 while an estimated 22 pilot plants were operating. The Irigaray project near Buffalo, Wyo., switched from NH_4NCO_3 to Na_2CO_3 in its leaching solution while the Ogle Petroleum project in Fremont County, Wyo., announced that $NaHCO_3$ rather than NH_4HCO_3 would be used in the leaching solution because $NaHCO_3$ is environmentally more acceptable. Wyoming Mineral Corp. plugged and abandoned 60 of its 391 wells in the Irigaray project because of liquid leakage caused when reaming plastic piping. Projects in commercial status or expansion phases that collectively were reported to have more than 3.6 million pounds per year capacity of U_3O_8 were Mobil Oil Corp., Bruni, Tex.; Cleveland Cliffs/Edison/Getty, Pumpkin Buttes, Wyo.; Energy Resources Co., Blanding, Utah; Mobil/TVA, Crown Point, N. Mex.; Rocky Mountain Energy Co., Converse County, Wyo.; Tenneco Uranium Inc., Webb County, Tex.; United States Steel Corp., Live Oak, Tex.; and Western Nuclear, Jeffery City, Tex.

In Situ Technology, Inc., received $85,000 from DOE to develop a method to recover uranium in the residual ash resulting from in situ coal gasification. Vulcan Materials and Food Machinery Corp. received approval to test ISL techniques for trona recovery in Wyoming using an aqueous solution containing a chemical additive. The Bureau of Mines tested an underground survey system, at a uranium slurry mining operation in Natrona County, Wyo., to assess cavities and their backfilling.

Interox America dedicated the Nation's largest singletrain hydrogen peroxide (H_2O_2) facility, rated at 5,000 gallons of product per hour, at Deer Park, Tex. Reportedly, H_2O_2 consumption for hydrometallurgy uses in the United States in 1979 was 14.4 million pounds (100% H_2O_2 basis).

Other news involving leaching not related to ISL included a Bureau of Mines developed method for leaching lead-smelter waste materials, and a method to enhance percolation rates in the heap leaching of gold-silver ores from small, low-grade deposits unworthy of conventional mining methods. Envirotech Research Center and Martin Marietta developed a hydrometallurgical process that combined leaching and electrowinning, was virtually nonpolluting, and required 20% less energy than conventional smelting. The only commercial U.S. plant for vat leaching of copper concentrates, operated by Duval Corp. in Arizona, reached its goal of 44,000 short tons per year of blister copper equivalent. The leaching solution, containing cupric chloride and ferric chloride, produced feed for continuous-flow electrolytic cells. Elemental sulfur was recovered as a byproduct. Cyprus Mines Corp. restarted the use of its Cymet process in a pilot plant capable of treating 12 tons daily of copper concentrate by a two-step chloride leaching solution. Envirotech Research Center patented its Electro Slurry process that used an acidic copper sulfate solution while ball milling copper concentrate to 2- to 3-micrometer size. The iron content of the concentrate was converted to iron sulfate. Anaconda's Arbiter process for hydrometallurgical recovery of copper from concentrates was shelved after 6 years' work because of high operating costs and mechanical problems. Holmes & Narver Inc., Orange, Calif., patented a thin-layer copper leaching process using a strong solution of sulfuric acid. Following solvent extraction and electrowinning, cathode copper was produced. A 2,640-ton-per-day commercial plant using this process started operation near Santiago, Chile.

Heap leaching using cyanide solution was used by Tombstone Exploration Inc. in Arizona for the profitable recovery of silver from ore grading as low as 2 ounces per ton. Two 300-ton-per-day Merrill-Crowe precipitation plants were used to extract silver and gold from the pregnant solution. E. R. Fegert Construction Co. recovered gold in Montana, where two 30-foot layers containing 1 troy ounce gold in 10 to 15 tons of ore were placed in a leach area underlain with locally produced bentonite. Reportedly, it was estimated that leaching will continue for 3 years before the recovery values decline to a level where further irrigation is uneconomic.

Health and Safety.—The Bureau of Mines developed equipment and methods applicable to underground mines, including a device to reduce derailing accidents; a borehole radar probe; mine shaft fire and smoke protection systems; the use of ultrasonic energy to evaluate roof-bolt integrity; a two-stage oxygen-supply system for miners' use during emergencies; individually worn samplers to determine workers' exposure to harmful oxides of nitrogen; a new roof-bolt cement and a way to mix it; and a mining tool operated through a borehole from the surface to extract ore without requiring workers underground.

The Bureau of Mines issued: IC 8828[4] dealing with surface mine truck safety; an open file report, in advance of formal publication, containing recommendations to curb structural damage from blast vibration; and held three workshops on noise control for bulldozers.

Taisei Construction Co., in cooperation with two other Japanese firms, developed and tested a magnetized dynamite that can be located easily in case of a misfire. The new dynamite, known as Magnemite, contains powdered barium ferrite. Tests proved that the new dynamite was very efficient and safe.

Magnitude of the Mining Industry.—Compared with that of 1978, there were 5 fewer metal mines and 938 fewer nonmetal mines in 1979. The 12,827 nonmetal mines in 1979 included 2,000 in the range from 1,000 to 10,000 tons per year of ore production. Economics, slowdown of business activities, and Government regulations apparently were responsible for the changes in mine count.

Mines that produced in 1979 in excess of 10 million short tons of crude ore comprised copper (10), iron ore (8), molybdenum (1), phosphate rock (8), and sand and gravel (1). Total crude ore handled (3.12 billion tons) and waste handled (1.95 billion tons) were greater than the respective 1978 tonnages.

Tables 8 and 9, list the 25 largest metal and 25 largest nonmetal mines in order of output of crude ore and total materials handled respectively.

In metal mining, copper and iron ore accounted for about 88% of all metallic ore production. Crude ore for three metals and for five nonmetals came entirely from surface mines. Three metallic ores and six nonmetallic ores were produced without using drilling or blasting.

Surface mining only was done in 23 States while both underground and surface mining was done in 36 States. Eight metal crude ores and 12 nonmetallic crude ores were produced in both surface and underground mines. All lead and zinc ores, potassium salts, sodium carbonate (trona), and staurolite came from underground mines.

Materials Handled.—Total ore plus waste, excluding tailings, handled at metal and nonmetal mines was about 11% greater in 1979 than in 1978. Crude ore equalled 80% of all ore plus waste handled in 1979. In underground metal mines, crude ore production was about 8% greater than in 1978 although about 81% less waste was handled. In surface metal mines, ore production was about 5% greater and waste production was 36% more than in 1978. In underground nonmetal mines, ore production was 9% less and waste production was 58% less than in 1978. In surface nonmetal mines, ore production was up about 2% while waste production was 3% more than in 1978.

Copper and iron ore mines collectively produced 88% of the crude ore and 73% of the ore and waste handled in metal mines. In the nonmetal sector, phosphate rock, sand and gravel, and stone operations accounted for 95% of the crude ores produced and accounted for 94% of the total materials handled.

Thirteen States each accounted for at least 100 million tons of all materials handled. The collective total for these 13 States equaled 70% of the Nation's total, with Florida, Arizona, and Minnesota collectively accounting for 31% of the total.

In underground mining, Arizona, New Mexico, and Colorado were leading producers of ore with 47% of the U.S. total. In surface mining, Florida, Minnesota, and Arizona produced 25% of all surface ore.

Total Value Per Ton of Principal Mineral Products and Byproducts.—These values represent crude ore treated, or in the case of nonmetals, crude ore shipped, and in some cases the total value includes that of byproducts. The average total value of all principal mineral commodities plus byproducts compared with that of 1978 increased 12% while that for all byproducts alone increased 35%.

The average value of all metals per ton of crude ore averaged $11.80 in 1979 compared with $9.99 in 1978 while the average value of byproducts associated with all metals per ton of ore was $1.33 compared with $1.05 in 1978. Values of selected metals per ton of ore compared with those in 1978 increased in percent as follows: Copper, 33; lead, 28; silver, 86; and zinc, 26. The value of bauxite decreased 7%. Gains in values of byproducts associated with selected metals were copper, 38; lead, 16; bauxite, 24; silver, 57; and zinc, 18.

The average value of all nonmetals per ton of ore averaged $3.77 compared with $3.45 in 1978 while the average value of byproducts associated with all nonmetals was 6 cents per ton of ore compared with 5 cents in 1978. The values of selected nonmetals per ton of ore compared with those of 1978 in percent, increased for barite, 161; feldspar, 34; fluorspar, 14; mica (scrap), 95; phosphate rock, 5; potassium salts, 26; sand and gravel, 8; crushed and broken stone, 11; and talc and soapstone, 200. Decreases in value per ton of ore compared with those of 1978 in percent were gypsum, 10; salt, 39; and dimension stone, 71. The values of byproducts, associated with selected nonmetals, per ton of ore compared with those of 1978 increased in percent for barite, 4,600; feldspar, 569; fluorspar, 61; phosphate rock, 20; sand and gravel, 67; and dimension stone, 1,088. The value of byproducts from salt was 18% less than in 1978.

Ratio of Treated Ore to Marketable Product.—The weight of crude ore treated to obtain 1 unit of marketable product in the metals ranged in 1979 from 1,369.9:1.0 for uranium to 0.1:1.0 for silver. For most of the nonmetals, the ratio generally was 1.0:1.0.

A comparison of 1979 data with 1978 data indicated percent increases in this ratio, indicative of lower grades of metallic ores treated, as bauxite, 5; copper, 5; lode gold, 596; placer gold, 271; iron ore, 3; lead, 22; and uranium, 40. Decreases in this ratio were ilmenite, 18; and zinc, 5.

Nonmetallic ores showing increases in the ratio in percent were diatomite, 100; gypsum, 18; perlite, 40; phosphate rock, 3; pumice, 60; sodium carbonate (natural), 5; and dimension stone, 30. Notable decreases in the ratio in percent were asbestos, 60; barite, 55; diatomite, 50; feldspar, 8; fluorspar, 6; mica (scrap), 46; perlite, 40; and potassium salts, 3.

Comparison of Materials From Surface and Underground Mines.—There was a decrease in the ratio of crude ore mined in 1979 to total ore plus waste handled in all surface and underground mines. Surface mines alone produced about 94% of all ores and 96% of the related total materials handled. In nonmetals, surface mines alone produced 76% of the total U.S. crude ore produced and handled 58% of all ore plus waste moved in all U.S. nonmetal mines.

Exploration and Development.—Total exploration drilling footage was 20% less in 1979 and total development drilling footage was 10% less than in 1978.

Rotary drilling accounted for about 80% of all exploration footage, of which 93% was related to uranium. Metals accounted for 90% of all diamond drilling. Uranium plus lode gold accounted for 90% of percussive drilling performed in 1979.

Of the total exploration drilling done in 34 States in 1979, 57% was drilled in New Mexico, Utah, and Wyoming. Of the total development drilling footage performed in 25 States in 1979, 83% was done in Texas, New Mexico, and Colorado.

Approximately 76% of the footage for drifting, crosscutting, and tunneling in development work was performed in New Mexico, Colorado, and Utah. Essentially all of the total drilling footage for solution mining development was done in Texas and Colorado.

Table 16 shows the total materials produced by mine development by commodity and State.

Explosives.—Metal mining and quarrying consumed 6% more explosives than in 1978. Of all explosives and blasting agents sold for consumption in metal mining, Arizona and Minnesota collectively consumed 58%, while in quarrying and nonmetal mining, Kentucky, Illinois, and Ohio collectively consumed 23%.

More detailed explosives information may be found in the annual explosives issue of Mineral Industry Surveys prepared by the Bureau of Mines.

Table 1.—Material handled at surface and underground mines in the United States, by type

(Million short tons)

Type and year	Surface			Underground			All mines[1]		
	Crude ore	Waste	Total[1]	Crude ore	Waste	Total[1]	Crude ore	Waste	Total
Metals:									
1975	535	1,170	1,700	74	13	87	609	1,180	1,790
1976	573	1,250	1,820	73	15	87	646	1,260	1,910
1977	490	1,030	1,530	74	12	87	564	1,050	1,610
1978	554	995	1,550	74	21	95	628	1,020	1,640
1979	580	1,350	1,930	93	10	103	673	1,360	2,030
Nonmetals:									
1975	1,910	372	2,290	79	6	84	1,990	378	2,370
1976	2,000	393	2,390	80	6	86	2,080	399	2,480
1977	2,120	472	2,590	80	6	86	2,200	478	2,680
1978	2,320	571	2,890	87	1	88	2,410	572	2,980
1979	2,360	590	2,950	81	(2)	81	2,440	590	3,040
Total metals and nonmetals:[1]									
1975	2,450	1,540	3,990	153	18	171	2,600	1,560	4,160
1976	2,570	1,640	4,210	153	21	174	2,720	1,660	4,390
1977	2,610	1,510	4,120	155	18	173	2,760	1,520	4,290
1978	2,870	1,570	4,440	161	22	183	3,030	1,590	4,620
1979	2,940	1,940	4,880	174	10	185	3,120	1,950	5,070

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 2.—Material handled at surface and underground mines in 1979, by commodity[1]

(Thousand short tons)

Commodity	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
METALS									
Bauxite	3,840	15,200	19,000	--	--	--	3,840	15,200	19,000
Copper	232,000	548,000	780,000	44,600	194	44,800	277,000	548,000	825,000
Gold:									
Lode	2,000	7,540	9,540	1,570	611	2,180	3,570	8,150	11,700
Placer	2,200	388	2,590	--	1	1	2,200	389	2,590
Iron ore	282,000	364,000	647,000	4,210	428	4,690	286,000	365,000	651,000
Lead	W	W	W	9,820	2,420	12,200	9,820	2,420	12,200
Silver	813	315	1,130	1,180	472	1,660	2,000	787	2,780
Titanium, ilmenite	27,000	W	27,000	--	--	--	27,000	W	27,000
Tungsten	14	W	14	803	419	1,220	817	456	1,270
Uranium	11,900	369,000	380,000	6,420	3,030	9,450	18,300	372,000	390,000
Zinc	--	W	W	5,540	1,810	7,350	5,540	1,810	7,350
Other[3]	17,400	43,100	60,500	19,200	530	19,700	36,600	43,700	80,300
Total metals[2]	580,000	1,350,000	1,930,000	93,400	9,970	103,000	673,000	1,360,000	2,030,000
NONMETALS									
Abrasives[4]	294	53	347	W	--	W	294	53	347
Asbestos	2,350	e1,320	3,670	W	--	W	2,350	e1,320	3,670
Barite	1,880	--	1,880	--	--	--	1,880	--	1,880
Clays	48,800	e42,500	91,300	795	e11	806	49,600	e42,500	92,100
Diatomite	1,100	--	1,100	--	--	--	1,100	--	1,100
Feldspar	1,500	114	1,620	W	--	W	1,500	114	1,620
Fluorspar	17	20	37	390	26	416	407	46	452
Gypsum	15,100	1,070	16,200	W	--	W	15,100	1,070	16,200
Mica (scrap)	780	255	1,030	--	--	--	780	255	1,030
Perlite	842	246	1,090	5	--	5	847	246	1,090
Phosphate rock	205,000	457,000	662,000	W	W	W	205,000	457,000	662,000
Potassium salts	--	--	--	19,100	123	19,300	19,100	123	19,300
Pumice	4,230	62	4,290	--	--	--	4,230	62	4,290

Salt	423	--	423	15,200	--	15,200	15,600	--	15,600
Sand and gravel	985,000	--	985,000	--	--	--	985,000	--	985,000
Sodium carbonate (natural)	--	--	--	12,800	W	12,800	12,800	W	12,800
Stone:									
Crushed and broken	1,080,000	e86,000	1,170,000	31,300	219	31,500	1,110,000	e86,200	1,200,000
Dimension	5,570	e1,810	7,380	W	--	W	5,570	e1,810	7,380
Talc, soapstone, pyrophyllite	913	164	1,080	595	9	604	1,510	173	1,680
Other[5]	5,970	1,670	7,640	369	19	389	6,340	1,690	8,030
Total nonmetals[2]	2,360,000	590,000	2,950,000	80,900	419	81,300	2,440,000	590,000	3,040,000
Grand total[2]	2,940,000	1,940,000	4,880,000	174,000	10,400	185,000	3,120,000	1,950,000	5,070,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, rare-earth metals, tin, and vanadium.
[4]Abrasive stone, emery, garnet, and tripoli.
[5]Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, staurolite, tube-mill liners, vermiculite, wollastonite, and quantity of metal and nonmetal items indicated by symbol W.

Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1979, by State[1]

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
Alabama	43,800	7,110	50,900	8	--	8	43,800	7,110	50,900
Alaska	55,700	355	56,100	--	1	1	55,700	356	56,100
Arizona	190,000	266,000	455,000	37,100	148	37,300	227,000	266,000	493,000
Arkansas	39,800	12,000	51,700	W	W	W	39,800	12,000	51,700
California	188,000	41,700	229,000	1,050	165	1,220	189,000	41,900	231,000
Colorado	40,400	15,000	55,400	20,200	1,470	21,700	60,600	16,500	77,100
Connecticut	18,700	793	19,500	--	--	--	18,700	793	19,500
Delaware	1,690	W	1,690	--	--	--	1,690	W	1,690
Florida	287,000	349,000	636,000	W	--	W	287,000	349,000	636,000
Georgia	55,700	13,600	69,300	W	W	W	55,700	13,600	69,300
Hawaii	8,350	563	8,910	--	--	--	8,350	563	8,910
Idaho	19,400	48,600	68,000	1,600	280	1,880	21,000	48,900	69,900
Illinois	108,000	5,510	113,000	2,670	42	2,710	110,000	5,560	116,000
Indiana	64,100	3,890	68,000	W	W	W	64,100	3,890	68,000
Iowa	51,100	3,050	54,100	W	W	W	51,100	3,050	54,100
Kansas	33,100	2,090	35,100	3,050	16	3,070	36,100	2,100	38,200
Kentucky	43,600	3,300	46,900	8,370	59	8,430	51,900	3,350	55,300
Louisiana	31,100	1,110	32,300	5,200	--	5,200	36,300	1,110	37,500
Maine	13,200	248	13,400	--	--	--	13,200	248	13,400
Maryland	36,500	2,460	38,900	W	W	W	36,500	2,460	38,900
Massachusetts	25,700	896	26,600	--	--	--	25,700	896	26,600
Michigan	148,000	122,000	270,000	6,010	--	6,010	154,000	122,000	276,000
Minnesota	249,000	195,000	444,000	--	--	--	249,000	195,000	444,000
Mississippi	21,300	1,710	23,000	--	--	--	21,300	1,710	23,000
Missouri	68,300	5,430	73,700	15,000	2,810	17,800	83,300	8,240	91,500
Montana	29,100	580	29,700	412	87	499	29,500	666	30,200
Nebraska	21,100	408	21,500	W	W	W	21,100	408	21,500
Nevada	20,400	31,700	52,100	324	293	617	20,800	31,900	52,700
New Hampshire	8,140	172	8,310	--	--	--	8,140	172	8,310
New Jersey	33,100	1,210	34,300	W	--	W	33,100	1,210	34,300
New Mexico	43,400	213,000	257,000	24,900	1,570	26,500	68,200	215,000	283,000
New York	65,600	4,230	69,800	5,090	21	5,110	70,700	4,250	74,900

North Carolina	66,200	57,400	124,000	--	--	--	66,200	57,400	124,000
North Dakota	6,730	W	6,730	--	--	--	6,730	W	6,730
Ohio	99,200	6,300	105,000	4,330	9	4,340	104,000	6,310	110,000
Oklahoma	42,300	2,910	45,200	W	W	W	42,300	2,910	45,200
Oregon	48,200	4,060	52,200	--	13	13	48,200	4,080	52,300
Pennsylvania	91,500	7,570	99,100	3,590	62	3,650	95,100	7,630	103,000
Rhode Island	3,790	20	3,810	--	--	--	3,790	20	3,810
South Carolina	27,400	2,860	30,300	--	--	--	27,400	2,860	30,300
South Dakota	10,300	610	10,900	W	W	W	10,300	610	10,900
Tennessee	59,100	16,200	75,300	8,670	1,730	10,400	67,800	17,900	85,700
Texas	140,000	66,200	206,000	605	4	610	140,000	66,200	207,000
Utah	58,500	134,000	192,000	999	1,050	2,050	59,500	135,000	194,000
Vermont	6,920	362	7,280	331	--	331	7,250	362	7,610
Virginia	62,700	4,980	67,600	2,470	27	2,500	65,100	5,000	70,100
Washington	40,900	5,550	46,500	W	W	W	40,900	5,550	46,500
West Virginia	14,900	1,040	16,000	2,840	22	2,860	17,800	1,060	18,800
Wisconsin	58,300	9,790	68,000	W	W	W	58,300	9,790	68,000
Wyoming	23,300	265,000	289,000	14,500	271	14,700	37,800	266,000	304,000
Undistributed	2,400	2,400	4,800	4,900	233	5,130	7,300	2,600	10,000
Total[2 3]	2,940,000	1,940,000	4,880,000	174,000	10,400	185,000	3,120,000	1,950,000	5,070,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes estimated data in table 2.

Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1979

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total
METALS									
Bauxite	$6.59	$15.82	$22.41	--	--	--	$6.59	$15.82	$22.41
Copper	9.34	2.08	11.42	$13.64	$1.47	$15.11	10.00	1.99	11.99
Gold:									
Lode	2.73	.41	3.14	62.82	2.03	64.85	8.02	.56	8.58
Placer	.75	--	.75	--	--	--	.75	--	.75
Iron ore	9.69	--	9.69	20.04	W	20.04	9.86	W	9.86
Lead	2.46	7.13	9.59	48.24	10.59	58.83	48.22	10.59	58.81
Silver	28.31	9.34	37.65	160.67	35.46	196.13	112.03	25.86	137.89
Titanium, ilmenite	1.27	.63	1.90	--	--	--	1.27	.63	1.90
Tungsten	79.27	--	79.27	49.90	3.34	53.24	50.22	3.30	53.52
Uranium	24.97	--	24.97	50.95	6.74	57.69	32.12	1.86	33.98
Zinc	--	--	--	27.30	6.87	34.17	27.30	6.87	34.17
Average[1]	9.80	1.01	10.81	24.53	3.36	27.89	11.80	1.33	13.13
NONMETALS									
Asbestos[e]	31.00	--	31.00	W	--	W	31.00	--	31.00
Barite	24.59	.47	25.06	--	--	--	24.59	.47	25.06
Clays	15.71	--	15.71	12.02	--	12.02	15.65	--	15.65
Diatomite	61.73	--	61.73	--	--	--	61.73	--	61.73
Feldspar	12.05	8.77	20.82	W	--	W	12.05	8.77	20.82
Fluorspar	23.27	--	23.27	34.15	8.22	42.37	33.63	7.82	41.45
Gypsum	5.37	--	5.37	W	--	W	5.37	--	5.37
Mica (scrap)	9.83	--	9.83	--	--	--	9.83	--	9.83
Perlite	11.77	--	11.77	W	--	W	11.77	--	11.77
Phosphate rock	5.09	.06	5.15	W	--	W	5.09	.06	5.15
Potassium salts	--	--	--	11.96	--	11.96	11.96	--	11.96
Pumice	2.28	--	2.28	--	--	--	2.28	--	2.28

Salt	.77	--	.77	10.15	1.96	12.11	9.89	1.90	11.79
Sand and gravel	2.43	.05	2.48	--	--	--	2.43	.05	2.48
Sodium carbonate (natural)	--	--	--	34.46	--	34.46	34.46	--	34.46
Stone:									
Crushed and broken	2.93	.02	2.95	3.81	--	3.81	2.95	.02	2.97
Dimension	22.70	1.90	24.60	W	--	W	22.70	1.90	24.60
Talc, soapstone, pyrophyllite	7.88	2.58	10.46	14.20	.16	14.36	10.54	1.56	12.10
Average[1]	3.48	.05	3.53	12.18	.44	12.62	3.77	.06	3.83
Average, metals and nonmetals[1]	4.79	.25	5.04	18.89	2.02	20.91	5.58	.35	5.93
Average, nonmetals (excluding stone and sand and gravel)[1]	8.58	.10	8.68	17.40	.71	18.11	9.84	.18	10.02
Average, metals and nonmetals (excluding stone and sand and gravel)[1]	9.40	.71	10.11	22.11	2.45	24.56	11.15	.95	12.10

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes unpublished data.

Table 5.—Crude ore and total material handled at surface and underground mines in 1979, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100.0	--	100.0
Bauxite	100.0	--	100.0	--
Beryllium	100.0	--	100.0	--
Copper	83.9	16.1	94.6	5.4
Gold:				
Lode	56.1	43.9	81.4	18.6
Placer	100.0	--	100.0	--
Iron ore	98.5	1.5	99.3	.7
Lead	.3	99.7	.2	99.8
Manganiferous ore	100.0	--	100.0	--
Mercury	100.0	--	100.0	--
Molybdenum	38.4	61.6	71.6	28.4
Nickel	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	40.7	59.3	40.5	59.5
Tin	--	--	--	100.0
Titanium, ilmenite	100.0	--	100.0	--
Tungsten	1.7	98.3	4.1	95.9
Uranium	65.0	35.0	97.6	2.4
Vanadium	100.0	--	100.0	--
Zinc	--	100.0	.6	99.4
Total metals	86.1	13.9	94.9	5.1
NONMETALS				
Aplite	100.0	--	100.0	--
Asbestos	[1]100.0	W	[1]100.0	W
Barite	100.0	--	100.0	--
Boron minerals	100.0	--	100.0	--
Clays	98.4	1.6	99.1	.9
Diatomite	100.0	--	100.0	--
Emery	100.0	--	100.0	--
Feldspar	[1]100.0	W	[1]100.0	W
Fluorspar	4.1	95.9	8.1	91.9
Garnet	100.0	--	100.0	--
Gypsum	97.9	2.1	98.1	1.9
Iron oxide pigments (crude)	100.0	--	100.0	--
Kyanite	100.0	--	100.0	--
Lithium minerals	100.0	--	100.0	--
Magnesite	100.0	--	100.0	--
Mica (scrap)	100.0	--	100.0	--
Millstones	100.0	--	100.0	--
Olivine	100.0	--	100.0	--
Perlite	99.4	.6	99.5	.5
Phosphate rock	[1]100.0	W	[1]100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	2.7	97.3	2.7	97.3
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Stone:				
Crushed and broken	97.1	2.9	97.3	2.7
Dimension	[1]100.0	W	[1]100.0	W
Talc, soapstone, pyrophyllite	60.5	39.5	64.1	35.9
Tripoli	[1]100.0	W	[1]100.0	W
Vermiculite	100.0	--	100.0	--
Total nonmetals	96.7	3.3	97.3	2.7
Grand total	94.4	5.6	96.3	3.7

W Withheld to avoid disclosing company proprietary data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.

Table 6.—Crude ore and total material handled at surface and underground mines in 1979, by State

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	100.0	--	100.0	--
Alaska	100.0	--	100.0	--
Arizona	83.6	16.4	92.4	7.6
Arkansas	[1]100.0	W	[1]100.0	W
California	99.4	.6	99.5	.5
Colorado	66.6	33.4	71.8	28.2
Connecticut	100.0	--	100.0	--
Delaware	100.0	--	100.0	--
Florida	100.0	--	100.0	--
Georgia	99.8	.2	99.8	.2
Hawaii	100.0	--	100.0	--
Idaho	92.4	7.6	97.3	2.7
Illinois	97.6	2.4	97.7	2.3
Indiana	99.5	.5	99.5	.5
Iowa	97.2	2.8	97.3	2.7
Kansas	91.6	8.4	92.0	8.0
Kentucky	83.9	16.1	84.8	15.2
Louisiana	85.7	14.3	86.1	13.9
Maine	100.0	--	100.0	--
Maryland	[1]100.0	W	[1]100.0	W
Massachusetts	100.0	--	100.0	--
Michigan	96.1	3.9	97.8	2.2
Minnesota	100.0	--	100.0	--
Mississippi	100.0	--	100.0	--
Missouri	82.0	18.0	80.6	19.4
Montana	98.6	1.4	98.3	1.7
Nebraska	[1]100.0	W	[1]100.0	W
Nevada	98.4	1.6	98.8	1.2
New Hampshire	100.0	--	100.0	--
New Jersey	99.4	.6	99.4	.6
New Mexico	63.4	36.6	90.6	9.4
New York	92.8	7.2	93.2	6.8
North Carolina	100.0	--	100.0	--
North Dakota	100.0	--	100.0	--
Ohio	95.8	4.2	96.0	4.0
Oklahoma	[1]100.0	W	[1]100.0	W
Oregon	100.0	--	100.0	--
Pennsylvania	96.2	3.8	96.4	3.6
Rhode Island	100.0	--	100.0	--
South Carolina	100.0	--	100.0	--
South Dakota	[1]100.0	W	[1]100.0	W
Tennessee	87.2	12.8	87.9	12.1
Texas	99.6	.4	99.7	.3
Utah	98.3	1.7	98.9	1.1
Vermont	95.4	4.6	95.6	4.4
Virginia	96.2	3.8	96.4	3.6
Washington	[1]100.0	W	[1]100.0	W
West Virginia	84.0	16.0	84.8	15.2
Wisconsin	[1]100.0	W	[1]100.0	W
Wyoming	61.7	38.3	95.1	4.9
Total	94.4	5.6	96.3	3.7

W Withheld to avoid disclosing company proprietary data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.

Table 7.—Number of domestic metal and nonmetal mines in 1979, by commodity and magnitude of crude ore production[1]

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	16	--	--	7	9	--	--
Copper	44	11	--	3	5	15	10
Gold:							
Lode	27	14	4	5	3	1	--
Placer	23	5	8	8	1	1	--
Iron ore	48	--	3	9	13	15	8
Lead	46	32	4	1	3	6	--
Silver	43	22	7	9	5	--	--
Titanium, ilmenite	5	--	--	--	1	4	--
Tungsten	48	41	4	1	2	--	--
Uranium	283	50	84	102	45	2	--
Zinc	21	3	2	2	14	--	--
Other[2]	18	4	1	4	5	3	1
Total metals	622	182	117	151	106	47	19
NONMETALS							
Abrasives[3]	15	1	7	5	2	--	--
Asbestos	5	--	--	2	2	1	--
Barite	27	--	10	11	6	--	--
Boron minerals	3	1	--	1	--	1	--
Clays	1,072	62	214	656	140	--	--
Diatomite	12	--	5	4	3	--	--
Feldspar	16	--	4	4	8	--	--
Fluorspar	6	--	3	1	2	--	--
Gypsum	67	2	4	17	43	1	--
Mica (scrap)	16	2	6	5	3	--	--
Perlite	12	1	3	5	3	--	--
Phosphate rock	46	1	4	6	8	19	8
Potassium salts	7	--	--	--	1	6	--
Pumice	89	6	23	52	8	--	--
Salt	20	1	3	3	7	6	--
Sand and gravel	6,789	135	1,032	3,244	2,264	113	1
Stone:							
Crushed and broken	4,147	157	484	1,565	1,731	210	--
Dimension	397	92	173	123	9	--	--
Talc, soapstone, pyrophyllite	46	4	19	19	4	--	--
Other[4]	35	4	6	11	9	5	--
Total nonmetals	12,827	469	2,000	5,734	4,253	362	9
Grand total	13,449	651	2,117	5,885	4,359	409	28

[1]Excludes wells, ponds, or pumping operations.
[2]Antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, rare-earth metals, tin, and vanadium.
[3]Abrasive stone, emery, garnet, and tripoli.
[4]Aplite, calcium chloride, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, sodium carbonate (natural), staurolite, sulfur, tube-mill liners, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1979, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
METALS				
Minntac	Minnesota	United States Steel Corp	Iron ore	Open pit.
Utah Copper	Utah	Kennecott Minerals Co	Copper	Do.
Sierrita	Arizona	Duval Sierrita Corp	do	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
San Manuel	Arizona	Magma Copper Co	Copper	Do.
Morenci	do	Phelps Dodge Corp	do	Do.
Hibbing Taconite	Minnesota	Pickands Mather & Co	Iron ore	Do.
Peter Mitchell	do	Reserve Mining Co	do	Do.
Empire	Michigan	Cleveland-Cliffs Iron Co	do	Do.
Thunderbird	Minnesota	Oglebay Norton Co	do	Do.
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Do.
Pinto Valley	Arizona	Cities Service Co	do	Do.
Berkeley Pit	Montana	The Anaconda Company	do	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Tilden	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Open pit.
Bagdad	Arizona	Cyprus-Bagdad Copper Co	Copper	Do.
Ray Pit	do	Kennecott Minerals Co	do	Do.
National Pellet Project	Minnesota	Hanna Mining Co	Iron ore	Do.
Twin Buttes	Arizona	Anamax Mining Co	Copper	Do.
Inspiration	do	Inspiration Consolidated Copper Corp.	do	Do.
Henderson	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving.
Metcalf	Arizona	Phelps Dodge Corp	Copper	Open pit.
Lakehurst	New Jersey	ASARCO Incorporated	Titanium	Dredging.
Republic	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Open pit.
Eagle Mountain	California	Kaiser Steel Corp	do	Do.
NONMETALS				
Noralyn	Florida	International Minerals & Chemical Corp.	Phosphate rock.	Open pit.
Suwannee	do	Occidental Petroleum Corp	do	Do.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Ft. Green	do	Williams Co	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Payne Creek	do	Williams Co	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Lee Creek	North Carolina	Texasgulf, Inc	Phosphate rock.	Open pit.
Hookers	Florida	W. R. Grace & Co	do	Do.
Thornton	Illinois	General Dynamics Corp	do	Do.
Feld	Texas	Texas Crushed Stone Co	do	Do.
Stoneport	Michigan	Presque Isle Corp	Stone	Do.
Big Four	Florida	Amax Chemical Corp	Phosphate rock.	Do.
Ft. Meade	do	Gardinier, Inc	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
McCook	Illinois	Vulcan Materials Co	Stone	Open quarry.
Nichols	Florida	Mobil Oil Corp	Phosphate rock.	Open pit.
Swift Creek	do	Occidential Petroleum Corp	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
FEC Hialea	Florida	Rinker Materials Corp	Stone	Open quarry.

[1]Brines and materials from wells excepted.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1979, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Minerals Co	Copper	Open pit.
Tyrone	New Mexico	Phelps Dodge Corp	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Empire	Michigan	Cleveland-Cliffs Iron Co	do	Do.
Hibbing Taconite	Minnesota	Pickands Mather & Co	do	Do.
Sierrita	Arizona	Duval Sierrita Corp	Copper	Do.
Shirley	Wyoming	Getty Oil Co	Uranium	Do.
Twin Buttes	Arizona	Anamax Mining Co	Copper	Do.
Shirley Basin	Wyoming	Utah International, Inc	Uranium	Do.
Morenci	Arizona	Phelps Dodge Corp	Copper	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Pinto Valley	Arizona	Cities Service Co	Copper	Do.
Jackpile-Paquate	New Mexico	The Anaconda Company	Uranium	Do.
Bagdad	Arizona	Cyprus Bagdad Copper Co	Copper	Do.
Highland	Wyoming	Exxon Corp	Uranium	Do.
Eagle Mountain	California	Kaiser Steel Corp	Iron ore	Do.
Chino	New Mexico	Kennecott Minerals Co	Copper	Do.
Conquista	Texas	Continental Oil Co	Uranium	Do.
Mitchell Pit	Minnesota	Reserve Mining Co	Iron ore	Do.
Lucky Me	Wyoming	Pathfinder Mines Corp	Uranium	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Metcalf	Arizona	Phelps Dodge Corp	Copper	Open pit.
Inspiration	do	Inspiration Consolidated Copper Corp.	do	Do.
Republic	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Do.
		NONMETALS		
Lee Creek	North Carolina	Texasgulf, Inc	Phosphate rock.	Open pit.
Kingsford	Florida	International Minerals & Chemical Corp.	do	Do.
Suwannee	do	Occidental Petroleum Corp	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Ft. Green	do	Williams Co	do	Do.
Payne Creek	do	do	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Haynsworth	do	do	do	Do.
Big Four	do	Amax Chemical Corp	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Nichols	do	Mobil Oil Corp	do	Do.
Ft. Meade	do	Gardinier, Inc	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Mabie Canyon	Idaho	Conda Partnership	do	Do.
Wooley Valley	do	Stauffer Chemical Co	do	Do.
Watson	Florida	Estech General Chemical Corp.	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Silver City	Florida	Estech General Chemical Corp.	do	Do.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Hardee	Florida	C. F. Mining Corp	Phosphate rock.	Open pit.
Thornton	Illinois	General Dynamics Corp	Stone	Open quarry.

[1]Brines and materials from wells excepted.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States in 1979, by commodity

Commodity and unit of marketable product	Surface			Underground			Total[1]		
	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product
METALS									
Bauxite ______ thousand long tons	3,780	1,790	2.1:1	--	--	--	3,780	1,790	2.1:1
Copper ______ thousand short tons	247,000	1,240	199.1:1	44,600	327	136.4:1	292,000	1,570	186.1:1
Gold:									
Lode ______ thousand troy ounces	16,100	143	112.7:1	1,560	318	4.9:1	17,700	462	38.3:1
Placer ______ do	2,890	7	409.7:1	--	--	--	2,890	7	409.7:1
Iron ore ______ thousand long tons	280,000	83,000	3.4:1	4,670	2,860	1.6:1	285,000	85,800	3.3:1
Lead ______ thousand short tons	W	W	W	11,700	535	21.8:1	11,700	535	21.8:1
Silver ______ thousand troy ounces	702	1,790	.4:1	1,210	17,500	.1:1	1,910	19,300	.1:1
Titanium, ilmenite ______ thousand short tons	25,900	646	40.0:1	--	--	--	25,900	646	40.0:1
Uranium ______ do	18,000	10	1,762.5:1	6,820	8	863.6:1	24,800	18	1,369.9:1
Zinc ______ do	--	--	--	5,530	202	27.3:1	5,530	202	27.3:1
NONMETALS									
Asbestos ______ do	e924	103	9.0:1	W	W	W	e924	103	9.0:1
Barite ______ do	1,880	1,870	1.0:1	--	--	--	1,880	1,870	1.0:1
Clays ______ do	48,600	48,500	1.0:1	795	795	1.0:1	49,400	49,300	1.0:1
Diatomite ______ do	1,460	717	2.0:1	--	--	--	1,460	717	2.0:1
Feldspar ______ do	1,550	663	2.3:1	W	W	W	1,550	663	2.3:1
Fluorspar ______ do	17	5	3.4:1	344	104	3.3:1	362	109	3.3:1
Gypsum ______ do	18,300	14,400	1.3:1	W	W	W	18,300	14,400	1.3:1
Mica (scrap) ______ do	707	135	5.2:1	--	--	--	707	135	5.2:1
Perlite ______ do	1,390	655	2.1:1	5	5	1.0:1	1,400	660	2.1:1
Phosphate rock ______ do	205,000	56,700	3.6:1	W	W	W	205,000	56,700	3.6:1
Potassium salts ______ do	--	--	--	19,100	2,210	8.7:1	19,100	2,210	8.7:1
Pumice ______ do	7,010	4,410	1.6:1	--	--	--	7,010	4,410	1.6:1
Salt ______ do	419	42	9.9:1	14,800	14,700	1.0:1	15,200	14,700	1.0:1
Sand and gravel ______ do	981,000	973,000	1.0:1	--	--	--	981,000	973,000	1.0:1
Sodium carbonate (natural) ______ do	--	--	--	12,800	6,880	1.9:1	12,800	6,880	1.9:1
Stone:									
Crushed and broken ______ do	1,070,000	1,060,000	1.0:1	31,300	31,200	1.0:1	1,100,000	1,090,000	1.0:1
Dimension ______ do	e5,570	1,430	3.9:1	W	W	W	e5,570	1,430	3.9:1
Talc, soapstone, pyrophyllite ______ do	979	706	1.4:1	712	573	1.2:1	1,690	1,280	1.3:1

eEstimated. W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States in 1979, by commodity

Commodity and unit of marketable product	Surface: Total material handled[2] (thousand short tons)	Surface: Marketable product (units)	Surface: Ratio of units of material handled to units of marketable product[3]	Underground: Total material handled[2] (thousand short tons)	Underground: Marketable product (units)	Underground: Ratio of units of material handled to units of marketable product[3]	Total[1]: Total material handled[2] (thousand short tons)	Total[1]: Marketable product (units)	Total[1]: Ratio of units of material handled to units of marketable product[3]
METALS									
Bauxite ---- thousand long tons	18,600	1,790	8.6:1	--	--	--	18,600	1,790	8.6:1
Copper ---- thousand short tons	780,000	1,240	567.8:1	44,800	327	136.5:1	825,000	1,570	477.9:1
Gold:									
Lode ---- thousand troy ounces	9,540	143	60.8:1	2,180	318	5.2:1	11,700	462	22.5:1
Placer ---- do	2,590	7	354.3:1	(4)	--	.0:1	2,590	7	354.3:1
Iron ore ---- thousand long tons	631,000	83,000	6.0:1	4,630	2,860	1.5:1	636,000	85,800	5.9:1
Lead ---- thousand short tons	W	W	W	12,700	535	19.3:1	12,700	535	19.3:1
Silver ---- thousand troy ounces	1,130	1,790	.5:1	1,660	17,500	.1:1	2,780	19,300	.1:1
Titanium, ilmenite ---- thousand short tons	27,000	646	43.0:1	--	--	--	27,000	646	43.0:1
Uranium ---- do	380,000	10	30,303.0:1	9,450	8	928.0:1	390,000	18	17,473.0:1
Zinc ---- do	W	--	W	7,350	202	28.1:1	7,350	202	28.1:1
NONMETALS									
Asbestos ---- do	[e]3,670	103	35.6:1	W	W	W	[e]3,670	103	35.6:1
Barite ---- do	1,880	1,870	1.0:1	--	--	--	1,880	1,870	1.0:1
Clays ---- do	[e]91,300	48,500	1.9:1	[e]806	795	1.0:1	[e]92,100	49,300	1.9:1
Diatomite ---- do	1,100	717	1.5:1	--	--	--	1,100	717	1.5:1
Feldspar ---- do	1,620	663	2.4:1	W	W	W	1,620	663	2.4:1
Fluorspar ---- do	37	5	3.2:1	416	104	3.8:1	452	109	3.7:1
Gypsum ---- do	16,200	14,400	1.1:1	W	W	W	16,200	14,400	1.1:1
Mica (scrap) ---- do	1,030	135	7.0:1	--	--	--	1,030	135	7.0:1
Perlite ---- do	1,090	655	1.7:1	5	5	1.1:1	1,090	660	1.7:1
Phosphate rock ---- do	662,000	56,700	11.3:1	W	W	W	662,000	56,700	11.3:1
Potassium salts ---- do	--	--	--	19,300	2,210	8.7:1	19,300	2,210	8.7:1
Pumice ---- do	4,290	4,410	1.0:1	--	--	--	4,290	4,410	1.0:1
Salt ---- do	423	42	10.0:1	15,200	14,700	1.0:1	15,600	14,700	1.1:1
Sand and gravel ---- do	985,000	973,000	1.0:1	--	--	--	985,000	973,000	1.0:1
Sodium carbonate (natural) ---- do	--	--	--	12,800	6,880	1.9:1	12,800	6,880	1.9:1
Stone:									
Crushed and broken ---- do	[e]1,150,000	1,060,000	1.1:1	[e]31,500	31,200	1.0:1	[e]1,180,000	1,090,000	1.1:1
Dimension ---- do	[e]7,380	1,430	5.2:1	W	W	W	[e]7,380	1,430	5.2:1
Talc, soapstone, pyrophyllite ---- do	1,080	706	1.3:1	604	573	1.1:1	1,680	1,280	1.2:1

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.
[2]Includes material from development and exploration activities.
[3]Material from development and exploration activities is excluded from the ratio calculation.
[4]Less than 1/2 unit.

Table 12.—Mining methods used in open pit mining in 1979, by commodity

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting[1]
METALS		
Bauxite	74	26
Beryllium	--	100
Copper	94	6
Gold:		
Lode	100	--
Placer	--	100
Iron ore	90	10
Lead	23	77
Manganiferous ore	97	3
Mercury	10	90
Molybdenum	89	11
Nickel	8	92
Rare-earth metals	100	--
Silver	100	--
Titanium, ilmenite	8	92
Tungsten	85	15
Uranium	63	37
Vanadium	5	95
NONMETALS		
Aplite	56	44
Asbestos	100	--
Barite	11	89
Boron minerals	87	13
Calcium chloride	--	100
Clays	--	100
Diatomite	--	100
Feldspar	85	15
Fluorspar	90	10
Graphite	100	--
Greensand marl	--	100
Gypsum	32	68
Iron oxide pigments (crude)	100	--
Kyanite	100	--
Lithium	47	53
Magnesite	100	--
Mica (scrap)	29	71
Millstones	100	--
Olivine	66	34
Perlite	4	96
Phosphate rock	5	95
Pumice	6	94
Salt	7	93
Sand and gravel	--	100
Stone:		
Crushed and broken	99	1
Dimension	--	100
Talc, soapstone, pyrophyllite	79	21
Vermiculite	--	100
Average	56	44

[1]Includes drilling or cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

Table 13.—Development and exploration activity in the United States in 1979, by method

Method	Metals		Nonmetals		Total[1]	
	Feet	Percent of total[2]	Feet	Percent of total[2]	Feet	Percent of total[2]
DEVELOPMENT						
Shaft and winze sinking	8,950	0.3	948	8.1	9,900	0.3
Raising	67,100	1.9	393	3.4	67,500	1.9
Drifting, crosscutting, tunneling	1,100,000	30.8	8,350	71.4	1,110,000	30.9
Solution mining	2,400,000	67.0	2,000	17.1	2,400,000	66.9
Total[1]	3,570,000	100.0	11,700	100.0	3,590,000	100.0
EXPLORATION						
Diamond drilling	1,710,000	9.4	180,000	42.9	1,890,000	10.1
Churn drilling	81,600	.4	--	--	81,600	.4
Rotary drilling	14,700,000	80.6	233,000	55.6	14,900,000	80.1
Percussion drilling	852,000	4.6	--	--	852,000	4.6
Other drilling	875,000	4.8	270	.1	876,000	4.7
Trenching	14,100	.1	6,000	1.4	20,100	.1
Total[1]	18,200,000	100.0	420,000	100.0	18,700,000	100.0
Grand total[1]	21,800,000	XX	431,000	XX	22,300,000	XX

XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Based on unrounded footage.

Table 14.—Development and exploration in 1979, by method and selected metals and nonmetals

(Feet)

Commodity	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
METALS												
Copper	30	2,080	22,400	120	24,600	259,000	--	25,200	9,630	2,680	3,260	300,000
Gold:												
Lode	1,260	12,800	49,000	W	63,100	197,000	1,250	99,900	115,000	185	515	414,000
Placer	--	--	306	--	306	--	177	500	--	--	78	755
Iron ore	--	--	22,300	--	22,300	48,500	--	6,500	17,000	212	--	72,200
Lead	--	2,330	40,900	W	43,200	150,000	21,400	79,400	5,740	134,000	5,080	396,000
Molybdenum	--	W	W	--	W	554,000	--	22,400	1,430	11,200	--	589,000
Silver	843	4,780	40,500	W	46,100	24,700	--	17,100	9,870	2,700	295	54,600
Tungsten	150	12,100	13,600	--	25,900	27,500	--	3,600	2,630	--	60	33,800
Uranium	5,630	21,600	811,000	2,080,000	2,920,000	160,000	6,300	13,900,000	652,000	276,000	4,800	15,000,000
Zinc	18	4,940	68,900	--	73,800	270,000	52,400	1,400	38,700	1,000	--	363,000
Other[2]	1,020	6,470	30,600	316,000	354,000	18,700	--	554,000	--	447,000	--	1,020,000
Total[1]	8,950	67,100	1,100,000	2,400,000	3,570,000	1,710,000	81,600	14,700,000	852,000	875,000	14,100	18,200,000
NONMETALS												
Boron minerals	--	--	--	--	--	2,000	--	16,400	--	--	--	18,400
Phosphate rock	--	--	5,380	--	5,380	8,490	--	160,000	--	270	--	169,000
Sulfur	--	--	--	--	--	4,200	--	--	--	--	--	4,200
Talc, soapstone, pyrophyllite	--	393	200	--	593	2,600	--	--	--	--	--	2,600
Other[3]	948	--	2,770	2,000	5,700	163,000	--	56,600	--	--	6,000	225,700
Total[1]	948	393	8,350	2,000	11,700	180,000	--	233,000	--	270	6,000	420,000
Grand total[1]	9,900	67,500	1,110,000	2,400,000	3,590,000	1,890,000	81,600	14,900,000	852,000	876,000	20,100	18,700,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.
[2]Antimony, bauxite, beryllium, mercury, and platinum.
[3]Barite, clays, diatomite, fluorspar, gypsum, mica (scrap), perlite, potassium salts, sodium carbonate (natural), and staurolite.

Table 15.—Development and exploration in 1979, by method and State

(Feet)

State	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
Alaska	--	--	350	--	350	52,500	177	750	--	--	278	53,800
Arizona	--	79	9,210	--	9,290	82,200	780	30,400	--	415	4,300	118,000
Arkansas	--	--	--	--	--	--	--	38,500	--	--	--	38,500
California	196	5,930	9,690	--	15,800	19,800	--	189,000	16,800	180	60	226,000
Colorado	2,370	13,500	121,000	123,000	260,000	136,000	--	1,140,000	213,000	1,100	--	1,490,000
Florida	--	--	--	--	--	W	--	112,000	--	--	--	112,000
Georgia	--	--	--	--	--	1,500	--	10,500	--	--	--	12,000
Idaho	601	5,660	15,300	3,040	24,600	26,000	--	16,000	440	--	--	42,400
Illinois	W	--	W	--	W	116,000	--	--	--	--	--	116,000
Michigan	--	--	--	--	--	12,100	--	--	--	--	--	12,100
Minnesota	--	--	--	--	--	36,300	--	1,000	1,450	--	200	39,000
Missouri	--	204	57,300	--	57,500	191,000	73,900	94,100	20,500	130,000	30	510,000
Montana	30	435	8,310	120	8,890	33,200	--	599,000	1,270	3,180	80	637,000
Nebraska	--	--	--	--	--	11,300	--	25,800	--	--	--	37,000
Nevada	1,350	6,630	8,940	--	16,900	109,000	467	132,000	122,000	2,700	7,760	373,000
New Mexico	2,910	14,900	638,000	2,000	657,000	114,000	--	2,210,000	307,000	269,000	6,580	2,900,000
Oregon	--	--	1,450	--	1,450	W	--	6,190	10	--	--	6,200
South Dakota	--	W	W	--	W	173,000	--	692,000	--	--	--	865,000
Tennessee	--	3,710	68,100	--	71,800	177,000	--	38,000	38,700	1,000	--	255,000
Texas	--	--	380	2,070,000	2,070,000	4,200	--	1,150,000	--	--	--	1,160,000
Utah	960	1,580	87,700	W	90,000	124,000	--	2,260,000	117,000	6,460	800	2,510,000
Washington	--	--	W	--	W	314,000	6,300	14,200	--	15,700	--	350,000
Wyoming	928	1,010	47,800	10,000	59,700	15,100	--	4,930,000	250	--	--	4,940,000
Undistributed[2]	548	13,860	34,300	190,000	239,000	142,000	--	1,260,000	--	446,000	--	1,850,000
Total[1]	9,900	67,500	1,110,000	2,400,000	3,590,000	1,890,000	81,600	14,900,000	852,000	876,000	20,100	18,700,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Alabama, Kansas, Kentucky, Maine, Massachusetts, New York, North Carolina, Ohio, Pennsylvania, Virginia, and Wisconsin.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1979, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
		COMMODITY			
METALS					
Copper	(2)	7	187	75,200	75,400
Gold:					
Lode	14	48	444	837	1,340
Placer	--	--	1	88	89
Iron ore	--	--	428	130,000	131,000
Silver	6	14	183	315	518
Tungsten	(2)	219	85	22	327
Uranium	58	95	1,960	71,700	73,800
Zinc	(2)	19	1,650	5	1,670
Other	20	90	2,330	24,700	27,100
Total metals[1]	98	493	7,270	303,000	311,000
NONMETALS					
Gypsum	--	--	--	307	307
Mica (scrap)	--	--	--	86	86
Phosphate rock	--	--	17	19,700	19,700
Talc, soapstone, pyrophyllite	--	2	(2)	139	142
Other	17	--	28	110	155
Total nonmetals[1]	17	2	45	20,300	20,400
Grand total[1]	115	496	7,320	323,000	331,000
		STATE			
Alabama	--	--	--	W	W
Alaska	--	--	1	14	15
Arizona	--	(2)	148	11,100	11,300
California	1	15	73	83	173
Colorado	23	108	868	148	1,150
Georgia	--	--	--	1,830	1,830
Idaho	5	21	118	7,020	7,160
Illinois	W	--	W	W	W
Michigan	--	--	--	55,800	55,800
Minnesota	--	--	--	74,500	74,500
Missouri	--	1	2,270	--	2,270
Montana	(2)	2	65	20	86
Nevada	9	205	30	22,100	22,400
New Mexico	39	78	1,010	62,400	63,500
New York	--	W	W	W	W
North Carolina	--	--	--	9,720	9,720
Oklahoma	--	--	--	W	W
Oregon	--	--	13	(2)	13
Pennsylvania	--	W	W	--	W
South Dakota	--	W	W	--	W
Tennessee	--	11	1,590	1,770	3,360
Texas	--	--	2	2,290	2,300
Utah	14	2	772	3,540	4,330
Virginia	--	W	W	W	W
Washington	--	--	W	W	W
Wyoming	19	4	208	69,500	69,800
Undistributed	5	50	155	1,510	1,720
Total[1]	115	496	7,320	323,000	331,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 17.—U.S. industrial consumption of explosives

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total mineral industry	Construction work and other uses	Total industrial
1975	1,652,251	449,271	493,125	2,594,647	524,380	3,119,027
1976	1,798,873	488,653	493,656	2,781,182	547,347	3,328,529
1977	2,093,312	446,406	522,678	3,062,396	647,354	3,709,750
1978	[1]2,168,630	[1]574,213	[1]604,955	3,347,798	[1 2]581,391	3,929,189
1979	[1]2,224,892	[1]603,154	[1]650,947	3,478,993	[1 2]586,168	4,065,161

[1]Some quantities of this use are included with "All other purposes" to avoid disclosing company proprietary data.
[2]Includes some quantities from coal mining, metal mining, quarrying and nonmetal mining, and construction work.

Note: Data for 1977, 1978, and 1979 are not comparable to prior years owing to change in reporting by the Institute of Makers of Explosives.

Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1975	41,996	241	1,083	43,320
1976	41,123	204	1,090	42,417
1977	46,663	225	694	47,582
1978	38,530	208	618	39,356
1979	44,891	281	615	45,787
OTHER HIGH EXPLOSIVES				
1975	36,875	25,118	74,796	136,789
1976	34,521	24,265	65,891	124,677
1977	34,407	25,174	63,378	122,959
1978	27,741	25,400	59,974	113,115
1979	25,783	23,699	60,734	110,216
WATER GELS AND SLURRIES				
1975	24,118	181,809	73,872	279,799
1976	30,871	205,429	74,176	310,476
1977	42,406	154,704	75,062	272,172
1978	63,494	234,470	89,322	387,286
1979	74,739	238,738	107,280	420,757
AMMONIUM NITRATE: FUEL-MIXED AND UNPROCESSED				
1975	1,549,262	242,103	343,374	2,134,739
1976	1,692,358	258,755	352,499	2,303,612
1977	1,969,836	266,303	383,544	2,619,683
1978	2,038,865	314,135	455,041	2,808,041
1979	2,079,479	340,436	482,318	2,902,233
TOTAL				
1975	1,652,251	449,271	493,125	2,594,647
1976	1,798,873	488,653	493,656	2,781,182
1977	2,093,312	446,406	522,678	3,062,396
1978	2,168,630	574,213	604,955	3,347,798
1979	2,224,892	603,154	650,947	3,478,993

FROTH FLOTATION[5]

Froth flotation is a process for separating finely ground mineral particles. The ore is ground sufficiently (approximately 200 micrometers) to liberate the mineral to be recovered. Then, a chemical reagent, the collector, is added to a slurry of the ground ore; the reagent selectively adsorbs only on the surface of the mineral to be recovered and renders it hydrophobic (that is, water-repellent). The hydrophobic particles are held at the air-water interface of air bubbles rising through the slurry to the surface. The mineral is skimmed off with the froth. The nonhydrophobic particles remain in the slurry. Whether flotation can be used to separate two or more mineral species depends on whether a collector can be found that will selectively adsorb on the surface of one mineral but not on the others. Froth flotation is used to obtain over one-third of the Nation's ore concentrates.

Every 5 years the Bureau of Mines conducts a survey of flotation plants in the United States to determine trends in this important segment of the minerals industry. The results of this survey in 1980 are presented in the following tables.

When using the tables it is important to note the following:

1. The totals in a given column may be greater than the sum of the elements listed in that column. To avoid disclosing a company's proprietary data, the data may not be listed separately, but are included in the totals.
2. Total energy consumption includes all energy used in the various processes inherent to the flotation plant including crushing, grinding, classifying, flotation, filtering, and material handling.
3. Total water quantities are reported, involving both recirculated and new or makeup water.
4. In 1980, many reagents were reported that were used for cleaning effluents from the plant. These reagents have not been included in the tabulations of flotation reagents.

Reagents are tabulated according to the following definitions:

Collectors.—Reagents used to provide a hydrophobic surface on the mineral to be floated to improve adherence of the mineral to air bubbles.

Modifiers.—Any reagent that changes the flotation response of a mineral. Modifiers include pH-regulating agents, dispersants, flocculants, activators, and depressants. In the tables, however, flocculants, activators, and depressants are listed individually and are not included under modifiers.

Activators.—Reagents that enhance collector adsorption, thereby increasing the floatability of the mineral.

Depressants.—Reagents that reduce or destroy the floatability of a mineral.

Flocculants.—Reagents that cause aggregation of small mineral particles into larger clusters.

Frothers.—Reagents used to produce a froth of adequate stability to permit removal of mineral-carrying bubbles.

In 1980, froth flotation was used to upgrade more than 485 million tons of ores to produce over 80 million tons of concentrates of minerals vital to the Nation's economy, table 20. To do this required 6.6 billion kilowatt-hours of energy, 644 billion gallons of water, and 1.7 billion pounds of chemical reagents. Of significance, however, are the increasing concentration ratios from 1960 to 1980, given in tables 23 and 25, for sulfides and nonmetallics, respectively. This is evidence for declining ore grades of the two largest classes of ores treated by froth flotation.

Research to improve flotation technology has been going on for as long as the process has been used (since 1911). So far, technology appears to have kept pace with industry needs, with emphasis being placed on the development of more selective reagents, larger capacity and more efficient equipment, and computer control of both grinding and flotation circuits. Improved flotation technology has helped to maintain favorable mineral processing economics in spite of declining ore grades. Because of the large quantities of ore involved, even small incremental improvements in efficiency can have a significant economic impact. However, as the mineral processing engineer faces lower grade and more complex ores, higher energy costs, and strict environmental controls, significant new technology must be forthcoming to maintain the same economic posture.

Research Activities.—The simplicity of the flotation process belies the complex physical chemistry that occurs from the time the ore is crushed to the time the concentrate is filtered and the effluent water cleaned for recycle or discharge. Current research activities encompass almost all phases of the process and may be classified into four general categories: Comminution and classification, machines and automation, chemical reagent development, and fundamental research.

Comminution is the most energy-intensive part of the concentration process. As ores become leaner, the valuable mineral constituent is often more finely dispersed throughout the gangue matrix, and grinding to finer sizes is required to ensure adequate liberation, with a resulting increase in energy consumption. Comminution research has centered around basic studies and the development of both analytical and predictive mathematical models. Chemical grinding aids have been shown to improve mill throughput, probably by reducing viscosity and altering the rheological properties of the pulp in the mill. However, still to be resolved are methods to improve mass flow in the grinding mill, improved sizing devices, and a method of promoting intergranular rather than transgranular fracture. Unless efforts are intensified, some researchers feel that the achievement of maximum grinding mill throughput with minimum energy consumption is a goal that will only be reached in the distant future.

Larger flotation cell volume continues to be one of the most significant trends in flotation technology to help increase plant throughput. Cells up to 14 cubic meters have been proven and cells up to 42 cubic meters are anticipated. These large cells are now being incorporated into new plant designs.

A new alternative to increase in cell size to obtain greater throughput is a flotation cell based on shear forces in a centrifugal field to obtain separation. Called an air-sparged hydrocyclone and presently undergoing pilot plant testing at the University of Utah, the new cell design should reduce retention times by at least an order of magnitude. Furthermore, the increased particle inertia produced by the centrifugal field makes the cell effective for separating much finer particles. The reduced retention time is expected to permit throughputs up to 1,766 tons per day per cubic meter of cell volume compared with 35 to 70 tons per day per cubic meter of cell volume for conventional flotation cells.

Online X-ray fluorescence techniques for particle analysis of process streams has opened the way for computer control of flotation circuits for the purpose of optimizing plant performance. Control strategies are presently being developed and tested. There is a need for more rugged primary sensors to determine various physical and chemical parameters of process streams and for computer models of various stages to relate measurable parameters to the physicochemical phenomena occurring in those stages of the process.

Flotation reagent development is an area of major research activity. In particular, there is increasing industry concern over the use of cyanide and other toxic reagents. Research to find alternatives is underway, and many plants are already treating effluent water for recycling as well as the removal of toxic reagents. This aspect of flotation processing is expected to receive more attention in the near future if reagent consumption increases.

Metal-specific organic chelating agents having additional polar groups are being investigated as collectors for nonsulfide minerals, in an effort to improve collector selectivity for that class of minerals. Research to produce more selective collectors, depressants, and flocculants for use throughout the industry is continuing.

Fundamental flotation research has centered around fine particle flotation, selective flocculation, and beneficiation of complex sulfide ores. Progress has been slow in determining the mechanisms governing interfacial processes involved in the flotation and flocculation of sulfides. This is at least partly owing to the difficulties of identifying and controlling both surface and solution species under various conditions. In spite of the extraordinary complexity of the processes involved and the difficulty in conducting experiments, significant progress is being made, particularly by researchers in the academic sector. To attempt to coherently review here even just the major results of these fundamental studies would be too extensive for this summary. Instead, the reader is referred to the following publications:

1. Fuerstenau, M. C. (ed.). Flotation: A. M. Gaudin Memorial Volume. American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1976, volumes 1 and 2.

2. Somasundaran, P. (ed.). Fine Particles Processing. American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1980, volumes 1 and 2.

3. Aplan, F. F. The Future of Mineral Beneficiation—The Impact of Scientific Studies. Ch. in Mineral Resources in Australia, ed. by D. F. Kelsall, and J. T. Woodcock: Australian Academy of Techno-

logical Sciences, Adelaide, Australia, 1979, pp. 170-189.

4. Jones, M. J. (ed.). Complex Sulfide Ores. Institution of Mining & Metallurgy, London, 1980, 278 pp.

Fundamental studies by the Bureau of Mines on the physical chemistry of mineral-reagent interactions on sulfide minerals have indicated the possibility of using electrochemical potential as a means of controlling the flotation response of these minerals. The degree of selectivity exhibited by this method may make possible the separation of sulfide minerals not separable by existing flotation technology.

The overall flotation research picture is filled with accomplishment in optimizing existing technology, and this has helped maintain the economic posture of minerals processing. But there is a limit to optimization. New technology is needed, and this is beginning to come from the fundamental studies. Future research must emphasize the fundamental mechanisms governing the flotation process if the U.S. mineral processing industry is to remain competitive in the face of depleting ore grades and environmental requirements.

Data from some flotation operations are not shown separately to avoid disclosing company information. Also, because of dissimilarity of data for various plants, it would be inappropriate to combine the data. However, the data have been included in the totals to present complete information on flotation in the minerals industry.

Flotation plants for which data have been handled in this manner included the following:

Commodity	Number and State
Antimony	1 in Montana.
Bastnäsite	1 in California.
Copper-zinc-iron	1 in Tennessee.
Fluorspar	2 in Illinois.
Ilmenite	1 in New York.
Kyanite	1 in Georgia and 2 in Virginia.
Mercury	1 in Nevada.
Molybdenum	2 in Colorado and 1 in New Mexico.
Talc	1 in Vermont.
Tungsten	1 in California and 1 in Nevada.
Vermiculite	1 in South Carolina and 1 in Montana.

[1]Physical scientist, Section of Ferrous Metals.
[2]Goth, J. W. The Costs of Regulations to the Metals Industry. J. Metals, v. 32, No. 11, November 1980, p. 17.
[3]Short tons unless otherwise stated.
[4]Staff—Bureau of Mines. Surface Mine Truck Safety. Proceedings: Bureau of Mines Technology Transfer Seminars, Minneapolis, Minn., June 25, 1980, Birmingham, Ala., July 9, 1980, and Tucson, Ariz., July 24, 1980. BuMines IC 8828, 1980, 61 pp.
[5]Prepared by Gertrude Greenspoon, minerals specialist, Branch of Domestic Data, and Garrett R. Hyde, staff scientist, Division of Mineral Resources Technology.

Table 19.—Froth flotation plants in 1980, by State

State	Number	State	Number
Alabama	8	Montana	4
Arizona	18	Nevada	7
Arkansas	1	New Jersey	2
California	6	New Mexico	9
Colorado	11	New York	2
Connecticut	1	North Carolina	10
Florida	20	Ohio	1
Georgia	5	Oregon	1
Idaho	9	Pennsylvania	18
Illinois	8	South Carolina	3
Indiana	1	Tennessee	8
Kentucky	5	Texas	1
Louisiana	1	Utah	11
Maryland	1	Vermont	2
Michigan	8	Virginia	13
Minnesota	1	Washington	1
Missouri	8	West Virginia	34
		Total	239

Table 20.—Froth flotation in 1980

Type	Plants: Number	Plants: Capacity (short tons per day)	Ore treated (short tons)	Concentrates produced (short tons)	Energy used (kilowatt-hours): Total (million)	Energy used: Per ton	Water used (gallons): Total (million)	Water used: Per ton	Rod consumption (pounds): Total	Rod consumption: Per ton	Ball consumption (pounds): Total	Ball consumption: Per ton	Liner consumption (pounds): Total	Liner consumption: Per ton
Antimony	1	W	W	W	W	W	W	W	--	--	W	W	W	W
Copper	12	215,500	53,588,700	1,384,815	840.1	15.7	33,514.4	625	4,786,750	0.330	68,176,647	1.272	4,967,029	0.093
Copper-molybdenum	16	622,000	172,845,700	3,253,514	2,493.3	14.4	107,192.6	620	52,655,358	.589	210,181,760	1.216	11,779,109	.068
Copper-lead-zinc	11	27,200	6,881,900	516,240	111.0	16.1	4,049.6	600	1,461,554	.233	2,803,554	.407	720,218	.105
Copper-zinc-iron	1	W	W	W	W	W	W	W	W	W	W	W	--	--
Gold-silver	5	550	101,800	5,909	2.6	26.0	61.2	600	--	--	348,255	3.420	44,801	.440
Lead-zinc	14	28,700	7,475,200	675,118	135.4	18.1	6,190.6	828	903,189	.183	4,876,275	.652	784,898	.105
Zinc	7	16,400	3,911,800	256,459	66.5	17.0	2,514.5	640	885,592	.226	989,708	.253	135,341	.035
Barite	6	4,600	406,800	214,277	5.4	13.4	495.1	1,200	20,727	.090	129,211	.318	31,158	.077
Bastnäsite	1	W	W	W	W	W	W	W	W	W	W	W	W	W
Feldspar-mica-quartz	12	11,500	2,844,500	1,444,925	70.8	25.0	6,312.4	2,200	2,011,763	.707	--	--	326,473	.115
Fluorspar	2	W	W	W	W	W	W	W	--	--	W	W	W	W
Glass sand	18	53,000	9,924,000	7,916,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ilmenite	1	W	W	W	W	W	W	W	W	W	W	W	W	W
Iron ore	6	143,700	41,764,500	23,678,100	1,010.2	24.2	57,581.5	1,380	19,445,232	1.023	24,427,502	.933	9,360,474	.229
Kyanite	3	W	W	W	W	W	W	W	W	W	NA	NA	NA	NA
Limestone-magnesite	4	1,600	229,000	194,700	4.7	20.6	111.6	490	NA	NA	NA	NA	NA	NA
Mercury	1	W	W	W	W	W	W	W	--	--	W	W	W	W
Molybdenum	3	W	W	W	W	W	W	W	--	--	W	W	W	W
Phosphate	22	433,900	119,824,200	29,357,693	938.5	7.8	399,012.7	3,330	NA	NA	NA	NA	NA	NA
Potash	8	47,000	14,250,000	3,298,344	202.0	14.2	3,984.4	280	NA	NA	NA	NA	NA	NA
Talc	1	W	W	W	W	W	W	W	--	--	W	W	--	--
Tungsten	2	W	W	W	W	W	W	W	W	W	W	W	W	W
Vermiculite	2	W	W	W	W	W	W	W	--	--	--	--	--	--
Anthracite and bituminous coal	80	78,300	12,900,800	7,556,900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total or average	239	1,802,800	485,514,000	81,608,589	6,557.7	14.2	643,877.1	1,390	83,464,468	.578	371,473,181	1.204	33,760,126	.106

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 21.—Consumption of reagents in froth flotation by type and plant in 1980

(Pounds)

Type of plant	Modifiers		Activators		Depressants		Collectors		Frothers		Flocculants		Total	
	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Antimony	--	--	W	W	--	--	W	W	W	W	--	--	W	W
Copper	243,799,444	4.549	112,769	0.013	399,242	0.031	2,330,070	0.043	2,463,802	0.046	1,220,082	0.035	[1]251,120,510	4.686
Copper-molybdenum	552,681,398	3.198	--	--	16,914,015	.153	11,249,544	.065	11,528,834	.067	507,098	.005	[1]592,979,996	3.431
Copper-lead-zinc	6,945,183	1.255	1,166,483	.207	7,906,616	1.167	670,490	.097	318,102	.046	77,150	.018	[1]17,549,380	2.550
Copper-zinc-iron	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Gold-silver	217,497	2.136	7,526	.120	--	--	23,831	.234	6,073	.063	3,889	.062	258,816	2.542
Lead-zinc	5,330,448	.789	2,555,916	.342	2,249,288	.306	996,713	.133	600,729	.082	144,040	.063	[1]12,018,487	1.608
Zinc	9,770	.034	2,129,011	.544	25,222	.033	323,716	.083	226,595	.058	10,344	.036	2,724,658	.697
Barite	2,506,206	6.160	--	--	--	--	753,433	1.852	W	W	W	W	3,260,466	8.014
Bastnäsite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Feldspar-mica-quartz	3,274,864	1.178	--	--	914,860	.763	4,781,686	1.681	234,844	.128	1,039,465	.510	10,245,719	3.602
Fluorspar	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Glass sand	9,987,861	1.134	--	--	375,000	1.000	9,549,624	.962	1,026,478	.174	14,234	.015	[1]20,985,197	2.115
Ilmenite	W	W	--	--	W	W	W	W	W	W	--	--	W	W
Iron ore	63,090,568	3.502	--	--	24,474,730	1.570	16,292,595	.390	693,142	.034	30,786,155	.798	[1]140,200,958	3.357
Kyanite	W	W	--	--	--	--	W	W	W	W	W	W	W	W
Limestone-magnesite	397,446	4.090	--	--	485,875	5.000	332,377	1.451	72,389	.316	1,539	.012	1,289,626	5.631
Mercury	W	W	W	W	--	--	W	W	W	W	--	--	W	W
Molybdenum	W	W	--	--	W	W	W	W	W	W	--	--	W	W
Phosphate	93,263,320	.859	--	--	--	--	394,013,071	3.288	316,693	.039	92,000	.010	487,685,084	4.070
Potash	720,060	.078	--	--	5,782,070	.514	4,419,585	.310	4,032,546	.283	701,637	.050	15,655,898	1.099
Talc	--	--	--	--	--	--	--	--	W	W	--	--	W	W
Tungsten	W	W	--	--	W	W	W	W	W	W	W	W	W	W
Vermiculite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Anthracite and bituminous coal	25,614	.059	--	--	--	--	4,916,434	.760	3,044,355	.253	3,521,162	.354	11,507,545	.892
Total or average	1,052,863,712	2.472	8,652,151	.291	73,545,406	.360	494,048,717	1.031	27,536,369	.080	39,079,900	.172	[1]1,702,330,651	3.506

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Includes other reagents as follows: Copper, 795,101 pounds (0.155 pound per ton); copper-molybdenum, 99,107 pounds (0.003 pound per ton); copper-lead-zinc, 465,356 pounds (0.074 pound per ton); lead-zinc, 141,353 pounds (0.066 pound per ton); iron ore, 4,863,768 pounds (0.312 pound per ton); glass sand, 32,000 pounds (0.040 pound per ton); unspecified nonmetallic minerals, 207,711 pounds (0.210 pound per ton); and total, 6,604,396 pounds (0.103 pound per ton).

Table 22.—Consumption and value of reagents in froth flotation in 1980

Function and name	Consumption (pounds)	
	Total	Per ton
Modifier:		
Alum	7,501,580	0.474
Ammonia	44,151,608	.419
Caustic soda	37,474,914	.771
Calgon	684,676	.039
Hydrochloric acid	298,825	.057
Lime	823,306,636	3.198
NL Industries	1,422,785	.014
Nalco	83,378	.005
Phosphates	855,680	.017
Soda ash	5,681,193	2.459
Sodium silicate	28,045,356	.292
Sulfur dioxide	2,898,533	.571
Sulfuric acid	77,234,719	.622
Other (Cyquest, lignin sulfonate, salt, miscellaneous)	23,223,829	.454
Total or average:		
Quantity	1,052,863,712	2.472
Value	$40,268,755	$0.095
Activator:		
Copper ammonium chloride	1,537,857	0.323
Copper sulfate	5,969,838	.408
Sodium hydrosulfide, sodium sulfide	490,176	.088
Other (ferrous sulfate, ferric sulfate, miscellaneous)	654,280	.135
Total or average:		
Quantity	8,652,151	.291
Value	$2,811,880	$0.094
Depressant:		
Caustic soda	62,895	0.004
Hydrofluoric acid	1,289,860	.819
Phosphorous pentasulfide	3,160,211	.088
Sodium cyanide	2,027,255	.026
Sodium dichromate	915,920	.146
Sodium hydrosulfide	14,789,133	.285
Sodium silicate	5,147,098	1.641
Sodium sulfite	49,964	.016
Starch	29,378,270	1.034
Zinc sulfate	8,330,868	.565
Other (lignin sulfate, sodium silicofluoride, miscellaneous)	8,393,932	.107
Total or average:		
Quantity	73,545,406	.360
Value	$11,700,695	$0.057
Collector:		
Aerofloats	1,065,923	0.019
Aero Promoters	1,362,895	.018
Amines	25,441,887	.148
Dow Z-200	85,296	.014
Fatty acids	168,963,208	1.476
Fuel oil	247,194,358	.922
Kerosine	6,812,291	.081
Minerec	1,386,706	.029
Petroleum sulfonate	5,038,885	1.106
Collector—continued:		
Potassium amyl xanthate	2,144,702	0.025
Sodium Aerofloat	277,965	.020
Sodium butyl xanthate, sodium isobutyl xanthate	706,208	.049
Sodium ethyl xanthate	1,891,896	.092
Sodium isopropyl xanthate	1,157,806	.017
Tall oil	25,115,516	1.128
Xanthates (unspecified)	99,323	.097
Other	5,303,852	.016
Total or average:		
Quantity	494,048,717	1.031
Value	$75,958,470	$0.159
Frother:		
Aerofroths	2,588,212	0.056
Barrett oil	3,112,242	.359
Dowell	258,910	.240
Dowfroth 250	1,700,597	.036
Dowfroth 1012	270,883	.015
Methyl isobutyl carbinol	12,239,765	.062
Nalco	559,506	.305
Pine oil	2,271,887	.038
UCON 23	66,696	.051
UCON 133, 190, 207	1,345,207	.049
Other (Cresylic acid, Tekfroth, miscellaneous)	3,122,464	.012
Total or average:		
Quantity	27,536,369	.080
Value	$12,099,332	$0.035
Flocculant:		
Aeroflocs	138,314	0.122
Alum	951,271	.079
Calgon	1,746,739	.072
Dowell	170,510	.108
Nalco	2,705,805	.076
Polyhall	472,007	.026
Separan	15,285	.001
Superflocs	8,981,835	.157
Other (lime and miscellaneous)	23,898,134	.338
Total or average:		
Quantity	39,079,900	.172
Value	$10,981,829	$0.048
Other:		
Aerodris	5,071,794	0.140
Dowfax	124,767	.004
Miscellaneous	1,407,835	.044
Total or average:		
Quantity	6,604,396	.103
Value	$2,683,347	$0.042
Total or average reagents:		
Quantity	1,702,330,651	3.506
Value	$156,504,308	$0.322

Table 23.—Froth flotation of sulfide ores

Operating data	1960	1965	1970	1975	1980
Plants:					
Number	95	108	105	86	71
Capacity ---------- short tons per day--	546,000	622,000	862,000	990,000	1,012,500
Ore treated --------- thousand short tons--	155,125	200,754	281,660	278,357	279,861
Concentrates produced ------------do----	5,855	7,213	8,863	7,395	7,356
Ratio of concentration	26.5:1	27.8:1	31.8:1	37.6:1	38.1:1

CONSUMPTION OF REAGENTS

Type	Total (thousand pounds)					Pounds per ton				
	1960	1965	1970	1975	1980	1960	1965	1970	1975	1980
Modifier	489,707	765,677	1,198,743	1,107,425	864,791	3.710	4.114	4.408	4.051	3.155
Activator	7,859	8,983	8,488	11,333	7,530	.353	.281	.371	.492	.272
Depressant	6,338	10,863	17,061	33,313	31,433	.089	.101	.104	.192	.182
Collector	25,346	23,983	32,133	27,972	38,704	.163	.120	.114	.100	.138
Frother	12,411	15,502	20,612	18,814	17,177	.080	.077	.073	.069	.061
Flocculant	1,129	551	2,624	4,708	1,984	.026	.007	.018	.045	.013
Other	--	112,349	136	695	1,501	--	4.867	.014	.019	.032
Total or average	542,790	937,908	1,279,797	1,204,260	963,120	3.499	4.684	4.556	4.326	3.441

Table 24.—Froth flotation of metallic carbonate and oxide ores

Operating data	1960	1965	1970	1975	1980
Plants:					
Number	13	14	13	13	13
Capacity ---------- short tons per day--	14,000	48,000	65,000	90,000	151,000
Ore treated --------- thousand short tons--	2,854	16,079	22,213	30,149	42,903
Concentrates produced ------------do----	941	7,086	13,040	15,582	24,049
Ratio of concentration	3.01:1	2.3:1	1.7:1	1.9:1	1.8:1

CONSUMPTION OF REAGENTS

Type	Total (thousand pounds)					Pounds per ton				
	1960	1965	1970	1975	1980	1960	1965	1970	1975	1980
Modifier	6,639	15,280	31,635	39,457	71,228	2.368	3.444	4.713	2.642	3.745
Activator	1,280	--	--	--	--	5.000	--	--	--	--
Depressant	610	1,588	2,627	18,226	30,393	.320	1.466	1.276	1.923	1.831
Collector	22,573	23,695	31,819	22,931	18,487	8.049	1.479	1.074	.779	.431
Frother	1,345	865	164	397	808	1.333	.090	.046	.046	.037
Flocculant	1,306	458	220	1,985	30,960	1.618	.250	.016	.099	.796
Other	--	--	--	--	4,864	--	--	--	--	.312
Total or average	33,753	41,886	66,465	82,996	156,740	12.036	2.614	2.244	2.821	3.653

Table 25.—Froth flotation of nonmetallic ores

Operating data	1960	1965	1970	1975	1980
Plants:					
Number	55	64	56	75	75
Capacity short tons per day	144,000	191,000	378,000	467,500	561,200
Ore treated thousand short tons	36,191	52,653	80,963	100,939	149,850
Concentrates produced do	11,888	17,376	23,823	29,111	42,812
Ratio of concentration	3.0:1	3.0:1	3.4:1	3.5:1	3.5:1

CONSUMPTION OF REAGENTS

Type	Total (thousand pounds)					Pounds per ton				
	1960	1965	1970	1975	1980	1960	1965	1970	1975	1980
Modifier	82,456	54,889	161,470	112,639	116,819	3.566	1.278	2.155	1.151	0.883
Activator	2,988	511	484	393	1,122	.887	1.038	.820	.688	.689
Depressant	9,231	4,346	11,023	7,314	11,719	.755	.451	.959	.636	.790
Collector	163,967	188,119	528,669	345,208	431,942	4.576	3.741	6.585	3.421	2.883
Frother	2,475	4,870	2,863	4,740	6,508	.166	.219	.119	.208	.198
Flocculant	875	3,207	751	2,477	2,614	.129	.187	.062	.139	.093
Other	--	--	--	79	240	--	--	--	.089	.134
Total or average	261,992	255,942	705,260	472,850	570,964	7.311	5.089	8.749	4.685	3.810

Table 26.—Froth flotation of anthracite and bituminous coal

Operating data	1960	1965	1970	1975	1980
Plants:					
Number	31	69	66	78	80
Capacity short tons per day	27,000	47,000	62,400	64,300	78,300
Raw coal treated thousand short tons	4,112	9,500	13,006	13,079	12,901
Clean coal produced do	2,795	7,033	8,418	8,179	7,557

CONSUMPTION OF REAGENTS

Type	Total (thousand pounds)					Pounds per ton				
	1960	1965	1970	1975	1980	1960	1965	1970	1975	1980
Modifier	1,609	298	2,716	298	26	3.841	1.922	2.861	0.284	0.059
Collector	8,142	4,055	7,772	4,615	4,917	3.015	1.988	2.039	1.069	.760
Frother	585	1,555	2,564	2,668	3,044	.175	.166	.204	.207	.253
Flocculant	394	2,301	2,204	1,303	3,521	.332	.365	.209	.122	.354
Total or average	10,730	8,209	15,256	8,884	11,508	2.610	.864	1.173	.679	.892

Table 27.—Froth flotation of copper ores in 1980

OPERATING DATA

Plants:		Water used, gallons:	
Number	12	Total ---- millions	33,514.4
Capacity ---- short tons per day	215,500	Per ton	625
Ore treated:		Rod consumption, pounds:	
Quantity ---- short tons	53,588,700	Total	4,786,750
Grade:		Per ton	0.330
Copper ---- percent	0.74	Ball consumption, pounds:	
Gold ---- ounce per ton	0.0024	Total	68,176,647
Silver ---- do	0.1281	Per ton	1.272
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total ---- millions	840.1	Total	4,967,029
Per ton	15.7	Per ton	0.093

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Recovery (percent): Copper	Recovery (percent): Gold	Recovery (percent): Silver
Copper	1,384,815	22.42	0.0570	3.2390	79	60	65

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Lime	239,975,883	4.846
Other (Calgon, Nalco, phosphates, sodium silicate, miscellaneous)	3,823,561	.076
Total or average:		
Quantity	243,799,444	4.549
Value	$8,757,978	$0.163
Activator:		
Quantity	112,769	0.013
Value	$17,904	$0.002
Depressant (Aero Depressant 633, calcium cyanide, sodium sulfite, miscellaneous):		
Quantity	399,242	0.031
Value	$115,701	$0.009
Collector:		
Aerofloats	524,915	0.017
Aero Promoter	86,471	.015
Dow Z-200	49,030	.019
Sodium isopropyl xanthate	438,960	.010
Other (Minerec, potassium amyl xanthate, sodium isobutyl xanthate, miscellaneous)	1,230,694	.046
Total or average:		
Quantity	2,330,070	0.043
Value	$1,826,978	$0.034
Frother:		
Dowfroth 250, Dowfroth 1012	755,481	0.055
Methyl isobutyl carbinol	288,060	.014
Other (Aerofroth, UCON 133, UCON 190, Shellfroth)	1,420,261	.038
Total or average:		
Quantity	2,463,802	.046
Value	$1,167,058	$0.022
Flocculant:		
Nalco	302,487	0.020
Other (lime and miscellaneous)	917,595	.046
Total or average:		
Quantity	1,220,082	.035
Value	$391,162	$0.011
Other (Aerodri, Calgon, miscellaneous):		
Quantity	795,101	0.155
Value	$317,163	$0.062
Total or average reagents:		
Quantity	251,120,510	4.686
Value	$12,593,944	$0.235

Table 28.—Froth flotation of copper-molybdenum ores in 1980

OPERATING DATA

Plants:		Water used, gallons:	
Number	16	Total ... millions	107,192.6
Capacity ... short tons per day	622,000	Per ton	620
Ore treated:		Rod consumption, pounds:	
Quantity ... short tons	172,845,700	Total	52,655,358
Grade:		Per ton	0.589
Copper ... percent	0.55	Ball consumption, pounds:	
Gold ... ounce per ton	0.0030	Total	210,181,760
Silver ... do	0.0617	Per ton	1.216
Molybdenum ... percent	0.024	Liner consumption, pounds:	
Energy used, kilowatt-hours:		Total	11,779,109
Total ... millions	2,493.3	Per ton	0.068
Per ton	14.4		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Grade: Molybdenum (percent)	Recovery (percent): Copper	Recovery (percent): Gold	Recovery (percent): Silver	Recovery (percent): Molybdenum
Copper	3,212,381	24.86	0.0831	2.2902	--	84	59	75	--
Molybdenite	41,133	--	--	--	53.84	--	--	--	58

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Lime	548,517,852	3.173
NL Industries	1,242,856	.013
Phosphates	623,090	.014
Sodium silicate	1,533,655	.034
Other (sulfuric acid, miscellaneous)	763,945	.034
Total or average:		
Quantity	552,681,398	3.198
Value	$15,862,884	$0.092
Depressant:		
Sodium cyanide and sodium ferrocyanide	990,788	0.020
Sodium hydrosulfide	14,789,133	.285
Other (caustic soda, Dextrine, miscellaneous)	1,134,094	.017
Total or average:		
Quantity	16,914,015	.153
Value	$2,564,118	$0.023
Collector:		
Aerofloats	174,812	0.009
Aero Promoters	877,696	.013
Fuel oil	5,613,293	.050
Minerec	1,079,718	.030
Potassium amyl xanthate	1,813,444	.023
Sodium butyl xanthate, sodium ethyl xanthate, sodium isopropyl xanthate	663,400	.017
Other	1,027,181	.024
Total or average:		
Quantity	11,249,544	.065
Value	$5,009,245	$0.029
Frother:		
Dowfroth 250, Dowfroth 1012	271,894	0.008
Methyl isobutyl carbinol	8,315,921	.064
Pine oil	1,085,673	.032
UCON 190, UCON 207	675,845	.088
Other (Aerofroth, cresylic acid)	1,179,501	.041
Total or average:		
Quantity	11,528,834	.067
Value	$4,941,237	$0.029
Flocculant (Nalco, Separan, Steinhall, Superflocs):		
Quantity	507,098	0.005
Value	$388,737	$0.004
Other:		
Quantity	99,107	0.003
Value	$65,462	$0.002
Total or average reagents:		
Quantity	592,979,996	3.431
Value	$28,831,683	$0.167

Table 29.—Froth flotation of copper-lead-zinc ores in 1980

OPERATING DATA

Plants:		Water used, gallons:	
Number	11	Total ____ millions	4,049.6
Capacity ____ short tons per day	27,200	Per ton	600
Ore treated:		Rod consumption, pounds:	
Quantity ____ short tons	6,881,900	Total	1,461,554
Grade:		Per ton	0.233
Copper ____ percent	0.23	Ball consumption, pounds:	
Lead ____ do	5.17	Total	2,803,554
Zinc ____ do	0.62	Per ton	0.407
Gold ____ ounce per ton	0.0928	Liner consumption, pounds:	
Silver ____ ounces per ton	1.4879	Total	720,218
Energy used, kilowatt-hours:		Per ton	0.105
Total ____ millions	111.0		
Per ton	16.1		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Lead (percent)	Grade: Zinc (percent)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Recovery (percent): Copper	Recovery: Lead	Recovery: Zinc	Recovery: Gold	Recovery: Silver
Copper	35,903	26.24	4.78	--	0.0917	187.3013	60	1	--	50	66
Lead	431,271	.77	74.43	0.17	--	4.3599	21	97	1	--	18
Zinc	49,066	.77	2.28	57.19	--	12.4534	2	--	72	10	6

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Caustic soda	122,573	0.031
Lime	724,732	.470
Sulfur dioxide	2,898,533	.571
Other (soda ash, sulfuric acid)	3,199,345	1.325
Total or average:		
Quantity	6,945,183	1.255
Value	$413,823	$0.075
Activator (copper chloride, copper sulfate):		
Quantity	1,166,483	.207
Value	$103,414	$0.018
Depressant:		
Sodium cyanide	61,522	0.009
Sodium dichromate	915,920	.146
Starch	555,960	.088
Zinc sulfate	6,373,214	1.102
Total or average:		
Quantity	7,906,616	1.167
Value	$1,137,571	$0.168
Collector:		
Aerofloats, Aero Promoters	5,249	0.016
Potassium amyl xanthate	150,249	.127
Sodium isopropyl xanthate	403,486	.078
Other (Dow Z-200, Minerec, Sodium Aerofloat)	111,506	.021
Total or average:		
Quantity	670,490	.097
Value	$567,467	$0.082
Frother:		
Aerofroths	220,314	0.042
Methyl isobutyl carbinol	53,320	.032
Other	44,468	.041
Total or average:		
Quantity	318,102	0.046
Value	$125,814	$0.018
Flocculant (Separan, Superfloc):		
Quantity	77,150	0.018
Value	$64,289	$0.015
Other:		
Quantity	465,356	0.074
Value	$228,002	$0.036
Total or average reagents:		
Quantity	17,549,380	2.550
Value	$2,640,380	$0.384

Table 30.—Froth flotation of gold-silver ores in 1980

OPERATING DATA

Plants:	
Number	5
Capacity short tons per day	550
Ore treated:	
Quantity short tons	101,800
Grade:	
Gold ounce per ton	0.2432
Silver ounces per ton	2.3342
Energy used, kilowatt-hours:	
Total millions	2.6
Per ton	26.0
Water used, gallons:	
Total millions	61.2
Per ton	600
Ball consumption, pounds:	
Total	348,255
Per ton	3.420
Liner consumption, pounds:	
Total	44,801
Per ton	0.440

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade (ounces per ton)		Recovery (percent)	
		Gold	Silver	Gold	Silver
Gold-silver	5,909	26.2896	256.3100	92	85

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Cyquest, other	160,997	2.567
Soda ash	56,500	1.445
Total or average:		
Quantity	217,497	2.136
Value	$10,276	$0.101
Activator:		
Quantity	7,526	0.120
Value	$4,440	$0.071
Collector:		
Aerofloats, Aero Promoters	16,556	0.162
Potassium amyl xanthate	459	.012
Sodium isobutyl xanthate, sodium isopropyl xanthate	6,816	.071
Total or average:		
Quantity	23,831	.234
Value	$27,777	$0.273
Frother:		
Dowfroth 250	3,540	0.037
Other (methyl isobutyl carbinol, pine oil)	2,533	.027
Total or average:		
Quantity	6,073	.063
Value	$6,222	$0.065
Flocculant:		
Quantity	3,889	0.062
Value	$7,267	$0.116
Total or average reagents:		
Quantity	258,816	2.542
Value	$55,982	$0.550

Table 31.—Froth flotation of lead-zinc ores in 1980

OPERATING DATA

Plants:		Water used, gallons:	
Number	14	Total millions	6,190.6
Capacity short tons per day	28,700	Per ton	828
Ore treated:		Rod consumption, pounds:	
Quantity short tons	7,475,200	Total	903,189
Grade:		Per ton	0.183
Lead percent	5.08	Ball consumption, pounds:	
Zinc do	2.86	Total	4,876,275
Copper do	0.211	Per ton	.652
Gold ounce per ton	0.0305	Liner consumption, pounds:	
Silver ounces per ton	2.4676	Total	784,898
Energy used, kilowatt-hours:		Per ton	0.105
Total millions	135.4		
Per ton	18.1		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade					Recovery (percent)				
		Copper (percent)	Lead (percent)	Zinc (percent)	Gold (ounce per ton)	Silver (ounces per ton)	Copper	Lead	Zinc	Gold	Silver
Lead	418,609	1.60	71.97	2.73	0.4690	15.4428	71	95	6	42	75
Zinc	257,509	0.43	2.63	56.80	.0332	3.2704	6	2	83	16	7

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Lime	4,557,009	0.687
Soda ash	427,084	1.006
Other (caustic soda, phosphate, miscellaneous)	346,355	.201
Total or average:		
Quantity	5,330,448	.789
Value	$437,262	$0.647
Activator (copper sulfate, sodium sulfide):		
Quantity	2,555,916	0.342
Value	$1,138,628	$0.152
Depressant:		
Sodium cyanide	372,660	0.054
Zinc sulfate	1,876,628	.294
Total or average:		
Quantity	2,249,288	.306
Value	$946,890	$0.129
Collector:		
Aerofloats	27,437	0.163
Aero Promoters	97,032	.060
Potassium amyl xanthate	76,420	.052
Sodium ethyl xanthate	431,889	.132
Sodium isoprophyl xanthate	260,503	.094
Other (Dow Z-200, potassium ethyl xanthate, Sodium Aerofloat)	103,432	.026
Total or average:		
Quantity	996,713	.133
Value	$767,315	$0.103
Frother:		
Dowfroth 250	37,120	0.025
Methyl isobutyl carbinol	485,940	.092
Other	77,669	.095
Total or average:		
Quantity	600,729	0.082
Value	$283,244	$0.038
Flocculant (Nalco, Superfloc):		
Quantity	144,040	0.063
Value	$137,211	$0.060
Other:		
Quantity	141,353	0.066
Value	$96,095	$0.045
Total or average reagents:		
Quantity	12,018,487	1.608
Value	$3,806,645	$0.509

Table 32.—Froth flotation of zinc ores in 1980

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	7	Total	885,592
Capacity short tons per day	16,400	Per ton	0.226
Ore treated:		Ball consumption, pounds:	
Quantity short tons	3,911,800	Total	989,708
Zinc percent	4.21	Per ton	0.253
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total millions	66.5	Total	135,341
Per ton	17.0	Per ton	0.035
Water used, gallons:			
Total millions	2,514.5		
Per ton	640		

CONCENTRATES PRODUCED

Quantity short tons	256,459
Zinc percent	61.64
Recovery do	96

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Quantity	9,770	0.034
Value	$6,057	$0.021
Activator (copper sulfate):		
Quantity	2,129,011	0.544
Value	$757,640	$0.194
Depressant:		
Quantity	25,222	0.033
Value	$10,201	$0.013
Collector (Aerofloats, Sodium Aerofloat):		
Quantity	323,716	0.083
Value	$219,195	$0.056
Frother (Aerofroths, Dowfroth 1012, UCON 23):		
Quantity	226,595	0.058
Value	$142,905	$0.037
Flocculant:		
Quantity	10,344	0.036
Value	$16,550	$0.058
Total or average reagents:		
Quantity	2,724,658	0.697
Value	$1,152,548	$0.295

Table 33.—Froth flotation of barite ores in 1980

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	6	Total	20,727
Capacity ______ short tons per day	4,600	Per ton	0.090
Ore treated ______ short tons	406,800	Ball consumption, pounds:	
Energy used, kilowatt-hours:		Total	129,211
Total ______ millions	5.4	Per ton	0.318
Per ton	13.4	Liner consumption, pounds:	
Water used, gallons:		Total	31,158
Total ______ millions	495.1	Per ton	0.077
Per ton	1,200		

CONCENTRATES PRODUCED

Quantity	short tons	214,277
$BaSO_4$	percent	93.25
$BaSO_4$ recovery	do	71

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Sodium silicate	1,223,590	3.559
Other (caustic soda, lime, soda ash, sulfuric acid)	1,282,616	3.834
Total or average:		
Quantity	2,506,206	6.160
Value	$189,768	$0.466
Collector:		
Fatty acid	724,933	1.782
Other	28,500	3.000
Total or average:		
Quantity	753,433	1.852
Value	$171,094	$0.428
Frother:		
Quantity	W	W
Value	W	W
Flocculant:		
Quantity	W	W
Value	W	W
Total or average reagents:		
Quantity	3,260,466	8.014
Value	$362,783	$0.892

W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 34.—Froth flotation of feldspar, mica, and quartz ores in 1980

OPERATING DATA

Plants:		Water used, gallons:	
Number	12	Total ... millions	6,312.4
Capacity ... short tons per day	11,500	Per ton	2,200
Ore treated ... short tons	2,844,500	Rod consumption, pounds:	
Energy used, kilowatt-hours:		Total	2,011,763
Total ... millions	70.8	Per ton	0.707
Per ton	25.0	Liner consumption, pounds:	
		Total	326,473
		Per ton	0.115

CONCENTRATES PRODUCED, SHORT TONS

Feldspar	515,803
Mica	81,176
Quartz	494,900
Other	353,046

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Caustic soda	734,429	0.367
Sulfuric acid	1,591,955	1.408
Other (Calgon, lignin sulfonate, lime)	948,480	1.517
Total or average:		
Quantity	3,274,864	1.178
Value	$223,778	$0.080
Depressant (hydrofluoric acid):		
Quantity	914,860	0.763
Value	$444,808	$0.371
Collector:		
Amines	556,340	0.526
Fatty acid	2,329,603	1.303
Other (fuel oil, miscellaneous)	1,895,743	1.941
Total or average:		
Quantity	4,781,686	1.681
Value	$1,456,642	$0.512
Frother (methyl isobutyl carbinol, pine oil, polyproplene glycol, Shellfroth):		
Quantity	234,844	0.128
Value	$123,407	$0.067
Flocculant (alum, Calgon, Hercofloc, Nalco, miscellanoeous):		
Quantity	1,039,465	0.510
Value	$453,736	$0.223
Total or average reagents:		
Quantity	10,245,719	3.602
Value	$2,702,371	$0.950

Table 35.—Froth flotation of glass sand in 1980

OPERATING DATA

Plants:		
Number		18
Capacity	tons per day	53,000
Raw sand treated	short tons	9,924,000
Clean sand produced	do	7,916,000

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Caustic soda	2,277,934	0.637
Sulfuric acid	923,254	.596
Other (calcium chloride, lime, sodium silicate)	6,786,673	.082
Total or average:		
Quantity	9,987,861	1.134
Value	$555,944	$0.063
Depressant:		
Quantity	375,000	1.000
Value	$206,250	$0.550
Collector:		
Aero Promoters	298,400	0.302
Fatty acids	4,430,334	.944
Other (Aerofloats, amines, fuel oil, miscellaneous)	4,820,890	.741
Total or average:		
Quantity	9,549,624	.962
Value	$2,779,909	$0.280
Frother:		
Aerofroths	203,930	0.216
Other	822,548	.166
Total or average:		
Quantity	1,026,478	0.174
Value	$648,777	$0.110
Flocculant:		
Quantity	14,234	0.015
Value	$23,945	$0.026
Other:		
Quantity	32,000	0.040
Value	$12,800	$0.016
Total or average reagents:		
Quantity	20,985,197	2.115
Value	$4,227,625	$0.426

Table 36.—Froth flotation of iron ores in 1980

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	6	Total	19,445,232
Capacity short tons per day	143,700	Per ton	1.023
Ore treated:		Ball consumption, pounds:	
Quantity short tons	[1]41,764,500	Total	24,427,502
Iron percent	39.7	Per ton	0.933
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total millions	1,010.2	Total	9,360,474
Per ton	24.2	Per ton	0.229
Water used, gallons:			
Total millions	57,581.5		
Per ton	1,380		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade (percent)	Recovery (percent)
Iron	23,678,100	62.1	89

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier (caustic soda, sodium silicate, sulfuric acid, miscellaneous):		
Quantity	63,090,568	3.502
Value	$5,860,017	$0.325
Depressant:		
Quantity	24,474,730	1.570
Value	$2,332,442	$0.150
Collector:		
Amines	5,253,181	0.145
Other (fatty acids, fuel oil)	11,039,414	1.911
Total or average:		
Quantity	16,292,595	.390
Value	$6,782,112	$0.162
Frother (Aerofroths, methyl isobutyl carbinol, UCON):		
Quantity	693,142	0.034
Value	$250,586	$0.012
Flocculant (Calgon, lime, Superfloc):		
Quantity	30,786,155	0.798
Value	$5,054,441	$0.131
Other:		
Quantity	4,863,768	0.312
Value	$1,784,155	$0.114
Total or average reagents:		
Quantity	140,200,958	3.357
Value	$22,063,753	$0.528

[1]Includes magnetic concentrates upgraded by flotation.

Table 37.—Froth flotation of limestone-magnesite ores in 1980

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	4	Total ____ millions	4.7
Capacity ____ short tons per day	1,600	Per ton	20.6
Ore treated ____ short tons	229,000	Water used, gallons:	
Concentrates produced ____ do	194,700	Total ____ millions	111.6
		Per ton	490

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Quantity	397,446	4.090
Value	$49,122	$0.506
Depressant:		
Quantity	485,875	5.000
Value	$14,576	$0.150
Collector (amines, fatty acids, fuel oil, other):		
Quantity	332,377	1.451
Value	$129,613	$0.566
Frother (Dowfax, pine oil, other):		
Quantity	72,389	0.316
Value	$39,432	$0.172
Flocculant (Hercofloc, Separan):		
Quantity	1,539	0.012
Value	$2,829	$0.022
Total reagents:		
Quantity	1,289,626	5.631
Value	$235,572	$1.029

Table 38.—Froth flotation of phosphate ores in 1980

OPERATING DATA

Plants		Ore treated		Energy used (kilowatt-hours)		Water used (gallons)	
Number	Capacity (short tons per day)	Quantity (short tons)	P_2O_5 (percent)	Total (millions)	Per ton	Total (millions)	Per ton
22	433,900	119,824,200	10.5	938.5	7.8	399,012.7	3,330

CONCENTRATES PRODUCED

Quantity	short tons	29,357,693
P_2O_5	percent	31.9
Recovery	do	74.0

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Ammonia, caustic soda	45,076,275	0.415
Sulfuric acid	48,187,045	.490
Total:		
Quantity	93,263,320	.859
Value	$4,554,868	$0.042
Collector:		
Amines	15,872,223	0.134
Fatty acids	178,035,248	1.486
Fuel oil	193,936,774	1.619
Kerosine	6,168,826	.072
Total:		
Quantity	394,013,071	3.288
Value	$43,248,161	$0.361
Frother:		
Quantity	316,693	0.039
Value	$219,046	$0.027
Flocculant:		
Quantity	92,000	0.010
Value	$4,600	$0.001
Total reagents:		
Quantity	487,685,084	4.070
Value	$48,026,675	$0.401

Table 39.—Froth flotation of potash ores in 1980

OPERATING DATA

Plants		Ore treated		Energy used (kilowatt-hours)		Water used (gallons)	
Number	Capacity (short tons per day)	Quantity (short tons)	K_2O (percent)	Total (millions)	Per ton	Total (millions)	Per ton
8	47,000	14,250,000	14.89	202.0	14.2	3,984.4	280

CONCENTRATES PRODUCED

Quantity	short tons	3,298,344
K_2O	percent	52.78
K_2O recovery	do	82

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Hydrochloric acid	298,815	0.057
Other (Marsperse, phosphates, sulfamic acid)	421,245	.083
Total:		
Quantity	720,060	0.078
Value	$130,643	$0.014
Depressant (Calgon, Guar, starch, other):		
Quantity	5,782,070	0.514
Value	$1,270,362	$0.113
Collector:		
Amines	2,235,892	0.158
Other (fuel oil, other)	2,183,693	.392
Total:		
Quantity	4,419,585	.310
Value	$1,902,454	$0.134
Frother:		
Barrett oil	3,112,242	0.359
Methyl isobutyl carbinol	906,760	.067
Other	13,544	.220
Total:		
Quantity	4,032,546	.283
Value	$674,746	$0.047
Flocculant:		
Polyhall	108,167	0.014
Other (Nalco, Separan, Steinhall, other)	593,470	.093
Total:		
Quantity	701,637	.050
Value	$825,158	$0.058
Total reagents:		
Quantity	15,655,898	1.099
Value	$4,803,363	$0.337

Table 40.—Froth flotation of anthracite and bituminous coal in 1980

OPERATING DATA

Plants:		
Number		80
Capacity	short tons per day	78,300
Raw coal treated	short tons	12,900,753
Clean coal produced	do	7,556,902

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Pounds	Pounds per ton
Modifier:		
Quantity	25,614	0.059
Value	$3,494	$0.008
Collector:		
Fuel oil	4,272,969	0.784
Kerosine	643,465	.635
Total:		
Quantity	4,916,434	.760
Value	$660,110	$0.102
Frother:		
Aerofroths	847,144	0.361
Dowell	258,910	.240
Methyl isobutyl carbinol	1,288,073	.163
Nalco	559,506	.305
Pine oil	54,312	.476
Other	36,390	.073
Total:		
Quantity	3,044,335	.253
Value	$1,422,200	$0.118
Flocculant:		
Aeroflocs	136,495	0.128
Alum	102,283	.053
Calgon	109,198	.053
Dowell	170,510	.108
Nalco	1,500,940	.385
Superflocs	1,337,245	1.041
Other (Betz, Polyhall, Separan)	164,491	.165
Total:		
Quantity	3,521,162	.354
Value	$3,029,754	$0.304
Total reagents:		
Quantity	11,507,545	0.892
Value	$5,115,558	$0.397

Abrasive Materials

By Staff, Section of Nonmetallic Minerals, Ceramics and Refractories Unit

Changes in the 1980 quantity and value of the sales of various natural abrasives, compared with the data for 1979, were of a mixed nature. Output of garnet and special silica stone products increased in both tonnage and value during the year, while emery and tripoli-type materials production decreased in both tonnage and value. The reported quantity and value of sales of manufactured abrasive material—fused alumina and alumina-zirconia, silicon carbide, and metallic iron and steel shot and grit—also decreased for 1980.

Table 1.—Salient abrasives statistics in the United States

Kind	1976	1977	1978	1979	1980
Natural abrasives (domestic) sold or used by producers:					
Tripoli (crude) short tons	124,281	125,661	138,311	e127,878	121,233
Value thousands	$776	$777	$849	e$831	$676
Special silica stone products[1] short tons	2,696	2,200	e2,175	r e2,094	2,131
Value thousands	$1,404	$3,236	e$2,630	r e$2,064	$2,233
Natural abrasives production:					
Garnet short tons	r25,661	r21,980	r20,822	r21,240	26,909
Value thousands	r$3,413	r$3,165	r$3,207	r$3,746	$3,957
Emery short tons	W	W	W	10,005	7,284
Value thousands	W	W	W	$204	$153
Manufactured abrasives[2 3] short tons	620,328	640,723	550,877	712,733	617,485
Value[3] thousands	$176,064	$186,654	$172,554	$230,024	$218,600
Foreign trade (natural and artificial abrasives):					
Exports (value) do	$113,199	$121,579	$138,659	$185,587	$193,679
Reexports (value) do	$29,285	$35,363	$41,016	r$42,922	$47,521
Imports for consumption (value) do	$157,232	$192,870	$231,720	r$270,599	$268,862

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.
[2]Includes Canadian production of silicon carbide and aluminum oxide and shipments of metallic abrasives by U.S. producers.
[3]Includes U.S. and Canadian production of aluminum-zirconium oxide.

FOREIGN TRADE

The following section contains foreign trade statistics (tables 2, 3, 4, and 9) for 1979-80. Table 10 contains imports of industrial diamonds, by country, for 1978-80.

Table 2.—U.S. exports of abrasive materials, by kind

(Thousands)

Kind	1979 Quantity	1979 Value	1980 Quantity	1980 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	27,297	$70,902	28,162	$68,866
Industrial diamond, natural or synthetic, other do	683	7,572	301	5,570
Emery, natural corundum, pumice in blocks pounds	9,627	1,776	31,612	1,195
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) do	39,986	19,754	37,857	18,864
Silicon carbide, crude or in grains do	20,410	9,410	27,311	13,258
Carbide abrasives, n.e.c. do	388	987	811	1,472
Other refined abrasives do	28,206	6,569	24,760	6,958
Grinding and polishing wheels and stones:				
Diamond carats	567	6,401	696	7,161
Polishing stones, whetstones, oilstones, hones, similar stone number	668	1,791	681	2,181
Wheels and stones, n.e.c pounds	6,560	21,083	5,978	23,330
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	18,608	30,864	19,141	35,912
Grit and shot, including wire pellets do	44,395	8,478	31,882	8,912
Total	XX	185,587	XX	193,679

XX Not applicable.

Table 3.—U.S. reexports of abrasive materials, by kind

(Thousands)

Kind	1979 Quantity	1979 Value	1980 Quantity	1980 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	472	$1,914	372	$1,382
Industrial diamond, natural or synthetic, other do	2,055	39,753	3,268	45,659
Emery, natural corundum, pumice in blocks pounds	214	[r]50	113	35
MANUFACTURED ABRASIVES				
Silicon carbide, crude or in grains do	--	--	11	6
Grinding and polishing wheels and stones:				
Diamond carats	22	237	34	276
Wheels and stones, n.e.c.[1] pounds	8	147	30	134
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	348	821	10	29
Total	XX	[r]42,922	XX	47,521

[r]Revised. XX Not applicable.
[1]Includes value of hones, whetstones, pulpstones, oilstones, polishing stones, and quantity and value of other abrasive wheels.

Table 4.—U.S. imports for consumption of abrasive materials (natural and artificial), by kind

(Thousands)

Kind	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Corundum, crude or crushed ---short tons--	5	$435	1	$20
Emery, flint, rottenstone, tripoli, crude or crushed ---do----	7	584	6	504
Silicon carbide, crude---do----	97	30,111	78	29,112
Aluminum oxide, crude ---do----	211	49,843	181	48,520
Other crude artificial abrasives---do----	3	795	1	196
Abrasives, ground grains, pulverized or refined:				
Rottenstone and tripoli---do----	4	1	(1)	1
Silicon carbide ---do----	6	7,480	5	8,314
Aluminum oxide---do----	8	5,310	7	4,914
Emery, corundum, flint, garnet, other, including artificial abrasives ---do----	4	3,781	4	5,744
Papers, cloths, other materials wholly or partly coated with natural or artificial abrasives ---	(2)	42,117	(2)	38,207
Hones, whetstones, oilstones, polishing stones --- number--	423	518	235	337
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones ---short tons--	(1)	3	(1)	1
Solid natural stone wheels--- number--	41	70	72	93
Diamond ---do----	103	4,192	93	4,526
Abrasive wheels bonded with resins ---pounds--	3,906	6,131	3,794	7,066
Other ---	(2)	5,506	(2)	7,614
Articles not specifically provided for:				
Emery or garnet---	(2)	53	(2)	44
Natural corundum or artificial abrasive materials---	(2)	770	(2)	579
Other, n.s.p.f ---	(2)	1,166	(2)	2,123
Diamond, natural and synthetic:				
Diamond dies--- number--	11	756	9	393
Crushing bort --- carats--	58	219	60	209
Natural industrial diamond stones---do----	6,062	65,612	5,013	69,118
Miners' diamond[3] ---do----	1,033	8,087	1,161	10,183
Powder and dust, synthetic ---do----	12,919	23,063	12,003	20,775
Powder and dust, natural ---do----	5,265	13,996	3,604	10,269
Total ---	XX	270,599	XX	268,862

XX Not applicable.
[1]Less than 1/2 unit.
[2]Quantity not reported.
[3]Includes 6,079 carats of synthetic miners' diamond in 1979, and 679 carats in 1980.

TRIPOLI

Fine-grained, porous silica materials are grouped together under the category tripoli because they have similar properties and end uses. Production of crude tripoli (table 1) decreased over 5% in quantity and nearly 19% in value in 1980. Processed tripoli sold or used (table 5) decreased over 14% in quantity while decreasing slightly in value. Of the processed tripoli, 60% was used for fillers in 1980 and 40% was used for abrasives, compared with 54% and 46%, respectively, for these uses in 1979.

Tripoli producers in 1980 were Malvern Minerals Co., Garland County, Ark., which produced crude and finished material; Midwestern Minerals Corp., Ottawa County, Okla., which produced crude and finished material; and American Tripoli Co., Div. of The Carborundum Co., which produced crude in Ottawa County, Okla., and finished material in Newton County, Mo. Illinois Minerals Co. and Tammsco, Inc., both in Alexander County, Ill., produced amorphous (microcrystalline) silica. Keystone Filler and Manufacturing Co., in Northumberland County, Pa., mined and processed rottenstone (decomposed fine-grained siliceous limestone or shale).

Prices quoted in Engineering and Mining Journal, December 1980, for tripoli and amorphous silica were as follows:

Tripoli, paper bags, carload lots, f.o.b., in cents per pound:	
White, Elco, Ill.: Air floated through 200 mesh	2.75
Rose and cream, Seneca, Mo., and Rogers, Ark.:	
Once ground	2.90
Double ground	2.90
Air float	3.15
Amorphous silica, 50-pound, paper bags, f.o.b., in dollars per ton:	
Elco, Ill.:	
Through 200 mesh, 90% to 95%	$55.00
Through 200 mesh, 96% to 99%	56.00
Through 325 mesh, 90% to 95%	57.00
Through 325 mesh, 96% to 98%	61.00
Through 325 mesh, 98% to 99.4%	59.50
Through 325 mesh, 99.5%	76.00
Through 400 mesh, 99.9%	104.50
Below 15 micrometers, 99%	112.50
Below 10 micrometers, 99%	137.00

Table 5.—Processed tripoli[1] sold or used by producers in the United States, by use[2]

Use		1976	1977	1978	1979	1980
Abrasives	short tons	68,874	70,631	75,574	53,600	39,352
Value	thousands	$2,525	$2,805	$3,709	$2,468	$2,253
Filler	short tons	40,247	42,599	36,505	62,409	59,909
Value	thousands	$1,811	$2,212	$2,220	$3,811	$4,025
Other	short tons	5,000	2,689	[e]2,190	(3)	--
Value	thousands	$175	$119	[e]$97	(3)	--
Total	short tons	114,121	115,919	114,269	116,009	99,261
Value	thousands	$4,511	$5,136	$6,026	$6,279	[4]$6,277

[e]Estimated.
[1]Includes amorphous silica and Pennsylvania rottenstone.
[2]Partly estimated.
[3]Revised to zero.
[4]Data do not add to total shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Special silica stone products produced in 1980 included oilstones-whetstones from Arkansas and Indiana, grindstones from Ohio, grinding pebbles from Minnesota, deburring media from Ohio and Wisconsin, and tube-mill liners from Minnesota.

Producers of oilstones-whetstones in Garland County, Ark., were Hiram A. Smith, Inc.; Norton Pike Div. of Norton Co.; and Pioneer Whetstone Co. Hindostan Whetstone Co. operated a plant in Lawrence County, Ind., to finish stone obtained from a quarry in Orange County, Ind. Cleveland Quarries Co. produced grindstones at its Amherst quarry, Lorain County, Ohio. Jasper Stone Co. produced grinding media, rough and rounded, from its quarry in Rock County, Minn.; and Baraboo Quartzite Co. Inc., produced deburring media at its quarry in Sauk County, Wis.

Table 6.—Special silica stone products sold or used in the United States[1]

Year	Quantity (short tons)	Value (thousands)
1976	2,696	$1,404
1977	2,200	3,236
1978[e]	2,175	2,630
1979[r]	2,094	2,064
1980	2,131	2,233

[e]Estimated. [r]Revised.
[1]Includes grinding pebbles, grindstones, oilstones, tubemill liners, and whetstones.

NATURAL SILICATE ABRASIVES

Garnet.—The United States accounted for about 70% of the world's garnet production; the rest comes primarily from India, the U.S.S.R., and Australia. Sales of domestic garnet increased 15% in quantity and 5% in value in 1980. Five producers were active—two each in Idaho and New York, and one in Maine. Barton Mines Corp., Warren County, N.Y., sold garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals, Inc., Essex County, N.Y., reported its garnet was used mostly in sandblasting and in bonded abrasives. Emerald Creek Garnet Milling Co. and Idaho Garnet Abrasive Co., both in Benewah County, Idaho, reported their garnet was used chiefly in sandblasting and water filtration. Industrial Garnet Extractives Inc., Oxford County, Maine, produced almandine garnet and a garnet-containing utility grit near Rangeley, which was used largely in sandblasting and water filtration.

Table 7.—Garnet sold or used by producers in the United States

Year	Quantity (short tons)	Value (thousands)
1975	17,204	[r]$2,092
1976	24,565	[r]3,568
1977	20,022	[r]3,136
1978	22,058	[r]3,678
1979	23,303	[r]4,335
1980	26,550	4,573

[r]Revised.

NATURAL ALUMINA ABRASIVES

Corundum.—No domestic corundum was produced in 1980. Requirements for domestic consumption were met by imports, primarily from Zimbabwe (indirectly), India, and the Republic of South Africa. Small quantities of corundum were imported from Nigeria. In 1980, imports totaled 536 tons at a declared value of $20,014.

Prices quoted in Engineering and Mining Journal, December 1980, for crystal corundum, per short ton of crude, c.i.f. U.S. ports, roughly 10% above 1979 prices, were $170 to $187.

Emery.—Three producers of emery were active in 1980: De Luca Emery Mine, Inc., John Leardi Emery Mine, and Emeri-Crete, Inc., all near Peekskill in Westchester County, N.Y. Domestic emery was used mostly in aggregates as a nonslip additive for floors, pavements, and stair treads. The minor use for domestic emery was in abrasive materials for coated abrasives and tumbling or deburring media.

Prices quoted for emery in Industrial Minerals, No. 159, December 1980, approximately 10% higher than in 1979, were as follows, in dollars per metric ton, c.i.f. main European port: Coarse grain, $180 to $192; medium and fine grain, $192 to $216.

Table 8.—Natural corundum: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
India	[r]580	[e]1,440	1,193	983	[3]1,603
Kenya	[r]17	--	(4)	6	6
South Africa, Republic of	156	152	20	82	55
U.S.S.R.[e]	8,300	8,800	9,400	9,400	9,500
Uruguay	420	464	247	[e]250	250
Zimbabwe	[e]4,400	[e]8,800	[e]13,200	18,329	17,600
Total	[r]13,873	[r]19,656	24,060	29,050	29,014

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 20, 1981.
[2]In addition to the countries listed, Argentina may have produced minor quantities of this commodity, but output is not reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Less than 1/2 unit.

INDUSTRIAL DIAMOND

Domestic production of synthetic industrial diamond in 1980 was estimated at 50 million carats. Secondary production, or salvage from used diamond tools and from wet and dry diamond-containing wastes, was estimated at 3.0 million carats for the year, using data from a consumption canvass conducted by the U.S. Department of Commerce.

The Government stockpile inventory as of December 31, 1980, included 23.7 million carats of crushing bort and 19.2 million carats of stones. Stockpile goals were 22.0 million carats for crushing bort and 7.7 million carats for stones, so excesses are 1.7 million carats and 11.5 million carats, respectively. The inventory of small diamond industrial dies was 25,473 pieces; the goal was 60,000 pieces.

The United States is the largest consumer of natural industrial diamond stones and is totally dependent on foreign sources. Owing to political instability, supplies from Zaire and other areas are in potential danger of disruption. Output of industrial stones is largely dependent on the output of gem diamond, which is limited by economic and other factors not directly related to the demand for industrial stones. World reserves are only marginally sufficient to meet world demand for industrial stones through 2000; therefore, increased use of polycrystalline diamond compacts and other synthetic products will be necessary to be certain that the demand will be met.

Exports and reexports of industrial diamond dust and powder, including synthetics, totaled 28.5 million carats valued at $70.2 million. Exports and reexports of stones totaled 3.6 million carats valued at $51.2 million. The total of exports and reexports of dust and powder and stones was 32.1 million carats valued at $121.4 million.

Domestic exploration for diamonds is underway. More than 90 kimberlite occurrences are known in the Colorado-Wyoming State Line District and the Iron Mountain District of Wyoming. Microdiamonds have been recovered from some of the State Line diatremes near Tie Siding, Wyo.

Table 9.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1978	22,190	87,762
1979	25,325	110,934
1980	21,848	110,566

Table 10.—U.S. imports for consumption of industrial diamond, by country[1]

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones (including glazers' and engravers' diamond, unset)				Miners' diamond[2]				Powder and dust, synthetic				Powder and dust, natural			
	1979		1980		1979		1980		1979		1980		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	305	2,948	534	3,513	6	31	6	67	86	144	658	1,119	558	966	365	766
Canada	46	617	20	292	21	140	31	54	97	188	15	20	8	22	7	42
Congo	88	594	31	657	--	--	--	--	--	--	--	--	1	1	4	99
Cyprus	21	589	--	--	--	--	--	--	--	--	--	--	55	38	7	29
Finland	2	26	--	--	--	--	--	--	231	339	585	731	--	--	--	--
France	2	8	3	12	--	--	--	--	32	74	2	5	--	--	--	--
Germany, Federal Republic of	4	80	2	93	2	40	(3)	(3)	125	199	85	228	48	95	43	134
Ghana	9	212	10	278	--	--	--	--	--	--	--	--	3	24	--	--
Greece	--	--	--	--	--	--	--	--	427	547	414	413	--	--	--	--
Hong Kong	4	30	1	9	--	--	--	--	--	--	2	5	--	--	38	48
Ireland	37	180	41	253	14	77	242	1,953	8,147	16,263	8,189	15,611	1,460	3,972	1,390	3,063
Israel	3	89	8	211	--	--	--	--	--	--	1	1	2	3	2	34
Japan	28	1,311	28	1,375	--	--	--	--	752	840	739	733	5	7	5	9
Liberia	--	--	5	63	--	--	--	--	--	--	--	--	--	--	16	63
Mexico	--	--	1	32	--	--	--	--	--	--	--	--	14	10	17	12
Netherlands	123	2,146	96	1,389	(3)	1	--	--	12	23	27	24	22	68	22	61
South Africa, Republic of	4,954	50,746	3,715	52,182	9	97	12	111	1,190	2,225	666	1,123	2,337	7,553	1,024	4,895
Switzerland	11	123	3	117	--	--	--	--	775	1,056	197	225	165	146	105	198
U.S.S.R.	119	129	--	--	--	--	--	--	903	962	135	151	177	183	60	53
United Kingdom	216	3,160	414	6,356	1	3	16	138	27	44	123	189	94	327	96	156
Upper Volta	1	112	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Venezuela	29	1,543	44	1,344	3	23	8	309	--	--	--	--	--	--	--	--
Other Africa, n.e.c	39	r616	18	694	--	--	--	--	--	--	--	--	--	--	--	--
Zaire	8	71	10	46	934	7,449	820	7,247	3	12	10	20	318	581	397	604
Other	16	r282	31	204	43	226	26	304	112	143	155	181	1	1	6	3
Total[4]	6,062	65,612	5,013	69,118	1,033	8,087	1,161	10,183	12,919	23,063	12,003	20,775	5,265	13,996	3,604	10,269

[r]Revised.
[1]Excludes 58,255 carats of crushing bort in 1979, and 59,772 carats in 1980, all from the Republic of South Africa.
[2]Includes 6,079 carats of synthetic miners' diamond in 1979, and 679 carats in 1980.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

Table 11.—Diamond (natural): World production, by type and country[1]

(Thousand carats)

Country	1976			1977			1978			1979[p]			1980[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:															
Angola	255	85	340	265	88	353	525	175	700	562	188	750	750	250	1,000
Botswana	[r]354	[r]2,007	[r]2,361	404	2,287	2,691	418	2,367	2,785	659	3,735	4,394	765	4,336	[2]5,101
Central African Republic	172	114	286	178	119	297	199	85	284	205	110	315	180	99	279
Ghana	228	2,055	2,283	230	1,717	1,947	142	1,281	1,423	125	1,128	1,253	100	1,100	1,200
Guinea[e]	25	55	80	25	55	80	25	55	80	27	58	85	27	57	84
Ivory Coast	22	38	60	7	11	18	--	10	10	5	32	37	6	34	40
Lesotho	[r]4	[r]1	5	[r]39	[r]3	42	62	5	67	48	4	52	50	4	[2]54
Liberia[3]	163	162	325	163	163	326	128	180	308	170	132	302	170	130	300
Namibia	1,609	85	1,694	1,901	100	2,001	1,803	95	1,898	1,570	83	1,653	1,482	78	[2]1,560
Sierra Leone	433	650	1,083	423	538	961	353	426	779	419	436	855	400	450	850
South Africa, Republic of:															
Finsch Mine	441	1,762	2,203	485	1,941	2,426	526	2,104	2,630	517	2,068	2,585	581	2,326	[2]2,907
Premier Mine	458	1,375	1,833	502	1,508	2,010	496	1,487	1,983	520	1,561	2,081	510	1,529	[2]2,039
Other De Beers properties[4]	[r]1,460	[r]972	[r]2,432	[r]1,617	[r]1,040	[r]2,657	1,638	1,011	2,649	2,054	1,166	3,220	1,829	1,210	[2]3,039
Other	[r]499	[r]56	555	[r]495	[r]55	550	418	[r]47	465	448	50	498	483	54	[2]537
Total	[r]2,858	[r]4,165	7,023	[r]3,099	[r]4,544	7,643	3,078	4,649	7,727	3,539	4,845	8,384	3,403	5,119	[2]8,522
Tanzania	219	219	[3]438	204	204	[3]408	146	147	[3]293	145	145	[e]290	120	120	240
Zaire[5]	[r]498	[r]11,323	11,821	[r]533	[r]10,681	[r]11,214	640	10,603	11,243	294	8,440	8,734	345	9,890	10,235
Other areas:															
Australia	--	--	--	--	--	--	--	--	--	--	--	--	--	48	48
Brazil[6]	[r]214	[r]47	[r e]261	[r]274	[r]46	[r e]320	291	49	[r e]340	305	55	[r e]360	305	55	360
Guyana	6	8	14	7	10	17	7	10	17	6	10	16	6	10	16
India	17	3	20	15	3	18	14	2	16	13	2	15	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	3	12	15

U.S.S.R.[e]	2,000	7,900	9,900	2,100	8,200	10,300	2,150	8,400	10,550	2,200	8,500	10,700	2,250	8,600	10,850
Venezuela	195	654	849	204	483	687	269	487	756	247	556	803	250	575	825
World total	[r]9,275	[r]29,583	[r]38,858	[r]10,074	[r]29,264	[r]39,338	10,253	29,038	39,291	10,542	28,471	39,013	10,624	30,969	41,593

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Aug. 28, 1981. Total diamond output (gem plus industrial) for each country is actually reported except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are Bureau of Mines estimates in the case of every country except the Central African Republic (1976-78), Liberia (1976-78), Sierra Leone (1977-78), and Venezuela (1978), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries is based on the best available data at time of publication. Mainland China also produces some natural diamond, but output is not reported.

[2]Reported figure.

[3]Total exports.

[4]All company output from the Republic of South Africa, except for that credited to the Finsch and Premier Mines for the years indicated; excludes De Beers Group output from Botswana, Lesotho, and Namibia.

[5]Excludes very substantial quantities produced and exported illicitly; estimates of these quantities are quite variable, but for recent years, the principal Zairian producer indicates 5 to 6 million carats annually (gem plus industrial) and may have exceeded this level in 1979 and 1980.

[6]Series revised to reflect the substantial output by small miners (garimpos), which is estimated as follows in thousand carats: 1976—185; 1977—254; 1978—269; 1979—280; 1980—280 (1976-77 estimates from the Brazilian Ministry of Mines and Energy; 1978-80 estimates by U.S. Bureau of Mines).

MANUFACTURED ABRASIVES

Six firms produced crude fused aluminum oxide in the United States and Canada in 1980. Operators with plants in both countries were The Carborundum Co., Div. of Kennecott Copper Corp.; Norton Co.; and General Abrasive Co., Div. of Dresser Industries, Inc. The Exolon Co.; Unicorn Abrasives of Canada, Ltd., Div. of Fusion du Saguenay (Simonds Canada Abrasive Co. Ltd.); and Washington Mills Abrasive Co. operated plants in Canada. The reported 1980 production of white, high-purity material was 34,091 tons, and production of regular material was 158,939 tons. Of the combined output of white and regular material, 13% was used for nonabrasive applications, principally in the manufacture of refractories. Stocks reported totaled 12,095 tons as of December 31, 1980. The estimated production was 61% of the rated capacity of U.S. and Canadian plants.

Two firms, Norton Co. and The Exolon Co., produced fused alumina-zirconia abrasive in Canada. One firm, General Abrasive Co., operated a plant in the United States. All production was reportedly used for abrasive applications. In 1980, output was 72% of the capacity of the furnaces that were used for production of fused alumina-zirconia. Stocks reported totaled 1,019 tons as of December 31, 1980.

Seven firms in the United States and Canada produced silicon carbide in 10 plants in 1980. In the United States, plants were operated by The Carborundum Co. (two plants), ESK Corp., and Satellite Alloy Corp. In Canada, plants were operated by Ferro Corp./Electro Div.; The Carborundum Co.; Electro-Refractories & Abrasives Canada, Ltd.; Exolon; Norton (two plants); and General Abrasive Co. These companies produced crude for abrasive uses and for refractory and other nonabrasive uses. Production reported in 1980 by the seven firms was 69% of capacity, and 18% of the output was reportedly used for abrasive applications. Nonabrasive use accounted for the remaining 82% of output. Most of the nonabrasive uses of crude were in refractory and metallurgical applications. Stocks totaled 25,811 tons as of December 31, 1980, according to reports.

In the Stockpile Report to the Congress by the General Services Administration, December 31, 1980, the inventory of crude fused aluminum oxide in calendar year 1980 was 249,864 tons. The stock of aluminum oxide abrasive grain increased slightly to 50,904 tons. The stock of silicon carbide crude was 80,550 tons, and the goal was 29,000 tons.

Metallic abrasives were produced by 14 firms operating 17 plants in the United States in 1980. Steel shot and grit comprised 88% of the total quantity sold or used, and chilled iron shot and grit, 11%. Pennsylvania supplied 26% of the total sold or used. Other large suppliers operated in Ohio, Michigan, Indiana, Virginia, Alabama, Connecticut, and New York.

Table 12.—Producers of metallic abrasives in 1980

Company	Location	Product (shot and/or grit)
Abbott Ball Co	Hartford, Conn	Steel.
Abrasive Materials, Inc	Hillsdale, Mich	Cut wire.
Cleveland Metal Abrasive Co	Birmingham, Ala	Do.
Do	Toledo, Ohio	Do.
Copperweld Corp	Glassport, Pa	Chilled iron.
Durasteel Co	Mt. Pleasant, Pa	Steel.
Ervin Industries, Inc	Adrian, Mich	Do.
Do	Butler, Pa	Do.
Globe Steel Abrasives Co	Mansfield, Ohio	Do.
Industeel Co	Pittsburgh, Pa	Chilled iron.
Metal Blast, Inc	Cleveland, Ohio	Do.
National Metal Abrasive Co	Wadsworth, Ohio	Steel.
Pangborn, A Kennecott Company	Butler, Pa	Do.
Pellets, Inc	Tonawanda, N.Y	Cut wire.
Steel Abrasives, Inc	Hamilton, Ohio	Chilled iron.
Wheelabrator-Frye Inc	Mishawaka, Ind	Steel.
Do	Bedford, Va	Do.

Table 13.—Crude manufactured abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind	1976	1977	1978	1979	1980
Silicon carbide[1]	159	192	182	[e]196	170
Value	$45,953	$53,814	$51,371	[e]$62,702	$64,346
Aluminum oxide (abrasive grade)[1]	191	185	142	[e]225	193
Value	$43,356	$48,819	$46,633	[e]$67,511	$63,881
Aluminum-zirconium oxide	20	20	23	28	19
Value	$11,383	$11,281	$14,668	$14,893	$8,438
Metallic abrasives[2]	250	243	204	264	235
Value	$75,372	$72,740	$59,882	$84,918	$81,935
Total	620	640	551	[e]713	617
Value	$176,064	$186,654	$172,554	[e]$230,024	$218,600

[e]Estimated.
[1]Figures include material used for refractories and other nonabrasive purposes.
[2]Shipments for U.S. plants only.

Table 14.—Disposition of crude silicon carbide as reported by producers, 1980

(Short tons)

Use	Quantity	Value	Yearend stocks
Abrasives	51,573	$19,370,719	2,640
Metallurgical	78,275	27,622,033	13,171
Refractories	38,174	16,553,260	2,334
Other	2,000	800,000	1,000
Total	170,022	64,346,012	19,145

Table 15.—Production, shipments, and annual capacities of metallic abrasives in the United States, by product

Year and product	Manufactured		Sold or used		Annual capacity[1] (short tons)
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
1979:					
Chilled iron shot and grit	18,766	$4,870	19,299	$3,172	[e]50,000
Annealed iron shot and grit	6,170	2,197	6,309	2,698	[e]25,000
Steel shot and grit	232,475	65,631	238,190	78,329	295,400
Other[2]	290	582	337	719	1,200
Total	257,701	73,280	264,135	84,918	XX
1980:					
Chilled iron shot and grit	32,491	8,105	33,256	9,016	47,100
Annealed iron shot and grit	XX	XX	115	36	XX
Steel shot and grit	207,992	63,160	201,640	72,120	373,150
Other[2]	251	549	279	763	1,150
Total	240,734	71,814	235,290	81,935	XX

[e]Estimated. XX Not applicable.
[1]Total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.
[2]Includes cut wire, aluminum, and stainless steel shot.

Aluminum

By Horace F. Kurtz[1] and Pamela A. Stephenson[2]

Domestic primary aluminum production in 1980 reached a new record high of 5.13 million short tons, despite hydroelectric power shortages and lower domestic demand resulting from a recession. Annual demand, as measured by net shipments of ingot and mill products to domestic industry, fell 13% to 6.0 million tons. The reduced domestic demand was partially offset by strong markets abroad that enabled producers to increase exports and maintain production. The United States, normally a net importer of aluminum, was a net exporter of 770,000 tons of crude, semifabricated, and scrap aluminum in 1980. The value of exports of these commodities exceeded the value of imports by $1.4 billion, a sum greater than the value of the industry's net imports of bauxite and alumina.

World production of aluminum increased to a record 16.9 million tons. Canada, which had production interrupted by a strike in 1979, showed the greatest increase in 1980. Other significant increases, reflecting production at new facilities, were made in Spain, Venezuela, and the United States. However, announced plans for new capacity indicated that Australia should provide the largest increases in production in the early and mid-1980's.

Legislation and Government Programs.—In May 1980, the Federal Emergency Management Agency announced an update of the Government's stockpile goals for strategic materials. The revised goal for the aluminum metal group of commodities was set at 7,150,000 short tons of aluminum, which was comprised of 700,000 tons of metal and 27.1 million long tons of bauxite (equivalent to 6,450,000 short tons of metal). Government inventories of aluminum metal remained at less than 2,000 tons throughout 1980.

The Pacific Northwest Power Planning and Conservation Act, Public Law 96-501, was signed into law in December. Among its provisions, the legislation authorized the Bonneville Power Administration (BPA) to acquire additional long-term power supplies and to enter into new contracts with direct service customers. These authorizations were expected to enable BPA to continue to allocate electric power to the aluminum industry in the Pacific Northwest and to charge significantly higher rates.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Primary production	4,251	4,539	4,804	5,023	5,130
Value	$3,785,397	$4,683,949	$5,191,064	$6,130,302	$7,346,410
Price: Ingot, average cents per pound	r44.5	51.6	r54.0	r61.0	71.6
Secondary recovery	1,155	1,271	1,323	1,401	1,389
Exports (crude and semicrude)	484	411	520	773	1,483
Imports for consumption (crude and semicrude)	749	836	1,080	840	713
Aluminum industry shipments[1]	r5,802	r6,136	r6,839	r6,932	6,014
Consumption, apparent	5,083	5,492	6,045	r5,888	5,072
World: Production	r13,913	r15,197	r15,562	p16,053	e16,940

eEstimated. pPreliminary. rRevised.
[1]To domestic industry.

DOMESTIC PRODUCTION

Primary.—Domestic production of primary aluminum totaled a record 5,129,699 tons in 1980. Annual production capacity was increased from 5,282,000 tons at the end of 1979 to 5,503,000 tons at the end of 1980. Most of the increase in capacity resulted from the completion of the first large smelter to be built in the United States since 1973. The new smelter, located at Mount Holly, Berkeley County, S.C., was owned by Alumax, Inc. (50% AMAX, Inc., 45% Mitsui & Co., Ltd., 5% Nippon Steel Co.). The plant came onstream in June and by the end of the year was producing at a rate approaching its annual rated capacity of 197,000 tons. Electric power for the plant was obtained from the South Carolina Public Service Authority, and alumina was being supplied by Alcoa of Australia Pty. Ltd. Power consumption at the new plant was expected to be as low as 6.2 kilowatt-hours per pound of aluminum.[3]

At the beginning of 1980, about 165,000 tons of annual primary aluminum capacity was shut down in the Pacific Northwest because of the unavailability of interruptible power normally supplied by BPA. Aluminum Co. of America (Alcoa), Kaiser Aluminum & Chemical Corp., and Reynolds Metals Co. each had two plants affected by the power curtailment. An additional 132,000 tons of capacity was idle at two plants in Texas at the start of the year.

Potlines were shut down and restarted in the Pacific Northwest throughout the first half of the year, in accordance with the availability of interruptible and advanced power from BPA, but throughout most of the second half of 1980 and at yearend only 23,000 tons of annual capacity was shut down in this region. Elsewhere, significant capacity was taken out of production in July because of a weaker market. At the end of the year a total of about 345,000 tons of capacity was shut down at Alcoa's plants at Point Comfort, Tex., (shut down completely in November) and Evansville, Ind., and Reynolds' plants at Listerhill, Ala., and San Patricio, Tex.

Potlines were frozen at Consolidated Aluminum Corp.'s (Conalco's) 35,000-ton-per-year smelter at Lake Charles, La., in April when power was disrupted after natural gas lines were accidentally cut by a dredge. Full production was resumed in July. At yearend, Phelps Dodge Corp. agreed to sell its 40% interest in Conalco to Swiss Aluminium Ltd. (Alusuisse), which owned the other 60%. Conalco also operated a 144,000-ton-per-year smelter at New Johnsonville, Tenn.

Alcoa announced plans to add another potline to its smelter at Badin, N.C., which would increase the annual capacity of the plant by 55,000 tons to 180,000 tons. Power for the additional capacity reportedly will be purchased from local public utilities.

In May the largest aluminum producers reached agreement on similar 3-year contracts with the Aluminum Workers International Union and the United Steelworkers Union, averting a work stoppage in the primary aluminum industry. The contracts reportedly included a wage increase of 60 cents per hour, a cost of living allowance based on changes in the Consumer Price Index, and other benefits.

Secondary.—Production and shipments of secondary aluminum alloys by independent smelters declined significantly in 1980, as shown in table 5, in part because of decreased demand from motor vehicle manufacturers. However, the total consumption of aluminum scrap by all users, as calculated from reports to the Bureau of Mines, was 1.69 million tons, only slightly below that of the previous year. The Bureau estimated that full coverage of the industry would result in a total consumption of purchased aluminum-base scrap of nearly 2 million tons in 1980. On this basis, aluminum recovery would total 1.62 million tons, and total metallic recovery would be 1.74 million tons.

The maintenance of aluminum scrap consumption and secondary aluminum recovery at levels near those of 1979, despite sharply reduced production of alloy ingot by secondary smelters in 1980, was largely a reflection of a continued strong growth in the recycling of old aluminum cans. Consumption of aluminum scrap in all major categories of scrap except cans declined. Most of the old can scrap was remelted by or toll treated for companies that also produced primary aluminum. Martin Marietta Aluminum Inc. began operations at a new recycling facility at Lewisport, Ky., near the end of 1980; Alcan Aluminum Corp. acquired additional secondary smelter capacity at Joliet, Ill., and Greensboro, Ga.; and Kaiser indicated that it would build a remelt plant at Bedford, Ind. Numerous new can collection centers were established throughout the United States. The growth of the aluminum can recycling industry was reviewed.[4]

Table 2.—Consumption of and recovery from purchased new and old aluminum scrap[1]

(Short tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
1979			
Secondary smelters	922,159	736,277	793,458
Primary producers	442,262	378,734	405,661
Fabricators	190,354	167,187	178,669
Foundries	104,323	89,394	96,203
Chemical producers	45,933	27,664	28,171
Total	1,705,031	1,399,256	1,502,162
Estimated full industry coverage	2,020,000	1,654,000	1,777,000
1980			
Secondary smelters	884,255	705,345	760,263
Primary producers	541,771	462,402	495,251
Fabricators	143,915	125,940	134,601
Foundries	81,830	69,525	74,887
Chemical producers	41,862	23,902	24,401
Total	1,693,633	1,387,114	1,489,403
Estimated full industry coverage	1,982,000	1,619,000	1,738,000

[1]Excludes recovery from other than aluminum-base scrap.

Table 3.—Aluminum recovered from purchased scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1979	1980	Form of recovery	1979	1980
New scrap:			Unalloyed	2,176	4,815
Aluminum-base	[1]920,994	[2]850,260	Aluminum alloys	[r]1,336,186	1,327,372
Copper-base	95	65	In brass and bronze	184	159
Zinc-base	253	[e]200	In zinc-base alloys	1,017	[e]900
Magnesium-base	327	394	In magnesium alloys	616	713
			Dissipative forms[3]	[r]60,894	54,927
Total	921,669	850,919	Total	1,401,073	1,388,886
Old scrap:					
Aluminum-base	[1]478,262	[2]536,854			
Copper-base	89	94			
Zinc-base	764	[e]700			
Magnesium-base	289	319			
Total	479,404	537,967			
Grand total	1,401,073	1,388,886			

[e]Estimated. [r]Revised.

[1]Aluminum alloys recovered from aluminum-base scrap in 1979, including all constituents, were 982,899 tons from new scrap and 519,263 tons from old scrap and sweated pig, a total of 1,502,162 tons.

[2]Aluminum alloys recovered from aluminum-base scrap in 1980, including all constituents, were 907,471 tons from new scrap and 581,932 tons from old scrap and sweated pig, a total of 1,489,403 tons.

[3]Includes recovery in deoxidizing ingot assuming 85% aluminum content in such ingot.

Table 4.—Stocks, receipts, and consumption of purchased new and old aluminum scrap and sweated pig in the United States in 1980[1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Net receipts[2]	Consumption	Stocks Dec. 31
Secondary smelters:				
New scrap:				
Solids and clippings	16,567	268,724	263,917	21,374
Borings and turnings	9,319	160,900	157,582	12,637
Foil	W	W	W	W
Dross and skimmings	6,187	95,680	93,463	8,404
Other[3]	557	19,131	19,397	291
Total new scrap	32,630	544,435	534,359	42,706
Old scrap:				
Castings, sheet, clippings	14,960	164,296	162,407	16,849
Aluminum cans	2,194	93,908	93,178	2,924
Other[4]	2,434	31,873	31,482	2,825
Total old scrap	19,588	290,077	287,067	22,598
Sweated pig	8,204	63,222	62,829	8,597
Total all classes	60,422	897,734	884,255	73,901
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids and clippings	17,608	421,997	415,507	24,098
Borings and turnings	283	17,766	17,401	648
Foil	W	W	W	W
Dross and skimmings	678	26,975	27,132	521
Other[3]	4,424	40,910	41,075	4,259
Total new scrap	22,993	507,648	501,115	29,526
Old scrap:				
Castings, sheet, clippings	1,698	55,399	55,871	1,226
Aluminum cans	14,208	210,596	206,066	18,738
Other[4]	2,492	26,528	26,603	2,417
Total old scrap	18,398	292,523	288,540	22,381
Sweated pig	2,181	18,675	19,723	1,133
Total all classes	43,572	818,846	809,378	53,040
Total of all scrap consumed:				
New scrap:				
Solids and clippings	34,175	690,721	679,424	45,472
Borings and turnings	9,602	178,666	174,983	13,285
Foil	1,702	6,911	6,843	1,770
Dross and skimmings	6,865	122,655	120,595	8,925
Other	3,279	53,130	53,629	2,780
Total new scrap	55,623	1,052,083	1,035,474	72,232
Old scrap:				
Castings, sheet, clippings	16,658	219,695	218,278	18,075
Aluminum-copper radiators	1,743	18,467	17,842	2,368
Aluminum cans	16,402	304,504	299,244	21,662
Other	3,183	39,934	40,243	2,874
Total old scrap	37,986	582,600	575,607	44,979
Sweated pig	10,385	81,897	82,552	9,730
Total all classes	103,994	1,716,580	1,693,633	126,941

W Withheld to avoid disclosing company proprietary data.
[1]Includes imported scrap. According to the reporting companies, 12.15% of total receipts of aluminum-base scrap, or 208,569 short tons, was received on toll arrangements.
[2]Includes inventory adjustment.
[3]Includes data on foil.
[4]Includes data on aluminum-copper radiators.

Table 5.—Production and shipments of secondary aluminum alloys by independent smelters

(Short tons)

	1979		1980	
	Production	Net shipments	Production	Net shipments
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	98,867	100,267	77,347	76,021
380 and variations	453,555	452,575	406,260	404,705
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	26,818	26,854	24,788	24,444
No. 12 and variations	W	W	W	W
No. 319 and variations	56,099	55,731	53,912	53,880
F-132 alloy and variations	21,317	21,238	16,970	16,609
Al-Mg alloys	1,854	2,213	1,948	1,705
Al-Zn alloys	7,929	7,742	6,754	7,180
Al-Si alloys (0.6% to 2.0% Cu)	6,161	6,152	5,901	6,013
Al-Cu alloys (1.5% Si, maximum)	3,216	3,213	2,492	2,400
Al-Si-Cu-Ni alloys	3,794	3,850	4,159	4,130
Other	8,392	8,473	6,687	6,029
Wrought alloys: Extrusion billets	101,982	101,446	94,497	95,510
Destructive and other uses: Steel deoxidation:				
Grades 1, 2, 3, and 4	39,095	39,611	36,500	35,978
Miscellaneous:				
Pure (97.0% Al)	2,176	2,172	4,826	4,815
Aluminum-base hardeners	3,422	3,631	4,900	4,504
Other[1]	10,386	10,626	11,347	11,318
Total	845,063	845,794	759,288	755,241
Less consumption of materials other than scrap:				
Primary aluminum	38,613	--	34,461	--
Primary silicon	48,834	--	40,697	--
Other	4,338	--	3,691	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[2]	753,278	--	680,439	--

W Withheld to avoid disclosing company proprietary data; included in "Other" under "Sand and permanent mold."
[1]Includes other die-cast alloys and other miscellaneous.
[2]No allowance made for melt-loss of primary aluminum and alloying ingredients.

CONSUMPTION

The Bureau of Mines estimate of apparent domestic aluminum consumption in end products such as beverage cans, automobiles, and residential siding declined sharply to slightly over 5 million tons, as shown in table 6. No statistics were collected on the actual consumption of aluminum metal in end products.

Consumption, as measured by net shipments of aluminum ingot and mill products to domestic manufacturers of end products, fell from 6.9 million tons (revised) in 1979 to about 6.0 million tons in 1980. Shipments to all major market segments declined except those to the containers and packaging segment.

Beverage cans comprised about two-thirds of the aluminum containers and packaging market, which also included consumer foil, flexible packaging, semirigid food containers, and other products. Aluminum's share of the beverage can market, by far the fastest growing use of aluminum in the 1970's, continued to increase in 1980.[5] According to Can Manufacturers Institute, 41.6 billion of the 55.2 billion metal beverage cans shipped in 1980 were aluminum. Aluminum cans supplied 87% of the metal beer can market and 62% of the metal soft drink can market.[6]

Shipments to the transportation industry showed the largest decline among the major aluminum markets in 1980, reflecting the weakness in domestic passenger car sales. The estimated average consumption of aluminum in domestic automobiles, however, has risen from 87 pounds per unit in 1976 models to about 130 pounds per unit in 1981 models.

Table 6.—Apparent aluminum supply and consumption in the United States

(Thousand short tons)

	1976	1977	1978	1979	1980
Primary production	4,251	4,539	4,804	5,023	5,130
Change in stocks:[1]					
Aluminum industry	+149	-3	+106	r+184	+32
Government	+9	--	--	--	--
Imports	749	836	1,080	840	713
Secondary recovery:[2]					
New scrap	1,062	1,074	1,098	1,163	1,058
Old scrap	409	531	575	614	680
Total supply	6,629	6,977	7,663	r7,824	7,613
Less total exports	484	411	520	773	1,483
Apparent aluminum supply available for domestic manufacturing	6,145	6,566	7,143	r7,051	6,130
Apparent consumption[3]	5,083	5,492	6,045	r5,888	5,072

rRevised.
[1]Positive figure indicates a decrease in stocks; negative figure indicates an increase in stocks.
[2]Metallic recovery from purchased, tolled, or imported new and old aluminum scrap expanded for full industry coverage.
[3]Apparent aluminum supply available for domestic manufacturing less recovery from purchased new scrap (a measure of consumption in manufactured end products).

Table 7.—Distribution of end-use shipments of aluminum products

Industry	1979 Quantity (thousand short tons)	1979 Percent of total	1980p Quantity (thousand short tons)	1980p Percent of total
Building and construction	1,528	20.5	1,305	18.4
Transportation	1,540	20.7	1,118	15.7
Containers and packaging	1,612	21.6	1,667	23.4
Electrical	787	10.6	689	9.7
Consumer durables	511	6.9	439	6.2
Machinery and equipment	474	6.4	414	5.8
Other markets } Statistical adjustment	480	6.4	382	5.4
Total to domestic users	6,932	93.1	6,014	84.6
Exports	512	6.9	1,096	15.4
Total	7,444	100.0	7,110	100.0

pPreliminary.

Source: The Aluminum Association, Inc.

Table 8.—Net shipments of aluminum wrought[1] and cast products by producers

(Short tons)

	1978	1979	1980[p]
Wrought products:			
Sheet, plate, foil	3,642,651	3,602,560	3,344,395
Rolled and continuous-cast rod and bar; wire	582,831	618,080	606,996
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing and rolled structural shapes	1,311,354	1,263,261	1,151,780
Powder, flake, paste	67,970	62,782	58,012
Forgings (including impacts)	68,203	73,770	66,237
Total	5,673,009	5,620,453	5,227,420
Castings:			
Sand	[r]126,594	[r]142,821	125,760
Permanent mold	[r]229,896	[r]241,131	196,317
Die	[r]666,099	[r]634,596	470,831
Other	[r]21,336	[r]21,714	15,144
Total	[r]1,043,925	[r]1,040,262	808,052
Grand total	[r]6,716,934	[r]6,660,715	6,035,472

[p]Preliminary. [r]Revised.
[1]Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipment of that shape.

Source: U.S. Department of Commerce.

Table 9.—Distribution of wrought products

(Percent)

	1979	1980[p]
Sheet, plate, foil:		
Non-heat-treatable	51.3	51.6
Heat-treatable	4.9	4.5
Foil	7.9	7.9
Rolled and continuous-cast rod and bar; wire:		
Rod, bar, wire	3.5	4.3
Cable and insulated wire	7.5	7.3
Extruded products:		
Rod and bar	.9	1.1
Pipe and tubing	1.4	1.3
Shapes[1]	18.6	17.9
Tubing:		
Drawn	.9	.8
Welded, non-heat-treatable[2]	.7	.9
Powder, flake, paste	1.1	1.1
Forgings (including impacts)	1.3	1.3
Total	100.0	100.0

[p]Preliminary.
[1]Includes a small amount of rolled structural shapes.
[2]Includes a small amount of heat-treatable welded tube.

Source: U.S. Department of Commerce.

STOCKS

Inventories of aluminum ingot, mill products, and scrap at reduction and other processing plants, as reported by the Bureau of Industrial Economics, U.S. Department of Commerce, declined slightly from 2,562,644 tons (revised) at the end of 1979 to 2,530,145 tons at the end of 1980.

PRICES

The price of 99.5% pure primary aluminum ingot, as listed by most domestic producers, was 66 cents per pound at the beginning of 1980. The price was increased early in April to 72 cents per pound and on October 1 to 76 cents per pound, where it remained for the rest of the year. Average monthly U.S. market prices, or spot prices, as published by Metals Week (McGraw-Hill, Inc.) ranged from a high of 90.6 cents per pound in February to a low of 67.4 cents per pound in December.

Prices of secondary smelters' alloyed ingot, as quoted in American Metal Market, ranged from 71 to 83 cents per pound at the end of 1979 and from 82 to 96 cents per pound at the end of 1980. Prices of aluminum-base scrap at yearend 1980 ranged from 22 to 47 cents per pound, depending on the type of scrap and location.

FOREIGN TRADE

Total exports of crude and semicrude aluminum, including scrap, reached a record high level of nearly 1.5 million tons, more than double total imports. Net exports of these commodities added approximately $1.4 billion to the United States balance of trade during 1980. Monthly net exports rose from about 10,000 tons in January to 133,000 tons in August and then declined to 5,000 tons by December. Most of the large gain in exports was attributed to increased shipments of ingot and other crude forms to Japan, other countries in the Far East, and Western Europe, and exports of scrap to Japan.

Total imports of crude and semicrude aluminum, including scrap, declined in 1980, largely because of sharply lower imports of semifabricated products from Western Europe and Japan. Receipts of crude metal and alloys increased slightly, as greater imports from Canada, the principal supplier, more than offset reduced shipments from other traditional sources.

As a result of the Tokyo Round of Trade negotiations completed in 1979, U.S. tariff rates in effect throughout 1980 included the following: Unwrought aluminum (in coils), 3.1% ad valorem; unwrought aluminum (other than aluminum silicon alloys), 0.8 cent per pound; and wrought aluminum (bars, plates, sheets, strip), 3% ad valorem. Effective January 1, 1981, the rate for unwrought aluminum (other than aluminum silicon alloys) was reduced to 0.7 cent per pound.

Table 10.—U.S. exports of aluminum, by class

Class	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	200,650	$264,296	714,906	$1,107,398
Scrap	307,080	290,316	444,681	483,138
Plates, sheets, bars, etc.	248,027	501,850	306,214	715,899
Castings and forgings	7,404	35,671	7,496	30,626
Semifabricated forms, n.e.c	10,224	38,236	9,914	43,686
Total	773,385	1,130,369	1,483,211	2,380,747
Manufactures:				
Foil and leaf	25,171	45,419	43,625	76,929
Powders and flakes	7,182	12,979	8,023	16,928
Wire and cable	11,248	24,137	16,683	36,007
Total	43,601	82,535	68,331	129,864
Grand total	816,986	1,212,904	1,551,542	2,510,611

Table 11.—U.S. exports of aluminum, by class and country

Country	1979						1980					
	Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap		Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Belgium-Luxembourg	692	$978	1,128	$3,257	8,414	$7,479	7,714	$12,569	3,093	$9,064	12,618	$14,688
Brazil	3,160	4,240	5,589	12,441	18,162	14,394	27,300	41,148	5,478	14,855	12,362	13,515
Canada	20,928	30,499	127,466	264,666	14,509	11,762	19,761	32,355	109,922	270,665	17,026	14,404
China:												
Mainland	--	--	283	1,875	--	--	9,433	14,894	101	331	(2)	1
Taiwan	3,882	5,188	968	3,718	7,992	4,459	30,109	46,353	1,833	6,139	14,706	7,613
Denmark	129	235	3,285	6,255	6	6	8	39	2,634	6,414	--	--
El Salvador	1,509	2,021	1,270	1,803	--	--	1,269	2,049	522	1,069	--	--
France	7,004	9,509	6,566	14,786	1,262	1,109	18,916	32,324	9,200	25,302	4,425	3,997
Germany, Federal Republic of	3,476	5,251	6,866	17,885	28,070	22,831	22,451	32,091	10,738	30,365	31,827	31,425
Hong Kong	272	2,169	697	2,256	296	427	7,457	13,799	4,066	10,100	1,750	2,652
India	2	9	33	121	134	91	28,789	44,920	24,677	40,775	1,283	1,338
Israel	335	760	2,887	7,818	55	66	1,295	2,872	3,149	10,229	27	34
Italy	1,294	2,419	7,946	23,306	9,599	8,171	19,456	29,911	8,944	32,322	16,878	17,340
Japan	99,376	118,824	8,329	22,443	173,808	178,207	338,482	503,092	19,007	50,999	269,356	321,214
Korea, Republic of	11,206	14,469	963	2,815	3,375	3,258	43,748	70,112	4,358	10,058	1,876	2,262
Malaysia	1,217	974	1,598	2,040	--	--	2,707	3,687	311	656	82	123
Mexico	24,316	33,209	27,748	50,634	12,370	13,381	38,754	65,591	33,698	69,026	28,526	19,803
Netherlands	3,957	6,948	6,886	16,002	9,883	8,488	34,373	54,775	9,580	24,038	16,288	16,991
Pakistan	695	1,074	336	563	765	541	1,873	2,974	4,754	8,577	2,367	1,307
Panama	1,411	1,659	242	763	--	--	1,368	1,819	250	598	--	--
Philippines	2,511	2,977	619	1,437	187	267	4,782	8,081	236	780	168	269
Saudi Arabia	228	731	2,273	6,565	--	--	1,914	4,232	3,867	11,334	18	29
Singapore	1,760	2,105	676	1,671	386	488	2,046	3,167	1,049	2,814	264	410
Spain	39	29	1,930	4,340	6,409	3,318	13	67	3,865	10,106	4,130	3,038
Sweden	331	407	285	1,260	3,449	2,982	53	108	1,447	3,646	1,143	1,189
United Kingdom	2,756	4,755	23,846	47,136	2,412	2,146	9,751	15,931	15,659	42,724	2,521	2,836
Venezuela	91	153	7,121	14,348	33	43	368	726	16,275	33,716	195	303
Other	8,073	12,704	17,819	43,553	5,504	6,402	40,716	67,712	24,911	63,509	4,845	6,357
Total	200,650	264,296	265,655	575,757	307,080	290,316	714,906	1,107,398	323,624	790,211	444,681	483,138

[1]Includes plates, sheets, bars, extrusions, forgings, and unclassified semifabricated forms.
[2]Less than 1/2 unit.

Table 12.—U.S. imports for consumption of aluminum, by class

Class	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	570,634	$645,769	580,515	$777,606
Circles and disks	10,765	19,929	3,879	8,721
Plates, sheets, etc., n.e.c	168,710	289,671	59,783	123,959
Rods and bars	20,867	31,020	8,571	17,274
Pipes, tubes, etc	674	2,690	490	2,182
Scrap	68,316	59,430	59,802	59,718
Total	839,966	1,048,509	713,040	989,460
Manufactures:				
Foil	8,963	34,906	4,550	27,219
Leaf	([1])	112	([1])	137
Flakes and powders	1,680	3,224	6,114	11,827
Wire	1,563	3,077	728	1,665
Total	12,206	41,319	11,392	40,848
Grand total	852,172	1,089,828	724,432	1,030,308

[1]1979—Aluminum leaf not over 30.25 square inches in area, 1,164,331 leaves, and aluminum leaf over 30.25 square inches in area, 152,758,208 square inches; 1980—aluminum leaf not over 30.25 square inches in area, 1,772,837 leaves, and aluminum leaf over 30.25 square inches in area, 82,489,898 square inches.

Table 13.—U.S. imports for consumption of aluminum, by class and country

Country	1979						1980					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	1,473	$2,128	--	--	--	--	--	--	--	--
Australia	(2)	(2)	6,690	10,577	10	$9	--	--	12,235	$20,869	23	$33
Austria	--	--	3,549	6,507	--	--	--	--	2,026	4,066	--	--
Belgium-Luxembourg	--	--	30,798	50,505	350	513	11	$28	2,559	6,313	358	475
Canada	372,480	$407,948	16,744	30,347	53,955	46,394	485,620	638,184	17,587	32,535	54,019	55,309
France	--	--	15,549	29,270	--	--	425	1,039	4,489	12,687	--	--
Germany, Federal Republic of	2,964	4,841	4,372	10,085	1	(2)	3,905	9,504	1,133	3,928	--	--
Ghana	109,808	134,835	--	--	12	9	84,894	118,665	--	--	178	68
Hong Kong	--	--	2,403	3,921	1	1	--	--	1,070	2,004	--	--
Israel	--	--	1,255	3,255	163	166	--	--	436	1,829	14	28
Italy	2,432	2,729	9,273	15,381	--	--	4	8	2,449	4,680	40	45
Japan	46	233	45,960	83,604	--	--	49	224	9,841	19,004	27	33
Mexico	254	198	797	1,481	1,505	998	348	375	194	489	3,466	2,327
Netherlands	50	87	3,670	11,728	71	212	118	324	3,209	12,172	4	74
Norway	44,056	52,811	12,782	19,527	--	--	2,189	4,327	1,096	2,316	--	--
Romania	113	108	7,557	8,879	--	--	--	--	836	1,082	--	--
Spain	551	747	3,593	5,560	--	--	--	--	1,243	2,448	--	--
Suriname	13,501	13,783	--	--	--	--	--	--	--	--	--	--
Sweden	3,331	3,701	1,464	2,500	--	--	6	62	375	1,242	--	--
U.S.S.R	11	80	--	--	9,886	8,830	11	101	--	--	--	--
United Kingdom	7,635	9,501	7,362	11,185	26	9	2,516	3,476	1,950	5,713	143	174
Venezuela	12,923	13,513	12,099	14,277	1,053	1,251	--	--	4,123	6,591	483	318
Yugoslavia	--	--	10,687	17,509	--	--	--	--	5,155	10,396	--	--
Other	479	654	2,939	5,084	1,283	1,038	419	1,289	717	1,772	1,047	834
Total	570,634	645,769	201,016	343,310	68,316	59,430	580,515	777,606	72,723	152,136	59,802	59,718

[1]Includes circles, disks, bars, plates, sheets, pipes, etc.
[2]Less than 1/2 unit.

WORLD REVIEW

World production of primary aluminum increased 5.5% in 1980 to 16.9 million short tons. World aluminum consumption did not keep pace with production, and stocks of primary aluminum held by members of the International Primary Aluminum Institute (IPAI), which represented the bulk of inventories held outside of the centrally controlled economies, increased 38%, or 635,000 tons, during 1980.

World primary aluminum production capacity increased 4% from the 1979 level to 20.4 million tons. Significant capacity expansions were completed in Australia, Canada, Egypt, France, the U.S.S.R., the United States, and Yugoslavia. New capacity—under construction and announced plans for construction—indicated that much of the world's capacity expansion in the first half of the 1980's will occur in Australia.

The United States and Canada, which provided over two-thirds of the world's aluminum production in 1950, provided only 37% of the total in 1980. The changes in the shares of world production among the industrialized areas during this period and the growth of production in the less industrialized countries of the rest of the world are indicated in the following table:

Country	Percent of world production			
	1950	1960	1970	1980
United States	43.8	40.7	37.4	30.3
Canada	24.2	15.4	10.1	6.9
Japan	1.6	3.0	7.6	7.1
Western Europe	16.5	18.6	20.3	23.3
Eastern Europe[1]	13.5	18.3	15.6	16.2
Australia and New Zealand	--	.3	2.1	3.0
Rest of world	.4	3.7	6.9	13.2

[1]Includes Yugoslavia and the U.S.S.R. in Asia.

Argentina.—Plans were under consideration for an $800 million aluminum complex to be built near Santa Cruz. The complex would include a primary smelter with an annual capacity of 154,000 tons.

Australia.—Comalco Pty. Ltd. began modernization at its Bell Bay, Tasmania, primary smelter that would increase its capacity 6,000 tons to 129,000 tons per year.

Gladstone Aluminium Ltd., formed by Comalco, Kaiser Aluminum & Chemical Corp., and five Japanese companies, began construction of a smelter at Gladstone, Queensland. The first 114,000-ton-per-year potline was scheduled to come onstream in 1982. The second potline was scheduled for 1983. A 228,000-ton-per-year expansion by the installation of two additional potlines was expected by 1990.[7]

Alcan Australia Ltd. announced plans to add a third 50,000-ton-per-year potline at its Kurri-Kurri, New South Wales, smelter. The $145 million expansion would increase the smelter's capacity to 150,000 tons per year and was scheduled to begin production in 1982. The second 50,000-ton-per-year potline was completed in 1980.

Alcan was considering Bundaberg, Queensland, as an alternate location for a 326,000-ton-per-year primary smelter it had considered building at Gladstone, Queensland. A decision was expected in early 1981. The smelter was scheduled to come onstream in 1983.

Reynolds Metals Co., Colonial Sugar Refining Ltd., and Shell of Australia undertook a feasibility study for a 254,000-ton-per-year smelter to be built in Western Australia. Production startup was scheduled for 1985-86. Alcoa of Australia Ltd. also considered plans for a smelter to be built in Western Australia. Alcoa's proposed $800 million facility would have a capacity of 265,000 tons per year.

The current and proposed additions to Australia's primary aluminum smelting capacity were reviewed.[8]

Brazil.—Nippon Amazon Aluminium Co. (NALCO), a consortium of Japanese firms, and Cia. Vale do Rio Doce (CVRD), Brazil's State mining company, reportedly reached agreement on financing of the Alunorte, S.A., 882,000-ton-per-year alumina refinery and the Albras, S.A., 352,000-ton-per-year primary smelter near Belém. The first phase of the smelter project would include construction of two 88,000-ton-per-year potlines and would be financed by NALCO. Startup was scheduled for 1984. The second phase, an additional 176,000 tons per year, would be financed by CVRD.

The Government of Brazil was considering proposals by Kaiser Aluminum & Chemical Corp. and the West German firm Vereinigte Aluminium-Werke A.G. (VAW) to build a 120,000-ton-per-year primary smelter at Recife. The $400 million facility was scheduled to go onstream in 1985, with capacity doubling by 1990.

Alcoa Aluminio do Brasil, S.A., and the Government of Brazil reportedly signed a letter of intent to build an alumina-

Table 14.—Aluminum: World production,[1] by country

(Thousand short tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	698	1,073	1,156	948	[2]1,177
Mexico	47	47	48	48	48
United States	4,251	4,539	4,804	5,023	5,130
South America:					
Argentina	48	55	54	131	[2]131
Brazil	153	184	205	262	282
Suriname	51	[r]64	61	71	55
Venezuela	51	48	84	228	345
Europe:					
Austria	98	101	101	102	104
Czechoslovakia	40	40	41	41	[2]42
France	424	441	431	435	[2]476
German Democratic Republic[e]	65	72	[r]66	[r]71	71
Germany, Federal Republic of	768	818	816	818	[2]806
Greece	148	143	159	155	[2]160
Hungary	78	79	79	79	81
Iceland	72	82	81	80	[2]82
Italy	228	287	298	297	[2]299
Netherlands	282	266	288	286	[2]285
Norway	681	[r]686	704	727	[2]718
Poland[3]	114	115	110	106	100
Romania[4]	[r]224	230	235	239	266
Spain	232	233	234	286	[2]426
Sweden	91	91	90	90	[2]90
Switzerland	86	88	88	91	[2]95
U.S.S.R.[e]	1,760	1,810	1,840	[r]1,930	1,970
United Kingdom	369	386	382	396	[2]413
Yugoslavia	[r]201	[r]195	194	192	[2]204
Africa:					
Cameroon	64	61	54	48	44
Egypt	65	98	111	85	132
Ghana	[r]167	169	123	186	187
South Africa, Republic of	86	86	89	91	91
Asia:					
Bahrain	135	134	135	139	139
China:					
Mainland[e]	[r]350	[r]385	[r]400	[r]400	400
Taiwan	28	33	56	62	[2]70
India	231	[r]204	226	233	[2]204
Iran	34	23	28	15	11
Japan[5]	1,013	1,310	1,166	1,114	[2]1,203
Korea, North[e]	11	11	11	11	11
Korea, Republic of	[r]20	20	22	24	[2]23
Turkey	39	57	35	[e]35	34
United Arab Emirates: Dubai	--	--	--	10	28
Oceania:					
Australia	256	273	290	297	[2]335
New Zealand	154	160	167	171	[2]172
Total	[r]13,913	[r]15,197	15,562	16,053	16,940

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Output of primary unalloyed ingot unless otherwise specified. Table includes data available through May 25, 1981.
[2]Reported figure.
[3]Includes secondary unalloyed ingot.
[4]Includes primary alloyed ingot.
[5]Production of superpure aluminum (99.99% Al) is reported as follows, in short tons: 1976—4,251; 1977—5,138; 1978—4,448; 1979—4,238; 1980—not available. Apparently this production is included in the reported total for unalloyed ingot production.

aluminum complex at São Luis, Maranhão. The $1 billion project would include a 550,000-ton-per-year alumina refinery, scheduled to go onstream in 1983, and a 110,000-ton-per-year primary smelter, scheduled for startup in 1984. The facility would use power from the Tucurui hydroelectric project now under construction.

Canada.—Alcan Aluminium Ltd. began production at its Grande Baie, Quebec, primary smelter. Full production of the first 63,000-ton-per-year potline was expected by mid-1981. Two additional 63,000-ton-per-year potlines were under construction and were scheduled to come onstream in 1981 and 1982. Alcan also began studies for a new primary smelter, which would be built in Manitoba and would be similar to its Grande Baie facility. The new $425 million smelter would have an annual capacity of 188,000 tons.

Alcan and the Canadian Association of Smelter and Allied Workers (CASAW) reached agreement on a new 30-month contract on November 4, 1980.

Canadian Reynolds Metals Co. Ltd. re-

Table 15.—Aluminum: World capacity, by country[1]

(Thousand short tons)

Country	1978	1979	1980
North America:			
Canada	1,175	1,175	1,238
Mexico	50	50	50
United States	5,197	5,282	5,503
South America:			
Argentina	154	154	154
Brazil	251	295	306
Suriname	73	73	73
Venezuela	r215	r446	446
Europe:			
Austria	101	101	101
Czechoslovakia	72	72	72
France	452	474	539
German Democratic Republic	94	94	94
Germany, Federal Republic of	841	841	841
Greece	160	160	160
Hungary	101	101	101
Iceland	84	95	95
Italy	315	353	342
Netherlands	293	293	293
Norway	772	772	772
Poland	127	127	127
Romania	220	220	275
Spain	439	439	439
Sweden	94	94	94
Switzerland	104	104	104
U.S.S.R	3,035	3,230	3,560
United Kingdom	403	403	403
Yugoslavia	226	275	325
Africa:			
Cameroon	68	68	68
Egypt	110	110	147
Ghana	220	220	220
South Africa, Republic of	88	r94	94
Asia:			
Bahrain	132	132	132
China:			
Mainland	300	300	300
Taiwan	83	83	83
India	390	390	390
Iran	55	55	55
Japan	1,803	r1,647	1,550
Korea, North	22	22	22
Korea, Republic of	20	20	20
Turkey	66	66	66
United Arab Emirates: Dubai	--	149	149
Oceania:			
Australia	274	309	405
New Zealand	r176	r176	176
Total	r18,855	r19,564	20,384

rRevised.

[1]Detailed information on the individual aluminum reduction plants is available in a 2-part report which can be obtained from Chief, Division of Finance, Bureau of Mines, Bldg. 20, Federal Center, Denver, CO 80225. Part I of "Primary Aluminum Plants, Worldwide," details location, ownership, and production capacity for 1978-85, and sources of energy and aluminum raw materials for foreign and domestic primary aluminum plants, including those in centrally planned economies. Part II summarizes production capacities for 1978-85 by smelter and country.

portedly was considering plans to expand its Baie Comeau, Quebec, smelter by 75,000 tons per year. Péchiney Ugine Kuhlman (PUK) was considering plans to build a 220,000- to 330,000-ton-per-year primary smelter near Trois Rivieres, Quebec.

China, Mainland.—Construction was begun on an 88,000-ton-per-year primary smelter in the southwestern Province of Guizhou. Production startup was scheduled for 1981. The Government of China postponed indefinitely the proposed 660,000-ton-per-year primary smelter planned for southern Guangxi.

Egypt.—The capacity at Egypt's Nag 'Hammâdi primary aluminum smelter reportedly was increased by 36,000 tons per year to 147,000 tons per year.

Guyana.—In October the World Bank approved an $8 million loan to Guyana for technical investigations of five potential hydroelectric power sites, including the site for the previously proposed Upper Mazaruni River project. This project would include a dam and hydroelectric powerplant of 750 megawatts or more capacity and an aluminum smelter of 165,000 tons annual capacity. A feasibility study for a smelter based on Upper Mazaruni power was completed in 1976.

India.—PUK and Bharat Aluminium Co. agreed to construct and operate an integrated aluminum project near Koraput, Orissa. The project would include development of bauxite deposits and construction of an 880,000-ton-per-year alumina refinery and a 240,000-ton-per-year primary smelter. PUK would provide technical assistance for the project. The project was estimated to cost $1.2 billion.

Indonesia.—An agreement was reportedly reached between P.T. Indonesia Asahan Aluminium (Inalum) and Japan's five aluminum companies to supply 714,000 tons per year of alumina over 4 years beginning in 1981 to the 248,000-ton-per-year primary smelter now under construction in North Sumatra. Initial production of 83,000 tons per year was scheduled to begin in 1982, and full production was scheduled for 1984.

Japan.—Nippon Light Metal Co. Ltd. (NLM) closed the remaining 24,000 tons per year of capacity at its 162,000-ton-per-year Niigata primary smelter by yearend 1980. In 1979, 42,000 tons per year of capacity was scrapped, and in 1980, NLM announced it would sell 96,000 tons per year of capacity that had been deactivated earlier to Alusaf Pty. Ltd. of the Republic of South Africa.

Showa Light Metal Co. scrapped 162 pots at its Chiba primary smelter, reducing capacity by 47,000 tons per year to 140,000 tons per year. Mitsubishi Light Metal Industry Ltd. scrapped 50,000 tons per year at its 212,000-ton-per-year Sakaide smelter.

Sumitomo Aluminium Smelting Co. announced plans to acquire its affiliate, Sumitomo Toyo Aluminium Refining Co.

Malaysia.—Plans for a $1.6 billion, 180,000-ton-per-year primary smelter at Labaun, Sabah, were postponed because of insufficient natural gas to generate electric power for the smelter.

Mexico.—Alcan Aluminium Ltd. undertook a feasibility study for construction of a joint-venture 50,000-ton-per-year primary aluminum smelter to be built near Tampico on the Gulf of Mexico. The study was funded jointly by Alcan and Conalum S.A.

New Zealand.—Plans of New Zealand Aluminium Smelters Ltd. to expand its smelter at Bluff by adding a third 90,000-ton-per-year potline, increasing capacity to 267,000 tons per year, were approved by the New Zealand Government. The $167 million expansion was scheduled to come onstream in 1983.

The Government of New Zealand also approved plans for a 220,000-ton-per-year primary smelter to be built near Dunedin, South Island. Participants in the project would be Fletcher Holdings of New Zealand (50%), Swiss Aluminium Australia Ltd. (25%), and Gove Alumina Ltd. (25%).

Philippines.—Reynolds Metals Co. and the Government of the Philippines reportedly signed an agreement to build a 154,000-ton-per-year primary smelter to be located on Mindanao Island at Misamis, Oriental. The $450 million facility was scheduled to come onstream in 1985.

Saudi Arabia.—Plans for a new smelter at Jubail were canceled.

South Africa, Republic of.—Alusaf Pty. Ltd. evaluated plans to double the capacity at its 94,000-ton-per-year primary smelter at Richards Bay. The cost of the expansion was estimated at $310 million.

Spain.—Alcan Aluminium Ltd. and Instituto Nacional de Industria announced that an agreement was signed on June 3, 1980, to increase Alcan's participation in Empresa Nacional del Aluminio, S.A. (ENDASA) to 42.5%. ENDASA operated two primary aluminum smelters in Spain with a combined capacity of 136,000 tons per year and had a 55% interest in the new smelter at San Ciprián de Viñas.[9]

Trinidad and Tobago.—A joint venture with the Government of Trinidad and Tobago, Southwire Co., and National Steel Corp. has been proposed for the construction of a 198,000-ton-per-year primary aluminum smelter in Trinidad. The smelter would cost an estimated $425 to $450 million and would begin production in 1984.

U.S.S.R.—The Aluminum Co. of America (Alcoa) discontinued talks with the U.S.S.R. Ministry of Trade on the planned $1 billion, 440,000-ton-per-year primary smelter to be built at Sayansk, Siberia. West German and French affiliates of Klöckner & Co. reportedly agreed to supply equipment for the smelter. The U.S.S.R. was to supply the technology that Alcoa originally was to contribute.

United Arab Emirates.—The construction and operation of the 149,000-ton-per-year primary aluminum smelter in Dubai, which began production late in 1979, were described.[10]

TECHNOLOGY

Much of the research and development on aluminum production in 1980 was related to energy conservation because of the continuing rise in energy costs and the limited availability of traditional sources of energy. Current and future energy use by the aluminum industry and energy conservation through the use and recycling of aluminum were analyzed in a number of papers and publications.[11]

In primary aluminum production technology, progress in the development of new high-intensity reduction cells was reported.[12] Aluminium Pechiney's 175,000-ampere reduction pots were reported to have increased production per unit of pot area, decreased electricity use per ton, and improved fume and dust collection. Pechiney was reportedly researching the use of 230,000- to 250,000-ampere cells.

The U.S. Department of Energy (DOE) and Alcoa agreed on joint funding of a 5-year program to continue development of an inert anode for use in the electrolytic reduction process. If successful, the anode, possibly made of mixed oxides, would reduce the need for petroleum coke, reduce electricity requirements, eliminate the carbon dioxide and carbon monoxide given off at conventional carbon anodes, and eliminate the need for frequent anode replacement. Under another agreement with DOE, Kaiser Aluminum continued research on the use of titanium diboride cathodes in aluminum electrolytic cells as a means of increasing energy efficiency. Reportedly, Alcoa was also investigating the use of titanium diboride cathodes.

A series of papers reporting research on explosions caused by molten aluminum and water and on procedures for the safe handling of molten aluminum were published.[13]

Alcoa continued development of its aluminum chloride smelting process at its experimental smelter at Palestine, Tex. Although the company reported problems in the chemical plant that provided feed for the smelter, development was continued because of potential energy savings and environmental improvements in the reduction process. The Japan Aluminum Federation, supported by Japan's primary aluminum producers and the Government, also began testing an electrolytic process to produce aluminum from aluminum chloride at the Kambara smelter of Nippon Light Metal Co. Ltd.

Rapidly solidified powders (RSP) were being investigated as a source of new aluminum alloys, and the performance of products made from consolidated RSP was being evaluated. Rapid freezing of molten droplets of metal enables the entrapment of greater quantities of alloying metals and metals that would not alloy with aluminum under slower cooling conditions. In addition to the number of alloys possible, the consolidated powders have better dispersion of alloying elements. Products made by this process have improved mechanical properties, such as strength to weight ratios, and may have higher-temperature applications.[14]

Aluminum and other products have been recovered from municipal solid wastes at a continuous separation pilot plant operated by the Bureau of Mines. A report describing the operation of the pilot plant, the effect of various modifications, and details on the products recovered was published.[15] The Bureau also developed a hydrometallurgical method to recover aluminum, aluminum oxide, and fluxing salts from aluminum salt slags produced during the processing of aluminum dross and scrap.[16] The purpose of the development was to reduce slag disposal and pollution problems as well as to recycle the fluxing salts and aluminum values in the slag. In the process, the slag is leached with water, screened to recover an aluminum-rich fraction, and vacuum filtered to produce an aluminum oxide filter cake. The filtrate is evaporated to recover the fluxing salt for reuse in the dross furnace.

Papers assessing aluminum production and markets in the 1980's were presented at a conference sponsored by the American Society of Mechanical Engineers.[17] Bureau of Mines methodologies used in making statistical projections and contingency forecasts of aluminum consumption were published.[18]

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[1]Industry economist, Section of Nonferrous Metals.

[2]Statistical assistant, Section of Nonferrous Metals.

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Antimony

By Patricia A. Plunkert[1]

The consumption of antimony declined in 1980 from that of 1979. Technological changes in the types of alloys used in automotive batteries have sharply reduced the use of antimony as a hardener for battery grids in recent years. The use of antimony trioxide declined owing to a general slowdown in the automotive and construction industries.

Domestic mine production decreased significantly in 1980 owing to an 8-month strike at the Sunshine Mine in Kellogg, Idaho. Imports in 1980 were also down from those of 1979 as the result of the general softening of demand in the antimony market.

Legislation and Government Programs.—The General Services Administration (GSA) reported that Government stocks of antimony totaled 40,729 short tons at yearend. The Government stockpile goal was raised to 36,000 tons in May 1980 compared with the previous goal of 20,130 tons.

Antimony and antimony trioxide are two of the substances that will be taxed under Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, or Superfund, which was signed by the President on December 11, 1980. The taxes, which are to be collected from producers and importers beginning April 1981, were set at $4.45 per short ton of antimony and $3.75 per short ton of antimony trioxide. A major provision of the law is the establishment of a $1.6 billion Hazardous Substance Response Fund to clean up disposal sites and spills of hazardous substances. The tax terminates on September 30, 1985.

Table 1.—Salient antimony statistics

(Short tons)

	1976	1977	1978	1979	1980
United States:					
Production:					
Primary:					
Mine	283	610	798	722	343
Smelter[1]	14,618	12,827	14,110	15,062	16,062
Secondary	19,799	30,601	26,456	24,155	NA
Exports of metal and alloys	341	742	556	485	453
Imports for consumption (antimony content)	21,770	13,335	r17,516	r22,141	17,996
Consumption[1]	15,337	13,823	13,152	11,753	11,239
Stocks, primary antimony, all classes, (antimony content), Dec. 31	15,070	8,591	8,201	7,144	8,411
Price: New York, average cents per pound	165.26	178.00	[2]175.00	[2]196.00	[2]200.00
World: Production	r71,388	r74,575	r69,409	r71,933	74,065

rRevised. NA Not available.
[1]Includes primary antimony content of antimonial lead produced at primary lead refineries.
[2]Antimony price in alloy, cents per pound.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of primary antimony in 1980 by two companies was down from that of 1979. The United States Antimony Corp. (USAC) produced antimony from the stibnite mined at the Babitt, Bardot, and Black Jack Mines at Thompson Falls, Mont. In 1980, USAC produced 260 tons of antimony compared with 299 tons in 1979. USAC discovered that one of its antimony veins contains a large tungsten deposit. By the end of 1981, the company plans to double the ore capacity of its mill to 40,000 tons of ore per year thereby increasing antimony production to 1.2 million pounds per year. The Sunshine Mining Co. operated the Sunshine Mine in the Coeur d'Alene District of Idaho and produced 83 tons of antimony, a decrease of 340 tons from the 1979 output. This decrease was the result of a work stoppage owing to disagreements between labor and management at the mine and mill that lasted more than 8 months. Antimony was produced as a byproduct of the treatment of tetrahedrite, a complex silver-copper-antimony sulfide, one of the principal ore minerals in the Kellogg, Idaho, area.

Antimony was also produced as a byproduct in smelting primary lead. The total antimony supply from domestic mines was 361 tons in 1980.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate	Antimony	
		Produced	Shipped
1976	1,111	283	310
1977	3,496	610	534
1978	4,231	798	863
1979	3,294	722	701
1980	3,041	343	382

SMELTER PRODUCTION

Primary.—Production of primary antimony products in 1980 was 16,062 tons. The production of metal in 1980 dropped sharply as primary smelters turned to antimony oxide production owing to the drop in demand for antimony metal. The increase in oxide production over the 1979 level was due in part to the inclusion of production from the new plant in Omaha, Nebr., of ASARCO Incorporated. Asarco obtains its antimony as a byproduct of its lead refining process. Anzon America Inc., through its parent company, Lead Industries Group Overseas Ltd. (LIG), purchased the 49% share held by NL Industries, Inc., in the Mexican antimony mining company, Cia. Minera y Refinadora, S.A. Anzon's antimony oxide plant at Laredo, Tex., is situated on a direct rail link with the antimony mine at Wadley, Mexico. The other major producers of antimony oxide were Harshaw Chemical Co., Gloucester City, N.J.; McGean Chemical Co., Inc., Cleveland, Ohio; M & T Chemicals Inc., Baltimore, Md.; and PPG Industries, Inc., La Porte, Tex. Producers of antimony metal included Sunshine Mining Co., Kellogg, Idaho, and USAC at Thompson Falls, Mont., which also produced sodium antimonate.

Secondary.—Production of antimony from secondary sources decreased in 1979 from that of 1978. Data were not available for 1980. Old scrap, predominantly battery plates, was the source of most of the secondary output; new scrap, mostly in the form of drosses and residues from various sources, supplied the remainder. The antimony content of scrap is usually recovered and consumed as antimonial lead with removal or addition of antimony as required in the refining stage to meet specifications for various antimonial lead alloys.

Table 3.—Primary antimony produced in the United States

(Short tons of antimony content)

Year	Class of material produced: Metal	Oxide	Residues	Byproduct antimonial lead	Total
1976	3,102	10,628	191	697	14,618
1977	1,877	9,907	277	766	12,827
1978	1,108	12,117	184	701	14,110
1979	2,642	12,141	--	279	15,062
1980	507	15,461	64	30	16,062

Table 4.—Byproduct antimonial lead produced at primary lead refineries in the United States

(Short tons)

Year	Gross weight	Antimony content				
		From domestic ores[1]	From foreign ores[2]	From scrap	Total: Quantity	Total: Percent of gross weight
1976	6,743	355	342	33	730	10.8
1977	7,557	598	168	134	900	11.9
1978	5,518	539	162	82	783	14.2
1979	3,750	208	71	20	299	8.0
1980	971	18	12	--	30	3.1

[1]Includes primary residues and a small quantity of antimony ore.
[2]Includes foreign base bullion and small quantities of foreign antimony ore.

Table 5.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons of antimony content)

	1979
Kind of scrap	
New scrap:	
Lead-base	4,713
Tin-base	15
Total	4,728
Old scrap:	
Lead-base	19,415
Tin-base	12
Total	19,427
Grand total	24,155
Form of recovery	
In antimonial lead[1]	20,367
In other lead alloys	3,774
In tin-base alloys	14
Total	24,155
Value (millions)	$94.5

[1]Includes 20 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1979.

CONSUMPTION AND USES

Domestic consumption of primary antimony in 1980 declined for the fourth consecutive year. The use of antimonial lead in the manufacture of starting-lighting-ignition (SLI) batteries for the automotive industry remained a major outlet, but the increased use of maintenance-free batteries has resulted in a decline in the use of antimony metal. The lead-calcium-tin alloy in maintenance-free battery systems uses no antimony. A reduction of 11% in SLI battery shipments in 1980 compared with those of 1979 also contributed to lower antimony usage. In a joint venture the U.S. Department of Energy, the Electric Power Research Institute, the Rural Electrification Administration, and two Michigan utilities are expected to build a lead acid battery load-leveling facility in the next 3 years. C & D Batteries, a division of the Eltra Corp., will supply the batteries for this facility. Load-leveling batteries enable utilities to produce and store electricity during off-peak hours and to later discharge the batteries back into their transmission system, thereby increasing the efficiency of their generating plant.

Antimony alloyed with lead also finds industrial use in chemical pumps and pipes, tank linings, roofing sheets, and cable sheaths. In these alloys, antimony increases strength and inhibits chemical corrosion.

The use of antimony in nonmetal products in 1980 increased slightly above that of 1979. Nonmetallic antimony was used in plastics both as a stabilizer and as a flame retardant. Antimony was used as a decolorizing and refining agent in some types of glass such as special optical glass.

The use of antimony oxide as a flame retardant decreased in 1980 owing primarily to a slowdown in the automotive and construction industries. Antimony trioxide in an organic solvent is used to make fabrics, plastics, and other combustibles flame retardant. Flames accompanying initial combustion are restricted or extinguished by chemicals released by heat from the treated materials.

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons of antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1976	640	3,375	10,397	37	191	697	15,337
1977	160	2,625	9,959	36	277	766	13,823
1978	131	2,709	9,399	28	184	701	13,152
1979	15	1,899	9,528	32	--	279	11,753
1980	--	1,648	9,469	28	64	30	11,239

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons of antimony content)

Product	1976	1977	1978	1979	1980
Metal products:					
Ammunition	63	138	133	253	362
Antimonial lead	3,861	2,936	2,832	1,300	748
Bearing metal and bearings	405	265	279	235	223
Cable covering	19	16	21	r16	31
Castings	24	13	15	r14	10
Collapsible tubes and foil	23	16	17	24	18
Sheet and pipe	74	56	39	36	29
Solder	188	220	206	199	134
Type metal	79	83	81	37	21
Other	164	104	113	99	74
Total	4,900	3,847	3,736	2,213	1,650
Nonmetal products:					
Ammunition primers	13	13	13	23	20
Fireworks	12	9	5	6	4
Ceramics and glass	1,260	1,547	1,259	1,127	1,303
Pigments	415	400	410	399	499
Plastics	1,277	1,503	1,456	1,580	1,636
Rubber products	578	473	254	182	325
Other	1,330	266	165	140	107
Total	4,885	4,211	3,562	3,457	3,894
Flame retardant:					
Plastics	3,777	3,972	4,063	4,262	3,874
Pigments	183	149	33	35	56
Rubber	199	219	196	146	189
Adhesives	141	246	298	302	461
Textiles	1,055	997	990	1,143	942
Paper	197	182	274	195	173
Total	5,552	5,765	5,854	6,083	5,695
Grand total	15,337	13,823	13,152	11,753	11,239

rRevised.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons of antimony content)

Stocks	1976	1977	1978	1979	1980
Ore and concentrate	7,899	1,869	1,610	1,757	2,743
Metal	1,662	1,359	1,119	1,184	680
Oxide	4,560	4,576	4,906	3,398	3,855
Sulfide	31	24	19	17	13
Residues and slags	475	516	457	730	1,116
Antimonial lead[1]	443	247	90	58	4
Total	15,070	8,591	8,201	7,144	8,411

[1]Inventories from primary sources at primary lead refineries only.

PRICES

The price of antimony in alloy remained at $2 per pound in 1980. The New York dealer price for antimony metal, quoted in January at $1.45 to $1.50 per pound, gradually increased to a high of $1.58 to $1.65 in April, but finished the year at $1.47 to $1.51. The industry price quotation for antimony trioxide was increased to $1.65 to $1.80 per pound in late January reportedly reflecting higher operating costs. In July, Asarco trimmed its price to $1.50 to $1.60 owing to a fall in demand, especially in the automotive and housing industries. Most of the other producers, however, continued to publish a price of $1.80 per pound through the end of the year. In April, the European market quotation for lump ore, on a 60% antimony basis, was placed at $23.50 to $25 per metric ton unit where it remained through yearend.

Table 9.—Antimony price ranges in 1980

Type of antimony	Price per pound
Domestic metal[1]	$2.00
Foreign metal[2]	$1.45-1.65
Antimony trioxide[3]	1.50-1.80

[1]Based on antimony in alloy.
[2]Duty-paid delivery, New York.
[3]Producer price.

FOREIGN TRADE

Total imports of antimony (antimony content) in 1980 decreased 19% compared with those of 1979. Most of the decrease was the result of lower imports of antimony ore and concentrates and antimony oxide, which had been increasing over the past several years.

In 1980, most of the antimony metal imports came from Bolivia. The Republic of South Africa remained the largest single source for imports of antimony oxide in 1980, followed by mainland China and France.

Imports of ore and concentrate declined in 1980 compared with 1979. Bolivia, Mexico, and Canada provided most of the imported antimony ore in 1980.

In January 1980, mainland China was granted most-favored-nation (MFN) trade status, which decreased the duty on commodities imported into the United States.

Tariff: Item	Number	Most-favored-nation (MFN) January 1, 1980	Most-favored-nation (MFN) January 1, 1979	Non-MFN January 1, 1980
Ore	601.03	Free	Free	Free
Needle or liquated	603.10	0.1 cent per pound	0.1 cent per pound	0.25 cent per pound
Metal, unwrought	632.02	0.9 cent per pound	1.0 cent per pound	2 cents per pound
Antimony oxide	417.50	0.3 cent per pound	0.3 cent per pound	2 cents per pound

Table 10.—U.S. imports for consumption of antimony, by country

Country	1979		1980	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Antimony metal:				
Belgium-Luxembourg	r339	r$916	172	$458
Bolivia	672	1,581	1,625	4,366
Burma	r55	r146	--	--
Canada	23	162	25	397
Chile	11	28	117	235
China, mainland	1,360	3,369	457	1,231
Dominican Republic	r1	r2	--	--
Germany, Federal Republic of	(1)	27	(1)	38
Hong Kong	28	61	--	--
Mexico	406	410	139	412
Peru	30	54	--	--
Spain	20	50	--	--
United Kingdom	(1)	4	--	--
Uruguay	--	--	55	140
Yugoslavia	77	201	--	--
Total	r3,022	r7,011	2,590	7,277
Antimony oxide:				
Belgium-Luxembourg	462	1,268	214	651
Bolivia	979	2,163	927	2,088
Canada	38	45	19	64
China:				
Mainland	1,846	4,351	2,388	6,092
Taiwan	42	95	--	--
France	1,734	4,328	1,055	2,861
German Democratic Republic	--	--	23	67
Germany, Federal Republic of	4	7	20	54
Hong Kong	--	--	20	50
Italy	141	370	20	54
Japan	124	298	35	92
Mozambique	--	--	19	6
Netherlands	--	--	20	55
South Africa, Republic of	7,268	2,194	7,047	2,137
Switzerland	19	122	19	120
United Kingdom	1,022	2,680	398	1,380
Total	13,679	17,921	12,224	15,771
Antimony sulfide:[2]				
Austria	5	34	2	14
Belgium-Luxembourg	28	90	8	27
France	--	--	8	27
United Kingdom	17	131	16	148
Total	50	255	34	216

rRevised.
[1]Less than 1/2 unit.
[2]Includes needle or liquated.

Table 11.—U.S. imports for consumption of antimony ore and concentrate, by country

Country	1979			1980		
	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)
Bolivia	2,716	1,694	$2,464	3,543	2,336	$6,608
Canada	2,732	1,716	2,924	1,624	1,017	2,073
Chile	1,636	1,067	1,944	79	56	131
Colombia	35	16	28	--	--	--
Denmark	40	10	38	--	--	--
Guatemala	--	--	--	107	64	127
Honduras	6	2	8	27	6	2
Mexico	5,725	1,613	1,911	4,771	1,252	1,501
Peru	37	35	57	--	--	--
South Africa, Republic of	1,247	733	1,245	694	397	996
Thailand	857	459	777	199	107	208
United Kingdom	449	212	223	--	--	--
Uruguay	265	175	241	--	--	--
Total	15,745	7,732	11,860	11,044	5,235	11,646

Table 12.—U.S. imports for consumption of antimony

Year	Antimony ore and concentrate: Gross weight (short tons)	Antimony ore and concentrate: Antimony content (short tons)	Antimony ore and concentrate: Value (thousands)	Antimony sulfide[1]: Gross weight (short tons)	Antimony sulfide[1]: Antimony content (short tons)	Antimony sulfide[1]: Value (thousands)	Antimony metal[2]: Gross weight (short tons)	Antimony metal[2]: Value (thousands)	Antimony oxide: Gross weight (short tons)	Antimony oxide: Antimony content (short tons)	Antimony oxide: Value (thousands)
1978	8,672	4,495	$6,174	r60	40	r$163	4,127	$7,897	10,667	8,854	$18,803
1979	15,745	7,732	11,860	r50	34	r255	3,022	r7,011	13,679	11,353	17,921
1980	11,044	5,235	11,646	34	23	216	2,590	7,277	12,224	10,148	15,771

r Revised.
[1] Includes needle or liquated.
[2] Does not include alloy containing 83% or more antimony.

WORLD REVIEW

Bolivia.—Bolivia remained the world's largest producer of antimony in 1980. Empressa Nacional de Fundiciones continued to produce metal and oxide at its Vinto refinery using the cyclone furnace smelting process in which antimony is volatized as antimony sulfide and, following an afterburn operation, is separated in a baghouse as high-concentration antimony trioxide. Design capacity of the installation was 9,300 tons of concentrate per year with an average content of 63.2% antimony. Anticipated annual production was 4,270 tons of metal, 1,000 tons of alloys, and 1,000 tons of antimony trioxide. Total antimony recovery for the smelter was reported to be 92%.

Cameroon.—The French-based Bureau de Recherches Géologiques et Minières began an investigation of a 70,000-square-kilometer area in southwest Cameroon to determine the possibilities of mining the iron, tin, titanium, antimony, and uranium deposits there. The study was funded by the French Government and the European Development Fund.

Canada.—Consolidated Durham Mines and Resources Ltd. discovered what could prove to be a very significant ore body at its Lake George antimony mine in New Brunswick. A deep drilling program outlined approximately 710,000 tons of mineralization grading 3.1% antimony. The company reported that this discovery could lead to a mill expansion from the present 400 tons to about 650 tons per day.

In British Columbia, a leaching plant, designed by Placer Development Ltd. to remove antimony and arsenic from the complex ore body of its Equity Silver Mine, is expected to be operating in early 1981 following a 6-month construction delay. The process is similar to that used at the Sunshine Mine in Idaho. The antimony will be recovered as antimony metal by electrowinning and sold on the world market.

China, Mainland.—Hsikwangshan and nearby areas in southwestern Hunan Province have long been China's main antimony producing districts. Kwangtung Province ranks a distant second in potential and output. Geologists have found verified deposits of antimony in the Province of Shaanxi. The reserves, 17,000 tons of antimony, are located in Xunyang County, south of the Qin Ling Mountain Range.

South Africa, Republic of.—Despite the production of byproduct gold, Consolidated Murchison Ltd. (CML) cut its antimony mine milling rate from 45,000 tons to 30,000 tons per month because of reduced demand for antimony oxide. CML expects this level of production to be sufficient to meet current demand without drawing on accumulated stocks. The oxide is produced by Antimony Products (Pty.), Ltd., which is owned in fairly equal proportions by CML, Chemetron Corp., McGean Corp., and the United Kingdom's LIG.

Yugoslavia.—Rudarsko Topionicki Bazen Zajaca (RTB-Zajaca) is planning to open the new Vinogradi antimony mine in Loznica, Serbia, about 60 miles east of Belgrade. Production is expected to be about 1,900 tons per year of concentrates from 60,000 tons per year of ore.

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[1]Physical scientist, Section of Nonferrous Metals.

Table 13.—Antimony: World mine production (content of ore unless otherwise indicated), by country[1]

(Short tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada[e 2]	2,535	3,500	3,310	3,255	2,360
Guatemala	1,235	[r]1,010	254	728	805
Honduras	129	[r]114	164	165	165
Mexico[3]	2,806	2,974	2,708	3,166	3,200
United States[4]	283	610	798	722	[5]343
South America:					
Argentina	2	[r]2	--	--	--
Bolivia	18,756	[r]18,012	14,702	14,351	[5]17,047
Brazil	[r]30	[r]289	216	[r e]220	220
Peru (recoverable)	665	[r]903	821	841	850
Europe:					
Austria	588	564	561	629	600
Czechoslovakia	314	[e]330	[e]330	[e]330	330
Greece	[r]25	--	--	--	--
Italy	1,112	891	1,026	1,045	1,050
Spain	287	[r]349	487	552	550
U.S.S.R.[e]	8,500	8,700	8,700	9,000	9,000
Yugoslavia	2,228	2,478	2,950	2,245	1,700
Africa:					
Morocco	[r]1,549	1,553	2,437	2,175	2,200
South Africa, Republic of[6]	[r]11,890	12,715	10,024	12,844	[5]14,410
Zimbabwe	330	330	280	280	260
Asia:					
Burma	[r]502	[r]616	683	783	830
China, mainland[e]	[r]9,300	[r]11,000	[r]11,000	[r]11,000	11,000
Korea, Republic of	11	--	(7)	--	--
Malaysia (Sarawak)	276	488	484	563	275
Pakistan	[r]12	[r]21	23	7	10
Thailand	4,047	2,705	3,167	3,235	3,140
Turkey	1,890	2,118	[e]2,610	[r e]2,080	2,000
Oceania: Australia[8]	2,086	2,303	1,674	1,717	1,720
Total	[r]71,388	[r]74,575	[r]69,409	71,933	74,065

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 27, 1981.
[2]Partly estimated on the basis of reported value of total production.
[3]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[4]Production from antimony mines; excludes a small amount produced as a byproduct of domestic lead ores.
[5]Reported figure.
[6]As reported by the Government of the Republic of South Africa; differs slightly from data reported by the nation's only significant producer, Consolidated Murchison. Official figures apparently represent content of hand-cobbed ores and antimony concentrates, apparently excluding antimony content of arsenical concentrates reported as follows by Consolidated Murchison in short tons: 1976—1,257; 1977—1,337; 1978—1,173; 1979 and 1980—Nil.
[7]Revised to zero.
[8]Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.

Asbestos

By R. A. Clifton[1]

Shipments of asbestos (all chrysotile) in 1980 from mines in the United States decreased 14% from those in 1979. Imports in 1980 were 36% lower than those in 1979.

U.S. apparent consumption declined 36% in 1980. Canadian production in 1980 was 13% lower than that for 1979. Shipments from Canada to the United States dropped 36% during 1980. Imports from Canada were 96% of total U.S. imports in 1980, and those from the Republic of South Africa accounted for 3%.

Table 1.—Salient asbestos statistics

	1976	1977	1978	1979	1980
United States:					
Production (sales) metric tons	104,873	92,256	93,097	93,354	80,079
Value thousands	$23,693	$25,267	$27,987	$28,925	$30,599
Exports and reexports (unmanufactured) metric tons	42,564	34,896	45,380	45,850	51,366
Value thousands	$12,791	$12,075	$20,533	$24,165	$29,677
Exports and reexports of asbestos products (value) do	$60,572	$62,665	$119,915	$130,906	$133,043
Imports for consumption (unmanufactured) metric tons	596,737	550,693	570,020	513,084	327,296
Value thousands	$142,145	$145,146	$154,351	r$135,210	$91,809
Released from stockpile (unmanufactured) metric tons	501	188	--	r1	--
Consumption, apparent[1] do	658,847	609,157	618,706	r560,600	358,700
World: Production do	r4,767,071	r4,793,257	r4,692,994	r4,889,688	4,818,369

rRevised.
[1]Measured by quantity produced, plus imports, plus stockpile releases, minus exports.

Legislation and Government Programs.—No date was set by the Occupational Safety and Health Administration (OSHA) for the public hearings mandatory for the proposed revisions to its asbestos standard for manufacturing. The proposal for a permissible-exposure level of 0.5 fibers per cubic centimeter has been pending for 6 years, with no hearings scheduled.

Asbestos was among the 61 chemical substances named by the Environmental Protection Agency (EPA) in a proposed rule under section 8(d) of the Toxic Substances Control Act. According to the proposal published December 31, 1979, in the Federal Register, all manufacturers, processors, distributors, and others in possession of the substances would be required to submit health and safety studies extant that are pertinent to the substance.

On March 28, 1980, the Interagency Regulatory Liaison Group (IRLG) announced in the Federal Register that four of its member agencies would implement an inspection referral program. A standardized procedure was adopted by which the four—EPA, Consumer Product Safety Commission (CPSC), Food and Drug Administration, and the Food Safety and Quality Service of the Department of Agriculture—would report suspected violations to the responsible agency. OSHA, while an IRLG member, deferred joining the program.

In the Federal Register of May 23, 1980, OSHA finalized its rule (effective August 21) requiring employers to make available to employees, their designated representatives, and OSHA the employees' asbestos exposure and medical records.

On June 14, 1980, the President signed

into law the Asbestos School Hazard Detection and Control Act of 1980. The bill provides funds for hazard detection grants and loans for detected hazard control.

On July 2, 1980, the U.S. Supreme Court upheld a lower court's findings invalidating OSHA's benzene standard. The lower court noted that OSHA, rather than demonstrating by substantial evidence that a reduction in the benzene permissible-exposure level would result in a significant reduction in the carcinogenic risk of exposure, relied on a series of assumptions and policy positions relative to the regulation of suspected carcinogens. OSHA's position that there is no safe level of exposure to a carcinogen, and that the burden was on industry to show that there is a safe level of exposure, was flatly rejected.

On November 5, 1979, under Section 7(a)(1) of the Strategic and Critical Materials Stock Piling Act, President Carter released 1,000 short tons of high-quality chrysotile asbestos to the Department of Defense. The shortage of these fibers was delaying the production of some weapons subsystems.

Stockpile goals for both chrysotile and amosite were revised in May of 1980. The new goals are shown in table 2.

Environmental Impact.—A trade journal article described the asbestos-related disease liability insurance in its headline as "...Becoming Problem of Monstrous Proportions."[2] Citing the Johns-Manville Corp.'s problems, the article said that the company was named a defendant in more than 5,000 suits by more than 9,300 people and that case costs have risen from $13,000 per claim in 1979 to $23,000 in 1980. In calling the problem "monstrous," William N. Edwards of American Re-Insurance Corp. said that by toting up plaintiffs and defendants, he surmised that loss and loss adjustment expense for claims filed in 1981 will approximate $1.35 billion.

The cancer policy published by OSHA in the Federal Register (January 22, 1980) to become effective April 21, 1980, would impact greatly on the asbestos industry if it were not probably contravened by the Supreme Court benzene decision. Under the rule, asbestos would undoubtedly be classified as Category I—substances that have been found to cause cancer in humans. The policy provides for lowering exposure to Category I agents to the lowest feasible levels and where suitable substitutes exist for certain uses, *no* occupational exposure will be permitted for those uses.

An article in a business magazine reported that neither labor nor industry likes the policy; among the things industry did not like was that OSHA has effectively barred the inclusion of human and animal studies that show no evidence of cancer after exposure to a suspected carcinogen.[3] Industry maintains that knowledge of vital scientific value may be excluded. (The National Institute of Environmental Health Science' (NIEHS) animal feeding study on the carcinogenicity of ingested asbestos could not be included in any deliberations of OSHA if the results continue as reported, and the cancer policy remains as written.) Concessions to industry such as omission of a provision to trigger temporary emergency standards for Category I substances have cut off much of labor's support.

Table 2.—Stockpile goals and Government inventories as of December 31

(Metric tons)

	Stockpile goals[r]	Total inventories			Sales of excesses, 1980
		1978	1979	1980	
Amosite	15,422	38,587	38,587	38,587	--
Chrysotile	2,722	9,940	[r]9,034	9,034	--
Crocidolite	--	2,163	2,163	2,163	--
Total	18,144	50,690	[r]49,784	49,784	--

[r]Revised.

DOMESTIC PRODUCTION

Mines in the United States shipped about 14% less asbestos in 1980 than in 1979, but the value increased 6%. Three States produced asbestos: California was the leader, followed by Vermont and Arizona. Total output was 80,079 tons valued at $30.6 million.

Calaveras Asbestos Corp. was California's and the Nation's leading producer from its Copperopolis Mine. One other mine was also active in California on the Joaquin Ridge near Coalinga. Atlas Asbestos Corp. apparently closed its Santa Cruz Mine (Fresno County), and Union Carbide Corp. operated its Santa Rita Mine (San Benito County), both on the ridge.

The Vermont Asbestos Group's Lowell Mine (Orleans County, Vt.), is second in the country in production.

Arizona production in 1980 was below the 1979 level. The Jaquays Mining Corp. in Gila County had the only active asbestos mine in the State.

Powhatan Mining Co. has gone out of business. No anthophyllite is now mined in the United States.

The Alaska Asbestos Co., jointly owned by International Paper Co., McIntyre Mines, Ltd., and Tanana Asbestos Corp., is maintaining an active program of drilling and engineering feasibility tests at the Eagle property owned by Doyon, Ltd. The work is being done by WGM, Inc., for a 5% interest. U.S. asbestos producers and mine sites follow:

State and company	County	Mine	Type of asbestos
Arizona: Jaquays Mining Corp	Gila	Chrysotile	Chrysotile.
California:			
Calaveras Asbestos Corp	Calaveras	Copperopolis	Do.
Union Carbide Corp	San Benito	Santa Rita	Do.
Vermont: Vermont Asbestos Group	Orleans	Lowell	Do.

Employment in U.S. asbestos mines and mills averaged about 480 persons during 1980.

CONSUMPTION AND USES

Total U.S. asbestos consumption decreased 36% from 1979 to 1980. Chrysotile was 93% of that consumed, crocidolite 7%, a little amosite was used, and no anthophyllite was reported used for the first time in many years. The demand was lower for every end use, but the degree of drop varied from 25% for flooring products to 67% for textiles.

Asbestos-cement pipe increased its share of the asbestos used from 38% in 1979 to 40% in 1980. Chrysotile was 83% of that used in asbestos-cement pipe, and crocidolite practically all of the rest. Flooring products with 25%, friction products with 12%, and roofing products with 7% were the other major uses.

Ninety-nine percent of the chrysotile used was either grade 4, 5, 6, or 7, with the grade 7's the most used at 40%, grade 5's next at 27%, grade 4's at 26%, and grade 6's at 6%.

Table 3.—U.S. asbestos consumption by end use, grade, and type

(Metric tons)

	Chrysotile								Crocido-lite	Amosite	Antho-phyllite	Total asbestos
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Total chrysotile				
1979	100	8,800	162,100	105,300	52,800	193,900	--	523,000	35,700	1,500	300	560,600
1980:												
Asbestos-cement pipe	--	--	81,700	29,800	4,300	3,900	--	119,700	24,100	200	--	144,000
Asbestos-cement sheet	--	--	--	100	4,300	3,500	--	7,900	--	--	--	7,900
Flooring products	--	100	--	35,900	200	53,800	--	90,000	--	200	--	90,200
Roofing products	--	100	300	100	3,900	22,100	--	26,500	--	--	--	26,500
Packing and gaskets	--	800	2,300	6,200	100	2,800	--	12,200	100	--	--	12,300
Insulation:												
Thermal	--	--	100	--	700	5,200	--	6,000	--	--	--	6,000
Electrical	--	200	--	100	--	2,600	--	2,900	--	--	--	2,900
Friction products	--	400	2,100	14,200	4,700	22,300	--	43,700	--	--	--	43,700
Coatings and compounds	--	--	100	--	100	10,700	--	10,900	--	--	--	10,900
Plastics	200	--	--	400	--	800	--	1,400	100	--	--	1,500
Textiles	200	1,700	--	--	--	--	--	1,900	--	--	--	1,900
Paper	--	100	--	200	100	--	--	400	100	--	--	500
Other	--	200	300	2,500	1,500	4,600	--	9,100	--	1,300	--	10,400
Total	400	3,600	86,900	89,500	19,900	132,300	--	332,600	24,400	1,700	--	358,700

PRICES

Published data from company price lists will be used from now on to reflect asbestos prices. The price list of the Asbestos Corp., as Quebec's largest independent producer, will probably be representative. There was no increase in its prices during 1980. Prices for British Columbia Cassiar chrysolite asbestos rose more than 20% for cement grades and 10% for other grades to start 1980.

Prices for Vermont chrysotile asbestos rose on July 1, 1980. For some grades (cement) the raise was 12%, shorts were 8%, and Hooker 17% and 20%. Arizona prices did not increase during 1980. The latest prices are still those that went into effect on July 1, 1976, and quotations, f.o.b. Globe, are shown below:

Grade	Description	Value per metric ton
Group 1	Crude	$3,307
Group 2	do	1,984
AAA		1,433
Group 3	Nonferrous filtering and spinning	$827- 926
Group 4	Nonferrous plastic and filtering	827- 926
Group 7	White shorts	110- 220

As of July 1, 1980, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Value per metric ton
4T	Fiber	$729
5K	do	564
5R	do	478
6D	Waste	351
7D	Shorts	226
7M	do	129
7R	do	119
Hooker No. 1		1,609
Hooker No. 2		926

Quotations for Asbestos Corp. (Quebec) chrysotile, f.o.b. mine, as of January 1, 1980, follow:

Grade	Description	Value per metric ton
Group 3Z to 3F	Spinning fiber	Can$1,240-$1,929
Group 4T to 4A	Asbestos-cement fiber	933-1,215
Group 5R to 5D	Paper fiber	584- 690
Group 6D	Paper and shingle fiber	419
Group 7TS to 7D	Shorts	134- 257

The latest prices for chrysotile asbestos from Cassiar Resources in British Columbia, Canada, effective January 1, 1980, f.o.b. Vancouver, follow:

Grade	Description	Value per metric ton
AAA	Nonferrous spinning fiber	Can$2,205
AA	do	1,764
A	do	1,268
AC	do	1,157
AK	Asbestos-cement fiber	1,075
AS	do	992
AX	do	909
AY	do	634
AZ	do	413

African asbestos producers privately negotiate sales, thereby ruling out market quotations. The following tabulation shows the average value per metric ton of South African imports, regardless of grade, calculated from 1980 U.S. Department of Commerce data:

Type	1976	1977	1978	1979	1980
Amosite	$508	$589	$569	$577	$902
Crocidolite	571	582	624	686	689
Chrysotile	259	485	451	679	692

FOREIGN TRADE

There was an increase in the value of asbestos and asbestos products exported from the United States in 1980 over that in 1979. Most of the gain was accounted for by a 26% increase in the value of unmanufactured asbestos, which had a 14% rise in tonnage. There was an increase in the value, in U.S. dollars, per metric ton from $521 to $576 in 1980. The fiber share of the export dollar declined from 16% in 1979 to 13% in 1980.

In 1980, the United States recovered 177% of the cost of imported asbestos by exporting and reexporting fibers and products.

Canada remained the largest user of U.S. asbestos and products. Thirty-eight percent of the value realized from these products in 1980 came from Canada, Saudi Arabia and Mexico tied for second in receiving U.S. asbestos and products and each provided 8% of the U.S. export dollars in 1980.

Other major buyers of U.S. asbestos and products were the Federal Republic of Germany, Japan, Venezuela, the United Kingdom, Australia, Colombia, and the Netherlands.

Canada provided 96% of the asbestos fiber imported into the United States in 1980, and the Republic of South Africa provided 3%. Several countries provided the remainder. Chrysotile again dominated the imported types, with 98% of the total. The dollar value of imported fiber in 1980 was just 68% of that for 1979.

Table 4.—Countries importing U.S. asbestos fibers and products, by type and country

(Thousand dollars)

	1979			1980		
	Unmanufactured fibers	Manufactured products	Total	Unmanufactured fibers	Manufactured products	Total
Australia	429	2,778	3,207	936	2,363	3,299
Canada	2,508	53,761	56,269	1,936	59,197	61,133
Colombia	364	3,324	3,688	249	1,557	1,806
Germany, Federal Republic of	924	4,009	4,933	1,309	3,455	4,764
Japan	4,686	2,950	7,636	4,551	3,522	8,073
Mexico	4,931	6,430	11,361	6,442	6,948	13,390
Netherlands	126	2,712	2,838	421	2,867	3,288
Saudi Arabia	596	11,448	12,044	678	12,751	13,429
United Kingdom	387	3,217	3,604	742	3,888	4,630
Venezuela	193	4,078	4,271	483	2,958	3,441
Other	8,250	r33,456	41,606	11,600	33,183	44,783
Total	23,394	r128,163	151,457	29,346	132,689	162,036

Table 5.—U.S. exports and reexports of asbestos and asbestos products

Products	1978		1979		1980	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS						
Unmanufactured:						
Crudes, fibers, and stucco metric tons	22,153	$8,371	31,635	$12,968	36,426	$17,044
Sand and refuse do	18,666	4,719	10,501	3,642	11,793	3,693
Asbestos fibers do	3,597	7,137	2,559	6,784	2,695	8,610
Total do	44,416	20,227	44,695	r23,394	50,914	29,347

See footnotes at end of table.

Table 5.—U.S. exports and reexports of asbestos and asbestos products —Continued

Products	1978		1979		1980	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS —Continued						
Products:						
Shingles and clapboard ---------- metric tons--	10,652	$5,256	7,323	$3,875	4,535	$2,560
Other articles of asbestos-------------- do----	14,340	11,700	17,758	13,301	16,646	14,236
Gaskets ------------------------------- do----	3,911	4,510	4,203	4,556	438	3,542
Packing and seals --------------------- do----	2,396	11,520	2,405	14,497	2,118	15,661
Insulation ---------------------------- do----	NA	5,193	NA	4,524	NA	6,151
Other articles, n.s.p.f --------------- do----	NA	24,876	NA	22,806	NA	25,442
Brake linings and disc brake pads ------ do----	NA	44,696	NA	55,270	NA	55,471
Clutch facings and linings ---------- number--	NA	11,090	NA	9,334	NA	9,626
Total ----------------------------------	XX	118,841	XX	128,163	XX	132,689
REEXPORTS						
Unmanufactured:						
Crudes and fibers ------------- metric tons--	896	296	1,039	851	383	307
Sand and refuse ------------------- do----	68	10	116	20	69	23
Total ------------------------------ do----	964	306	1,155	871	452	330
Products:						
Shingles and clapboard --------------- do----	--	--	--	--	477	78
Gaskets ------------------------------- do----	NA	37	--	--	--	--
Packing and seals --------------------- do----	NA	20	4	109	1	5
Insulation ---------------------------- do----	NA	1	--	--	NA	1
Other articles, n.s.p.f --------------- do----	NA	103	NA	68	NA	14
Brake linings and disc brake pads ------ do----	NA	683	NA	2,492	NA	219
Clutch facings and linings ---------- number--	NA	230	NA	52	NA	24
Other articles of asbestos -------- metric tons--	--	--	NA	22	3	13
Total ----------------------------------	XX	1,074	XX	2,743	XX	354

NA Not available. XX Not applicable.

Table 6.—U.S. imports for consumption of asbestos fibers by type, origin, and value

Type	Canada		Republic of South Africa		Other		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1978 ------------	543,233	$139,742	24,908	$14,165	1,879	$444	570,020	$154,351
1979:								
Chrysotile:								
Crude -------	138	28	378	269	16	4	532	301
Spinning fibers --	8,070	7008	-	--	--	--	8,070	7,008
All other ------	487,499	116,577	2,235	1,504	460	148	490,194	118,229
Crocidolite (blue) --	[1]134	54	[r]13,327	9,138	[1]366	250	13,827	9,442
Amosite -------	[1]73	6	[r]388	224	--	--	461	230
Total ------	[r]495,914	[r]123,673	[r]16,328	[r]11,135	842	402	513,084	[r]135,210
1980:								
Chrysotile:								
Crude -------	129	20	--	--	29	32	158	52
Spinning fibers --	5,424	4,571	360	338	567	578	6,351	5,487
All other ------	309,886	78,371	2,041	1,379	899	721	312,826	80,471
Crocidolite (blue) --	[1]52	12	7,545	5,201	--	--	7,597	5,213
Amosite -------	[1]49	302	315	284	--	--	364	586
Total ------	315,540	83,276	10,261	7,202	1,495	1,331	327,296	91,809

[r]Revised.
[1]Transshipment from the Republic of South Africa.

WORLD REVIEW

The 1% reduction in world asbestos production in 1980 was attributable to the general recession and environmental factors, according to a Canadian trade journal.[4] The article noted the slowed construction activity in Western Europe and the United States and the environmental problems that seem to have caused a loss of market for the shorter asbestos fibers. The growing market in the less developed countries was described. New asbestos cement plants, either in operation or under construction, were mentioned in Tunisia, the Middle East, the Philippines, Nigeria, Malaysia, Sri Lanka, and elsewhere.

New asbestos discoveries in the Arab world were noted in a letter to the editor of a trade magazine.[5] A member of the geology department of the American University in Beirut said the unexploited deposits were in Saudi Arabia, Iraq, Syria, and Morocco.

Canada.—The Canadian asbestos industry had, in 1980, one of the leanest years in recent history. Asbestos Corp., for example, had a 12-week strike from March 4 to May 26 and still had such large inventories of fibers that it had to announce a suspension of all operations for the first 26 days of 1981 and a reduction of the normal 6-day work week to 5 days for the following 6 months.

In Quebec, the Provincial Government had not relinquished its plans to expropriate the controlling shares of the Asbestos Corp., now owned by General Dynamics Corp. of the United States. The purchase of Bell Asbestos Mines Ltd. and its two affiliated manufacturers of asbestos products—Atlas Turner Co. and Turner Building Products Co.—in May did not alter the Province's stand. The May decision by the Quebec Superior Court upholding the constitutionality of the expropriation act has been appealed.

Brinco Ltd. acquired 98% of the outstanding shares of Cassiar Resources and plans to acquire the remainder. The mining and exploration activities of Cassiar will be combined with those of Brinex Ltd., and the whole entity will be renamed Brinco Mining Ltd.

Colombia.—Late 1980 was the scheduled startup time for the Minera Las Brisas, S. A. asbestos mine at Antioquia. Production is set for 20,000 metric tons per year of grades 4, 5, 6, and 7.

Cyprus.—While production of chrysotile on Cyprus varied little from the previous few years, Cyprus Asbestos Mines, Ltd., in 1979 exported 32% more than in 1978, a total 120% of production.

France.—French imports of asbestos rose 14% in 1979 over 1978, but the most interesting data concerned the changes in the supplying countries' shares of this market. Canada's share rose from 39% in 1978 to 47% in 1979, the U.S.S.R.'s share dropped from 34% to 20%, and the Republic of South Africa's share rose from 8% to 13%.

Germany, Federal Republic of.—The Bonn Government was preparing a program to support industrial stockpiling of five minerals which it characterizes as "sensitive basic commodities with high economic importance and high supply risk." It says of asbestos, the only nonmetallic on the list, that, "for the short term, substitution in sources of supply as well as in uses is not possible."

Greece.—Full-scale operation of the new Zidani chrysotile mine near Kozani was rescheduled for late 1980, with hopes that 100,000 tons can be produced in 1981. Grades 4, 5, 6, and 7 will be produced with grade 4's providing 15% of the total and grade 7's 10%. About 20% to 25% of the production will be used domestically.

Turkey.—Asbestos production is one of the few encouraging events in Turkey's mineral picture. The 1979 production was more than four times that of 1977 at 17,210 metric tons.

U.S.S.R.—Geologists of the Tuva A.S.S.R. have announced completion of a survey of a major new deposit at Sayan. Reportedly containing 7 million tons of chrysotile, experimental development and long-range planning have started. Output from the Kiyembay asbestos combine was threatened by transportation difficulties according to a trade journal item.[6] Citing a Pravda article, the item said that "rock delivery was held up because the locomotives assigned by the Building Materials Ministry were 10 to 15 years old and broke down frequently."

Yugoslavia.—The West German company KHD Humboldt Wedag AG has the contract to supply the equipment for improvements at the Stragari-Azbest asbestos mine of Kolubara, Serbia. The ore from the open pit mine will be milled in a wet process plant reportedly environmentally safe that will increase fiber yield by 6% to 7%.

Downstream capacity for asbestos board and paper will be extended.

Zimbabwe.—With the removal of United Nations sanctions, data on the Zimbabwe asbestos industry are once again available, and it is apparent that it is a healthy and growing industry. Asbestos production increased by a 3.1% average annual growth rate during the first 10 years of the sanctions (1966-75) and a 2.65% overall growth rate from 1964 through 1979. Production peaked in 1976 at 281,400 metric tons and dropped off somewhat after that.

African Associated Mines (Pvt.) Ltd. (AAM), a subsidiary of Turner & Newell of the United Kingdom, is by far the largest asbestos producer in the country having 90% of the production. AAM operates a mine and brand new mill (July 1980) at Shabanie. Near Mashaba, the King Mine has a new (1973) mill, and the company operates another mine (Gaths Mine), and another mine and mill (Temeraire). They are presently remilling considerable old dump material for the now recoverable fibers.

According to Industrial Minerals, AAM is not the only Zimbabwean asbestos producer to install a major new plant recently.[7] Both Asbestos Investments Ltd. and Kudu Asbestos Ltd. have also made plant investments. An interesting facet of this modernization of the country's asbestos industry is that, because of the sanctions, all the needed equipment was manufactured domestically.

Table 7.—Asbestos: World production, by country[1]

(Metric tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada (shipments)	1,536,091	1,517,360	1,421,808	1,492,719	[3]1,291,371
Mexico	1	--	--	--	--
United States (sold or used by producers)	104,873	92,256	93,097	93,354	[3]80,079
South America:					
Argentina	889	686	1,069	1,196	1,100
Brazil	92,703	92,773	122,815	138,457	140,000
Colombia	[e]5,000	--	--	--	--
Europe:					
Bulgaria[e]	300	500	[r]700	[r]600	700
Italy	164,788	149,327	135,402	143,931	145,000
U.S.S.R.[e]	[r]1,850,000	[r]1,900,000	1,945,000	2,020,000	2,150,000
Yugoslavia	12,830	[r]9,066	10,360	10,041	[3]12,106
Africa:					
Egypt	1,096	478	349	238	230
Mozambique	--	--	--	789	800
South Africa, Republic of	369,840	380,164	257,325	249,187	270,000
Swaziland[4]	41,847	38,046	36,951	34,294	35,000
Zimbabwe	281,000	273,000	249,000	260,000	[3]251,000
Asia:					
Afghanistan	13,260	[e]13,000	[e]13,000	[e]4,000	--
China:					
Mainland[e]	150,000	200,000	250,000	250,000	250,000
Taiwan	853	673	2,031	2,957	[3]683
Cyprus	34,518	36,684	34,342	35,472	35,000
India	24,119	22,177	24,263	37,816	38,000
Japan	7,703	[r]6,307	5,746	3,502	3,300
Korea, Republic of	4,762	6,180	13,616	14,804	14,000
Thailand	15	4	4	--	--
Turkey	9,941	3,975	13,372	17,210	20,000
Oceania: Australia	60,642	50,601	62,744	79,121	80,000
Total	[r]4,767,071	[r]4,793,257	4,692,994	4,889,688	4,818,369

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Apr. 30, 1981.

[2]In addition to the countries listed, Czechoslovakia, North Korea, and Romania also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[3]Reported figure.

[4]Exports.

TECHNOLOGY

Current research of most interest to asbestos producers and users is the series of animal feeding studies begun a few years ago by NIEHS. Now under the National Toxicology Program, the research aims to ascertain the carcinogenicity of ingested asbestos on hamsters and rats. Excerpts from the latest status report are given.[8]

Test Materials.—Two samples of chrysotile, and single samples of amosite and crocidolite asbestos plus a tremolite material are being tested. A repository of these materials was established and has also served as a source for other scientific studies on asbestos.

Hamster Studies.—Three asbestos materials are being studied at the Illinois Institute of Technology at Chicago. The lifetime exposure phase of these experiments has been completed. There was no indication of major differences in the mortality rate between the hamsters receiving the asbestos diet or the control diet. Histopathologic examination of tissues from female hamsters has been completed. The contractor has reported that a preliminary analysis of the hamster data indicates that no carcinogenic or cocarcinogenic effect was observed.

Rat Studies.—Five test materials are being studied in this species at the Hazleton Laboratories, Vienna, Va. In addition, a subset of two studies includes neonatal as well as lifetime oral exposure to asbestos. The lifetime exposure phase of the study has been completed. Although data have not yet been statistically analyzed, it appears that longevity was not affected by exposure to the various types of fibers, although the known carcinogen, dimethylhydrazine, did significantly shorten lifespan.

Sherbrooke University in Quebec is the scene of much ongoing research regarding asbestos. As the site of the research laboratories of both the Association des Mines d'Amiante du Québec (AMAQ) and the la Société Nationale de l'Amiante (SNA) of the Quebec Government, this is only natural. One report originating there describes the process by which asbestos tailings will be the feed for a new magnesium metal plant.[9] Another report on a joint effort by AMAQ and SNA holds high interest.[10] Professor Jacques Dunnigan has, by a simple reaction of asbestos fibers with a phosphoric salt, produced a fiber which reportedly has all the useful properties of asbestos, but has substantially less harmful physiological effects. A third interesting report from Sherbrooke decribes how magnetic concentration of asbestos tailings gives a forsterite-type material that exceeds the refractory properties of olivine because of its very low iron content. The magnetic fraction, on the other hand, surpasses olivine in thermal conductivity and heat capacity because of its higher iron content.

Substitutes.—In July, EPA, CPSC, and IRLG held a 3-day National Workshop on Substitutes for Asbestos. The meeting was intended as a factfinding exercise to ensure that future laws on minerals and health would be fair and practical. The intention was not met according to one journal.[11] In the comment section of that magazine, the meeting program was characterized as designed to uphold the traditional EPA line to nail down and bury asbestos as a commercial product and to promote substitutes. If that had indeed been the design of the workshop, then it, too, failed. The manufacturers of products containing asbestos who had found, through research too costly for smaller concerns, substitutes in the products for asbestos, characterized the new products as (1) a great deal more costly than their former asbestos-containing products, (2) inferior to the former products, and (3) containing materials of unknown health effects.

Two new organic fibers have been announced as asbestos substitutes in some areas. A trade journal carried news of the first.[12] The heat and chemical resistant fiber is called PBI (polybenzimidazole) by Celanese Corp., its developer. Celanese claims it is nonflammable in air, emits little or no smoke or toxic offgases up to 500° C, and has excellent chemical resistance. The projected $30 per pound ($60,000 per short ton) price would not compete with asbestos.

The Dupont Co. announced a new product in 1980 even though it is not a new fiber. It is also described in a trade journal.[13] Through process changes, Dupont is now able to produce a pulp of short (2 to 4 millimeters) Kevlar (aramid) fibers that are highly fibrillated, fine (less than a micrometer in diameter), and with an aspect ratio often over 500. Even though the Kevlar costs at least seven times as much as asbestos, Dupont claims cost-effectiveness if amount needed and lifetime costs are evaluated.

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[5]Khawlie, M. Letter to the Editor. Industrial Minerals (London), No. 153, June 1980.
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[10]Industrial Minerals (London). Quebec Claims to Safer Asbestos. No. 154, July 1980, p. 9.
[11]——. No. 156, September 1980, p. 7.
[12]Chemical Week. Business Newsletter. V. 127, No. 14, Oct. 1, 1980, p. 13.
[13]Materials Engineering. V. 93, No. 1, January 1981, p. 22.

Barite

By David E. Morse[1]

Domestic production of barite increased to a record of over 2.24 million tons in 1980. Nevada continued to lead all States in production with nearly 1.92 million tons, 85% of the national total and 23% of the estimated world output. Missouri, Arkansas, and Georgia were the other principal barite-producing States in 1980. Imports for consumption of crude barite continued to increase, reaching 1.85 million tons and surpassing the previous record 1.49 million tons imported in 1979. The principal use for barite, as a weighting agent in oil- and gas-well-drilling fluids, accounted for 95% of U.S. consumption. The phased decontrol of domestic oil prices coupled with a nearly 100% increase in the world price of oil in 1979 fostered a record level of drilling activity by the domestic oil- and gas-well-drilling industry in 1980, which also pushed barite consumption to an unprecedentedly high level.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Barite:					
Primary (sold or used by producers)	1,234	1,494	r2,170	2,112	p2,245
Value	$28,689	$30,264	r$45,130	$53,581	p$65,958
Exports	41	50	39	109	97
Value	$2,871	$3,436	$2,724	$10,861	$13,794
Imports for consumption (crude)	905	955	1,291	1,489	1,850
Value	$24,849	$25,787	$40,525	$64,072	$101,956
Crushed and ground (sold or used by producers)	2,204	2,593	r2,897	r3,223	3,649
Value	$93,283	$110,409	r$132,312	r$179,009	$365,632
Barium chemicals (sold or used by producers)	52	56	55	50	40
Value	$19,698	$23,151	$24,018	$26,063	$22,441
World: Production	r5,738	r6,465	7,552	7,855	8,326

pPreliminary. rRevised.

DOMESTIC PRODUCTION

The term "primary barite" denotes the first marketable product and includes crude run-of-mine barite, flotation concentrates, and other beneficiated material such as washer, jig, or magnetic separation concentrate. Run-of-mine barite sold or used by producers represented 34% of total production in 1980 compared with 67% in 1979; other beneficiated material was 63% of the 1980 total compared with 29% of the 1979 output; flotation concentrate was 3% of the 1980 total compared with 4% of the 1979 production.

In 1980, primary barite was produced from 37 mines in 10 States. Nevada with 16 mining operations and Missouri with 10 were the leading States in the number of operations and in barite output. Other States producing barite in descending order of production in 1980 were Arkansas, Georgia, Montana, California, Alaska, Illinois, Tennessee, and New Mexico. Some barite was also produced in Idaho as a byproduct of lead-zinc mining.

The leading producers of domestic barite in 1980 were (in alphabetical order) Baroid Div., NL Industries, Inc., with mines in Arkansas, Missouri, and Nevada; Dresser Minerals Div., Dresser Industries, Inc., with mines in Missouri and Nevada; IMCO Services Div., Halliburton Co., with mines in Missouri and Nevada; and Milchem, Inc., with mines in Missouri and Nevada.

Domestic and/or imported barite was ground at 49 plants in 12 States during 1980. Texas (10 plants), Louisiana (9 plants), and Nevada (5 plants) continued to be the leading producers of ground barite. Other States with grinding plants in 1980 were Utah, Missouri, California, Arkansas, Georgia, Illinois, Montana, Oklahoma, and Tennessee.

Considerable expansion in the domestic barite industry occurred in 1980; production, beneficiating, and grinding capacities all increased. A. W. Arnold Co. began construction of a new grinding plant in Baton Rouge, La. The two-mill grinding plant was slated for completion in 1981.

All Minerals Corp. added a new mill to its Murry, Utah, grinding plant and began construction on a two-mill grinding facility in Clinton, Okla. The company also planned to expand the capacity of its barite beneficiating plant at its East Northumberland Canyon Mine in Nye County, Nev.

Blast Abrasives, Inc., completed a new grinding facility at Houma, La. Concentrated Mud Chemicals, Inc., began production in its new two-mill grinding facility at Corpus Christi, Tex.

Chromalloy American's Drilling Fluids Group increased the capacity of its Houma, La., and Houston, Tex., grinding plants. Reportedly, Common Port Corp. brought a new barite grinding plant onstream in November at Brownsville, Tex.[2]

DeSoto Mining Co., a subsidiary of Galveston-Houston Fluid Services, completed its twin jigging plants at Richwood, Mo., rehabilitated the Kingston jigging plant in Washington County, Mo., and began construction of an additional plant on the same site to double capacity. Galveston-Houston increased the capacity of its Amelia, La., grinding plant by adding a new 66-inch mill.

Dresser Minerals expanded the output of its Greystone Mine and jigging plant in Lander County, Nev. Dresser Minerals was installing new mills at its Battle Mountain, Nev., Galveston, Tex., and New Orleans, La., grinding plants.

Eisenman Chemical Co., a subsidiary of Newpark Resources, Inc., expanded capacity by adding two mills to its Salt Lake City, Utah, grinding plant and began constructing a new grinding plant at Clinton, Okla. Newpark completed the merger of Atlas Mud Co., a retail distributor of drilling fluid products with headquarters in Oklahoma City. Under the terms of the merger, Atlas became a wholly owned Newpark subsidiary.

IMCO placed its new Apex washer plant in Washington County, Mo., into service late in the year. IMCO completed construction of grinding plants at Brownsville, Tex., and Houma, La.

Milchem increased production from its Nevada mining operations and began site preparations for its new Fancy Hill Mine and mill near Glenwood, Ark. It was expanding grinding facilities at Battle Mountain, Nev., and New Orleans, La., and commenced operating new grinding plants at Clinton, Okla., and Galveston, Tex.

Old Soldier Mining Co. brought its Stormy Creek, Nev., mine and jigging plant onstream during the fourth quarter of 1980. Old Soldier also began construction of a two-mill grinding plant at Abbeville, La., which was scheduled to be in operation in 1981.

Rocky Mt. Refractories, Inc., began shipping ore from its Spanish Mine near Grass Valley, Calif. Uni Minerals Corp. completed a two-mill grinding plant at Houston, Tex., late in the year.

Table 2.—Barite sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Missouri	121	4,661	89	3,679	117	5,570
Nevada	r1,838	r30,875	r1,804	r35,707	1,918	47,800
Other[1]	r210	9,594	r219	14,195	p210	p12,587
Total[2]	r2,170	r45,130	r2,112	r53,581	p2,245	p65,958

pPreliminary. rRevised.
[1]Includes Alaska, Arkansas, Georgia, Idaho, Illinois, Montana, New Mexico, and Tennessee.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic sales of crushed and ground barite reached an alltime high in 1980. Use as a weighting agent in oil- and gas-well-drilling fluids continued to be the dominant end use, accounting for 95% of total sales volume in 1979 and 1980. The oil- and gas-well-drilling industry had a record year by completing over 60,800 wells and drilling more than 284 million feet of hole. Total footage drilled exceeded 10 million feet in seven States: Texas, 99.6 million feet; Oklahoma, 42.4 million feet; Louisiana, 31.2 million feet; Kansas, 17.4 million feet; Ohio, 11.6 million feet; New Mexico, 11.2 million feet; and Wyoming, 10.8 million feet. Generally, the deeper a hole is drilled, the more barite is used per foot of drilling; thus, the total footage drilled has a larger effect than the number of wells. In the seven States with the greatest footage drilled in 1980, Wyoming had the highest average with over 7,650 feet per well and Kansas the lowest with about 3,400 feet per well. The U.S. average was 4,675 feet. An average of 23.8 pounds of barite was consumed per foot of drilling in 1980, compared with 24.9 pounds per foot in 1979.

The data in table 4 are mainly for ground barite but include quantities of crushed barite used by the barium chemical industry and by some glass manufacturers. Other uses of ground barite include filler in paint, paper, plastics, and rubber; flux, oxidizer, and decolorizer in glass manufacture; and miscellaneous uses. Some crude barite is used in heavy concrete aggregate for containment buildings of nuclear powerplants.

Table 3.—Crushed and ground barite sold or used by producers in the United States, by State

State	1979			1980		
	Number of plants	Quantity (thousand short tons)	Value (thousands)	Number of plants	Quantity (thousand short tons)	Value (thousands)
Louisiana	r7	r993	r$55,886	9	1,293	$120,877
Missouri	6	139	6,931	6	179	9,054
Nevada	5	728	20,843	5	610	62,169
Texas	r9	r963	r58,936	10	1,106	129,761
Utah	5	143	11,465	6	151	13,817
Other[1]	11	256	24,948	13	310	29,954
Total	r43	r [2]3,223	r179,009	49	3,649	365,632

rRevised.
[1]Includes Arkansas, California, Georgia, Illinois, Montana, Oklahoma, and Tennessee.
[2]Data do not add to total shown because of independent rounding.

Table 4.—Crushed and ground barite sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use[2]	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Barium chemicals	86	5,363	74	6,124	67	4,472
Glass	36	829	W	W	W	W
Filler or extender:						
Paint	61	10,247	37	6,201	34	7,249
Rubber	(3)	(3)	(3)	(3)	(3)	(3)
Other filler	38	4,719	27	2,738	24	2,582
Well drilling	r2,669	r111,030	r3,047	r163,009	3,462	346,500
Other	6	125	37	937	60	4,829
Total[4]	r2,897	r132,312	r3,223	r179,009	3,649	365,632

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imported barite.
[2]Uses reported by producers of ground and crushed barite, except for barium chemicals.
[3]Withheld to avoid disclosing company proprietary data; included with "Other filler."
[4]Data may not add to totals shown because of independent rounding.

Table 5.—Barium chemicals produced and sold or used by producers in the United States[1]

Barium chemical	1979				1980			
	Plants[2]	Production (short tons)	Sold or used by producers		Plants[2]	Production (short tons)	Sold or used by producers	
			Quantity (short tons)	Value (thousands)			Quantity (short tons)	Value (thousands)
Barium carbonate	4	31,240	31,450	$12,039	4	30,000	25,000	$10,000
Barium chloride	3	W	W	W	2	W	W	W
Barium hydroxide	3	W	W	W	1	W	W	W
Black ash	2	W	W	W	2	W	W	W
Blanc fixe	1	W	W	W	1	W	W	W
Other	4	23,750	18,600	14,024	3	23,546	15,045	12,441
Total	r4	54,990	50,050	26,063	5	53,546	40,045	22,441

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Only data reported by barium-chemical plants that consume barite are included. Partially estimated.
[2]A plant producing more than one product is counted only once.

Table 6.—U.S. hydrocarbon well-drilling and barite consumption

Year	Barite used for well drilling (thousand short tons)	Wells drilled (thousands)[1]				Successful wells (percent)	Average depth per well (feet)	Average barite per well (short tons)
		Oil	Gas	Dry holes	Total			
1960	920	22.23	5.13	18.19	45.55	60.1	4,217	20.20
1961	942	21.41	5.46	17.38	44.25	60.7	4,285	21.29
1962	934	21.73	5.35	17.08	44.16	61.3	4,408	21.15
1963	907	20.14	4.57	16.76	41.47	59.6	4,405	21.87
1964	931	19.91	4.69	17.69	42.29	58.2	4,431	22.01
1965	987	18.07	4.48	16.23	38.77	58.2	4,510	25.46
1966	1,022	16.78	4.38	15.23	36.38	58.1	4,478	28.09
1967	965	15.33	3.66	13.23	32.25	58.9	4,385	29.94
1968	1,006	14.33	3.46	12.81	30.60	58.1	4,738	32.88
1969	1,235	14.37	4.08	13.74	32.19	57.3	4,881	38.37
1970	1,119	13.02	3.84	11.26	28.12	60.0	4,952	39.79
1971	1,044	11.86	3.83	10.16	25.85	60.7	4,806	40.39
1972	1,183	11.31	4.93	11.06	27.29	59.5	4,932	43.35
1973	1,326	9.90	6.39	10.31	26.59	61.2	5,129	49.87
1974	1,440	12.78	7.24	11.67	31.70	63.2	4,750	45.43
1975	1,638	16.41	7.58	13.25	37.24	64.4	4,685	43.98
1976	1,986	17.06	9.09	13.62	39.77	65.7	4,571	49.94
1977	2,372	18.91	11.38	14.69	44.98	67.3	4,687	52.74
1978	r2,632	17.76	12.93	16.25	46.93	65.4	4,829	r56.08
1979	r2,967	19.38	14.68	15.75	49.82	68.4	4,791	r59.55
1980	3,385	26.99	15.74	18.09	60.81	70.3	4,675	55.66

rRevised.
[1]Includes exploratory and development wells; excludes service wells, stratigraphic tests, and core test.

Source: U.S. Department of Energy. Energy Information Administration.

PRICES

The total reported value of primary barite produced in the United States in 1980 was $65.96 million; the average value per ton was $29.38, compared with the 1979 average value of $25.47 per ton. The average value per ton of ground barite from Texas and Louisiana was $104.48. The prices listed in table 7 are from trade publications; they serve as a general guide but do not necessarily reflect actual transactions.

Table 7.—Barite price quotations

Item	Price per short ton[1] 1979	Price per short ton[1] 1980
Barite:[2]		
Chemical, filler, glass grades, f.o.b. shipping point, carlots:		
Handpicked, 95% $BaSO_4$, not over 1% Fe	$66.00	$72.00
Magnetic or flotation, 96% to 98% $BaSO_4$, not over 0.5% Fe	60.00- 70.00	60.00- 70.00
Water-ground, 95% $BaSO_4$, 325 mesh, 50-pound bags	80.00-133.00	80.00-133.00
Drilling-mud grade:		
Dry ground, 83%-93% $BaSO_4$, 3%-12% Fe, specific gravity 4.20-4.30, f.o.b. shipping point, carlots	70.00- 90.00	70.00- 90.00
Crude, imported, specific gravity 4.20-4.30, f.o.b. shipping point	19.00- 47.00	30.00- 60.00
Barium chemicals:[3]		
Barium carbonate:		
Precipitated, bulk, carlots, freight equalized (per pound)	.206	.206
Electronics grade, bags	335.00	335.00
Barium chloride:		
Technical crystals, bags, carlots, works	300.00	300.00
Anhydrous, bags, carlots, same basis	400.00	400.00
Barium hydrate: Mono, 55-pound bags, carlots, delivered (100 pounds)	39.50	39.50
Barium sulfate:		
Blanc fixe, technical grade, bags, carlots	430.00	430.00
USP, X-ray diagnosis grade, powder, 250-pound drums, 1,250-pound lots (per pound)	.24- .25	.53- 1.06
Barium sulfide (black ash), drums, carlots, works	115.00-150.00	150.00

[1]Unless otherwise noted.
[2]Engineering and Mining Journal. V. 180, No. 12, December 1979, p. 23, and v. 181, No. 12, December 1980, p. 23.
[3]Chemical Marketing Reporter. V. 216, No. 27, Dec. 31, 1979, p. 27, and v. 218, No. 26, Dec. 29, 1980, p. 27.

FOREIGN TRADE

During 1980, a total of 96,800 tons of "natural barium sulfate" was exported. U.S. export tables do not indicate what type or form of barite was exported; however, based on the reported value of each shipment, it was estimated that 80% of barite exports was ground drilling mud grade, 15% was crude barite, and 5% was chemical, filler, or glass grade. Mexico and Canada continued as the leading importers of barite from the United States, accounting for 84.5% of total exports. Barite was exported to 38 nations worldwide in 1980.

U.S. imports of crude barite continued at a record pace, reaching 1.85 million tons, 361,000 tons greater than in 1979, the previous record year. The average value of imports of crude barite was $55.11 per ton (c.i.f.). In 1979, the average value was $43.02 per ton (c.i.f.). The principal source countries and average values per ton in 1980 were mainland China, $62.16; Peru, $44.21; Morocco, $59.93; Chile, $54.32; India, $54.79; Thailand, $65.68; and Mexico, $43.36.

Most of the imported crude barite was drilling mud grade, and nearly 97% of the 1980 imports entered the United States through customs districts along the gulf coast. This reflects the concentration of domestic grinding plants along the gulf and the nearness to the largest U.S. drilling mud market. The import distribution by district in 1980 (1979 in parentheses) was New Orleans, La., 55% (50%); Galveston, Tex., 15% (17%); Laredo, Tex. (Port of Brownsville, Tex.), 12.6% (13%); Houston, Tex., 11.9% (12%); and Port Arthur, Tex. (Port of Lake Charles, La.), 2.4% (3.6%).

Table 8.—U.S. exports of natural barium sulfate and carbonate

Country	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Angola	--	--	256	$58	431	$50
Argentina	155	$37	60	27	312	141
Australia	--	--	--	--	3	2
Austria	--	--	--	--	211	17
Bangladesh	--	--	25	5	--	--
Barbados	--	--	451	59	310	40
Brazil	1,125	55	64	5	1,059	139
Canada	19,790	1,180	38,348	2,488	31,473	5,715

See footnotes at end of table.

Table 8.—U.S. exports of natural barium sulfate and carbonate —Continued

Country	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Chile	17	$2	1,538	$152	2,550	$276
Colombia	804	92	--	--	5	2
Costa Rica	3	1	--	--	2	1
Dominican Republic	--	--	--	--	61	26
Egypt	3,163	198	47	4	--	--
France	242	44	14	13	--	--
Gabon	115	9	--	--	--	--
Guatemala	528	47	4,084	438	4,480	459
Haiti	--	--	50	2	--	--
Indonesia	121	6	--	--	3	4
Italy	171	23	--	--	--	--
Japan	455	47	20	5	--	--
Korea, Republic of	4	8	--	--	--	--
Mexico	1,694	181	62,181	7,426	50,313	6,030
New Zealand	1	3	--	--	--	--
Nicaragua	224	20	--	--	--	--
Philippines	303	46	45	4	--	--
Seychelles	--	--	700	100	250	42
South Africa, Republic of	3	14	16	5	--	--
Suriname	1,062	111	--	--	--	--
Switzerland	15	1	--	--	--	--
Trinidad and Tobago	4,411	357	([1])	1	--	--
United Kingdom	198	12	824	41	159	64
Venezuela	4,002	195	117	28	3,142	397
Yugoslavia	41	4	--	--	--	--
Zaire	--	--	--	--	1,518	241
Other	47	31	--	--	536	150
Total[2]	38,694	2,724	108,841	10,861	96,819	13,794

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. imports for consumption of barite, by country

Country	1978		1979		1980	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Crude barite:						
Australia	--	--	--	--	49,629	$2,479
Brazil	--	--	5,412	$242	--	--
Canada	36,449	$1,075	2,185	69	111	4
Chile	195,377	8,267	142,466	6,826	174,285	9,468
China:						
Mainland	50,009	2,034	233,569	12,322	525,055	32,636
Taiwan	--	--	1,857	108	--	--
France	6,441	341	--	--	413	36
Germany, Federal Republic of	--	--	1	1	--	--
Greece	13,228	711	--	--	31,748	2,451
Guatemala	1,475	69	2,580	127	1,438	51
India	13,227	552	204,753	9,800	145,060	7,948
Ireland	217,754	5,551	170,444	5,272	82,823	2,603
Mexico	111,803	2,338	134,569	4,269	129,788	5,627
Morocco	129,938	4,994	133,346	7,256	204,928	12,282
Peru	383,264	10,252	338,452	11,794	326,908	14,453
Spain	--	--	1,719	158	--	--
Thailand	95,164	2,763	117,932	5,828	130,427	8,567
Tunisia	11,023	492	--	--	--	--
Turkey	7,617	326	--	--	--	--
United Kingdom	18,204	760	--	--	--	--
Total	1,290,973	40,525	1,489,285	64,072	[2]1,850,334	[2]101,956
Ground barite:						
Belgium-Luxembourg	16	5	6	2	17	8
Canada	5,448	660	990	96	397	164
China, mainland	--	--	21	4	118	20

See footnotes at end of table.

Table 9.—U.S. imports for consumption of barite, by country —Continued

Country	1978 Quantity (short tons)	1978 Value[1] (thousands)	1979 Quantity (short tons)	1979 Value[1] (thousands)	1980 Quantity (short tons)	1980 Value[1] (thousands)
Ground barite —Continued						
Germany, Federal Republic of	2	$3	24	$8	35	$12
India	--	--	11,024	803	--	--
Mexico	383	17	4,688	277	3,224	228
Morocco	3,417	220	--	--	--	--
Singapore	11,813	782	8,820	1,016	--	--
Spain	--	--	--	--	40	13
United Kingdom	--	--	8	3	--	--
Venezuela	--	--	62	6	--	--
Total	21,079	1,687	[3]25,643	[3]2,215	3,831	445

[1]C.i.f. value.
[2]Includes 47,721 tons valued at $3,351,000 from Taiwan not believed to have originated in Taiwan.
[3]Excludes 4,292 tons valued at $12,000 from Japan believed to be improperly categorized.

Table 10.—U.S. imports for consumption of barium chemicals

Year	Lithopone Quantity (short tons)	Lithopone Value (thousands)	Blanc fixe (precipitated barium sulfate) Quantity (short tons)	Blanc fixe Value (thousands)	Barium chloride Quantity (short tons)	Barium chloride Value (thousands)	Barium hydroxide Quantity (short tons)	Barium hydroxide Value (thousands)
1976	69	$25	7,971	$2,643	3,425	$690	2,422	$1,090
1977	65	27	8,729	3,069	5,384	1,170	2,448	1,222
1978	142	58	9,424	4,160	5,287	1,173	3,138	1,539
1979	1,535	662	9,352	4,152	6,839	1,398	3,912	2,009
1980	1,310	599	7,752	4,460	4,216	980	2,917	1,694

Year	Barium nitrate Quantity (short tons)	Barium nitrate Value (thousands)	Barium carbonate, precipitated Quantity (short tons)	Barium carbonate, precipitated Value (thousands)	Other barium compounds Quantity (short tons)	Other barium compounds Value (thousands)
1976	520	$122	2,420	$423	86	$102
1977	899	197	6,911	1,391	395	286
1978	468	123	10,712	2,465	2,987	1,186
1979	517	117	11,596	2,770	1,540	783
1980	1,143	243	6,876	2,050	883	597

Table 11.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude, unground Quantity (short tons)	Crude, unground Value (thousands)	Crushed or ground Quantity (short tons)	Crushed or ground Value (thousands)
1976	6	$5	278	$56
1977	--	--	518	103
1978	--	--	1,809	387
1979	5	1	436	105
1980	22,145	713	62	23

Table 12.—Barite: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	111	129	97	74	95
Guatemala	--	[e]1	1	4	5
Mexico	298	298	255	167	365
United States[3]	1,234	1,494	2,170	2,112	[p]2,245
South America:					
Argentina	45	34	36	61	[4]64
Bolivia[5]	1	2	3	2	10
Brazil	35	55	118	119	120
Chile	23	72	201	250	225
Colombia	[r]3	4	4	4	4
Peru	365	479	399	481	500
Europe:					
Austria	(6)	(6)	(6)	(6)	(6)
Czechoslovakia	[r e]65	[r e]70	[r e]70	75	[4]67
France	165	243	248	259	250
German Democratic Republic[e]	34	34	39	40	40
Germany, Federal Republic of	289	293	186	178	165
Greece[7]	48	43	49	53	53
Ireland	356	411	385	362	365
Italy	197	[r]150	261	237	240
Poland	89	98	100	106	100
Portugal	[r](6)	1	1	1	1
Romania	[e]94	[e]94	96	97	97
Spain	[e]102	92	79	82	80
U.S.S.R.[e]	440	500	525	550	550
United Kingdom	55	55	60	50	55
Yugoslavia	62	58	47	51	47
Africa:					
Algeria	83	53	81	99	100
Egypt	(6)	[r]1	1	2	3
Kenya	[e](6)	(6)	(6)	(6)	(6)
Morocco	142	[r]165	195	316	350
South Africa, Republic of	2	3	3	3	3
Swaziland	[e](6)	--	--	--	--
Tunisia	26	18	18	18	[4]30
Zimbabwe	(6)	(6)	(6)	(6)	(6)
Asia:					
Afghanistan[8]	6	[e]6	14	3	--
Burma	17	18	39	44	46
China, mainland[e]	330	385	440	550	750
India	[r]259	[r]365	428	427	[4]381
Iran	254	204	320	[e]200	165
Japan	59	[r]64	78	61	55
Korea, North[e]	130	130	120	120	120
Korea, Republic of	5	3	2	1	[4](6)
Malaysia	7	12	6	2	--
Pakistan	10	[r]20	21	38	42
Philippines	4	6	6	7	7
Thailand	167	[r]131	303	417	[4]336
Turkey	[r]110	158	35	120	165
Oceania: Australia	16	13	12	12	[4]30
Total	[r]5,738	[r]6,465	7,552	7,855	8,326

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 11, 1981.
[2]In addition to the countries listed, Bulgaria also produces barite, but available information is inadequate to make reliable estimates of output levels.
[3]Sold or used by producers.
[4]Reported figure.
[5]Series represents exports only; Bolivia also produces barite for domestic consumption, but available data are not adequate for formulation of estimates or levels of production to meet internal needs.
[6]Less than 1/2 unit.
[7]Barite concentrates.
[8]Year beginning March 21 of that stated.

WORLD REVIEW

Estimated world production of barite increased 6% to over 8.3 million tons in 1980. The U.S. output was 27% of the world total.

Canada.—Canadian barite output increased in 1980, reversing the downward trend of the past several years. In Newfoundland, ASARCO Incorporated and Price Co. began constructing a barite recovery section in the Buchans lead-zinc-copper flotation mill.[3] In the Yukon Territory, St. Joe Minerals Corp. was to conduct a diamond drilling program on the Mel lead-zinc-barite property 55 miles northeast of Watson Lake. Previous drilling had indicated a resource of nearly 4 million tons of material containing 1.93% lead, 5.20% zinc, and 61.4% barite.

China, Mainland.—Exports to the United States in 1980 were over 525,000 tons or 28% of the total imported. Barite was produced in four Provinces; the Hobei Provincial Government reported barite reserves of 20 million tons in seven counties.[4]

France.—Kali-Chemie GmbH of the Federal Republic of Germany reportedly purchased a majority shareholding in Barytine de Chaillac, France's largest barite producer. Kali-Chemie is the largest consumer of chemical-grade barite in the Federal Republic of Germany.[5] France exported 93,822 metric tons of barite to the Federal Republic of Germany in 1979.[6]

Mexico.—The Fedeicomiso No Metalicos Mexicanos installed a new barite operation at Mazatan in Sonora about 65 miles east of Hermasillo. Barita de Sonora S.A. de CV, the operating company, began production at 500 tons of ore per day, which will be increased in stages to the design capacity of 1,000 tons per day and will make the firm the largest barite producer in Mexico.[7] The basis of the operation is 3.32 million tons of ore with a barite content that ranges between 73% and 95% $BaSO_4$. The barite is found in layers varying in thickness from less than 2 inches to nearly 50 feet that are interbedded with Devonian shales, mudstones, and chert. Mexico's other barite producers had the capacity to produce about 300,000 tons per year of drilling-mud-grade product in 1980.

India.—The Ministry of Commerce and Civil Supplies revised the Nation's export policy for barite effective May 17, 1980. The new policy again allowed private mine owners to negotiate export contracts and not be restricted to selling through the national Minerals and Metals Trading Corp. (MMTC). The minimum floor price was revised upward from $37 to $44 per metric ton for crude barite with a minimum 4.2 specific gravity and from $57 to $60 per metric ton for ground barite with a minimum 4.2 specific gravity. Mine owners were restricted to exporting 20% of crude barite to nations in the Persian Gulf. Government-to-Government contracts continued to be handled by MMTC.[8]

Thailand.—Chromalloy American's Drilling Fluids Group developed a new barite mine at Hua Fai. Planned output was 100,000 tons per year with deliveries expected to begin in mid-1981.[9]

On July 9, 1980, the Thai Ministry of Industry announced an increase in the royalty rate for five minerals which included barite. The royalty rate for barite was increased from 0.5% to 7%. Mining companies protested that the new rates would have an adverse effect on Thailand's ability to compete in the world market for these minerals.[10]

United Kingdom.—In Derbyshire, S.P.O. Minerals Ltd. planned to have a new barite-fluorite-galena milling plant "fully operational" by April 1981. The first ore was put through the first-stage heavy media circuit on December 3, 1980; the grinding and flotation circuit was expected to be operating by yearend. The company planned to market drilling- and filler-grade barite, metallurgical-grade fluorspar, and galena concentrates.[11]

Yugoslavia.—Reportedly, Yugoslavia planned to begin construction on a new barite mine and processing plant between Bobija and Tisovik in Serbia during 1980. The designed capacity was reported as 150,000 metric tons per year of ore to yield 55,000 metric tons of barite concentrate.[12]

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[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Mitchell, A. W. Barite. Min. Eng., v. 33, No. 5, May 1981, pp. 567-568.
[3]Work cited in footnote 2.
[4]Wang, K. P. China. 1980 Mining Annual Review. Mining Magazine (London), 1980, p. 452.
[5]Industrial Minerals. No. 158, November 1980, p. 10.
[6]Annales Des Mines. C 1-Barytine. (Barite). September-October 1980, p. 93.
[7]Industrial Minerals. No. 153, June 1980, p. 29.
[8]U.S. Embassy, New Delhi, India. State Department Telegram 7740, May 22, 1980.
[9]Castelli, A. V. Barite, U.S. Production Sets Record of 2,600,000 S.T. Eng. and Min. J., v. 182, No. 3, March 1981, pp. 103-104.
[10]U.S. Embassy, Bangkok, Thailand. State Department Airgram A-37, Apr. 20, 1980, p. 2.
[11]Industrial Minerals. SPO Speeds Ahead. No. 160, January 1981, pp. 14-15.
[12]Mining Journal (London). New Barite Mine in Serbia. V. 294, No. 7552, May 16, 1980, p. 405.

Bauxite and Alumina

By Luke H. Baumgardner[1] and Ruth A. Hough[2]

World bauxite production in 1980 increased less than 3% over that of 1979. Australian production was virtually unchanged, while Jamaica and Guinea achieved modest gains over that of the preceding year. These three countries produced nearly 60% of the world's bauxite. Brazil, Indonesia, and Malaysia reported significant increases in bauxite production over that of the previous year in contrast to substantially lower bauxite output for France, India, and the United States. Both U.S. and world alumina production increased in 1980. Large gains by Brazil, Canada, Guyana, Jamaica, and Japan were offset partially by lower overall alumina production by the 19 other producing countries.

Most of the crude and dried bauxite imported into the United States in 1980 came from Jamaica, Guinea, and Suriname. Australia, Jamaica, and Suriname supplied nearly all of the alumina imported in 1980.

Legislation and Government Programs.—Stocks of bauxite in the national stockpile, which was maintained by the General Services Administration, did not change in 1980. Metal-grade bauxite, including Suriname- and Jamaica-type ore, totaled 14.4 million metric tons,[3] while approximately 177,000 tons of calcined refractory-grade bauxite remained in the stockpile at the end of 1980. Stockpile goals included 27.5 million metric tons of metal-grade bauxite, 1.4 million metric tons of calcined refractory-grade bauxite, and 1.0 million metric tons of calcined abrasive-grade bauxite. There were no stocks or inventory goals for alumina.

Import duties on bauxite and alumina were suspended in 1971 and have not been reinstated.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Production: Crude ore (dry equivalent)	1,989	2,013	1,669	1,821	1,559
Value	$26,645	$27,555	$23,185	$24,875	$22,353
Exports (as shipped)	15	26	13	15	21
Imports for consumption[1]	12,749	12,989	13,847	13,780	14,087
Consumption (dry equivalent)	14,039	14,528	14,738	15,697	15,962
World: Production	[r]77,417	[r]82,068	[r]79,851	[r]87,676	89,933

[r]Revised.
[1]Excludes calcined bauxite. Includes bauxite imported into the Virgin Islands.

DOMESTIC PRODUCTION

Seven companies mined bauxite in three States in 1980. In Arkansas, The Aluminum Co. of America (Alcoa), American Cyanamid Co., and Reynolds Metals Co. operated surface mines in Saline County. Reynolds also produced bauxite from a surface mine in Pulaski County. Most of the Arkansas bauxite was consumed by local Alcoa and Reynolds refineries to produce alumina. American Cyanamid produced calcined bauxite at its Benton plant, and Porocel Corp. (a subsidiary of Engelhard Corp.) produced activated bauxite from purchased ore at its Berger plant located near Little Rock, Ark.

Bauxite was mined in the Eufaula mining district of Alabama by A. P. Green Refractories Co., Harbison-Walker Refractories Co. (Dresser Industries, Inc.,) and Mullite Co. of America (Combustion Engineering Inc.) in Barbour County. In Henry County, within the same mining district, Harbison-Walker and Didier Taylor Refractories Corp. operated bauxite mines. In 1980 only the Mullite Co. mined bauxite in Georgia, with operations near Andersonville, Sumter County. All bauxite produced from Alabama and Georgia mines was dried or calcined for special nonalumina usage by the chemical and refractory industries.

Nine domestic Bayer process refineries, including the St. Croix, U.S. Virgin Islands, plant, produced 6.8 million metric tons (calcined equivalent weight) of alumina, including calcined alumina, commercial alumina trihydrate, and tabular, activated, and other alumina, but excluding aluminates.

Primary aluminum plants received an estimated 6 million tons of calcined alumina in 1980. The balance of alumina shipments went to the chemical, abrasives, ceramics, and refractories industries.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand metric tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers[1]		
	Crude	Dry equivalent	Value[2]	As shipped	Dry equivalent	Value[2]
1978:						
Alabama and Georgia	288	223	2,083	133	180	8,007
Arkansas	1,778	1,446	21,103	1,734	1,483	24,230
Total[3]	2,066	1,669	23,185	1,866	1,663	32,237
1979:						
Alabama and Georgia	501	391	4,320	222	286	14,821
Arkansas	1,685	1,430	20,555	1,695	1,442	24,600
Total	2,186	1,821	24,875	1,917	1,728	39,421
1980:						
Alabama and Georgia	336	260	3,101	172	236	12,442
Arkansas	1,533	1,299	19,252	1,499	1,309	23,388
Total[3]	1,869	1,559	22,353	1,671	1,545	35,830

[1]May exclude some bauxite mixed in clay products.
[2]Computed from values assigned by producers and from estimates of the Bureau of Mines.
[3]Data may not add to totals shown because of independent rounding.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Thousand metric tons)

Year	Crude ore treated	Total processed bauxite recovered[1]	
		As recovered	Dry equivalent
1979	466	235	336
1980	355	179	277

[1]Dried, calcined, and activated bauxite. May exclude some bauxite mixed in clay products.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1976	1977	1978	1979	1980
Less than 8	6	2	2	1	--
From 8 to 15	50	54	55	55	62
More than 15	44	44	43	44	38

Table 5.—Production and shipments of alumina in the United States

(Thousand metric tons)

Year	Calcined alumina	Other alumina[2]	Total[1]	
			As produced or shipped[3]	Calcined equivalent
Production:[e]				
1976	5,400	600	6,000	5,800
1977	5,580	660	6,230	6,030
1978	5,550	580	6,130	5,960
1979	5,950	700	6,650	6,450
1980	6,310	720	7,030	6,810
Shipments:[e]				
1976	5,400	600	6,000	5,800
1977	5,510	660	6,160	5,960
1978	5,620	580	6,200	6,020
1979	5,970	710	6,680	6,480
1980	6,160	720	6,880	6,660

[e]Estimated.
[1]Data may not add to totals shown because of independent rounding.
[2]Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.
[3]Includes only the end product if one type of alumina was produced and used to make another type of alumina.

Table 6.—Capacities of domestic alumina plants,[1] December 31

(Thousand metric tons per year)

Company and plant	1979	1980
Aluminum Co. of America:		
Bauxite, Ark	325	325
Mobile, Ala	800	800
Point Comfort, Tex	1,325	1,325
Total	2,450	2,450
Martin Marietta Aluminum, Inc.: St. Croix, V.I	508	508
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, La	930	930
Gramercy, La	726	726
Total	1,656	1,656
Ormet Corp.: Burnside, La	544	544
Reynolds Metals Co.:		
Hurricane Creek, Ark	650	650
Corpus Christi, Tex	1,400	1,400
Total	2,050	2,050
Grand total	7,208	7,208

[1]Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Most of the bauxite consumed in 1980 was refined to various forms of alumina. Bauxite consumption compared with alumina production during the year indicated that 2.2 metric tons of bauxite (dry basis) was consumed for each metric ton of alumina (calcined basis) produced. Seven of the U.S. alumina refineries used only imported bauxite, one plant processed a blend of foreign and domestic ore, and one plant operated solely on domestic bauxite.

Bauxite consumption decreased in 1980 for most industrial uses except the production of alumina as shown in table 7. Domestic mines supplied about 34% of the bauxite consumed by the refractories industry. A minor amount of bauxite blended with clay has been excluded from consumption figures.

Data on abrasives in table 7 include bauxite consumed in Canada to make intermediate abrasive materials that were used to manufacture abrasive products in U.S. plants. The cement, oil, and gas industries and municipal waterworks consumed an estimated 77,000 tons of bauxite.

In the United States, 32 primary aluminum plants consumed 8,838,000 metric tons of calcined alumina in 1980. Consumption data for other uses were not available, although a substantial amount of aluminum fluoride and synthetic cryolite made from alumina was used by the primary aluminum industry.

Table 7.—Bauxite consumed in the United States, by industry

(Thousand metric tons, dry equivalent)

Year and industry	Domestic	Foreign	Total[1]
1979:			
Alumina	1,426	13,098	14,524
Abrasive[2]	--	327	327
Chemical	[3]70	[3]255	256
Refractory	169	351	520
Other	W	W	70
Total[1 2]	1,665	14,032	15,697
1980:			
Alumina	1,681	13,287	14,968
Abrasive[2]	--	277	277
Chemical	[3]64	[3]224	211
Refractory	145	285	430
Other	W	W	77
Total[1 2]	1,890	14,072	15,962

W Withheld to avoid disclosing company proprietary data; included with "Chemical."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption by Canadian abrasive industry.
[3]Includes other.

Table 8.—Crude and processed bauxite consumed in the United States

(Thousand metric tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total[1]
1979:			
Crude and dried	1,437	13,354	14,792
Calcined and activated	228	677	905
Total[1]	1,665	14,032	15,697
1980:			
Crude and dried	1,692	13,523	15,214
Calcined and activated	198	550	748
Total[1]	1,890	14,072	15,962

[1]Data may not add to totals shown because of independent rounding.

Table 9.—Production and shipments of selected aluminum salts in the United States, in 1979

(Thousand metric tons and thousand dollars)

Item	Number of producing plants	Production	Total shipments including interplant transfers: Quantity	Total shipments including interplant transfers: Value
Aluminum sulfate:				
Commercial and municipal (17% Al_2O_3)	67	1,192	1,104	107,559
Iron-free (17% Al_2O_3)	17	106	93	8,813
Aluminum chloride:				
Liquid and crystal (32° Bé)	4	18	4	1,142
Anhydrous (100% $AlCl_3$)	6	66	28	23,739
Aluminum fluoride, technical	4	112	114	57,623
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	662	651	117,006
Other inorganic aluminum compounds[1]	XX	XX	XX	53,277

XX Not applicable.
[1]Includes aluminum chloride, liquid and crystal; sodium aluminate; light aluminum hydroxide; cryolite and alums.

Source: Data are based upon Bureau of the Census report Form MA-28A, Annual Report on Shipments and Production of Inorganic Chemicals.

STOCKS

The Government stockpile remained unchanged at 9,001,000 metric tons of Jamaica-type ore, 5,385,000 tons of Suriname-type ore, and 177,401 tons of calcined refractory-grade bauxite. The Federal stockpiles held no alumina, except as aluminum oxide abrasive grain and fused crude.

Table 10.—Stocks of bauxite in the United States,[1] December 31

(Thousand metric tons, dry equivalent)

Sector	1979	1980
Producers and processors	[r]620	661
Consumers	[r]7,958	7,749
Government	14,661	14,661
Total	[r]23,239	23,071

[r]Revised.
[1]Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.

Table 11.—Stocks of alumina in the United States,[1] December 31

(Thousand metric tons, calcined equivalent)

Sector	1979	1980
Producers[e]	143	245
Primary aluminum plants	1,278	1,283
Total	1,421	1,528

[e]Estimated.
[1]Excludes consumers stocks other than those at primary aluminum plants.

PRICES

World trade in bauxite and alumina is largely based on transfers between affiliated companies or through long-term negotiated contracts. For this reason prices are not generally quoted as they are for commodities traded on the open market.

For 1980, the Bureau of Mines estimated the average value of crude domestic shipments, f.o.b. mine or plant, at $11.95 per metric ton. The average value of shipments of domestic calcined bauxite was estimated at $101 per metric ton, compared with $98 (revised) in 1979 and $78 (revised) in 1978. The Bureau's estimates of shipment values were based on incomplete data supplied by producers. Because of grade differences, values varied widely among producers.

Insufficient company data were available for 1980 to determine the average value of imported bauxite consumed at domestic alumina plants. The Engineering and Mining Journal published the following prices on super-calcined, refractory-grade bauxite imported from Guyana, car lots, per metric ton:

	January 1980-March 1980	April 1980-December 1980
F.o.b. Baltimore, Md	$224.62	$208.39
F.o.b. Mobile, Ala	224.62	208.39

In 1980, the average value of domestic shipments of calcined alumina was estimated at $218 per metric ton. The average value of imported alumina (including a small amount of hydrate) as reported by the Bureau of Census, was $180 per ton at port of shipment (f.a.s.) and $196 per ton at U.S. ports (c.i.f.) in 1980.

Table 12.—Average value of U.S. imports of crude and dried bauxite[1]

(Per metric ton)

Country	1979		1980	
	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)
To U.S. mainland:				
Brazil	$22.51	$31.36	$23.05	$33.17
Dominican Republic	32.75	35.91	31.11	35.34
Guinea	21.46	28.13	25.94	32.67
Guyana	28.07	42.47	31.36	44.64
Haiti	26.33	31.35	24.20	29.46
Jamaica	28.10	31.29	27.25	30.51
Sierra Leone	15.37	25.16	16.59	26.44
Suriname	24.82	34.93	31.61	41.46
Other	18.45	44.28	--	--
To U.S. Virgin Islands: Guinea	13.18	19.03	13.77	20.54
Weighted average	25.46	30.70	26.25	32.02

[1]Computed from quantity and value data reported to U.S. Customs Service and compiled by the Bureau of the Census, U.S. Department of Commerce. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

Table 13.—Market quotations on alumina and aluminum compounds

(Per metric ton, in bags, carlots, freight equalized)

Compound	Dec. 31, 1979	Jan. 2, 1980
Alumina, calcined	$228.18	$228.18
Alumina, hydrated, heavy	143.30	203.93
Alumina, activated, granular, works	352.74	352.74
Aluminum sulfate, commercial, ground (17% Al_2O_3)	160.94	200.62
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	237.00	270.06

Source: Chemical Marketing Reporter.

FOREIGN TRADE

In 1980, the United States exported 28,400 metric tons of bauxite, including 7,600 tons in calcined form. Nearly all of the 1980 exports, valued at $6.8 million, went to Canada (63%) and Mexico (29%).

Exports of alumina included shipments of 271,000 metric tons from the U.S. Virgin Islands refinery, over 70% of which was shipped to Norway, with smaller amounts to Sweden, Poland, the U.S.S.R., Brazil, and Venezuela. Alumina, including 38,000 tons of aluminum hydroxide, originating from U.S. gulf coast alumina refineries accounted for an additional 867,000 tons of exports. Approximately 48,000 metric tons of exports identified as "other aluminum compounds" were shipped to 65 countries. A large part of this material was believed to be aluminum fluoride and synthetic cryolite used by other countries as a flux in making primary aluminum.

Imports of calcined bauxite in 1980 increased by more than 41% over 1979 receipts. Most of this substantial gain was due to large imports of refractory-grade bauxite from mainland China by the refractory industry to build up stocks.

Australia, Guinea, and Suriname supplied abrasive-grade calcined bauxite to Canada for manufacture into fused crude aluminum oxide, which was subsequently exported to the United States for use in abrasive and refractory products.

Imports of alumina increased by nearly one-half million tons in 1980, largely the result of increased shipments from Australia. The three principal sources of imported alumina were Australia, Jamaica, and Suriname, a supply pattern unchanged for over 10 years.

Table 14.—U.S. exports of alumina,[1] by country

(Thousand metric tons and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	1	387	3	1,754	16	4,514
Australia	1	641	3	1,099	4	1,920
Belgium-Luxembourg	(2)	366	(2)	323	1	729
Brazil	1	766	1	863	18	5,829
Canada	186	41,456	185	44,954	264	71,488
France	5	2,723	4	2,558	4	4,214
Germany, Federal Republic of	4	4,031	6	5,867	6	7,581
Ghana	134	17,966	94	14,295	151	24,958
Japan	2	4,627	3	4,592	3	9,489
Mexico	121	21,994	131	25,691	125	29,655
Netherlands	2	1,392	2	1,391	2	1,768
Norway	93	12,231	204	30,042	226	36,241
Poland	(2)	36	(2)	80	23	2,570
Sweden	28	4,749	2	1,585	72	16,749
U.S.S.R	239	31,120	70	8,462	18	2,124
United Kingdom	5	3,070	5	3,547	6	4,502
Venezuela	46	8,245	128	26,915	189	36,057
Other	10	6,600	8	8,050	10	11,554
Total	878	162,400	849	182,068	1,138	271,942

[1]Includes exports of aluminum hydroxide: 1978—44,100 tons; 1979—36,800 tons; 1980—38,000 tons. Also includes alumina exported from the U.S. Virgin Islands to foreign countries: 1978—332,000 tons; 1979—264,000 tons; 1980—271,000 tons

[2]Less than 1/2 unit.

Table 15.—U.S. imports for consumption of bauxite, crude and dried, by country[1]

(Thousand metric tons)

Country	1978	1979	1980
Australia	19	--	--
Brazil	--	168	777
Dominican Republic[2]	628	551	565
Greece	3	10	--
Guinea	3,363	3,924	4,112
Guyana	419	425	585
Haiti	588	572	452
Jamaica[2]	6,448	6,469	6,146
Sierra Leone	107	141	75
Suriname	2,259	1,520	1,369
Trinidad and Tobago[3]	13	--	--
Other	--	--	6
Total	13,847	13,780	14,087

[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries: 1978—1,033,000 tons; 1979—1,051,000 tons; 1980—1,241,000 tons.

[2]Dry equivalent of shipments to the United States.

[3]Shipments probably originated in Guyana or Suriname.

Note: Total U.S. imports of crude and dried bauxite (including U.S. Virgin Islands) as reported by U.S. Bureau of the Census were: 1978—15,069,625 tons; 1979—15,274,570 tons (revised); 1980—15,136,854 tons.

Table 16.—U.S. imports for consumption of bauxite (calcined), by country[1]

(Thousand metric tons and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	--	--	3	241	16	1,147
China, mainland	--	--	24	2,513	111	10,387
Guyana	220	28,609	190	27,006	199	34,314
Suriname	31	2,569	50	4,530	49	5,420
Other	1	292	(2)	93	3	89
Total	252	31,470	267	34,383	378	51,357

[1]Value at foreign port of shipment as reported to U.S. Customs Service.
[2]Less than 1/2 unit.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand metric tons and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Australia	2,879	382,017	2,938	433,382	3,408	578,031
Canada	28	6,327	23	5,704	37	9,380
France	12	19,753	12	21,350	5	14,452
Germany, Federal Republic of	7	4,425	11	8,158	8	8,934
Guyana	30	3,777	18	1,539	17	1,472
Jamaica	628	113,313	587	106,120	634	113,392
Japan	(3)	274	1	1,080	1	875
Suriname	382	58,650	239	41,245	246	55,440
Other	1	1,276	8	1,844	1	925
Total[4]	3,967	589,812	3,837	620,422	4,358	782,902

[1]Includes aluminum hydroxide; excludes shipments from the U.S. Virgin Islands to the United States: 1978—123,353 tons ($22,619,924); 1979—182,673 tons ($30,730,428); 1980—not available.
[2]Value at foreign port of shipment as reported to U.S. Customs Service.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World bauxite production from the 27 producing countries increased from 87.7 million metric tons in 1979 to 89.9 million tons in 1980. About 60% of the 1980 bauxite production was mined in Australia (31%), Guinea (15%), and Jamaica (14%). The gain in total world production was due primarily to expanded output by medium and small producing countries. As anticipated, Brazil's bauxite production recorded a substantial gain as Mineraçâo Rio do Norte S.A.'s (MRN) Trombetas mining operation expanded.

Alumina production in 1980 totaled 32.9 million metric tons from 25 countries. Australia and the United States produced over 40% of the world's total. Spain became a new alumina producer during 1980.

Australia.—Despite small decreases in both bauxite and alumina production in 1980 compared with that of 1979, Australia easily maintained its position as world supply leader for these essential raw materials of the aluminum industry. Alcoa of Australia (W.A.) Ltd., Comalco Ltd., and Nabalco Pty. Ltd. produced all of the metal-grade bauxite mined in Australia. Two of these companies, Alcoa and Nabalco, along with Queensland Alumina Ltd. (QAL), accounted for all alumina production.

In the State of Western Australia, Alcoa continued engineering design work on its Wagerup alumina refinery, scheduled to start operation in 1982 with an annual capacity of 500,000 metric tons. A 6-week labor strike at Alcoa's Pinjarra refinery lowered the company's bauxite and alumina production in 1980. Raymond Engineers Australia Pty. Ltd. has been contracted to design and construct the new $1.1 billion Worsley Alumina Pty. Ltd. refinery and bauxite mining complex 130 kilometers southeast of Perth. Construction of the 1-million-ton-per-year plant started in September 1980, and the first alumina shipments are scheduled for mid-1983. Participants in the venture include Reynolds Australia Alumina Ltd. (subsidiary of Reynolds Metals Co., 40%), Shell Co. of Australia (subsidiary of Royal Dutch/Shell Group, 30%), Dampier Mining Co. Ltd. (subsidiary of the Broken Hill Proprietary Co. Ltd., 20%), and Kobe Alumina Associates (Australia) Pty. Ltd. (jointly owned by Kobe Steel Ltd., Nissho-Iwai Co. Ltd., and C. Itoh & Co. Ltd., 10%).

Conzinc Riotinto of Australia, Ltd., (CRA) exercised an option with Alumax Bauxite Corp. that increased CRA's interest from 10% to 52.5% in the Mitchell Plateau bauxite reserves. Late in 1980, Alcoa reportedly also acquired a 17.5% interest in Mitchell Plateau plus a 22.5% interest in the adjacent Cape Bougainville bauxite reserves.

In Queensland, Tipperary Corp. of Midland, Tex., was reported to have sold its 40% interest in the 350-million-ton Aurukun bauxite deposit southeast of the Weipa Mine to Billiton Aluminium and Aluminium Pechiney for $27.8 million.

Comalco Ltd. produced 9.4 million tons of beneficiated bauxite at Weipa in 1980. Calcined abrasive-grade bauxite production increased from 248,000 tons in 1979 to 285,000 tons in 1980. Studies were initiated by Comalco during the year to consider (1) building an alumina refinery at Weipa, (2) utilizing coal rather than fuel oil for calcining bauxite and generating electrical power, and (3) developing the Weipa kaolin clay deposits as a marketable commodity. QAL's refinery at Gladstone reported 1980 production at 2.44 million metric tons, slightly lower than 1979 output, though in excess of its rated capacity of 2.0 million tons per year. QAL initiated plans to expand plant capacity by 360,000 tons by 1983.

Brazil.—The rise in bauxite output was primarily due to the continuing scheduled growth of the MRN mining operations at Trombetas, in the Amazon Basin.

The bauxite reserves of the Santa Patricia Mining Co. (subsidiary of National Bulk Carriers) were offered for sale to Alcoa Aluminio S.A. (subsidiary of Alcoa, 68%, and Hanna Mining Co., 32%); however, the Brazilian Government suspended approval of the transfer until the bauxite reserves could be further studied. The deposit, reported to contain 250 million tons, is adjacent to bauxite reserves held by Alcoa Aluminio near the Trombetas Mines operated by MRN.

CONSIDER, the Brazilian iron, steel, and nonferrous metals council, approved Alcoa Aluminio's proposed $1,300 million refinery and primary aluminum smelter complex to be built at São Luis, Maranhão. Construction started in 1980 and the 500,000-ton-per-year alumina plant was scheduled to start operating in 1983.

Guinea.—Production in 1980 of 13.8 million tons of bauxite retained Guinea's position as the world's second largest producer. Modifications to the Friguia alumina plant, owned by the Government of Guinea (49%) and Frialco (51%), a partnership of European and Canadian companies, lowered the rated capacity to about 660 metric tons per year at yearend 1980. The capacity loss, resulting from conversion from floury to sandy alumina, was expected to be regained during the first half of 1981 by adding new capacity.

Guyana.—In a move to boost bauxite production, Guymines, a State-owned company, has awarded a contract to Green Construction Co., a U.S. firm, for the removal of 10 million cubic yards of overburden. The U.S. $28 million project was to be completed in 20 months and was expected to provide an improved lead-time of stripping in advance of mining.

Jamaica.—Following the September 1980 election, Jamaica's new Prime Minister, Edward Seaga, announced that he planned to increase bauxite and alumina production and improve the general health of the country's aluminum industry. Jamaican bauxite production increased by 7% from 1979 to 1980 to 12.3 million metric tons. Alumina production of 2.5 million tons in 1980 represented an increase of almost 20% above 1979 production. Part of the alumina increase was attributed to an upgrading of the Alumina Partners of Jamaica (Alpart) Mine and alumina plant operated by Reynolds, Kaiser, and The Anaconda Company.

In February 1980, Kaiser Jamaica Bauxite Co., owned by Kaiser Bauxite Co. (subsidiary of Kaiser Aluminum and Chemical Corp.) (49%) and the Jamaican Government (51%), was formed as a bauxite mining partnership for Kaiser's north coast bauxite operations. Revere Jamaica Alumina Ltd. (a subsidiary of Revere Copper and Brass Inc.) offered for sale its alumina refinery at Maggoty, which has been closed since August 1975.

The Jamaican Government announced a plan to double the capacity of the Jamalco alumina plant (owned by Alcoa 94%, Jamaica 6%) at Clarendon. Financing of the expansion from the present annual capacity of 550,000 metric tons to 1 million tons was to come mainly from three new Norwegian partners, Norsk Hydro A/S, Ardal og Sunndal Verk A/S (ASV), and Elkem Spigerverket A/S, which were to receive alumina in proportion to their respective equity interests.

Spain.—In the second half of 1980, the San Ciprián alumina plant operated by Aluminio Española, S.A. (owned 45% by Aluminio de Galicia, S.A., and 55% by Empresa Nacional del Aluminio, S.A.) began operations. Although production during the last few months of 1980 was only 58,000 metric tons, the plant was expected to reach its initial designed capacity of 800,000 tons per year by the second quarter of 1981.

Sierra Leone.—An agreement was signed between Alusuisse and the Government of Sierra Leone establishing the Sierra Leone Bauxite Co. in June 1980. The partners were to share equally in a 1.6-million-ton-per-year mining project near Port Loko.

Table 18.—Bauxite: World production, by country[1]

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America and Caribbean Islands:					
Dominican Republic[2 3]	[r]627	[r]575	568	524	[4]605
Haiti[5]	660	588	580	584	[4]452
Jamaica[6]	[r]10,296	11,433	11,777	11,505	[4]12,261
United States[1]	1,989	2,013	1,669	1,821	[4]1,559
South America:					
Brazil[e 7]	827	1,120	1,160	[r]2,388	3,970
Guyana[e 2]	2,686	2,731	[r]2,425	[r]2,312	2,348
Suriname	[r]4,613	[r]4,805	5,188	5,010	4,696
Europe:					
France[8]	2,330	2,059	1,978	1,969	[4]1,665
Germany, Federal Republic of	([9])	([9])	([9])	([9])	([9])
Greece	2,551	[r]2,882	2,664	2,915	2,950
Hungary	2,918	2,949	2,899	2,976	3,020
Italy	24	35	24	26	[4]23
Romania	680	702	708	708	708
Spain	13	[r]10	6	17	20
U.S.S.R.[e 10]	4,500	4,600	4,600	4,600	4,600
Yugoslavia	2,033	2,044	2,565	3,012	[4]3,138
Africa:					
Ghana	272	244	328	214	[4]225
Guinea	[r]10,848	[r]10,841	10,456	13,700	[4]13,780
Mozambique	2	--	--	--	--
Sierra Leone	651	745	716	583	[4]590
Zimbabwe	[r]3	[r]3	5	5	4
Asia:					
China, mainland[e]	[r]1,300	[r]1,500	[r]1,500	1,500	1,500
India	[r]1,449	[r]1,519	1,663	1,934	[4]1,740
Indonesia	940	1,301	1,008	1,052	[4]1,224
Malaysia	660	616	615	387	[4]920
Pakistan	([9])	([9])	2	1	1
Turkey	461	667	454	350	350
Oceania: Australia	24,084	26,086	24,293	27,583	[4]27,584
Total	[r]77,417	[r]82,068	79,851	87,676	89,933

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 1, 1981.
[2]Dry bauxite equivalent of crude ore.
[3]Shipments.
[4]Reported figure.
[5]Dry bauxite equivalent of ore processed by drying plant.
[6]Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.
[7]Estimated dry bauxite equivalent of crude ore, calculated from reported crude ore, assuming a moisture content of 17.2%.
[8]Includes bauxite identified as "usable for fabrication of alumina" as follows, in thousand metric tons: 1976—2,250; 1977—1,966; 1978—1,875; 1979—1,874; 1980—(estimated) 1,610.
[9]Less than 1/2 unit.
[10]In addition to the bauxite reported in the body of the table, the U.S.S.R. produces nepheline syenite concentrates and alunite ore as sources of aluminum. Estimated nepheline syenite production was as follows, in thousand metric tons: 1976—2,400; 1977—2,500; 1978—2,500; 1979—2,500; 1980—2,500, and estimated alunite ore production was as follows, in thousand metric tons: 1976—600; 1977—600; 1978—600; 1979—600; 1980—600. Nepheline syenite concentrate grades 25% to 30% alumina and alunite ore grades 16% to 18% alumina; these commodities may be converted to their bauxite equivalent by using factors of 1 ton of nepheline syenite concentrate equals 0.55 ton of bauxite and 1 ton of alunite equals 0.34 ton of bauxite.

Table 19.—Alumina: World production,[1] [2] by country

(Thousand metric tons)

Continent and country[3]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	490	1,061	1,054	824	[4]1,138
Jamaica	[r]1,644	[r]2,048	2,111	2,074	[4]2,478
United States[e]	5,800	6,030	5,960	6,450	6,810
South America:					
Brazil	[r]306	[r]340	352	449	540
Guyana[5]	281	271	237	154	219
Suriname	1,162	[r]1,172	1,310	1,325	1,316
Europe:					
Czechoslovakia[e]	90	95	100	100	100
France	1,020	1,081	1,056	1,075	[4]1,173
German Democratic Republic	44	39	38	41	41
Germany, Federal Republic of	1,333	1,454	1,410	1,352	1,400
Greece	[r]462	474	478	496	490
Hungary	732	783	782	788	800
Italy	[r]798	[r]788	819	854	[4]900
Romania[e]	425	442	449	500	500
Spain	--	--	--	--	58
United Kingdom	96	99	94	88	90
U.S.S.R.[e]	2,500	2,600	2,600	2,600	2,700
Yugoslavia	455	499	496	836	870
Africa: Guinea	560	562	610	660	[e]708
Asia:					
China:					
Mainland[e]	[r]750	[r]750	[r]750	[r]750	750
Taiwan	48	51	51	58	65
India	442	[e]390	480	493	500
Japan	1,411	1,785	1,502	1,545	1,950
Turkey	139	[e]170	[e]85	[e]140	[e]140
Oceania: Australia	6,206	6,659	6,776	7,415	7,247
Total	[r]27,194	[r]29,643	29,600	31,067	32,983

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 1, 1981.
[2]Figures presented generally represent calcined alumina; exceptions are noted individually.
[3]In addition to the countries listed, Austria produces alumina (fused aluminum oxide), but output is entirely for abrasives production. Output totaled 28,223 metric tons in 1973; production data subsequent to 1973 are not available.
[4]Reported figure.
[5]Calcined alumina plus calcined alumina equivalent of alumina hydrate.

Table 20.—World annual alumina capacity

(Thousand metric tons, yearend)

Country	1978	1979	1980
North America:			
Canada	1,225	1,225	1,225
Jamaica	2,824	2,824	2,824
United States	7,208	7,208	7,208
South America:			
Brazil	430	460	540
Guyana	354	354	354
Suriname	1,350	1,350	1,350
Europe:			
Czechoslovakia	100	100	100
France	1,320	1,320	1,320
German Democratic Republic	65	65	65
Germany, Federal Republic of	1,729	1,729	1,745
Greece	500	500	500
Hungary	790	817	895
Italy	920	920	920
Romania	540	540	540
Spain	--	--	80
United Kingdom	130	138	138
U.S.S.R.[e]	3,400	3,400	3,400
Yugoslavia	1,560	1,600	1,635

See footnotes at end of table.

Table 20.—World annual alumina capacity —Continued

(Thousand metric tons, yearend)

Country	1978	1979	1980
Africa: Guinea	700	700	660
Asia:			
China:			
Mainland[e]	600	650	650
Taiwan	140	140	140
India	675	675	675
Japan	2,614	2,614	2,614
Turkey	200	200	200
Oceania: Australia	7,044	7,044	7,340
Total	36,418	36,573	37,118

[e]Estimated.

TECHNOLOGY

Research by the U.S. Bureau of Mines on domestic nonbauxitic sources of alumina was continued during 1980. Five companies participated in the Bureau's miniplant project on a cooperative cost-sharing plan. Digestion and extraction tests on recovery of alumina from clay were performed at the Bureau's Boulder City Engineering Laboratory in Nevada. Supplementary analytical and physical support work was provided by other Bureau research centers.[4]

[1]Physical scientist, Section of Nonferrous Metals.

[2]Statistical assistant, Section of Nonferrous Metals.

[3]All quantities in this chapter are given in metric tons unless otherwise indicated.

[4]Bengston, K. B., P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm (contract J0265048, Kaiser Engineers, Inc.). Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume I. Process Technology and Costs. BuMines Open File Report 122(1)-80, 1980, 232 pp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies available from the National Technical Information Service, Springfield, Va., PB 81-125031.

Berylluim

By Benjamin Petkof[1]

Low-grade bertrandite ore mined in Utah was the mainstay of domestic beryllium minerals production. Imports of beryl increased and augmented the domestic supply of beryllium concentrates. Beryllium mineral concentrate consumption declined from that of 1979 but was above that of 1978. Exports of beryllium material declined.

Legislation and Government Programs.—The Federal Emergency Management Agency issued new strategic stockpile goals for beryllium materials on May 2, 1980, replacing the goals issued on October 1, 1976. The new stockpile goals are beryl, 18,000 tons; beryllium-copper master alloy, 7,900 tons; and beryllium metal, 400 tons. No beryllium materials were released from the strategic stockpiles during 1980.

The Occupational Safety and Health Administration, U.S. Department of Labor, did not finalize its proposed beryllium occupational and health standards, as published in the Federal Register, October 17, 1975, during 1980.

Table 1.—Salient beryllium mineral statistics

	1976	1977	1978	1979	1980
United States:					
Beryllium mineral concentrates:					
Shipped from mines[1] short tons	W	W	W	W	W
Imports do	1,058	746	1,031	1,037	1,703
Consumption[1] do	3,740	4,165	5,916	9,518	8,508
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$36	$40	$43	$47	$69
Yearend stocks[1] short tons	3,957	3,557	1,346	835	1,350
World production of beryl do	2,553	[r]2,800	3,094	[p]2,974	[e]3,098

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Includes bertrandite ore, which was calculated as equivalent to beryl containing 11% BeO.

DOMESTIC PRODUCTION

Brush Wellman, Inc., (Brush) remained the only major commercial domestic producer of beryllium concentrates in 1980. Brush mined low-grade bertrandite ore at its Spor Mountain, Utah, operation for processing into beryllium hydroxide.

Brush converted its ore to beryllium hydroxide at a facility north of Delta, Utah, and shipped the hydroxide to its Elmore, Ohio, facility and elsewhere for conversion into various beryllium products. By yearend 1980, Brush completed its announced increase in capacity at the bertrandite ore processing facility. Brush also had the capability to convert beryl to beryllium hydroxide at Delta, Utah.

The Cabot Berylco Div. (formerly Kawecki-Berylco Industries, Inc.) of the Cabot Corp. produced beryllium-copper and other beryllium alloys at its plant in Reading, Pa., from imported and domestic ores that were converted to beryllium hydroxide.

Domestic production of beryllium metal, beryllium oxide, and beryllium-copper master alloy was strong in 1980 and close to the levels of 1979.

CONSUMPTION AND USES

In 1980, the domestic beryllium industry consumed beryllium ore equivalent to 8,508 tons of beryl containing nominal 11% beryllium oxide (BeO). Consumption was below that of 1979 but above that of 1978.

Products utilizing beryllium-copper alloys accounted for the greatest quantity of beryllium consumption. These alloys were used by the business machine, appliance, transportation, and communications industries. Beryllium-copper alloys were also widely used in electrical and electronic systems for connectors, sockets, switches, and temperature- and pressure-sensing devices to provide reliability and long service life.

Beryllium oxide (beryllia) has found increased use in lasers, microwave tubes, and semiconductors, primarily for heat dissipation. Beryllia was used also as a substrate in various electronic devices and equipment.

Beryllium metal, with its high stiffness-to-weight ratio and excellent thermal conduction properties, was used in items such as inertial navigation systems, satellite structures, space optics, nuclear devices, and military aircraft brakes.

STOCKS

Consumer stocks of beryllium minerals totaled 1,350 tons (11% BeO equivalent) at yearend. Stocks increased to the level of yearend 1978 reflecting increased mineral production and imports.

PRICES AND SPECIFICATIONS

At the beginning of 1980, Metals Week quoted the price of imported beryl at $75 to $85 per short ton unit of contained BeO. From midyear to yearend the price was quoted at $90 to $100 per short ton unit.

At yearend 1980, the American Metal Market quoted the following prices for beryllium materials: Vacuum cast ingot, $140 per pound; metal powder (in 5,000-pound lots), $120 per pound; beryllium-copper master alloy, $105 per pound of contained beryllium; beryllium-copper casting alloy $3.92 to $4.43 per pound; beryllium-copper in rod, bar, and wire, $6.38 per pound; beryllium-copper in strip, $6.36 per pound; beryllium-aluminum alloy ingot (100,000-pound lots), $149.50 per pound; and beryllium oxide powder, $31.45 to $39.41 per pound. All beryllium metal quotations were for 97%-purity metal.

FOREIGN TRADE

Exports of wrought and unwrought beryllium alloys and waste and scrap declined in quantity from that of 1979 but increased in total value. About two-thirds of U.S. exports were destined for the United Kingdom, France, and Canada.

Beryl was the only beryllium mineral ore imported. The average value of imported beryl increased from $471 per ton in 1979 to $686 per ton in 1980. Brazil, the historical major source of U.S. beryl imports, was replaced by mainland China as the major source of beryl. Mainland China supplied about half of U.S. imports in 1980. In addition, 11,236 pounds of wrought, unwrought, and waste and scrap beryllium metal valued at $237,344 was imported primarily from the United Kingdom, Canada, and Mexico.

Table 2.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap[1]

Country	1979		1980	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Argentina	291	$3	209	$4
Australia	--	--	1,148	10
Belgium-Luxembourg	112	66	34	3
Canada	10,698	211	7,829	170
Finland	86	19	--	--
France	17,370	1,635	12,633	1,128
Germany, Federal Republic of	1,022	195	1,042	267
Hong Kong	2,200	11	--	--
India	253	8	--	--
Italy	249	6	4,342	35
Jamaica	--	--	14	5
Japan	4,691	397	2,788	366
Mexico	326	21	--	--
Netherlands	1,057	40	4,276	126
New Zealand	65	1	--	--
Norway	192	2	--	--
Singapore	1,367	6	--	--
Switzerland	3,939	50	208	23
Taiwan	4,000	15	2,500	12
Turkey	--	--	2,546	13
United Kingdom	23,915	999	18,582	1,701
Venezuela	319	1	--	--
Other	--	--	304	4
Total	72,152	3,686	58,455	3,867

[1]Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; beryllium rods, sheets, and wire.

Table 3.—U.S. imports for consumption of beryl, by customs district and country

Customs district and country	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Philadelphia district:				
Brazil	187	$94	328	$260
China, mainland	265	115	640	415
Mozambique	--	--	14	10
Portugal	--	--	44	25
Rwanda	110	77	131	74
South Africa, Republic of	21	8	--	--
Total	583	294	1,157	784
Los Angeles district:				
Argentina	84	40	55	33
Brazil	331	141	243	190
China, mainland	--	--	222	147
Mozambique	22	6	--	--
South Africa, Republic of	17	7	15	6
Total	454	194	535	376
New York City district: South Africa, Republic of	--	--	11	8
Grand total	1,037	488	1,703	1,168

WORLD REVIEW

World beryl production remained low in 1980 in response to limited world industrial demand for beryllium mineral concentrates. Brazil and the U.S.S.R. were the major world beryl producers. The United States continued to mine and process bertrandite ore. A recent article reviewed the world status of the beryllium industry.[2]

[1]Physical scientist, Section of Nonferrous Metals.
[2]Industrial Minerals. Beryllium Minerals - Bertrandite Now Established. No. 143, June 1980, pp. 55-63.

Table 4.—Beryl: World production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Argentina	123	182	219	31	110
Brazil	406	[r]547	815	[e]800	850
Kenya	--	--	--	(2)	--
Madagascar	19	[e] [r]17	12	[e]11	11
Mozambique	(2)	NA	NA	30	22
Nepal[3]	[e]1	1	(2)	(2)	(2)
Portugal	--	--	(2)	--	--
Rwanda	51	[e] [r]60	64	51	55
South Africa, Republic of	3	3	4	[e] [r]1	--
Uganda[e]	60	50	NA	--	--
U.S.S.R.[e]	1,820	1,870	1,930	2,000	2,000
United States[4]	W	W	W	W	W
Zimbabwe[e]	70	70	50	50	50
Total	2,553	[r]2,800	3,094	2,974	3,098

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]In addition to the countries listed, mainland China produced beryl and Bolivia and Namibia may also have produced beryl, but available information is inadequate to formulate reliable estimates of output levels. Table includes data available through Apr. 5, 1981.
[2]Less than 1/2 unit.
[3]Fiscal year ending in July of year stated.
[4]Primarily bertrandite ore.

Bismuth

By James F. Carlin, Jr.[1]

Domestic consumption of bismuth was 2.3 million pounds in 1980, the lowest level in the past 5 years, due to the general economic slowdown. Imports increased slightly over 1979 levels to 2.2 million pounds, as consumer stocks were built up. Exports declined sharply to 128,732 pounds, returning to a level more consistent with that of prior years. The domestic producer price for refined bismuth fell from $3 per pound to $2.50 per pound in August where it remained until October 1, at which time the only domestic producer suspended its daily list price. World bismuth mine production was 7.3 million pounds, a slight decrease from that of 1979, and continued the generally declining trend of recent years.

Legislation and Government Programs.—Government stocks remained at 2,081,298 pounds, including 567,186 pounds in the national stockpile and 1,514,112 pounds in the supplemental stockpile. The stockpile goal was increased from 771,000 pounds to 2,200,000 pounds.

Federal income tax laws provided a depletion allowance of 22% for domestic production and 14% for U.S. companies producing from foreign sources.

Table 1.—Salient bismuth statistics

(Pounds unless otherwise specified)

	1976	1977	1978	1979	1980
United States:					
Consumption	2,410,584	2,379,635	2,511,876	2,727,153	2,288,807
Exports[1]	68,488	95,334	96,346	427,809	128,732
Imports, general	2,328,051	2,013,333	2,657,763	2,167,278	2,217,359
Producer price, average per pound (ton lots)	$7.50	$6.01	$3.38	$3.01	$2.64
Consumer stocks, Dec. 31:	483,810	436,092	781,868	629,741	673,975
World: Production[2] thousand pounds	[r]8,689	[r]9,704	[r]9,442	[r]7,880	[e]7,321

[e]Estimated. [r]Revised.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Excludes the United States.

DOMESTIC PRODUCTION

Bismuth was produced almost entirely from the treatment of lead ores and bullion of both foreign and domestic origin. A single primary refinery operated by ASARCO Incorporated at Omaha, Nebr., accounted for all primary production. United Refining and Smelting Co., Franklin Park, Ill., ceased secondary bismuth production after many years as a recycler of bismuth scrap materials. Refinery production statistics are withheld to avoid disclosing company proprietary data.

CONSUMPTION AND USES

Most consumption categories experienced a decline from 1979 levels due to generally weak economic conditions in 1980. The most severe decline occurred in metallurgical additives where the demand for malleable iron castings suffered from weakness in various transportation sectors.

Inland Steel Co., Chicago, Ill., introduced a new bismuth-bearing steel grade, Incut 200, for the free-machining bar steel market. In recent years, various combinations of metal additives such as lead, bismuth, or tellurium have been used by domestic steel producers to achieve free-machining qualities. This is the first product to use only bismuth to obtain those properties.

Table 2.—Bismuth metal consumed in the United States, by use

(Pounds)

Use	1979	1980
Fusible alloys	721,043	650,895
Metallurgical additives	703,770	467,939
Other alloys	22,029	26,484
Pharmaceuticals[1]	1,248,656	1,115,615
Experimental uses	3,153	1,197
Other uses	28,502	26,677
Total	2,727,153	2,288,807

[1]Includes industrial and laboratory chemicals and cosmetics.

STOCKS

During the year consumer stocks rose slightly but did not reach the peak levels of 1978.

PRICES

Asarco maintained its producer price at $3 per pound until early August when the price was lowered to $2.50 per pound where it remained through September. On October 1, Asarco suspended its list price for bismuth owing to weak market conditions. Dealer quotations started the year at $2.50 to $2.60 per pound, peaked at $2.95 to $3.10 per pound in January, then generally declined throughout the year to finish at $2 to $2.10 per pound.

FOREIGN TRADE

Exports of bismuth returned to the lower levels of prior years, following the abnormally large figure for 1979.

Imports of bismuth were mainly from Mexico, Peru, and the United Kingdom.

Starting January 1, 1980, the tariff rates for bismuth were unwrought metal (No. 632.10), free for most favored nation (MFN) and 7.5% ad valorem (non-MFN); alloys (No. 632.66), 8.6% ad valorem (MFN) and 45% ad valorem (non-MFN); compounds (Nos. 418.00 and 423.80), 13.1% ad valorem (MFN) and 35% ad valorem (non-MFN).

Table 3.—U.S. exports of bismuth alloys, waste and scrap, by country

(Pounds, gross weight)

Country	1979		1980	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Argentina	2,875	$47	3,185	$21
Belgium-Luxembourg	--	--	17,630	55
Brazil	2,604	7	--	--
Canada	13,853	224	70,551	444
Colombia	185	2	570	6
Denmark	--	--	400	3
Dominican Republic	--	--	400	1
France	550	11	101	4
Germany, Federal Republic of	6,095	14	940	44

Table 3.—U.S. exports of bismuth alloys, waste and scrap, by country —Continued

(Pounds, gross weight)

Country	1979 Quantity (pounds)	1979 Value (thousands)	1980 Quantity (pounds)	1980 Value (thousands)
Greece	--	--	8,158	$28
India	4,446	$16	3,500	15
Israel	1,202	9	784	7
Italy	205	7	569	2
Japan	5,414	39	1,293	6
Korea, Republic of	3,212	24	209	6
Leeward-Windward Islands	--	--	840	2
Mexico	304	2	45	2
Netherlands	329,340	906	4,400	12
Saudi Arabia	--	--	2,460	5
Singapore	3,146	7	331	7
South Africa, Republic of	--	--	5,176	197
Sweden	4,400	17	926	14
Taiwan	3,008	7	--	--
United Kingdom	45,967	48	5,345	31
Venezuela	465	11	313	13
Other	538	10	606	17
Total	427,809	1,408	128,732	942

Table 4.—U.S. general imports[1] of metallic bismuth, by country

Country	1979 Quantity (pounds)	1979 Value (thousands)	1980 Quantity (pounds)	1980 Value (thousands)
Belgium-Luxembourg	100,112	$74	88,224	$31
Bulgaria	17,950	34	--	--
Canada	102,591	324	80,640	197
Germany, Federal Republic of	170,829	896	158,778	563
Israel	--	--	820	2
Japan	185,496	392	138,378	339
Korea, Republic of	230,781	398	9,692	21
Mexico	604,753	1,266	860,363	2,008
Peru	648,733	1,620	619,091	1,416
Poland	--	--	3	1
Spain	--	--	331	2
United Kingdom	106,033	414	261,039	784
Total	2,167,278	5,418	2,217,359	5,364

[1]General imports and imports for consumption were the same in 1979 and 1980.

WORLD REVIEW

World production of bismuth continued the decline exhibited since 1977. This was attributed to weak demand caused by the general worldwide economic slowdown in 1980 and also was due to deliberate production reductions by some major producers in response to the continued decline in the bismuth market price. Bolivia reportedly ceased production in 1980 until world prices improved.

Canada.—Bismuth was produced by two companies in Canada. Brunswick Mining & Smelting Corp. Ltd. closed down permanently the bismuth refinery at its Belledune plant, and produced only a 60% lead-40% bismuth crystal, mainly for export to Europe. Bismuth metal was produced by Cominco Ltd. at its lead-zinc plant in Trail, British Columbia. Cominco derived most of its Canadian output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley; other sources included lead concentrates from other company mines and from domestic and foreign custom shippers. Although Brunswick Tin Mines Ltd., a subsidiary of Sullivan Mining Group Ltd., and Billiton Canada Ltd. reached an agreement whereby Billiton would bring Brunswick

Tin's property in Charlotte County, New Brunswick, into production, it was reported that production of bismuth would be delayed indefinitely. Some bismuth was mined by Terra Mining and Exploration Ltd. from the silver-copper deposits near Port Radium, Northwest Territories.

U.S.S.R.—Bismuth was recovered as a byproduct of lead and zinc smelting in the Republic of Kazakhstan and other areas in the U.S.S.R., from dust and crude metal at the Balkhash copper complex in the Republic of Kazakhstan, the Kirovgrad and Mednogorsk copper complexes in the Urals, and from tungsten and molybdenum ores. The Taryzkan and the Kantarkhana copper-bismuth deposits in the Republic of Tadzhikistan were under exploration. The Ustarassy Mine in the Chatkal Mountains in Central Asia was the only operation where bismuth ore was mined directly; its concentrates were shipped to the Chimkent lead refinery in the Republic of Kazakhstan. Renovation and enlargement of bismuth production facilities at the lead complex of the Dalpolimetall Association in the Primorsk Kray were completed in 1980.

[1]Physical scientist, Section of Nonferrous Metals.

Table 5.—Bismuth: World mine production, by country

(Thousand pounds)

Country[1]	1976	1977	1978[p]	1979[e]	1980[e]
Australia (in concentrates)	1,650	2,054	2,324	[e]2,200	2,000
Bolivia (in concentrates)	1,349	[r]1,435	677	22	[2]24
Canada[3]	286	363	320	301	[2]377
China, mainland (in ore)[e]	[r]485	[r]500	[r]530	[r]570	570
France (metal)[4]	139	[r]110	110	130	130
Germany, Federal Republic of (in ore)[e]	24	24	20	22	20
Japan (metal)[4]	1,502	1,538	1,375	1,070	700
Korea, Republic of (metal)[4]	384	[r]293	269	192	200
Mexico[5]	1,228	1,607	2,156	1,660	1,650
Peru[5]	1,149	1,290	[e]1,300	1,323	1,150
Romania (in ore)[e]	180	180	180	180	180
Sweden (in ore)[e]	([6])	([6])	([6])	([6])	--
Uganda (in ore)[e]	11	7	2	([6])	--
U.S.S.R. (metal)[4] [e]	130	140	150	160	160
United States (in ore)	W	W	W	W	W
Yugoslavia (metal)[4]	172	[r]163	29	50	160
Total	[r]8,689	[r]9,704	9,442	7,880	7,321

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from total.

[1]In addition to the countries listed, Brazil, Bulgaria, the German Democratic Republic, and the Territory of South-West Africa (Namibia) are believed to have produced bismuth, but available information is inadequate for formulation of reliable estimates of output levels.

[2]Reported figure. Table includes data available through Apr. 5, 1981.

[3]Refined metal and bullion plus recoverable bismuth content of exported concentrate.

[4]Although output reported is at the smelter stage of production rather than at the mine stage, and thus could include metal contained in ores mined in other countries, it is believed that any such production derived from ores from other countries is not duplicative to any significant extent of mine production reported elsewhere in this table.

[5]Bismuth content of refined metal, bullion, and alloys produced indigenously, plus recoverable bismuth content of ores and concentrates exported for processing.

[6]Revised to zero.

Boron

By Phyllis A. Lyday[1]

In 1980, production and consumption of boron minerals in the United States decreased below that of 1979. California continued to provide the entire U.S. production of boron materials. Total value of sales increased to $367 million, the largest amount in history. Exports of boric acid increased to the 1978 level with an increase in value. Exports of refined sodium borates decreased during 1980.

Principal uses for borate minerals consumed in the United States during 1980 were, in decreasing order of quantity consumed, glass fiber insulation, cellulose insulation, textile-grade fiberglass, borosilicate glasses, and soaps and detergents. Borates used in all types of glass production represented over 50% of consumption. Use of boron in textile-grade fiberglass was expected to increase in use for transportation. Metallurgical use of boron during 1980 increased 17% over that of 1979.

Legislation and Government Programs.—In June, the Department of the Interior announced that 2 million acres of land near Death Valley National Monument (DVNM) would be redesignated as a class 1 air pollution control area. Under provisions of the Clean Air Act, the change in class would mean that no new emissions would be allowed within 50 miles of the monument. American Borate Co.'s borate mines in DVNM, U.S. Borax & Chemical Corp.'s 600 acres of patented claims in DVNM, and Kerr McGee Chemical Corp.'s borate operation at Trona would be affected. The Mountain State Legal Foundation was challenging the ruling at yearend.

The Environmental Protection Agency issued final regulations on standards for new glass manufacturing on October 7, 1980, as follows:

Glass category	Standard[1] (pounds per ton)
Pressed and blown glass:	
Borosilicate	1.0
Other	.5
Wool fiberglass	.5

[1]The Glass Industry. EPA Issues Final Regulations for Glass Manufacturing Plants. V. 61, No. 12, December 1980, pp. 28-29.

A 4-year moratorium on surface disturbances by mining in Death Valley National Park expired on September 28, 1980. Exploration drilling was expected to start in the near future.

Table 1.—Salient statistics of boron minerals and compounds in the United States

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Sold or used by producers:					
Quantity:					
Gross weight[1]	1,246	1,469	1,554	1,590	1,545
Boron oxide (B_2O_3) content	630	735	778	799	783
Boron content	196	228	242	248	243
Value	$184,852	$236,163	$279,927	$310,211	$366,760
Exports:					
Sodium borates (refined):[2]					
Quantity	211	265	304	332	325
Value	$49,156	$64,634	[e]$80,000	[e]$94,000	[e]$64,737
Boric acid:[3]					
Quantity	36	36	46	42	45
Value	$12,363	$12,931	$22,217	$22,938	23,735
Imports for consumption:					
Colemanite:					
Quantity	30	51	[4]94	[4]81	63
Value	$1,953	$3,695	$9,320	$10,946	$6,218
Boric acid:					
Quantity	([5])	14	16	8	10
Value	$14	$5,596	$8,921	$4,267	$6,393
Apparent consumption: Boron content[6]	94	121	128	127	121

[e]Estimated.
[1]Minerals and compounds sold or used by producers, including both actual mine production and a marketable ore equivalent of brine products.
[2]Comparable quantities of crude sodium borates are exported also; however, export data are not available.
[3]Includes orthoboric and anhydrous boric acid.
[4]Includes approximately 23,000 tons of ulexite in 1978 and 10,000 tons in 1979.
[5]Less than 1/2 unit.
[6]Measured by domestic boron sold or used plus imports.

DOMESTIC PRODUCTION

California continued as the sole producer of borates. Production from the Boron open pit mine in Kern County, Calif., provided over three-quarters of borates produced in the United States. The balance was produced in Inyo and San Bernardino Counties. Production by the four producers of boric acid was 150,000 tons valued at $66 million.

U.S. Borax & Chemicals Corp. mined kernite and tincal from its mine at Boron, Calif. U.S. Borax is the world's primary supplier of sodium borates. Crude and refined hydrated sodium borates and their hydrous derivatives, and hydrous boric acid are produced at the Boron refinery. A second plant at Wilmington, Los Angeles County, produced boric acid and a variety of borate specialty compounds. In 1980, the new boric acid plant with a production capacity of 200,000 tons per year went into operation at Boron. Production of boric acid increased 10% over that of 1979. The plant used kernite as a feed in a process that was developed by U.S. Borax. Production of technical-grade boric acid at the Wilmington plant was to be discontinued in 1981.

U.S. Borax decreased production of most products. Output of refined decahydrate, pentahydrate, and anhydrous borax for domestic and foreign customers accounted for half of the company's total sales. Crude sodium borates were produced for foreign markets.

Kerr-McGee Chemical Corp. operated the Trona and Westend Plants at Searles Lake in San Bernardino County. Kerr-McGee produced refined sodium borate compounds and boric acid from mineral-rich underground brines. Coproducts included potassium compounds, soda ash, and salt cake. At the Trona Plant, Kerr-McGee utilized an evaporative process to produce boric acid and pentahydrate, decahydrate, and anhydrous borax. Additional boric acid was produced from weak brines and recycled plant liquors by solvent extraction. The carbonation process at the Westend Plant produced sodium borates, some of which were used to manufacture boric acid.

Kerr-McGee's production at the Trona Plant decreased 9% below that of 1979. The decrease was a result of power and water shortages and fires. Production at the Westend Plant increased 38% over that of 1979.

American Borate Co. produced ulexite-probertite, which are two similar sodium-calcium borates, and colemanite, which is a calcium borate. All production was in DVNM. Low-grade stockpiles of probertite-ulexite and colemanite from the Boraxo open pit mine were upgraded onsite. Development of the upper level drift in the Billie underground mine produced probertite-ulexite and colemanite. Completion of the drift has been slowed by water seepage through faults but was planned to be completed by June 1981. Colemanite was also produced at the underground Sigma No. 22 and No. 30 Mines by a room-and-pillar method. Colemanite was also reclaimed from tailing ponds at Lathrop Wells, Nev. At the Lathrop Wells facility, colemanite is upgraded by a flotation-calcining process. Ore is trucked to Dunn, Calif., where it is ground and shipped by rail. Most shipments went to manufacturers of glass fiber insulation.

Duval Mining Co. was exploring for borate minerals in the Mohave Desert near Barstow, Calif. Drilling has proven a large colemanite reserve at depths greater than 1,200 feet. A 5-year development program that includes a test shaft has been planned.

Users of borates continued to increase in 1980. A $40 million fiberglass plant for Certainteed, Corp., was completed in California and PPG Industries, Inc. announced a $20 million expansion of its glass fiber plant at Shelby, N.C.

CONSUMPTION AND USES

Domestic consumption of boron minerals and compounds are shown in tables 2 and 3. U.S. consumption of boron minerals and compounds during 1980 decreased over that of 1979. Insulation products and glass-fiber-reinforced plastics continued to be the most important consuming sectors. Textile-grade glass fibers continued to be produced with domestic colemanite, Turkish colemanite, orthoboric acid, and anhydrous boric acid. Advantages of fiberglass composites are lower cost, light weight, high tensile and impact strengths, and high chemical resistance.

Consumption of borates in the manufacture of borosilicate glasses decreased. Boron compounds in cleaning and bleaching declined sharply. Boron compounds find application in the manufacture of biological growth control chemicals for use in water treatment, algicides, fertilizers, herbicides, and insecticides. Boron compounds were also used in metallurgical processes as fluxes, as shielding slag in nonferrous metallurgical industry, and as components in plating baths in the electroplating industry.

Many important end uses for borates and boron-containing chemical derivatives are placed in the miscellaneous category. Another group of borate compounds were sold to chemical distributors, and their ultimate uses are unknown.

Metallurgical use of borates increased. Boron filament was converted into boron-aluminum composite forms for use on the Space Shuttle Orbiter. Two companies reportedly produced boron filament in the United States. They are Avco Systems Div. and Composite Technology, Inc. The other known producers of boron filament are in France and the U.S.S.R. Other uses for boron composites are in the B-1 bomber and F-14 and F-15 jet fighter planes.[2] Small amounts of boron and ferroboron were used in nonferrous alloys and specialty steels.

Table 2.—U.S. consumption of boron minerals and compounds

(Short tons of boron content and short tons of boron oxide content)[1]

End use	1979		1980	
	B	B_2O_3	B	B_2O_3
Glass-fiber insulation	31,100	100,000	28,100	89,400
Fire retardants:				
Cellulosic insulation	15,300	49,100	15,800	50,200
Other	1,800	5,800	400	1,300
Textile-grade glass fibers	18,100	58,300	15,800	50,400
Borosilicate glasses	15,300	49,400	14,100	44,800
Soaps and detergents	12,000	38,700	8,400	26,600
Enamels, frits, glazes	4,900	15,900	4,200	13,300
Agriculture	5,300	17,000	5,000	15,700
Metallurgy	1,800	5,900	2,100	6,600
Nuclear applications	140	460	160	500
Miscellaneous uses	9,300	29,800	15,200	48,300
Sold to distributors, end use unknown	12,300	39,500	11,600	36,900
Total consumption[2]	127,000	410,000	120,900	384,000

[1]Includes imports of boric acid, colemanite, and ulexite.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—U.S. consumption of orthoboric acid

(Short tons H_3BO_3)

End use	1979	1980
Fire retardants:		
Cellulosic insulation[1]	39,800	44,335
Other	4,100	2,707
Textile-grade glass fibers	32,900	31,528
Borosilicate glasses	10,900	10,169
Metallurgy	2,300	1,764
Soaps and detergents	400	206
Enamels, frits, glazes	1,200	1,409
Nuclear applications	800	815
Agriculture	100	201
Glass-fiber insulation	--	--
Miscellaneous uses	24,700	25,725
Sold to distributors, end use unknown	22,100	26,274
Total consumption	[2]139,000	145,133

[1]Includes imports of 7,704 and 9,939 tons in 1979 and 1980, respectively.
[2]Data do not add to total shown because of independent rounding.

PRICES

At midyear, prices of sodium borates, boric acid, and specialty compounds produced in the United States were raised from 9% to 29%. A second increase at yearend raised prices an additional 14% to 15%. The reason for the increase was rising energy costs.

Table 4.—Borate prices per short ton[1]

Product	Price, Dec. 31,1980 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carlots, works[2]	489
Borax, technical, granular, pentahydrate, 99.5%, bulk, carlots, works[2]	169
Borax, technical, granular, decahydrate, 99.5%, bulk, carlots, works[2]	147
Boric acid, technical, granular, 99.9%, bulk, carlots, works[2]	448
Boric acid, technical, granular, 99.9%, bags, carlots, works[2]	506
Boric acid, U.S. Borax & Chemical Corp., anhydrous, 96% B_2O_3, bulk, carlots, Boron, Calif	966
Colemanite, American Borate Co., calcined and screened, minus 70-mesh, 42% B_2O_3, bulk, carlots, Dunn, Calif	414
Colemanite, American Borate Co., flotation concentrate (uncalcined), 37% B_2O_3, bulk, carlots, Dunn, Calif	290
Colemanite, Turkish, 30%-42% B_2O_3, crude, lump, f.o.b. railcars, U.S. east coast port	155-330
Ulexite-probertite, American Borate Co., screened, minus 7-mesh, bulk, carlots, Dunn, Calif.[3]	52

[1]U.S. f.o.b. plant or port prices per short ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.
[2]Chemical Marketing Reporter. V. 218, No. 26, Dec. 29, 1980, p. 27.
[3]21% B_2O_3 in 1980.

FOREIGN TRADE

The U.S. Bureau of Census discontinued publishing export statistics on refined sodium borate compounds in 1978. Export data from a Bureau of Mines canvass are presented in table 5.

U.S. imports from Turkey of commercial-grade colemanite and ulexite during 1980 decreased below that of 1979. A military takeover of the Turkish Government was expected to stabilize the country's economy and bring civilian management back into the borate mines.

Table 5.—U.S. exports of boric acid and refined sodium borate compounds, in 1980

Destination	Boric acid[1]		Refined sodium borates[2]
	Quantity (short tons)	Value (thousands)	(short tons)
Abu Dhabi	--	--	2
Argentina	115	$35	2
Australia	2,325	1,405	7,351
Austria	--	--	694
Bangladesh	105	55	222
Belgium-Luxembourg	195	70	6,639
Brazil	3,578	1,824	16,582
Canada	e10,014	5,045	68,976
Czechoslovakia	--	--	2,187
Chile	31	18	126
China:			
Mainland	289	130	11,731
Taiwan	652	310	7,546
Colombia	449	243	2,001
Costa Rica	19	12	1,444
Denmark	187	94	117
Dominican Republic	28	19	22
Ecuador	15	6	94
El Salvador	3	3	--
Finland	48	23	575
France	67	15	20,488
Gabon	--	--	9
German Democratic Republic	346	132	2,370
Germany, Federal Republic of	--	--	13,805
Greece	--	--	43
Guatemala	132	27	620
Hong Kong	--	--	5,166
Hungary	--	--	518
India	4	2	3

See footnotes at end of table.

Table 5.—U.S. exports of boric acid and refined sodium borate compounds, in 1980 —Continued

Destination	Boric acid[1] Quantity (short tons)	Boric acid[1] Value (thousands)	Refined sodium borates[2] (short tons)
Indonesia	163	$77	5,060
Ireland	--	--	12
Israel	25	13	156
Italy	436	155	13,335
Jamaica	3	3	4
Japan	16,443	8,498	51,007
Kenya	--	--	71
Korea, Republic of	1,102	592	14,348
Liberia	60	22	--
Malaysia	12	9	5,426
Mexico	3,487	2,124	24,168
Morocco	--	--	11
Nicaragua	--	--	83
Netherlands	1,932	1,071	3,702
New Guinea	384	178	110
New Zealand	428	208	2,912
Nigeria	148	57	--
Norway	181	68	116
Pakistan	97	71	816
Panama	22	11	24
Peru	556	332	195
Philippines	484	232	1,870
Poland	--	--	110
Portugal	58	22	477
Romania	--	--	33
Singapore	144	171	2,821
South Africa, Republic of	76	66	7,479
Spain	--	--	4,637
Sri Lanka	9	6	364
Sweden	--	--	483
Switzerland	44	22	2,131
Thailand	111	71	733
Tunisia	--	--	198
United Kingdom	25	14	8,419
United Arab Republic	--	--	10
Uruguay	--	--	304
Venezuela	286	174	1,480
Yugoslavia	--	--	1,087
Zambia	--	--	345
Zimbabwe	--	--	992
Total	45,318	23,735	324,862

[e]Estimated.
[1]Source: U.S. Bureau of the Census.
[2]Source: U.S. exporters of sodium borates.

Table 6.—U.S. imports for consumption of boric acid, by country

Exporting sources	1979 Quantity (short tons)	1979 Value[1] (thousands)	1980 Quantity (short tons)	1980 Value[1] (thousands)
Argentina	276	$150	1,210	$708
Belgium	159	86	40	24
Brazil	59	30	60	35
Canada	60	47	41	36
Chile	--	--	6	2
China, mainland	--	--	146	86
France	491	280	3,184	2,143
Germany, Federal Republic of	79	51	(2)	5
Italy	1,761	1,041	1,607	1,031
Mexico	--	--	(2)	(2)
Netherlands	60	33	40	24
Romania	55	26	66	31

See footnotes at end of table.

Table 6.—U.S. imports for consumption of boric acid, by country —Continued

Exporting sources	1979 Quantity (short tons)	1979 Value[1] (thousands)	1980 Quantity (short tons)	1980 Value[1] (thousands)
Singapore	--	--	65	$40
Spain	478	$266	377	219
Turkey	3,658	1,983	2,270	1,356
United Kingdom	119	55	([2])	([2])
U.S.S.R	330	164	707	587
Yugoslavia	119	57	119	64
Total[3]	7,704	4,267	9,938	6,393

[1]U.S. Customs declared values.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

WORLD REVIEW

Argentina.—A mining development law passed in 1979 and a revised mining code passed in 1980 were expected to encourage investment to develop borates and other minerals in Argentina. The code provides long-term and larger prospecting claims, larger mining concessions, and establishes the rights and obligations of prospecting or mining concessions.

Brazil.—A magnesium plant being built by Brasmag in Minas Girais, Rio Grande Do Norte, was studying solvent extraction of boron.[3]

Chile.—Foote Mineral Co. and Saleni Processors Inc. formed a joint venture named Sociedad Chilena du Litio (CORFO) to study recovering boric acid as an accessory of lithium and magnesium production. The evaporate deposit could produce 61,000 tons per year of boric acid.[4]

China, mainland.—The largest boron mine in China has gone into operation in the northeast in Yingkou County, Liaoning Province. Planned capacity was 100,000 tons per year of high-grade ore by an open pit operation.[5] A salt lake in Qinghai Province contained boron and other minerals.[6]

Laos.—Boricite ($Mg_3C1B_7O_{13}$) was found in sylvite deposits in the Khorat Basins of Laos. Content of the borate ranged from 1.5% to 8.5%.[7]

Mexico.—Two borate deposits in Tertiary beds occurred in Sonora, Mexico. At Mesa del Alamo, an area near Magdalena, occurrences of howlite ($Ca_2SiB_3O9.OH_5$) were discovered and other borates were exposed over a large area.[8] The geologic environment and occurrences of howlite are similar to borate areas in Turkey and in the United States in the Death Valley region of California. Howlite occurs in two forms, syngenetic beds, which are unique to Mexico, and as epigenetic intersecting veins. The B_2O_3 content in Mexico ranged from 33% to 43%.[9] U.S. Borax & Chemical Corp. was involved in exploratory drilling and claim registrations during 1980.

Another occurrence of borates occurred in the Tubutama area in Miocene lacustrian sediments 325 feet thick. Major borate minerals were colemanite, ulexite, and howlite.[10]

Peru.—Borex, Inc., acquired 80% of a concession to mine a deposit owned by Unidad Economica Y Adminis Trathis Y Ohos in Arequipa Province. The borates form a discontinuous bed in a playa lake. The primary borate mineral is ulexite of 34% B_2O_3. Based on 6-foot drill cores, resources were estimated at 11 million short tons. Based on more recent data, resources could reach 100 million tons of borates.

Turkey.—During 1980, a military takeover delayed borate exports temporarily. The Government of Turkey indicated a reversal of the 1979 nationalization of the borate mines. Three of the four previous private sector mine owners indicated to the Government that they were interested in taking over the mines. All three companies indicated that they would make investments in order to improve production.

Etibank's borax and boric acid plant in Bandirima continued production during 1980. Plant capacity in short tons by product was reported to be as follows: Borax decahydrate (60,600), boric acid (27,600), and sodium perborate (22,000). New capacities planned for the future were: A 100,000-short-ton-per-year boric acid plant constructed by a French firm to be completed by 1982 and a 100,000-short-ton-per-year borax plant in Eskisehir to be completed by 1982.[11]

U.S.S.R.—A 13,200-short-ton-per-year glass-fiber plant at Palotsk, near Minst, was reported to cost $100 million and to be completed by 1983.[12]

Table 7.—Boron minerals: World production, by country[1]

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Argentina	89	92	140	146	[e]152
Chile	4	5	29	[e]30	30
China, mainland[e]	25	30	30	30	30
Peru[e]	10	20	22	30	30
Turkey	1,005	1,211	1,455	1,036	990
United States[2]	1,246	1,469	1,554	1,590	[3]1,545
U.S.S.R.[e]	200	200	220	220	220
World total	[r]2,579	[r]3,027	3,450	3,082	2,997

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 5, 1981.
[2]Minerals and compounds sold or used by producers, including both actual mine production and a marketable ore equivalent of brine products.
[3]Reported figure.

TECHNOLOGY

A symposium on boron steels sought to review the latest metallurgical technology. Small quantities of boron increase the hardness of steel and can be used to place many of the metallic alloying elements. The use of boron also improves the elevated temperature strength of stainless steels.[13]

Important new technological advances have occurred in the area of metallurgy. A new boron metal was developed that required no cobalt but achieved the hardness available in tungsten carbide materials that use cobalt. The source of the boron is boron carbide, and molybdenum completely substitutes for tungsten. The new material was planned for use in high-pressure anvils and in diamond-press applications as a diamond-support material.[14]

A chrome-free stainless steel was produced by an alloy of iron, aluminum, titanium, and boron. The resulting metal had a 20% reduction in weight and a 200° F improvement in heat resistance over commercial ferritic stainless steels.[15]

A patent was filed for a 0.4% to 0.8% boron alloy for use in fast breeder reactors. The boron was selected to minimize the swelling characteristics of nickel and chrome alloys.

A boride coating that has a hardness equivalent to that of diamonds was created by Aves Industries West, Inc. The coating is corrosive resistant in seawater and to hydrochloric and sulfuric acid. The patented process uses a vapor to deposit a boride coating on a metal. The coating was planned for use on combustion chambers, valve stems, piston rings, jet engines, turbine blades, and pulp and paper digestors.[16]

Boron was used to coat the interior of magnetically confined fusion reactors in contact with fusion plasma. The purpose of the coating was to stop cracking by helium incorporation and hydrogen embrittlement. Boron coating materials under consideration are TiB_2, B_4C, B, and VB_2 on substrates of graphite and copper coatings.[17]

In other uses of boron as a neutron absorber, boron carbide emerged as the best overall absorber material for use in the control levels of a fast breeder reactor.[18] The best protection against neutron bomb radiation in tanks was an internal wall covering of a borated polyethlene. The lining would protect tank occupants in the event of an enhanced radiation warhead or neutron bomb.[19]

In the fiberglass area, a patented process for the production of glass fiber was developed by Vitro Strand Technologies, Inc., and Nitto Boseki Co., Ltd. The new process uses less platinum and rhodium and has less capital costs.[20] Glass-reinforced nylons were being used in various car parts. Fiberglass rocker-arm covers were being used in engine parts.[21] Owens-Corning Fiberglass Corp. announced a new composite yarn of fiberglass wrapped in wool and knit fabrics using nylon and polyester. A continuous method to make ethanol by bacterial fermentation of glucose used borosilicate glass fibers to immobilize the organisms.[22]

In continuing studies at Duke University on boron compounds, synthesized ammonia-carboxyborane showed promise as a therapeutic agent. This glycine boron analog was the first compound to show potential to form peptide linkages and to incorporate into proteins. The isoelectronic and isosteric boron analog form showed a significant activity inhibiting tumor growth and lowering serum cholesterol levels in studies on mice.[23]

Two new borate minerals were reported during 1980. A rare-earth borofluorosilicate was found in granite in the United States in the State of Washington. The new mineral has been named okanoganite, after the county in which it was found.[24] An oxyborate mineral was found in Sweden in dolomite and calcite. The mineral was named takeuchiite.[25]

Two patents for the removal of boron from aqueous solutions were filed. The first is a two-step process for removing boron compounds from aqueous solutions of magnesium chloride. Trimethyl borate is formed and removed with methanol by distillation.[26] The second process used lime calcium chloride to precipitate calcium borate.[27]

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Bromine

By Phyllis A. Lyday[1]

Domestic producers sold or used 389 million pounds of elemental bromine in 1980, a decrease of 22% below that of 1979. Demand for ethylene dibromide (EDB) and methyl bromide (MB) was down while consumption of flame retardants and calcium bromide increased. The total value of bromine sold or used by producers was $96 million.

Significant events that affected the bromine industry during 1980 were: The Environmental Protection Agency's (EPA) final lead-in-gasoline regulations went into effect; EPA proposed a ban on some pesticide uses of EDB; the Comprehensive Environmental Response Compensation and Liability Act of 1980, which taxed hazardous substances including bromine, was signed into law; and a producer in Arkansas announced plans to sell its flame-retardant business and bromine plant.

Legislation and Government Programs.—By far the most significant program affecting the bromine industry has been the attempt by EPA to reduce lead in the atmosphere. EDB, a major use of bromine, is used as a scavenger for lead in gasoline. On October 1, 1980, an EPA regulation went into effect, after a 1-year delay, to reduce the lead content of gasoline from 0.8 gram per gallon to 0.5 gram per gallon for major refiners; small refiners have until 1982 to meet requirements.[2] EPA was being

Table 1.—Salient bromine and bromine compound statistics

(Thousand pounds and thousand dollars)

	1976	1977	1978	1979	1980[p]
United States:					
Bromine sold:					
Quantity	57,400	59,000	53,200	69,500	62,200
Value	$12,900	$12,800	$11,300	$15,100	$12,500
Bromine used:					
Quantity	402,700	374,800	393,400	429,700	327,000
Value	$99,500	$86,900	$88,700	$98,200	$83,300
Exports:					
Elemental bromine:					
Quantity	4,400	5,400	6,400	10,100	8,100
Value	$900	$1,100	$1,300	$2,100	$1,700
Bromine Compounds:					
Gross weight	74,100	64,400	106,000	[r]92,800	83,200
Contained bromine	62,600	54,100	87,900	[r]77,600	70,000
Value	$29,200	$27,300	$38,500	[r]$35,500	$33,800
Imports:[1]					
Elemental bromine:					
Quantity	109	517	669	34	1
Value	$24	$102	$102	$5	$5
Ethylene dibromide:					
Quantity	3	79	589	193	861
Value	$1	$22	$102	$33	$165
Potassium bromide:					
Quantity	247	89	119	794	667
Value	$152	$56	$84	$536	$457
Sodium bromide:					
Quantity	83	106	320	2,190	310
Value	$52	$60	$175	$1,056	$201
World: Production	[r]682,242	[r]663,190	[r]683,017	766,097	653,836

[p]Preliminary. [r]Revised.
[1]Source: U.S. Bureau of the Census.

challenged in the U.S. Court of Appeals for a 1-year deferral on the lead phasedown. Arguments in favor of a delay were imported oil saved and health benefits achieved.

EPA proposed to ban some uses of EDB, while phasing out other uses by July 1, 1983.[3] EPA has identified EDB as 1 of 37 pesticides that can cause human cancers, genetic damage, and reproductive disorders. The conclusions of the Rebuttablė Presumption Against Registration (RPAR) were to be published in the Federal Register before any final action was taken.

Fumigant use of EDB on stored grain and felled logs would be barred in the proposal. The proposal phaseout by July 1, 1983, would apply to control of certain fruit flies in some fruits and vegetables. At present, there are no available substitutes.[4]

EDB use as a soil fumigant, which accounts for approximately 90% of its agriculture usage, would be allowed to continue under the EPA proposal. Preliminary evidence indicates that residues of EDB were not detected in EDB-treated soils. Termite control use of EDB could continue under a commercial applicator.

Two court cases, against Velsicol Chemical Corp. (Velsicol), which alleged injury from polybrominated biphenyls (PBB) in a 1973 accident involving cattle feed, ended in favor of Velsicol.[5] A criminal indictment against Velsicol for withholding evidence was dismissed.

Efforts to dispose of PBB-contaminated cattle were halted in 1978 for lack of a suitable site. During 1980, disposal began at Beatty, Nev.[6]

On December 11, 1980, the Comprehensive Environmental Response Compensation and Liability Act of 1980 (Superfund) was signed into law. The law provides $1.6 billion for the cleanup of abandoned waste sites.[7] Chemical companies will provide 87.5% of the total amount by a special tax on 42 hazardous chemicals. Included are funds to clean up all types of chemical releases, including bromine, and excluding oil spills. The Internal Revenue Service will begin levying the tax April 1, 1981.[8] The tax will terminate on September 30, 1985.[9]

EPA won the right to make certain information public in a Federal Appeals Court in New York.[10] Under debate was authority of EPA to make public information on health and safety and environmental effects of a pesticide's active ingredients. Bromine is a common ingredient of some pesticides. The information must be provided to EPA before a product can be licensed for manufacture or import. Premature Manufacturing Notices (PMN), which are required under Section 5 of the Toxic Substances Control Act of 1976 (TSCA), must be filed as of November 24, 1980, for manufacture or import of chemicals not on the PMN "inventory." Substances subject to other laws and regulations may be exempted from TSCA. A rule under 12-b would require exporters to submit one notice per calendar year within 7 days of accepting a definite contract or agreement.[11] PBB and tris (2,3-dibromoprophyl) were included on the PMN list.[12]

Massachusetts Institute of Technology's Center for Policy Alternatives completed a study for EPA on TSCA. The study stated the TSCA stimulated the development of new and safer chemicals. To complement this report, EPA has begun another 3-year study analyzing innovation.

Occupational Safety and Health Administration (OSHA) published a list of 107 substances that may be candidates for further scientific review. Ethyl bromoacetate and vinyl bromide were included in the list.[13]

A suit filed in California alledged ground water well contamination by dibromochloropropane (DBCP). Eighty manufacturers, distributors, and retailers were named as defendants.[14] A study of former workers for DBCP pesticide plants show half of the workers, who were found sterile in previous tests, now have sperm counts in the "fertile range."[15]

DOMESTIC PRODUCTION

Domestic production of elemental bromine during 1980 decreased by 23% below that of 1979. The decrease was largely a result of government regulations (see Legislation and Government Programs section).

In 1980, there were six companies operating nine plants in two States. Bromine production from the leading State, Arkansas, decreased 24% below that of 1979. Michigan experienced a 17% decrease.

The producers of elemental bromine are also the major producers of bromine compounds (table 2) except for two plants that extracted elemental bromine only. In addition, other plants not shown in the table, made compounds from bromine.

Production of calcium bromide increased 37% in 1980. Production capacity of calcium bromide completion and work-over fluid was estimated to be 295 million pounds of aqueous solution containing 42% bromine.[16] The Dow Chemical Co. continued plans to expand calcium bromide production at its Magnolia, Ark., facility.

Four plants had a total estimated capacity of 350 million pounds of EDB.[17]

Additional tetrabromophthalic production capacity, a bromine-based fire retardant, was reported being constructed during 1980. Velsicol planned a 10-million-pound-per-year plant at El Dorado, Ark., and Saytech planned a 5-million-pound-per-year plant at Sayeville, N.J. At yearend, Velsicol Chemical Corp. announced plans to sell its flame-retardant business and related bromine plant to Great Lakes Chemical Corp. (GLC) for $30 million. Production of bromine for flame retardants was 198.2 million pounds in 1980.

GLC and Merichem Co. of Houston, Tex., have agreed to enter into a joint venture to supply a key intermediate for synthetic pyrethroid insecticide manufacture to Shell Chemical Co. GLC planned to construct a facility in Arkansas to produce the final intermediate.[18]

Table 2.—Bromine-producing plants in the United States

State and company	County	Plant	Production source
Arkansas:			
Arkansas Chemicals, Inc	Union	El Dorado	Well brines.
The Dow Chemical Co	Columbia	Magnolia	Do.
Ethyl Corp	do	do	Do.
Great Lakes Chemical Corp	Union	El Dorado	Do.
Do	do	do	Do.
Velsicol Chemical Corp	do	do	Do.
Michigan:			
The Dow Chemical Co	Mason	Ludington	Do.
Do	Midland	Midland	Do.
Morton Chemical Co	Manistee	Manistee	Do.

Table 3.—Bromine compounds sold by primary U.S. producers

(Million pounds and million dollars)

	1979			1980^p		
	Quantity		Value	Quantity		Value
	Gross weight	Bromine content		Gross weight	Bromine content	
Ethylene dibromide	289.1	245.7	65.4	212.9	180.9	54.1
Methyl bromide	52.1	43.8	26.8	32.8	27.5	23.8
Other compounds[1]	226.9	161.7	169.8	225.6	168.4	173.4
Total	568.1	451.2	262.0	471.3	376.8	251.3

^{p}Preliminary.
[1]Includes hydrobromic acid, tetrabromobisphenol-A, ethyl, calcium, ammonium, sodium, potassium, and other bromides, plus some methyl bromide exports.

CONSUMPTION AND USES

Consumption of EDB decreased during 1980. During 1980, EDB was used as a substitute for the banned uses of the fumigant DBCP. Consumption of EDB as a fumigant was estimated at 15 million pounds.[19] The future use of EDB in preplant soil fumigation depends on negative ground water contamination tests.

The two major companies that produced DBCP stopped production during 1979 after DBCP was banned from all applications except in Hawaiian pineapple groves. Amvac Chemical Corp. (AMVAC) and Woolfolk Chemical Works Inc. were the only producers in 1978, and AMVAC was the only known producer in 1980. During 1980, investigation of black market sales of DBCP in California were being investigated.

Consumption of MB during 1980 decreased. The primary use is as a space fumigant; can be substituted for EDB in some pesticide applications, but consumption is not expected to be significant unless EDB is banned by government regulations. Use of

MB as a methylating agent was reported to be growing.

Calcium bromide consumption increased during 1980. Unlike other bromine compounds, calcium bromide can be recycled.

Consumption of bromine during 1980 for flame retardants was 161.6 million pounds. A significant part was in compounds for export. Several tragic fires during 1980 were expected to initiate fire code regulations that possibly would increase domestic consumption of flame retardant chemicals.

Monobromatrifluoromethane (DuPont's Halon 1301) is the fire suppressant in the Spector-mix Automatic Fire Extinguishing (SAFE) system. The SAFE system for military tanks can dispense a fire suppressant within 0.06 second; therefore, fire and explosive overpressures never reach levels that could harm the crew. Grumman Aerospace Corp. is adopting the system under an arrangement with Spectronix, Ltd., of Tel Aviv, Israel, for commercial use in the United States.[20] Halogenated fire extinguishants continued to be used in protecting sophisticated electronics and computer installations, offshore platforms, terminals, refineries, and power generating stations. A significant feature of the system is that people can live in the halogenated hydrocarbon atmosphere (about 7% concentration) required to extinguish a fire. The U.S. Navy planned to retrofit major ships in its fleet.[21]

PRICES

The average price for bulk elemental bromine, f.o.b. plant, as reported by producers in 1980 was 24.86 cents per pound, an increase over the 1979 average price of 22.03 cents per pound. Quoted yearend prices for elemental bromine and selected compounds follow:

Product	Value per pound (cents)
Bromine, purified:	
Carlots, truckloads, delivered	75
Drums, carlots, truckloads, delivered east of the Rocky Mountains[1]	55 - 69
Bulk tank car, tank trucks (45,000-pound minimum), delivered east of the Rocky Mountains[1]	26.5- 28
Ammonium bromide, national formulary (N.F.), granular, drums, carlots, truckloads, freight equalized	74
Bromochloromethane, drums, carlots, f.o.b. Midland	98
Bromoform, pharmaceutical grade, 5-gallon drums, f.o.b. works	270
Ethyl bromide, technical, 98%, drums, carlots, freight allowed, East	72
Ethylene dibromide, drums, carlots, freight equalized	37
Hydrobromic acid, 48%, drums, carlots, truckloads, f.o.b. works	39 - 41
Hydrogen bromide, anhydrous, cylinders, 130 pounds, f.o.b. works	700
Methyl bromide, distilled, tanks, 140,000-pound minimum, freight allowed	57
Potassium bromate, granular, powdered, 200-pound drums, carlots, f.o.b. works	106
Potassium bromide, N.F. granular, drums, carlots, f.o.b. works	67
Sodium bromide, 99% granular, 400-pound drums, freight, f.o.b. works	65

[1]Delivered prices for drums and bulk shipped west of the Rockies, 1 cent per pound higher. Bulk truck prices 1 cent per pound higher for 30,000-pound minimum and 2 cents per pound higher for 15,000-pound minimum. Price f.o.b. Midland and Ludington, Mich., freight equalized, 1 cent per pound lower.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 218, No. 28, Dec. 29, 1980, pp. 26-37.

FOREIGN TRADE

Exports of elemental bromine and bromine contained in compounds decreased during 1980. The closer proximity of Israel to overseas markets gave producers there an advantage in transportation costs.

In 1980, approximately 87% of U.S. imports of bromine and bromine compounds were from Israel and approximately 13% were from France. Small quantities were also imported from the Federal Republic of Germany, Italy, Japan, Sweden, and the United Kingdom. Because imports of bromine compounds are classified into multiproduct categories, some bromine compounds imported by the United States are not easily identified.

WORLD REVIEW

The United States continued to be the world's leading producer of bromine. Other principal bromine-producing nations included, in decreasing order, Israel, the United Kingdom, the U.S.S.R., France, and Japan.

Brazil.—Riomag proposed a complex of plants in Rio Grande Do Norte that would produce bromine as a byproduct of magnesium metal production. The plant had a planned capacity of 1.4 million cubic meters of evaporated seawater bitterns that average 1.86 grams of bromine per liter. A plant being built at Minas Gerais by Brasmag had a planned production of 2,000 tons of bromine per year as a byproduct of magnesium production.

India.—Three Indian companies with a total capacity of 1,653,000 pounds continued to produce bromine during 1980. The decline in production beginning in 1978 was a result of cyclones, floods, and power cuts. Present demand for bromine is approximately 1,323,000 pounds primarily for use in gasoline additives and flame retardants.

Israel.—Dead Sea Bromine (DSB), a subsidiary of Israel Chemical, Ltd. (ICL), was the major elemental bromine producer outside the United States. Production of bromine at the Sodom plant was either sent for processing in the Netherlands or processed locally at Bromine Compounds, Ltd. (BCL). BCL was owned by several companies which included DSB. BCL produced 20 new bromine products in the past 5 years and exported 95% of bromine and bromine compounds produced. BCL completed a plant at Ramat Hovav in 1978. This plant accounted for 50% of Israel's world trade in bromine compounds during 1980. Methyl bromide, a versatile fumigant, is a major product of the Ramat Hovav plant. A planned addition of equipment from the Beersheva plant, planned to close soon, will expand production capacity at Ramat Hovav.

To help finance the bromine expansion, the Government will sell shares of the Dead Sea works to the public. The proportion of privately owned shares was to increase from 9% to 20%.

Jordan.—The Arab Potash Co. planned a $40 million bromine plant to be in production in 1982. The plant would process bitterns from the Dead Sea.

Netherlands.—The Dutch processing and marketing subsidiaries both continued to operate at a loss due to environmental constraints imposed by the Dutch Government.[22]

United Kingdom.—Great Lakes Chemical Corp. purchased a subsidiary of Dalgety Ltd. The plant, which is located at Aycliffe, United Kingdom, will produce brominated fire retardants and other specialty chemicals. Great Lakes has another European plant at Halton, United Kingdom. The Halton plant increased production to near the design capacity during 1980.

Table 4.—Bromine: World production, by country[1]

(Thousand pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
France	33,466	34,326	35,714	[r] [e]33,000	31,000
Germany, Federal Republic of	9,158	8,236	8,583	8,862	8,800
India	[r]970	[r]1,124	1,014	660	736
Israel	46,100	69,450	76,170	101,000	110,000
Italy	1,230	[e]1,300	[e]1,300	1,300	1,300
Japan[e]	26,500	26,500	26,500	26,000	26,500
Spain[e]	900	900	900	900	900
United Kingdom	[r]65,918	[r]54,454	53,336	64,375	60,000
United States[3]	468,000	433,900	446,500	497,000	[4]381,600
U.S.S.R.[e]	30,000	33,000	33,000	33,000	33,000
Total[3]	[r]682,242	[r]663,190	683,017	766,097	653,836

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 27, 1981.
[2]In addition to the countries listed, several other nations produce bromine, but output data are not reported and available general information is inadequate for formulation of reliable estimates of output levels.
[3]Sold or used by producers.
[4]Reported figure.

TECHNOLOGY

Headlights, which used bromine or iodine in all-plastic, sealed-beam systems, won the Material Engineering 1980 Grand Award. The headlights weigh one-third as much as glass units, and are stronger than glass in impact tests. The halogen bulb emits a brighter, whiter light than conventional lamps. On high beam, the visible distance of a halogen lamp is 25% more than a conventional lamp.[23]

Zinc bromide is used in the phosphite and phosphotriester methods of synthesizing deoxyribonucleic acid (DNA). Synthesis of DNA sequences 10 to 20 nucleotides long was used in three functions of genetic engineering, as follows: Insertion into microorganisms for a known gene content; incubation of DNA to isolate a whole natural gene; and synthesis of promoter DNA sequences for better efficiency.[24]

Bromide was found to be a substance useful for its ability to decompose monochloramine (MCA). MCA is persistent in water and toxic to fish. The principal reaction product is postulated to be a mixed haloamine, NHBrCl.[25]

Bromine geochemistry was used to search for potash deposits of the Khorat Plateau, Thailand, and Laos. Based on initial bromine data, the Khorat and Sakhon Narkhon Basins were suggested to contain potash deposits. Bromine geochemistry was used to delineate drilling and to provide a better understanding of the carnallite-sylvite facies of the deposits.[26]

Bromine was used as a tracer in solution mining of uranium. A pilot research project in Campell County, Wyo., used bromine in reverse osmosis water to aid excursion detection.[27]

Other new developments included the synthesis of the first organobromine compound. The compound can oxidize hyrogen bromide or hydrogen iodine to bromine or iodine, respectively.[28] Also, hydrogen bromide was decomposed in the sulfur bromide cycle as a promising way to produce hydrogen.[29]

The U.S. Geological Survey published a circular on heavy liquids in the geologic laboratory. Included are data on physical properties, hazards of handling, proper storage facilities, and adequate protective clothing for bromoform. Toxicity data, and suggested first aid treatment are included.[30]

A new bromine chapter of the Bureau of Mines publication, Mineral Facts and Problems, was written in 1980; the publication covers such aspects as industry structure and supply. Demand is predicted for bromine to the year 2000.[31]

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Cadmium

By V. Anthony Cammarota, Jr.[1]

Domestic production of cadmium metal in 1980 declined 13% and shipments of cadmium decreased 49% from the revised levels of 1979. Six companies operating seven plants produced all of the domestic cadmium during 1980. Canada continued as a major source of imported zinc concentrates from which cadmium was extracted as a byproduct. The producer price of cadmium, at $2.50 to $3 per pound at the beginning of the year, declined to $2.50 by yearend.

Legislation and Government Programs.—On December 11, 1980, the President signed the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510, commonly known as the Superfund. The tax, which is to be collected beginning April 1981 on a number of materials, was set at $4.45 per short ton of cadmium. A major provision of the law is to establish a $1.6 billion fund to clean up disposal sites and spills of hazardous substances. The tax terminates on September 30, 1985.

The strategic stockpile goal was revised downward from 11,204 metric tons of cadmium to 5,307 tons because of a decline in anticipated requirements, according to the Federal Emergency Management Agency.[2] The stockpile inventory remained at 2,871 tons on December 31, 1980.

Table 1.—Salient cadmium statistics

	1976	1977	1978	1979	1980
United States:					
Production[1] metric tons	2,047	1,999	1,653	r1,823	1,578
Shipments by producers[2] do	2,707	1,837	1,957	r2,468	1,271
Value thousands	$10,498	$7,072	$5,906	$9,498	$5,219
Exports metric tons	229	107	326	211	236
Imports for consumption, metal do	3,094	2,332	2,881	2,572	2,617
Apparent consumption do	5,381	3,818	4,510	r4,928	3,532
Price: Average per pound[3]	$2.66	$2.96	$2.45	$2.76	$2.84
World: Production metric tons	r16,998	r18,250	r17,332	r18,592	17,716

rRevised.
[1]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2]Includes metal consumed at producer plants.
[3]Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

DOMESTIC PRODUCTION

Domestic cadmium metal production in 1980 decreased from that of 1979, reflecting the closure of the electrothermic zinc smelter at Monaca, Pa., by St. Joe Zinc Co., a major producer of zinc and byproduct cadmium. The New Jersey Zinc Co. ceased slab zinc production at its vertical retort zinc smelter in Palmerton, Pa., but planned to continue producing cadmium in 1981 from stockpiled residues.

In 1979, the latest year for which data are available, recovery of cadmium metal averaged 3.86 kilograms per ton of primary slab zinc produced in domestic smelters, compared with 4.06 kilograms in 1978, and an average of 4.8 kilograms recovered between 1973 and 1977.

During 1980, production of cadmium compounds other than cadmium sulfide (cadmium content), which includes both electroplating salts and cadmium oxide, decreased from that of 1979. Cadmium oxide was produced at two primary metal-producing plants. The production of cadmium sulfide, including cadmium sulfoselenide and lithopone, registered a significant decrease from 1979 production, but was at a level similar to those levels of 1975-78.

Harshaw Chemical Co. constructed a $6 million plant next to its existing facility in Louisville, Ky., to produce cadmium pigments for use in plastics.

Table 2.— Primary cadmium producers in the United States in 1980

Company	Plant location
AMAX Zinc Co., Inc	Sauget, Ill.
ASARCO Incorporated	Corpus Christi, Tex., and Denver, Colo.
The Bunker Hill Co	Kellogg, Idaho.
Jersey Miniere Zinc Co	Clarksville, Tenn.
National Zinc Co	Bartlesville, Okla.
The New Jersey Zinc Co	Palmerton, Pa.

Table 3.—U.S. production of cadmium compounds other than cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1976	990
1977	695
1978	708
1979	912
1980	826

[1]Includes plating salts and oxide.

Table 4.—Cadmium sulfide[1] produced in the United States

(Metric tons)

Year	Quantity (cadmium content)
1976	729
1977	639
1978	698
1979	1,494
1980	801

[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

The apparent consumption of cadmium in 1980 was 28% lower than that of 1979, mainly because of the economic downturn that led to lower automobile and plastics production. Though actual consumption data are not collected by the Bureau of Mines, the distribution of apparent consumption during 1980 was estimated for the following principal use categories: Transportation, coating and plating, batteries, pigments, plastics and synthetic products, and alloys and other uses. Cadmium consumed directly in the transportation category, which included cadmium from each of the remaining end-use categories, accounted for about one-fifth of the total demand. Electrically or mechanically plated hardware consumed an estimated one-third, while cadmium used in nickel-cadmium, silver-cadmium, and mercury-cadmium batteries was estimated to have consumed about one-fifth of the total. Cadmium use in pigments, plastics and synthetic products, and the alloys category was estimated to have accounted for just over one-tenth each, and miscellaneous other uses accounted for the remainder of the total apparent consumption.

Table 5.—Supply and apparent consumption of cadmium

(Metric tons)

	1978	1979	1980
Stocks, Jan. 1	2,571	2,269	1,525
Production	1,653	r1,823	1,578
Imports, metal	2,881	2,572	2,617
Total supply	7,105	r6,664	5,720
Exports	326	211	236
Stocks, Dec. 31	2,269	r1,525	1,952
Apparent consumption[1]	4,510	r4,928	3,532

rRevised.
[1]Total supply minus exports and yearend stocks.

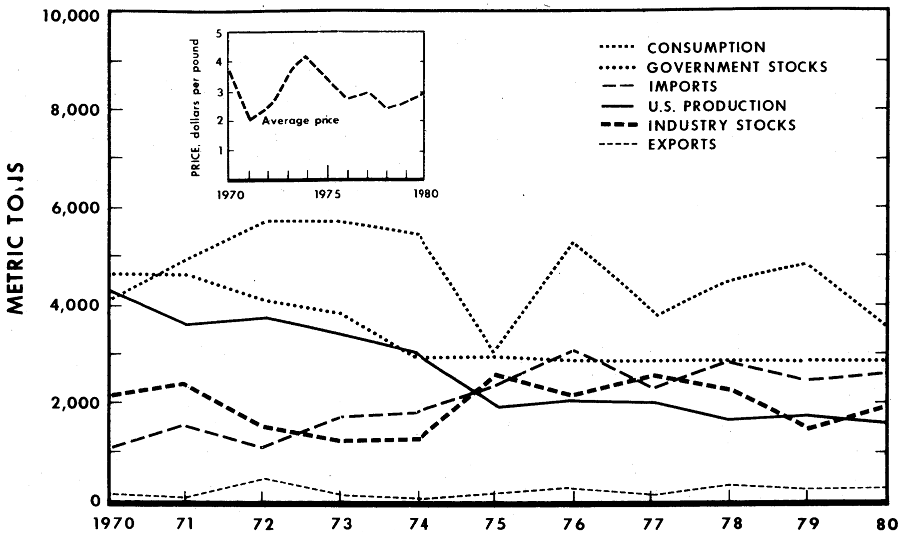

Figure 1.—Trends in production, consumption, yearend stocks, exports, imports, and average price of cadmium metal in the United States.

STOCKS

Inventories of cadmium metal held by metal producers increased each quarter during the year while cadmium metal and cadmium in compounds held by compound manufacturers generally declined during 1980. The quantity of both cadmium metal and cadmium in compounds held by merchants and distributors of these products remained level during 1980, but on an annual basis stocks increased by a little over 100 tons in 1980 over those of yearend 1979.

Table 6.—Industry stocks, December 31

(Metric tons)

	1979		1980	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	r517	W	841	W
Compound manufacturers	52	609	39	612
Distributors	r327	20	442	18
Total	r896	629	1,322	630

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Compound manufacturers."

PRICES

The producer price, at $2.50 to $3 per pound at the beginning of the year, was increased to $3.25 by the end of January. In late April the price was adjusted to $3 to $3.25; in July it was reduced to $2.50 to $3, and from August to yearend it was quoted uniformly at $2.50 per pound. On October 28, The New Jersey Zinc Co. stopped posting a price and began selling cadmium on a daily market basis. Dealer prices showed a similar pattern, starting January at $2.85 to $2.95 per pound and falling to $2 to $2.10 by yearend.

FOREIGN TRADE

Cadmium metal and scrap exports during 1980 registered a small increase over those of 1979. Principal recipient countries during 1980 were Belgium-Luxembourg, Canada, Ecuador, and Finland.

Cadmium metal imports, which have increased since 1972 and reached a peak of 2,881 tons during 1978, continued near that level in 1980. Canada continued to be the principal supplier, followed by Australia, Mexico, and the Republic of Korea.

Imports of metal and flue dust from most favored nations (MFN), and imports of flue dust from non-MFN continued to be duty free, but a statutory duty of 15 cents per pound continued to be imposed on cadmium metal imported from non-MFN.

Table 7.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

Year	Quantity (metric tons)	Value (thousands)
1978	326	$864
1979	211	550
1980	236	464

Table 8.—U.S. imports for consumption[1] of cadmium metal, by country

Country	1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	319	$1,716	573	$3,197
Belgium-Luxembourg	237	1,356	42	292
Canada	[2]695	3,709	825	4,494
China, mainland	--	--	16	94
Cocos Islands	--	--	9	46
Denmark	5	23	--	--
Finland	128	710	119	616
France	100	537	37	177
Germany, Federal Republic of	20	114	10	57
India	--	--	50	267
Japan	10	45	9	45
Korea, Republic of	200	1,020	175	907
Mexico	288	1,579	339	1,801
Netherlands	103	574	110	557
Norway	107	528	31	161
Peru	142	762	142	735
Portugal	8	36	--	--
Spain	59	272	50	272
Sweden	[2]23	135	5	35
United Kingdom	[2]23	153	5	29
Yugoslavia	[2]80	404	70	399
Zaire	25	167	--	--
Total	2,572	13,840	2,617	14,181

[1]General imports and imports for consumption were the same in 1979 and 1980.
[2]Includes waste and scrap (gross weight).

WORLD REVIEW

A new electrolytic zinc plant was under construction at Cajamarquilla, Peru, and was scheduled to begin production in early 1981. In addition to zinc and sulfuric acid, plans call for the production of about 355 tons of refined cadmium per year.

The Government of Sweden delayed a proposed ban on the use and import of cadmium, originally scheduled for 1980, until July 1, 1982, in order to allow industry more time to substitute other materials for those containing cadmium.

Table 9.—Cadmium: World smelter production,[1] by country

(Metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada (refined)	1,314	1,185	1,151	1,209	[2]1,083
United States[2]	2,047	1,999	1,653	1,823	[3]1,578
Latin America:					
Argentina	[e]35	40	22	[e]20	20
Brazil	19	10	10	17	25
Mexico (refined)	710	908	897	[r e]850	800
Peru	174	182	169	190	190
Europe:					
Austria	29	26	33	34	30
Belgium	[r]1,200	[r]1,400	1,164	1,440	1,400
Bulgaria[e]	220	200	210	210	210
Finland	428	527	611	590	600
France	532	790	689	792	800
German Democratic Republic[e]	[r]18	[r]18	[r]18	[r]15	15
Germany, Federal Republic of	1,275	1,336	1,182	1,266	1,200
Italy	436	449	378	527	500
Netherlands[e]	397	302	402	416	400
Norway	80	97	120	115	110
Poland	[e]750	754	761	733	760
Romania[e]	100	90	90	90	90
Spain	246	303	253	222	235
U.S.S.R.[e]	2,700	2,750	2,800	2,850	2,850
United Kingdom	190	295	291	424	400
Yugoslavia	[e]180	189	187	289	290
Africa:					
Algeria	29	133	175	185	180
South-West Africa, Territory of	83	88	79	81	90
Zaire	266	246	186	212	200
Zambia	7	4	([4])	([4])	([4])
Asia:					
China, mainland[e]	[r]200	[r]200	[r]220	[r]225	225
India	34	44	113	166	75
Japan	2,500	2,844	2,531	2,597	2,200
Korea, North[e]	[r]150	[r]150	[r]150	[r]150	150
Korea, Republic of	--	20	40	50	50
Oceania: Australia (refined)	649	671	747	804	960
Total	[r]16,998	[r]18,250	17,332	18,592	17,716

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table gives unwrought metal production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, London) and from Metal Statistics (published by Metallgesellschaft Aktiengesellschaft, Frankfurt am Main). Cadmium is found in ores, concentrates, and/or flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not recorded in this table to avoid double counting. Table includes data available through Apr. 3, 1981.

[2]Includes secondary.

[3]Reported figure.

[4]Revised to zero.

TECHNOLOGY

The basic technology for the hydrometallurgical process in the leach and purification processes at the cadmium plant of The New Jersey Zinc's new Clarksville zinc plant was described.[3] Cadmium sponge, cemented from the zinc electrolyte with zinc dust, is leached in sulfuric acid, purified, and electrolyzed to produce pure cadmium at a rate of about 270 tons per year.

Researchers at the Institute of Energy Conversion at the University of Delaware developed a multilayer cadmium sulfide-copper sulfide thin-film solar cell that has demonstrated a conversion efficiency of 9.2%. The principal advantage of the cell over more efficient single crystal cells is cost.[4]

Developments in cadmium technology are abstracted in Cadmium Abstracts, a quarterly publication available through the Cadmium Association, 34 Berkeley Square, London W1X 6AJ, England. Progress reports of the projects supported by the International Lead Zinc Research Organization, Inc., are released annually in the Cadmium Research Digest.

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[1]Supervisory physical scientist, Section of Nonferrous Metals.

[2]Quantities in metric tons unless otherwise noted.

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Calcium and Calcium Compounds

By J. W. Pressler[1]

Calcium metal was manufactured by one company in Connecticut. Natural calcium chloride was produced by three companies in California and two companies in Michigan. Synthetic calcium chloride was manufactured by one company in New York and two companies in Washington.

DOMESTIC PRODUCTION

Pfizer Inc. produced calcium metal at Canaan, Conn., by the Pidgeon process—an aluminothermic process in which high-purity quicklime and aluminum powder are briquetted and heated in vacuum retorts. At 1,300° C, the calcium oxide is reduced to calcium metal, which vaporizes and is subsequently collected as "crowns" in a water-cooled condenser at the other end of the retort at about 700° C.

National Chloride Co. of America, Leslie Salt Co., and Hill Brothers Chemical Co. produced calcium chloride from dry-lake brine wells in San Bernardino County, Calif. Output increased 14% in 1980 compared with that of the previous year. The Dow Chemical Co. and Wilkinson Chemical Corp. recovered calcium chloride from brine in Lapeer, Mason, and Midland Counties, Mich. Average output in Michigan decreased 20% in 1980 compared with that of the previous year. Total production of natural calcium chloride in 1980 was 581,012 tons, a decrease of 19% compared with 1979 production.

Allied Chemical Corp. recovered synthetic calcium chloride as a byproduct of soda ash production at its Solvay plant near Syracuse, N.Y.; Reichold Chemicals, Inc., recovered synthetic calcium chloride as a byproduct of pentachlorophenol manufacture at Tacoma, Wash.; and Hooker Chemicals & Plastics Corp. manufactured calcium chloride at Tacoma using limestone and hydrochloric acid. Total output of synthetic calcium chloride in 1980 was 230,123 tons, a 12% decrease compared with the 1979 level.

Table 1.—Production of calcium chloride (75% $CaCl_2$ equivalent) in the United States

Year	Natural		Synthetic		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1976	648,979	$32,889	248,272	$14,381	897,251	$47,270
1977	710,385	45,048	257,231	17,683	967,616	62,731
1978	773,138	53,868	257,763	21,172	1,030,901	75,040
1979	719,709	51,884	261,052	22,566	980,761	74,450
1980	581,012	47,950	230,123	26,150	811,135	74,100

CONSUMPTION AND USES

Calcium metal was used as a reducing agent to recover refractory metals such as tantalum, uranium, and zirconium from their oxides; to form alloys with metals such as aluminum, lead, and silicon; as a desulfurizer and deoxidizer in steel refining; in the manufacture of calcium hydride used in the production of chromium, titanium, and zirconium in the Hydromet process; and as an aid in removing bismuth in the refining of lead. Some minor, but interesting, uses were in the preparation of vitamin B and as a cathode coating in some types of photo tubes.

A high growth rate was forecast for the use of calcium in the battery sector, particularly in the maintenance-free (MF) lead-calcium (0.1% Ca) automotive storage battery. As with nickel-cadmium batteries, the lead batteries were completely sealed, and replacement of the electrolyte is not necessary. The MF batteries were sold particularly on their merit of being of long life. Although demand in the United States was strong in 1979, the weak economy in 1980 resulted in reduced demand for the MF batteries.

In the refining of crude lead bullion, calcium metal consumption in the removal of bismuth was more than that used in MF batteries for 1980.

In addition to its use in the refining of steel, calcium was used as an additive to high-tensile steels, such as those used in oil pipelines. Research has pointed to possibilities of using calcium additives in other high-quality steels.

The uses of calcium chloride in 1980 were principally for deicing (30%), dust control (25%), industrial uses (20%), oil recovery (10%), concrete acceleration (5%), tire ballasting (3%), and miscellaneous (7%). The use of calcium chloride and bromide in oil and gas recovery is a rapidly growing application and was a major outlet for these liquid formulations in 1980.

The principal use of calcium chloride was to melt snow and ice from roads, streets, bridges, and pavements. Calcium chloride is more effective at lower temperatures than rock salt and is mainly used in the Northern and Eastern States. Because of its considerably higher price, it is used in conjunction with rock salt for maximum effectiveness and economy. It was also used to stabilize the surface of roads and driveways for dust control and as a set-accelerator for concrete. Because winter temperatures were warmer than normal in 1980, less solid calcium chloride demand was experienced in the Northeastern States.

Sales of calcium bromide as a packer and completion solids-free fluid for oil and gas wells increased 50% in 1980 compared with that of 1979, principally because the number of oil and gas wells drilled increased in a similar amount. The Dow Chemical Co. with two plants in Midland, Mich., and Magnolia, Ark., Great Lakes Chemical Corp. in El Dorado, Ark., and Velsicol Chemical Corp.'s two plants in Beaumont, Tex., and El Dorado, Ark., are the principal producers.

PRICES AND SPECIFICATIONS

The price of calcium metal crowns increased from $1.89 per pound to $2.47 per pound on January 1, 1980, and to $2.78 per pound on November 15, 1980. The price of calcium-silicon alloy increased from 71 cents per pound to 76.3 cents per pound on April 1, 1980, maintaining that level for the remainder of 1980. Yearend published prices and specifications for 1980 were as follows:

	Value per pound
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$2.78
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.763

Source: Metals Week. V. 50, No. 52, Dec. 29, 1980, p. 7.

Calcium metal is usually sold in the form of crowns, broken pieces, or billets, shipped in 55-gallon metal containers with a maximum content of 300 pounds, and gasketed to provide an airtight condition, with argon atmosphere provided if desired. The value for imported calcium metal in 1980 ranged from $1.61 to $2.61 per pound, and averaged $2.55 per pound for the year. This did not include the assessed tariff, which was 7.5% ad valorem for most favored nation status and 25% ad valorem for non-most favored nation status.

Calcium chloride is usually sold either as solid flake or pellet averaging about 75% $CaCl_2$, or as a concentrated liquid averaging about 40% $CaCl_2$. The price of flake calcium chloride increased 55%, and liquid $CaCl_2$ increased 48% in 1980 compared with that of 1979. Yearend published prices and specifications for 1980 were as follows:

	Value per ton[1]
Calcium chloride, regular grade, 77% to 80%, flake, bulk, carload, works	$99.00-$114.00
Calcium chloride, liquid, 40% to 45%, tank car or tank truck, works	38.75- 45.00

[1]Differences between high and low price are accounted for by differences in quantity, quality, and location.

Source: Chemical Marketing Reporter. V. 218, No. 26, Dec. 29, 1980, p. 27.

As reported by producers on an f.o.b. warehouse basis, with conversions of all products to a 75% $CaCl_2$ basis, the average value in 1980 for natural calcium chloride was $82.53 per ton; the average value for synthetic calcium chloride was $113.64 per ton. Combining natural and synthetic products, the average value of solid 75% $CaCl_2$ for the year was $111.90 per ton, and the average value of liquid 40% $CaCl_2$ was $33.22 per ton.

FOREIGN TRADE

Exports of calcium phosphates in 1980 were 43,314 tons valued at $27,577,000 compared with 129,532 tons valued at $24,114,000 in 1979; leading destinations were Venezuela, Canada, Mexico, Thailand, and the Philippines. Exports of calcium chloride in 1980, mainly to Canada and Mexico, were 49,215 tons valued at $9,754,000 compared with 30,307 tons valued at $5,723,000 in 1979. Exports of other calcium compounds in 1980, including precipitated calcium carbonate, mainly to Canada, the Netherlands, and Mexico, totaled 25,068 tons valued at $15,589,000 compared with 20,417 tons valued at $11,874,000 in 1979.

Total imports of calcium and calcium compounds in 1980 were 266,200 tons valued at $31.1 million. Imports of calcium metal from Canada, Japan, and the Federal Republic of Germany were 114 tons valued at $582,000. Imports of calcium chloride, mainly from Canada and Mexico, were 46,439 tons valued at $2.1 million. Imports of other calcium compounds, mainly from Norway, Turkey, the United Kingdom, France, and Canada, totaled 219,600 tons, valued at $28.4 million.

Imports of other calcium compounds in 1980 included 119,417 tons of calcium nitrate, mainly from Norway; 63,389 tons of calcium borate, mainly from Turkey; 8,243 tons of chalk whiting, mainly from France; 7,258 tons of precipitated calcium carbonate, mainly from the United Kingdom, France, and Japan; 6,726 tons of calcium carbide, mainly from Canada; 1,744 tons of calcium cyanamide, mainly from Canada; 4,610 tons of calcium hypochlorite, mainly from Japan and India; and 8,212 tons of other compounds, mainly from the United Kingdom, Japan, Canada, and the Federal Republic of Germany.

Table 2.—U.S. imports for consumption of calcium and calcium chloride, by year

Year	Calcium		Calcium chloride	
	Quantity (pounds)	Value[1]	Quantity (short tons)	Value[1]
1976	461,965	$475,119	16,046	$480,259
1977	458,319	705,634	19,708	1,002,386
1978	523,835	825,008	42,523	2,101,794
1979	717,726	1,015,183	58,091	3,018,443
1980	227,814	581,525	46,439	2,071,463

[1]U.S. Customs import value, generally representing value in foreign country, and, therefore, excluding U.S. import duties, freight, insurance, and other charges incurred in shipping merchandise to the United States.

Table 3.—U.S. imports for consumption of calcium chloride, by country

(Short tons)

Country	1979 Quantity	1979 Value[1]	1980 Quantity	1980 Value[1]
Canada	57,993	$2,920,938	28,010	$1,261,488
France	3	4,405	--	--
Germany, Federal Republic of	91	86,829	79	70,057
Ireland	(2)	934	--	--
Japan	(2)	450	10	5,346
Mexico	--	--	18,321	717,261
Netherlands	--	--	(2)	324
Sweden	4	2,926	--	--
Switzerland	(2)	305	18	10,602
United Kingdom	(2)	1,656	1	6,385
Total	58,091	3,018,443	46,439	2,071,463

[1]U.S. Customs import value. See detailed explanation in footnote 1 of table 2.
[2]Less than 1/2 unit.

WORLD REVIEW

The market economy world annual production of calcium metal is estimated to be between 1,400 and 1,600 short tons.

Canada.—Chromasco Corp. Ltd. produced calcium metal at its Haley smelter near Renfrew, Ontario. Canada continued to lead all other countries in the production of calcium metal in 1980, producing about 1,157,000 pounds. Most of it was exported to the United States (58%), with the balance to the Republic of South Africa, Mexico, the Federal Republic of Germany, and Australia. About 335 short tons valued at $839,000 was exported to the United States. In 1979, final Canadian production was 1,005,000 pounds of calcium metal valued at $1,851,000.

Canada was the leading source of U.S. imports of calcium chloride in 1980. U.S. imports decreased from 57,993 tons in 1979 to 28,010 tons in 1980.

U.S. exports of calcium chloride to Canada decreased from 30,307 tons in 1979 to 20,027 tons in 1980.

France.—Planet Wattohm S.A., a subsidiary of Compagnie de Mokta, produced calcium metal by the Pidgeon process. No metal was exported to the United States in 1980, although it is possible that about 14,000 pounds of nuclear grade metal was exported to the United States.

U.S.S.R.—Substantial quantities of calcium metal was produced in the U.S.S.R. in 1980. Although 211 tons of Soviet calcium metal was exported to the United States in 1979, none was exported in 1980.

TECHNOLOGY

Calcium bromide and its mixtures with calcium chloride and zinc bromide to produce high-density, solids-free liquids in the completion of oil and gas wells continued its strong demand pattern in 1980. The number of multiple completion wells drilled in 1980 increased 16% compared with that of 1979, and consumption of calcium bromide high-density liquids increased commensurately. There were some spot shortages, and plant capacities were taxed. Some technical advances were developed in 1980, mostly in the use of additives such as inhibitors and viscosifiers. More facilities were established to recycle used fluids for refining and reuse. Heretofore mostly used for land-based wells and some inland waters, calcium bromide and its mixtures were used more extensively in offshore wells. Deeper wells also required denser fluids compared with the traditional mud. It is probable that new and/or increased calcium bromide plant capacities will be announced in 1981.[2]

Thermal energy storage containers utilizing calcium chloride hexahydrate ($CaCl_2 \cdot 6H_2O$) as a material that stores thermal energy in its melting phase at 81° F, and is released at the rate of 82 British thermal units per pound when it crystallizes, were developed. Additives have been developed that allow congruent melting and prevent supercooling and will not degrade when properly encapsulated. At least five companies are manufacturing products containing this compound for use in energy recovery systems.[3]

An innovative chemical heat pump system was developed that uses methanol refrigerant and a calcium chloride absorber to use and store solar energy for heating, air conditioning, and hot water. The heat pump system is based on the reaction of methanol vapor with anhydrous calcium chloride to form the solid-phase methanolate ($CaCl_2 \cdot 2CH_3OH$), and its primary virtue is its ability to store high-quality energy that can be used to provide both heating and air conditioning in the same package.[4]

The external desulfurization of steel in the ladle using technologically advanced injection systems gained considerable importance in 1980 both for minimills and integrated steelmakers. Calcium powder is being utilized as the desulfurizing agent for steels made in basic oxygen furnaces, and calcium metal compounds such as calcium silicide are finding applications in competition with magnesium-based materials.[5]

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[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Dowell Division of The Dow Chemical Co. (Houston, Tex.). Private communication, Apr. 15, 1981.
[3]Industrial Research & Development. V. 22, No. 10, October 1980, p. 119.
[4]Chemical & Engineering News. V. 58, No. 42, Oct. 20, 1980, pp. 36-37.
[5]33 Metal Producing. Desulphurization '80: Heavy Booking on a Bandwagon Promising Quality. V. 18, No. 11, November 1980, pp. 43-48.

Cement

By Richard H. Singleton[1] and Charles L. Davis[2]

U.S. cement consumption, excluding Puerto Rico, decreased 12% in 1980 to 77.6 million tons valued at about $3.95 billion. This decrease was caused by a slump in the construction industry. Total value of construction, in terms of constant dollars, decreased 10% to $228 billion, according to data published by the U.S. Department of Commerce. Housing starts decreased 26% to 1.3 million units.

Imports, a volatile indicator of domestic demand, decreased by 44% to 5.3 million tons, and accounted for 7% of consumption compared with 11% in 1979. Of these imports, 36% was clinker in 1980, compared with 50% in 1979.

Total cement shipments from U.S. plants, excluding Puerto Rico but including cement imported and distributed by producers and produced by grinding imported clinker, decreased by 11% in 1980 to 76.2 million tons. Demand remained low and no significant regional shortages occurred during the year. Shipments decreased by at least 10% to all regions of the United States except the South Atlantic and the West South Central regions where receipts changed less than 2%. Shipments to Florida increased by 16%. Shipments to the North Central regions decreased by 21%.

Two new plants, both in Texas, and two expanded plants came onstream in 1980, increasing capacity by 2.3 million tons per year. However, total U.S. capacity did not change significantly because of plant closings. Capacity increases totaling 4.5 million tons per year were planned for 1981.

A cement company announced plans to construct a slag cement plant near Baltimore, Md., by 1982. However, production of blended cements using additives such as fly ash and slag remained far behind European and Asian practice.

Table 1.—Salient cement statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:[1]					
Production[2]	72,950	78,647	83,986	84,491	75,224
Shipments from mills[2 3]	73,668	80,247	86,557	85,747	76,242
Value[2 3 4]	$2,510,100	$2,932,403	$3,543,996	$3,991,580	$3,886,488
Average value per ton[2 3 4]	$34.07	$36.54	$40.94	$46.55	$50.98
Stocks, Dec. 31 at mills[2]	7,154	6,041	5,320	6,600	6,825
Exports	343	236	55	149	186
Imports for consumption	3,074	3,989	6,577	9,393	5,244
Consumption, apparent[5 6]	74,136	81,537	87,619	87,799	77,599
World: Production	[r]834,288	[r]876,546	[r]939,755	[p]963,198	[e]977,626

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes Puerto Rico.
[2]Portland and masonry cement only.
[3]Includes imported cement shipped by domestic producers.
[4]Value received, f.o.b. mill, excluding cost of containers.
[5]Quantity shipped, plus imports, minus exports.
[6]Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

Civil antitrust suits, originally filed in 1976 by the attorneys general of California, Arizona, and Colorado against the Portland Cement Association and several cement producers, alleging a conspiracy to fix, maintain, and stabilize cement prices, was not resolved during 1980. The plaintiffs in the multidistrict litigation, 296, reportedly had increased from the original 3 States to at least 15 States, with the addition of 29 private plaintiffs. The actions were to have been heard in the U.S. District Court for the District of Arizona in September 1980, but they were reported delayed because of the judge's absence from the case. The hearing was not rescheduled and the case was still pending at yearend 1980.

DOMESTIC PRODUCTION

During 1980, 1 State agency and 54 companies operated 161 plants in 39 States. In addition, two companies operated two plants in Puerto Rico, manufacturing one or more kinds of hydraulic cement.

Some of the tables show statistical data arranged by State or by groups of States that form cement districts. A cement district may represent a group of States or a portion of a State. The States of California, New York, and Pennsylvania have, on some tables, been divided to provide additional marketing information. Divisions for these States are as follows:

California, Northern.—Points north and west of the northern borders of San Luis Obispo and Kern Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

New York, Western.—All counties west of a dividing line following the eastern boundaries of St. Lawrence, Lewis, Oneida, Madison, Chenango, and Broome Counties.

New York, Eastern.—All counties east of the above dividing line.

New York, Metropolitan.—The five counties of New York City (Bronx, Kings, New York, Queens, and Richmond) plus Westchester, Rockland, Suffolk, and Nassau Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Potter, Clinton, Centre, Huntingdon, and Franklin Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

PORTLAND CEMENT

Clinker production in the United States, excluding Puerto Rico, decreased 9% to 68.3 million tons of clinker in 1980, and imported clinker decreased 49% to 2.1 million tons. A total of 72.2 million tons of portland cement was ground in the United States in 1980. Stocks at mills increased by about 200,000 tons to 6.4 million tons at yearend.

Production Capacity.—By yearend 1980, multiplant operations were being run by 28 companies. Company size, as indicated by percentage of the national total clinker production capacity during 1980, of individual companies ranged from 8.4% to 0.23%. The five largest producers provided 33% of the total 1980 production compared with 28% in 1979; the 10 largest producers provided for a combined 54% in 1980. The 10 largest companies, in terms of 1980 clinker production, were (1) Lone Star Industries, Inc.; (2) Ideal Basic Industries, Inc.; (3) Gifford Hill & Co., Inc.; (4) Lehigh Portland Cement Co.; (5) General Portland, Inc.; (6) Martin Marietta Corp.; (7) Dundee Cement Co; (8) Kaiser Cement Corp; (9) Marquette Cement Co.; and (10) National Gypsum Co.

At yearend 1980, 368 kilns located at 152 plants were being operated by 48 companies and 1 State agency in the United States and Puerto Rico. Annual clinker production capacity at yearend, excluding Puerto Rico, was 89.7 million tons, a 2% increase over that of 1979. An average of 62 days downtime was reported for kiln maintenance and replacing refractory brick. The industry operated at 76% of its apparent capacity, compared with 85% in 1979. Average annual clinker capacity of U.S. kilns was 250,000 tons; average plant capacity was 605,000 tons and average company capacity was about 1.9 million tons. Six plants produced white cement. In addition, nine plants operated grinding mills using only imported or purchased clinker, or interplant transfers of clinker. Of these, six produced portland cement only and three produced ground clinker for both masonry and portland cement. Based on the fineness necessary to grind Types I and II cements and making allowance for downtime required for maintenance, the cement industry in the United States and Puerto Rico had an estimated annual grinding capacity of 107 million tons of cement, essentially the same as in 1979.

During 1980, clinker was produced by wet-process kilns at 85 plants and by dry-process kilns at 60 plants; 8 additional plants operated both wet and dry kilns. Most new plants that came onstream in 1980 and those currently under construction are dry-process, preheater, or precalciner equipped single kiln systems with capacities in excess of 500,000 tons of clinker. During 1980, 14 new suspension preheaters were put into operation, bringing the year-end totals to 54 suspension and 6 grate preheaters.

Capacity Added in 1980.—General Portland Inc. began operating, in late 1980, its new $93 million cement plant at New Braunfels, Tex. Annual designed plant capacity was 925,000 tons of cement.

Medusa Corp. completed its $50 million conversion of its Charlevoix, Mich., plant from a wet to dry process. Annual plant capacity was increased by 80% to 1.37 million tons per year. The plant began operation in 1980.

Monolith Portland Cement Co. increased capacity of its Laramie, Wyo., plant by 60% to 500,000 tons per year. A second kiln was added. The enlarged wet-process plant went online in November 1980.

Texas Industries, Inc.'s, new $50 million plant at Hunter, Tex., began operating in 1980. Design capacity was 550,000 tons per year.

These four additions, mostly in Texas, represent a total added capacity of about 2.3 million tons.

Capacity Additions Scheduled for Completion in 1981.— Alamo Cement Co.'s new $50 million plant near San Antonio, Tex., is designed to produce about 0.5 million tons of clinker annually and reportedly will boost Alamo's production capacity to about 1 million tons of cement per year. Alamo Cement is wholly owned by Vigier Ciment Ltd. of Switzerland and Presa S.p.A. Cementaria di Robilante of Italy.

California Portland Cement Co. scheduled completion in early 1981 of a $100 million modernization and expansion of its plant in Mojave, Calif. The expansion is expected to nearly double annual plant capacity to 2.1 million tons. The modernized plant was scheduled to begin operation in April 1981.

The Flintkote Co. continued a $42 million expansion and modernization of its Redding, Calif., plant to 600,000 tons per year. The kiln was designed to use either gas or coal for fuel.

Ideal Basic Industries, Inc., scheduled operation of its new $267 million Theodore plant near Mobile, Ala., for May 1981. Designed capacity was 1.5 million tons per year. Ideal's $55 million expansion and complete renovation of its plant at Boettcher, Colo., was rescheduled to early 1981. Design capacity was increased by about one-third to 425,000 tons per year.

Kaiser Cement Corp.'s $112 million modernization of its 1.5-million-ton-per-year cement plant at Permanente in northern California was completed and the new coal-fired kiln was started. The kiln replaced six oil-fired wet units.

Lone Star Industries, Inc.'s, expansion and modernization of its plant at Davenport near Santa Cruz, Calif., was nearly completed. Capacity was to be approximately doubled to 750,000 tons per year. The plant was scheduled to go into operation in early 1981.

Marquette Cement Co.'s $80 million modernization and expansion of its plant at Cape Girardeau, Mo., continued. The new 1-million-ton-per-year capacity plant was to replace the old 250,000-ton-per-year wet plant. Operation was scheduled for early 1981.

Martin Marietta Corp.'s $80 million expansion and conversion from a wet to a dry process at Buffalo near Davenport, Iowa, continued. Operation of the 850,000-ton-per-year dry-process plant was scheduled for the third quarter of 1981. Capacity of the previous wet-process plant had been 500,000 tons per year.

Scheduled added capacity for 1981, about 4.5 million tons, was mainly on the west coast, in the South, and in the Central States. No added capacity was scheduled for east of the Mississippi River.

Capacity Additions Scheduled for After 1981.—Atlantic Cement Co., Inc., scheduled construction of a slag cement plant at Bethlehem Steel Corp.'s complex at Sparrows Point, Md. The plant was expected to consume about 800,000 tons annually of water-granulated blast furnace iron slag. The process was claimed to use six times less energy than that required to manufacture portland cement. The comminuted product was to be blended with portland cement. Construction was scheduled to begin in August 1981, and end at midyear 1982.

Columbia Cement Corp. had plans to conduct an estimated $75 million expansion of its plant at Bellingham, Wash. Cement annual capacity was to be approximately doubled to 750,000 tons per year. No schedule was announced.

Florida Mining and Materials Corp. planned to double the capacity of its plant in Brooksville, Fla., to 1.1 million tons. Startup was scheduled for early 1982.

Kaiser Cement Corp.'s $130 million expansion and conversion from wet to dry process of its Cushenburg plant at Lucerne Valley, Calif., was scheduled for completion in late 1982. Annual capacity was designed to be 1.5 million tons.

Lehigh Portland Cement Co. scheduled a new 750,000-ton-per-year plant at Alsen, N.Y., to be operational by 1984. This was to replace an existing plant at the same location with about one-half the capacity of the new plant. Lehigh also planned a modernization and expansion, from a capacity of 500,000 tons to 1.4 million tons per year, of its plant at Union Bridge, Md. No date had been set for completion of this expansion.

Martin Marietta Corp. continued building an $85 million plant at Leamington, Utah. Startup of the 500,000-ton-per-year plant was scheduled for early 1982.

Monolith Portland Cement Co.'s expansion and conversion from a wet to a dry process at its Monolith, Calif., plant was designed to double capacity to 1.0 million tons per year. Plant operation was scheduled for 1982.

Plant Closings.—Alpha Portland Cement, Inc., closed its 170,000-ton-per-year plant at Jamesville, N.Y., at yearend and converted it into a cement terminal.

Citadel Cement Corp. closed its 300,000-ton-per-year plant in Birmingham, Ala., in September 1980, and converted it into a terminal. Citadel Cement is a subsidiary of Canada Cement Lafarge Ltd.

Medusa Corp. closed its Toledo, Ohio, plant at yearend 1979.

Corporate Changes.—Lehigh Portland Cement Co. purchased, in October 1980, all 8 cement plants and 12 terminals of the Universal Atlas Cement Div. of United States Steel Corp. Lehigh is a subsidiary of the Federal Republic of Germany's Heidelberger Zement A.G.

Lone Star Industries, Inc., purchased OKC Corp.'s only two cement plants in 1980, at New Orleans, La., and Pryor, Okla. Lone Star also purchased, in March 1980, Medusa Corp.'s dry-process, coal-fired plant at Dixon, Ill. Lone Star had purchased, in September 1979, Portland Cement Co.'s 420,000-ton-per-year wet-process plant at Salt Lake City, Utah.

Penn-Dixie Industries, Inc., expected to file for reorganization in May 1981, under the Federal Bankruptcy Act and was negotiating at yearend to sell all of its cement plants. One plant, in Nazareth, Pa., was sold in June 1980, to Coplay Cement Manufacturing Co.

Table 2.—Portland cement production, capacity, and stocks in the United States, by district[1] [2]

(Thousand short tons)

District	1979					1980				
	Plants active during year	Production[3]	Capacity[4]		Stocks[5] at mills Dec. 31	Plants active during year	Production[3]	Capacity[4]		Stocks[5] at mills Dec. 31
			Finish grinding	Percent utilized				Finish grinding	Percent utilized	
New York and Maine	9	4,187	5,562	75.3	525	9	3,648	5,399	67.6	472
Pennsylvania, eastern	11	4,872	6,563	74.2	575	11	4,036	6,586	61.3	480
Pennsylvania, western	5	1,946	2,681	72.6	215	4	1,435	2,155	66.6	181
Maryland and West Virginia	4	2,330	2,836	82.1	154	4	2,148	2,850	75.4	175
Ohio	6	2,045	2,735	74.8	211	5	1,693	2,380	71.1	130
Michigan	7	5,776	7,423	77.8	412	7	4,767	7,686	62.0	397
Indiana	5	2,664	3,721	71.6	232	5	2,033	3,402	59.8	319
Illinois	4	1,998	2,796	71.5	228	4	1,768	2,818	62.7	255
Tennessee	6	1,394	2,653	52.5	133	6	1,328	2,447	54.3	97
Kentucky, North Carolina, Virginia	3	1,862	2,482	75.0	186	3	1,640	2,482	66.1	203
South Carolina	3	2,014	3,044	66.2	125	3	1,780	3,268	54.5	95
Florida	6	3,255	3,930	82.8	158	6	3,336	4,055	82.3	129
Georgia	3	1,379	1,702	81.0	80	3	1,227	1,753	70.0	76
Alabama	7	2,682	3,839	69.9	273	7	2,520	3,769	66.9	279
Louisiana and Mississippi	4	1,590	1,993	79.8	114	4	1,657	1,993	83.1	108
Nebraska and Wisconsin	5	1,151	1,741	66.1	148	5	820	1,741	47.1	126
South Dakota	1	660	1,806	36.5	46	1	464	1,806	25.7	50
Iowa	5	2,384	3,287	72.5	218	5	2,058	3,121	65.9	310
Missouri	7	4,368	5,166	84.6	375	7	3,606	5,164	69.8	496
Kansas	5	2,117	2,400	88.2	137	5	1,968	2,308	85.3	191
Oklahoma and Arkansas	5	2,752	3,447	79.8	173	5	2,752	3,620	76.0	244
Texas	18	9,070	10,430	87.0	434	19	9,151	11,601	78.9	504
Wyoming, Montana, Idaho	4	1,049	1,194	87.9	72	4	998	1,194	83.6	117
Colorado, Arizona, Utah, New Mexico	8	3,973	5,500	72.2	263	8	3,521	5,270	66.8	203
Washington	4	1,843	2,105	87.6	149	4	1,572	2,103	74.8	136
Oregon and Nevada	3	984	1,325	74.3	62	3	1,025	1,775	57.7	75
California, northern	4	2,941	3,278	89.7	219	4	2,608	3,188	81.8	278
California, southern	8	6,921	8,359	82.8	237	8	6,241	8,199	76.1	208
Hawaii	2	451	560	80.5	25	2	372	560	66.4	39
Puerto Rico	2	1,413	1,888	74.8	37	2	1,485	2,209	67.2	40
Total or average	164	82,071	106,446	77.1	6,216	163	73,657	106,902	68.9	6,413

[1]Includes Puerto Rico.

[2]Includes data for six white cement facilities; Texas (two); Pennsylvania (two); California (one); and Wisconsin (one). Includes data for nine grinding plants in 1980 and seven in 1979 as follows: Florida (one); Indiana (one in 1980 only); New York (one); Michigan (two); Pennsylvania (two in 1980 and one in 1979); and Wisconsin (two).

[3]Includes cement produced from imported clinker (1979—4,171; 1980—2,111).

[4]Grinding capacity based on fineness necessary to grind Types I and II cement, making allowance for downtime required for maintenance.

[5]Includes imported cement. Source of imports withheld to avoid disclosing company proprietary data.

Table 3.—Clinker capacity and production in the United States, by district, as of December 31, 1980[1] [2]

District	Active plants: Process used: Wet	Dry	Both	Total	Number of kilns	Daily capacity (thousand short tons)	Average number of days for maintenance	Apparent annual capacity[3] (thousand short tons)	Production[4] (thousand short tons)	Percent utilized
New York and Maine	6	2	--	8	13	15.7	54	4,882	3,536	72.4
Pennsylvania, eastern	3	6	--	9	31	19.5	64	5,867	4,008	68.3
Pennsylvania, western	3	1	--	4	8	6.0	57	1,845	1,434	77.7
Maryland and West Virginia	2	2	--	4	10	8.2	50	2,585	2,102	81.3
Ohio	2	2	1	5	9	7.5	52	2,348	1,656	70.5
Michigan	3	2	--	5	15	18.7	70	5,522	4,088	74.0
Indiana	2	2	--	4	11	11.1	50	3,502	1,851	52.9
Illinois	--	4	--	4	10	10.0	44	3,216	1,599	49.7
Tennessee	5	1	--	6	9	5.8	57	1,787	1,355	75.8
Kentucky, North Carolina, Virginia	1	2	--	3	8	6.9	81	1,962	1,642	83.7
South Carolina	2	1	--	3	7	7.4	97	1,986	1,700	85.6
Florida	4	1	--	5	11	11.4	69	3,369	2,987	88.7
Georgia	--	2	1	3	5	4.7	44	1,510	1,240	82.1
Alabama	2	4	--	6	11	10.9	71	3,202	2,574	80.4
Louisiana and Mississippi	4	--	--	4	8	5.8	49	1,801	1,526	84.7
Nebraska and Wisconsin	1	--	1	2	6	3.0	59	918	767	83.6
South Dakota	--	--	1	1	4	3.3	137	752	460	61.2
Iowa	3	2	--	5	13	17.1	63	5,170	2,099	40.6
Missouri	5	2	--	7	12	15.2	53	4,739	3,768	79.5
Kansas	3	2	--	5	15	7.3	53	2,277	1,878	82.5
Oklahoma and Arkansas	3	2	--	5	12	9.5	56	2,937	2,759	93.9
Texas	12	5	2	19	47	31.9	54	9,934	8,565	86.2
Wyoming, Montana, Idaho	4	--	--	4	5	3.1	41	1,003	957	95.4
Colorado, Arizona, Utah, New Mexico	3	5	--	8	20	13.9	79	3,970	3,336	84.0
Washington	3	1	--	4	7	3.7	35	1,222	1,158	94.8
Oregon and Nevada	1	1	1	3	8	4.8	34	1,589	1,104	69.5
California, northern	2	2	--	4	13	9.5	54	2,950	2,263	76.7
California, southern	2	5	1	8	29	22.3	77	6,416	5,535	86.3
Hawaii	1	1	--	2	2	1.8	99	479	368	76.8
Puerto Rico	2	--	--	2	9	7.4	63	2,238	1,433	64.0
Total or average	84	60	8	152	368	303.4	62	91,978	69,748	75.8

[1]Includes Puerto Rico.
[2]Includes white cement producing facilities.
[3]Calculated on individual company data; 365 days, minus average days for maintenance, times the reported 24-hour capacity.
[4]Includes production reported for plants which added or shut down kilns during the year.

Table 4.—Daily clinker capacity, December 31[1 2]

Short tons per 24-hour period	Number		Total capacity (short tons)	Percent of total capacity
	Plants	Kilns[3]		
1979:				
Less than 600	5	7	2,271	0.8
600 to 1,150	33	59	28,792	10.0
1,150 to 1,700	49	108	69,052	23.7
1,700 to 2,300	29	70	57,868	19.9
2,300 to 2,800	16	41	39,291	13.5
2,800 and over	25	92	93,571	32.1
Total	157	377	290,845	100.0
1980:				
Less than 600	3	4	1,530	0.5
600 to 1,150	31	54	28,175	9.3
1,150 to 1,700	44	100	64,305	21.2
1,700 to 2,300	33	79	65,344	21.5
2,300 to 2,800	15	36	37,376	12.3
2,800 and over	26	95	106,686	35.2
Total	152	368	303,416	100.0

[1]Includes Puerto Rico.
[2]Includes white cement-producing facilities.
[3]Total number in operation at plants.

Table 5.—Raw materials used in producing portland cement in the United States[1]

(Thousand short tons)

Raw materials	1978	1979	1980
Calcareous:			
Limestone (includes aragonite, marble, chalk)	78,452	83,163	80,554
Cement rock (includes marl)	34,429	30,987	24,991
Oystershell	2,064	1,341	1,123
Argillaceous:			
Clay	6,758	7,016	6,220
Shale	4,399	4,289	4,193
Other (includes staurolite, bauxite, aluminum dross, pumice, and volcanic material)	225	362	313
Siliceous:			
Sand	2,306	2,128	1,994
Sandstone and quartz	710	808	668
Ferrous: Iron ore, pyrites, millscale, and other iron-bearing material	1,037	1,063	1,175
Other:			
Gypsum and anhydrite	4,260	4,324	3,859
Blast furnace slag	479	483	132
Fly ash	483	509	601
Other, n.e.c	22	6	171
Total	135,624	136,479	125,994

[1]Includes Puerto Rico.

MASONRY CEMENT

Shipments of masonry cement totaled 3.1 million tons, a decrease of 19% from that of 1979. At yearend, 103 plants were manufacturing masonry cement in the United States.

Table 6.—Masonry cement production and stocks in the United States, by district

(Thousand short tons)

District	1979 Plants active during year	1979 Production	1979 Stocks[1] at mills Dec. 31	1980 Plants active during year	1980 Production	1980 Stocks[1] at mills Dec. 31
New York and Maine	3	86	10	4	83	16
Pennsylvania, eastern	9	285	26	8	226	28
Pennsylvania, western	5	144	21	4	96	15
Maryland and West Virginia	3	149	11	3	117	10
Ohio	4	178	18	4	129	21
Michigan	5	278	77	5	205	71
Illinois and Indiana	4	464	56	3	293	51
Tennessee	5	173	15	5	144	22
Kentucky, North Carolina, Virginia	4	255	20	4	199	25
Florida	4	267	9	4	299	17
Georgia	3	108	12	3	88	15
Alabama	6	308	29	6	246	35
Louisiana, Mississippi, South Carolina	4	280	18	5	253	24
Nebraska, Wisconsin, Washington	6	32	7	4	26	9
South Dakota	1	3	3	1	5	2
Iowa	3	77	15	3	45	11
Missouri	4	83	9	3	72	19
Kansas	5	88	14	5	63	17
Oklahoma and Arkansas	5	131	9	5	107	10
Texas	11	269	27	13	220	23
Wyoming, Montana, Idaho	4	11	3	3	7	2
Colorado, Arizona, Utah, New Mexico	5	154	10	6	116	7
Oregon and Nevada	--	--	(2)	--	--	(2)
Hawaii	2	10	2	2	13	2
Total	105	[3]3,833	421	103	[3]3,052	452

[1]Includes imported cement.
[2]Less than 1/2 unit.
[3]Includes 3,129 tons produced from clinker, and 704 tons produced from cement (1979); 2,619 tons produced from clinker, and 431 tons produced from cement (1980).

ALUMINOUS CEMENT

Aluminous cement, also known as calcium aluminate cement, high-alumina cement, and "Ciment Fondu," is a nonportland hydraulic cement. It was produced at the following three plants in the United States: United States Steel Corp., Universal Atlas Cement Div., Buffington, Ind.; Lone Star Lafarge Co. at Chesapeake, Va.; and Aluminum Co. of America at Bauxite, Ariz.

ENERGY

High energy costs and fuel availability have been an industry concern since 1974, and progress has been made since that time toward lowering the amount of energy required to produce a ton of finished cement. Approximately 90% of the energy use in cement production is fuel consumed in kiln firing to produce clinker. Most new or planned plants and most converted plants in 1980 were dry-process systems with preheaters and precalciners and were coal burning. Energy consumption per ton of clinker was reduced by 2.5% in 1980 to about 5.5 million British thermal units (Btu's) per ton.

The average amount of electrical energy increased 2% to about 142 kilowatt-hours per ton. Assuming a 40% energy efficiency in conversion of fuel to electrical energy, this represents a fuel equivalent of about 1.2 million Btu's per pound. Average fuel consumption for kiln firing plus electrical energy was approximately 6.7 million Btu's per ton in 1980.

Average fuel consumption in kiln firing in wet-process plants, 5.9 million Btu's per ton, was 20% higher than average fuel consumption in dry-process plants, 4.9 million Btu's per ton. Approximately 45% of clinker production in 1980 was by the dry-process compared with 44% in 1979.

Kilns without preheaters averaged 5.8 million Btu's per ton; those with suspension preheaters averaged 4.6 million Btu's per ton, and those with grate type preheaters averaged 5.1 million Btu's per ton of clinker produced.

Coal accounted for 76% of kiln fuel consumption, compared with 72% in 1979. Natural gas accounted for 16% of kiln fuel consumption, compared with 21% in 1979. Oil accounted for 8% in 1980, compared with 7% in 1979. On the average, 1 ton of clinker production in 1980 consumed 350 pounds of coal, 869 cubic feet of natural gas, and 2.47 gallons of oil.

Interest in energy-saving additives, mainly fly ash and iron and steel slag, increased. Atlantic Cement Co. planned construction of a slag cement plant near Baltimore, Md., by 1982. Use of fly ash in cements increased by 17% to 601,000 tons in 1980. However, use of slags decreased by 73% to 132,000 tons.

Table 7.—Clinker produced in the United States, by kind of fuel[1]

Year and fuel	Clinker produced			Fuel consumed		
	Plants active during year	Quantity (thousand short tons)	Percent of total	Coal[2] (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1979:						
Coal	41	19,339	25.4	4,499	--	--
Oil	6	2,578	3.4	--	2,316	--
Natural gas	6	2,011	2.6	--	--	11,863,215
Coal and oil	16	8,948	11.8	1,741	549	--
Coal and natural gas	53	23,359	30.7	4,414	--	37,404,465
Oil and natural gas	10	6,775	8.9	--	1,333	29,304,201
Coal, oil, natural gas	25	13,133	17.2	2,290	816	9,239,488
Total	157	76,143	100.0	12,944	5,014	87,811,369
1980:						
Coal	38	16,719	23.9	3,751	--	--
Oil	3	1,623	2.3	--	1,634	--
Natural gas	4	1,596	2.3	--	--	8,551,904
Coal and oil	19	8,848	12.7	1,536	820	--
Coal and natural gas	52	22,352	32.0	4,488	--	23,773,914
Oil and natural gas	7	3,802	5.5	--	660	16,827,953
Coal, oil, natural gas	30	14,881	21.3	2,449	995	11,529,607
Total	153	69,821	100.0	12,224	4,109	60,683,378

[1]Includes Puerto Rico.
[2]Includes 97.5% bituminous and 2.5% petroleum coke in 1979; 95.6% bituminous and 4.4% petroleum coke in 1980.

Table 8.—Clinker produced and fuel consumed by the portland cement industry in the United States, by process[1]

Year and process	Clinker produced			Fuel consumed		
	Plants active during year	Quantity (thousand short tons)	Percent of total	Coal[2] (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1979:						
Wet	88	40,285	52.9	7,286	3,579	54,744,897
Dry	61	31,076	40.8	5,058	1,345	20,342,502
Both	8	4,782	6.3	600	90	12,723,970
Total	157	76,143	100.0	12,944	5,014	87,811,369
1980:						
Wet	85	36,116	51.7	6,605	2,709	40,424,076
Dry	60	29,417	42.1	4,915	1,197	15,408,815
Both	8	4,288	6.2	704	203	4,850,487
Total	153	69,821	100.0	12,224	4,109	60,683,378

[1]Includes Puerto Rico.
[2]Includes 97.5% bituminous and 2.5% petroleum coke in 1979; 95.6% bituminous and 4.4% petroleum coke in 1980.

Table 9.—Electric energy used at portland cement plants in the United States, by process[1] [2]

Year and process	Electric energy used						Finished cement produced (thousand short tons)	Average electric energy used per ton of cement produced (kilowatt-hours)
	Generated at portland cement plants		Purchased		Total			
	Active plants	Quantity (million kilowatt-hours)	Active plants	Quantity (million kilowatt-hours)	Quantity (million kilowatt-hours)	Percent		
1979:								
Wet	4	126	86	5,536	5,662	49.5	43,694	129.6
Dry[3]	4	475	68	4,585	5,060	44.2	33,558	150.8
Both	--	--	8	718	718	6.3	4,819	149.0
Total	8	601	162	10,839	11,440	100.0	82,071	139.4
Percent of total electric energy used	--	5.3	--	94.7	--	--	--	--
1980:								
Wet	1	4	85	5,037	5,041	48.2	38,365	131.4
Dry[3]	3	448	70	4,321	4,769	45.6	31,132	153.2
Both	--	--	8	657	657	6.2	4,160	157.9
Total	4	452	163	10,015	10,467	100.0	73,657	142.1
Percent of total electric energy used	--	4.3	--	95.7	--	--	--	--

[1]Includes grinding plants and white cement facilities.
[2]Includes Puerto Rico.
[3]Includes data for grinding plants.

TRANSPORTATION

Consumers continued to receive most of their cement directly from cement plants. Only 24% of this cement was shipped directly from terminals in 1980. A tendency prevailed to build plants and terminals near waterway systems because of transportation economics. However, plant to terminal shipments by water, 45% in 1980, decreased while shipments by rail, 47% in 1980, increased. Shipments from terminal or plant to consumer remained mostly by truck. Only 7% of cement shipments to consumers was by rail and 1% was by water.

CONSUMPTION AND USES

Cement consumption in the United States, excluding Puerto Rico, decreased 12% in 1980 to 77.6 million tons. This was caused by the general slump in the construction industry. Domestic producers shipped 76.2 million tons in 1980, an 11% decrease from that of 1979. This included 3.7 million tons of cement and clinker imported and sold or used by domestic producers, plus 1.6 million tons of cement imported by certain other importers. Still other imports, 1.4 million tons net, reported by the U.S. Bureau of the Census, accounted for the difference between consumption and domestic shipments.

Domestic shipments in 1980 decreased by more than 10% to all regions of the United States except the South Atlantic and the West South Central regions where receipts changed less than 2%. Florida showed the largest consumption gain, 16%, of any State. Texas showed no significant change in consumption. Shipments to destinations in the North Central regions were particularly depressed, decreasing 21% compared with those of 1979. No significant cement shortages occurred in the United States during 1980.

The value of total U.S. construction decreased about 10% in terms of constant dollars in 1980 to $228 billion actual dollars, according to data issued by the U.S. Department of Commerce.[3] Of this total 1980 value, 38% was in private housing, 35% was industrial and commercial, 3% was on farms, 8% was in public buildings, 6% was in highways, and 10% was in other public construction. Total private construction decreased 13% in real value to $173 billion and public construction increased 1% in real value to $55 billion. Value of private residential units put in place in 1980 decreased 28% in constant dollar value to $63 billion. This was partially counterbalanced by a 7% increase in real value of additions and alterations to private residential units to $24 billion. Industrial-commercial construction decreased 3% in real value to approximately $80 billion. Public buildings put in place in 1980 increased 8% in real value to $19 billion and highway construction increased 2% in real value to $13 billion.

Housing starts decreased 26% to 1.30 million units, consisting of 0.85 million single units and 0.45 multiunits, according to the U.S. Department of Commerce. Single housing starts decreased 41%. On a regional basis, total housing starts decreased 14% in the South to 644,000 units, 29% in the Northeast to 125,000 units, 35% in the West to 305,000 units, and 38% in the North Central Region to 218,000 units. The ratio of cement consumption to housing unit starts was nearly 50% greater in the Northeast and North Central Regions than in the South, reflecting the relatively greater influence of construction other than housing on cement consumption in the northern regions.

Ready-mix concrete producers were the primary consumers of portland cement, accounting for 68% of the total quantity shipped by domestic producers. Manufacturers of concrete products used 13% of the total to produce concrete blocks, pipe, precast, prestressed, and other concrete products. The remainder was used by highway contractors; building contractors; cement dealers; Federal, State, and other government agencies; and miscellaneous.

Table 10.—Shipments of portland cement from mills in the United States, in bulk and in containers, by type of carrier[1]

(Thousand short tons)

Year and type of carrier	Shipments from plant to terminal: In bulk	Shipments from plant to terminal: In containers	Shipments to ultimate consumer: From terminal to consumer: In bulk	Shipments to ultimate consumer: From terminal to consumer: In containers	Shipments to ultimate consumer: From plant to consumer: In bulk	Shipments to ultimate consumer: From plant to consumer: In containers	Total shipments
1979:							
Railroad	7,372	192	753	27	6,085	186	7,051
Truck	1,252	78	17,356	1,021	51,394	5,142	74,913
Barge and boat	8,638	49	49	33	614	38	734
Unspecified[2]	4	--	59	3	590	40	692
Total	17,266	319	18,217	1,084	58,683	[3]5,405	[4]83,390
1980:							
Railroad	7,519	159	438	7	4,572	187	5,204
Truck	1,190	178	16,769	767	46,163	4,140	67,839
Barge and boat	7,336	76	71	1	614	6	692
Unspecified[2]	2	--	58	14	795	70	937
Total	16,047	413	17,336	789	52,144	4,403	[3 4]74,674

[1]Includes Puerto Rico.
[2]Includes cement used at plant.
[3]Data do not add to total shown because of independent rounding.
[4]Bulk shipments were 92.2% (76,900 tons), and container (bag) shipments were 7.8% (6,490 tons) for 1979. Bulk shipments were 93.0% (69,481 tons), and container (bag) shipments were 7.0% (5,196 tons) for 1980.

Table 11.—Portland cement shipped by producers in the United States, by district[1 2]

District	1979: Quantity (thousand short tons)	1979: Value (thousands)	1979: Average per ton	1980: Quantity (thousand short tons)	1980: Value (thousands)	1980: Average per ton
New York and Maine	4,123	$139,593	$33.86	3,550	$134,855	$37.99
Pennsylvania, eastern	4,667	181,019	38.79	4,066	167,855	41.28
Pennsylvania, western	1,841	78,737	42.77	1,504	69,829	46.43
Maryland and West Virginia	2,280	88,570	38.84	2,079	91,159	43.85
Ohio	1,921	87,483	45.54	1,625	77,696	47.81
Michigan	5,683	252,058	44.35	4,651	224,685	48.31
Indiana	2,389	95,549	40.00	1,769	73,049	41.29
Illinois	1,889	79,604	42.14	1,649	75,315	45.67
Tennessee	1,335	57,146	42.81	1,304	58,827	45.11
Kentucky, North Carolina, Virginia	1,775	80,482	45.34	1,588	72,910	45.91
South Carolina	1,831	79,377	43.35	1,704	74,539	43.74
Florida	2,957	126,562	42.80	3,574	182,590	51.09
Georgia	1,335	55,117	41.29	1,231	55,463	45.06
Alabama	2,578	103,187	40.03	2,491	108,438	43.53
Louisiana and Mississippi	1,563	77,937	49.86	1,621	95,752	59.07
Nebraska and Wisconsin	1,218	59,319	46.70	842	44,136	52.42
South Dakota	670	31,273	46.68	459	23,042	50.20
Iowa	2,371	109,628	46.23	1,998	101,008	50.55
Missouri	4,430	194,285	43.85	3,515	156,368	44.48
Kansas	2,086	88,619	42.48	1,835	86,103	46.92
Oklahoma and Arkansas	2,702	122,343	45.28	2,726	127,483	46.77
Texas	9,353	475,836	50.88	9,517	535,690	56.29
Wyoming, Montana, Idaho	1,050	55,522	52.88	1,004	56,106	55.88
Colorado, Arizona, Utah, New Mexico	3,996	206,382	51.65	3,647	207,740	56.96
Washington	1,761	98,659	56.02	1,546	89,208	57.70
Oregon and Nevada	981	54,988	56.05	960	57,277	59.66
California, northern	2,894	161,338	55.75	2,556	151,156	59.14
California, southern	6,830	380,477	55.71	6,241	391,331	62.70
Hawaii	469	29,346	62.57	358	23,722	66.26
Puerto Rico	1,406	70,197	49.93	1,482	102,872	69.41
U.S. total or average[3]	80,384	3,720,633	46.29	[4]73,095	3,716,204	50.84
Foreign imports[5]	3,006	[r]135,712	45.48	1,580	83,718	52.99
Total or average	83,390	3,856,345	46.24	[4]74,674	3,799,923	50.89

[r]Revised.
[1]Includes data for six white cement facilities: Texas (two); Pennsylvania (two); California (one); and Wisconsin (one). Includes data for nine grinding plants in 1980 and seven in 1979 as follows: Florida (one); Indiana (one in 1980 only); New York (one); Michigan (two); Pennsylvania (two in 1980 and one in 1979); and Wisconsin (two).
[2]Includes Puerto Rico.
[3]Includes cement produced from imported clinker.
[4]Data do not add to total shown because of independent rounding.
[5]Cement imported and distributed by domestic producers only.

Table 12.—Masonry cement shipped by producers in the United States, by district[1]

District	1979 Quantity (thousand short tons)	1979 Value (thousands)	1979 Average per ton	1980 Quantity (thousand short tons)	1980 Value (thousands)	1980 Average per ton
New York and Maine	84	$3,793	$45.15	79	$3,813	$48.27
Pennsylvania, eastern	275	16,948	61.63	221	14,482	65.53
Pennsylvania, western	141	7,229	51.27	103	5,816	56.47
Maryland and West Virginia	146	6,793	46.53	121	6,733	55.64
Ohio	170	10,869	63.94	126	8,549	67.85
Michigan	262	16,455	62.81	206	14,292	69.38
Illinois and Indiana	455	23,699	52.09	300	14,937	49.79
Tennessee	170	8,600	50.59	132	7,241	54.86
Kentucky, North Carolina, Virginia	247	13,236	53.59	193	10,191	52.80
Florida	255	13,098	51.36	285	22,074	77.45
Georgia	102	5,172	50.71	89	5,464	61.39
Alabama	303	13,930	45.97	242	13,012	53.77
Louisiana, Mississippi, South Carolina	291	16,420	56.43	256	15,705	61.35
Nebraska, Wisconsin, Washington	31	2,254	72.71	24	1,727	71.96
South Dakota	7	434	62.00	6	377	62.83
Iowa	69	3,844	55.71	48	3,340	69.58
Missouri	82	4,159	50.72	62	3,117	50.27
Kansas	89	4,525	50.84	60	3,310	55.17
Oklahoma and Arkansas	128	7,000	54.69	107	6,031	56.36
Texas	268	15,593	58.18	241	18,310	75.98
Wyoming, Montana, Idaho	11	702	63.82	7	490	70.00
Colorado, Arizona, Utah, New Mexico	150	8,892	59.28	119	8,444	70.96
Oregon and Nevada	1	64	64.00	1	41	41.00
Hawaii	12	1,086	90.50	13	960	73.85
U.S. total or average[2]	3,748	204,797	54.63	3,040	188,456	61.99
Foreign imports[3]	14	637	45.50	10	982	98.20
Total or average	3,762	205,434	54.59	3,050	189,438	62.11

[1]Does not include quantities produced on the job by masons.
[2]Data may not add to totals shown because of independent rounding.
[3]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.

Table 13.—Cement shipments, by destination and origin[1]

(Thousand short tons)

	Portland cement[2]			Masonry cement		
	1978	1979	1980	1978	1979	1980
Destination:						
Alabama	1,498	1,270	1,133	141	116	93
Alaska[3]	116	90	94	W	--	W
Arizona	1,617	1,808	1,457	W	W	W
Arkansas	952	892	758	75	62	49
California, northern	3,430	3,813	3,012	([4])	1	([4])
California, southern	5,327	5,734	5,226	7	13	([4])
Colorado	1,517	1,515	1,404	42	40	28
Connecticut[3]	769	766	614	15	16	16
Delaware[3]	140	155	132	9	8	7
District of Columbia[3]	170	126	117	7	5	4
Florida	4,260	4,602	5,412	360	396	408
Georgia	2,207	2,100	2,050	202	189	159
Hawaii	381	422	365	11	12	13
Idaho	459	471	362	2	2	2
Illinois	3,666	3,378	2,664	142	133	90
Indiana	1,792	1,713	1,323	134	114	85
Iowa	1,923	1,779	1,294	33	28	19
Kansas	1,234	1,294	1,207	33	29	24
Kentucky	1,224	1,231	954	139	116	80
Louisiana	2,848	2,755	2,735	108	91	73
Maine	260	242	221	12	12	9
Maryland	1,386	1,358	1,290	126	122	115
Massachusetts[3]	982	1,005	959	40	42	35
Michigan	2,936	2,874	1,993	183	169	109
Minnesota[3]	1,764	1,714	1,447	66	58	43
Mississippi	1,020	947	861	86	76	65
Missouri	2,094	1,863	1,430	59	51	38
Montana	362	335	292	4	4	2
Nebraska	974	1,053	828	20	19	14
Nevada	612	610	565	1	([4])	--
New Hampshire[3]	336	307	221	11	11	10
New Jersey[3]	1,693	1,727	1,486	69	69	57
New Mexico	633	583	600	15	10	11

See footnotes at end of table.

Table 13.—Cement shipments, by destination and origin[1] —Continued

(Thousand short tons)

	Portland cement[2]			Masonry cement		
	1978	1979	1980	1978	1979	1980
Destination —Continued						
New York, eastern	733	776	669	30	29	24
New York, western	942	885	788	47	41	34
New York, metropolitan[3]	838	916	905	32	35	35
North Carolina	1,781	1,656	1,463	258	227	184
North Dakota[3]	357	371	271	10	9	6
Ohio	3,429	3,202	2,659	242	208	151
Oklahoma	1,659	1,699	1,626	80	69	56
Oregon	967	976	831	2	1	1
Pennsylvania, eastern	1,917	1,797	1,583	79	71	55
Pennsylvania, western	1,122	1,105	920	109	94	72
Puerto Rico	1,442	1,343	1,414	--	--	--
Rhode Island[3]	160	159	126	5	6	5
South Carolina	939	926	883	141	123	107
South Dakota	344	411	257	10	8	6
Tennessee	1,519	1,515	1,369	210	172	134
Texas	8,603	8,745	8,839	275	251	224
Utah	900	921	799	3	2	2
Vermont[3]	148	138	125	6	5	4
Virginia	1,885	1,973	1,788	226	191	147
Washington	1,633	1,846	1,374	11	11	8
West Virginia	614	580	546	59	51	41
Wisconsin	1,874	1,766	1,544	78	64	46
Wyoming	385	462	478	4	4	3
Total United States	84,773	84,700	75,763	4,069	3,686	3,003
Foreign countries[5]	65	160	296	106	109	86
Total shipments	84,838	84,860	76,059	4,175	3,795	3,089
Origin:						
United States[6]	80,009	78,978	71,610	4,124	3,749	3,044
Puerto Rico	1,442	1,406	1,482	--	--	--
Foreign:[7]						
Domestic producers	2,398	3,006	1,580	26	14	10
Others	989	1,470	1,387	25	32	35
Total shipments	84,838	84,860	76,059	4,175	3,795	3,089

W Withheld to avoid disclosing company proprietary data; included with "Foreign countries."
[1]Includes cement produced from imported clinker and imported cement shipped by domestic producers, Canadian cement manufacturers, and other importers. Includes Puerto Rico.
[2]Excludes cement (1978—428; 1979—425; 1980—283) used in the manufacture of prepared masonry cement.
[3]Has no cement-producing plants.
[4]Less than 1/2 unit.
[5]Direct shipments by producers to foreign countries and U.S. possessions and territories; includes States indicated by symbol W.
[6]Includes cement produced from imported clinker by domestic producers.
[7]Imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Origin of imports withheld to avoid disclosing company proprietary data.

Table 14.—Cement shipments, by regional destination[1]

Region and subregion	Portland cement: Thousand short tons		Portland cement: Percent of total		Masonry cement: Thousand short tons		Masonry cement: Percent of total	
	1979	1980	1979	1980	1979	1980	1979	1980
Northeast	9,823	8,617	11.8	11.6	431	356	11.7	11.9
New England	2,617	2,266	3.1	3.0	92	79	2.5	2.7
Middle Atlantic	7,206	6,351	8.7	8.6	339	277	9.2	9.2
South	32,530	31,956	39.0	43.0	2,265	1,946	61.4	64.8
Atlantic	13,476	13,681	16.2	18.4	1,312	1,172	35.6	39.0
East Central	4,963	4,317	5.9	5.8	480	372	13.0	12.4
West Central	14,091	13,958	16.9	18.8	473	402	12.8	13.4
North Central	21,418	16,917	25.7	22.8	890	631	24.2	21.0
East	12,933	10,183	15.5	13.7	688	481	18.7	16.0
West	8,485	6,734	10.2	9.1	202	150	5.5	5.0
West	19,586	16,859	23.5	22.6	100	70	2.7	2.3
Mountain	6,705	5,957	8.0	8.0	62	48	1.7	1.6
Pacific	12,881	10,902	15.5	14.6	38	22	1.0	.7
U.S. total	83,357	74,349	100.0	100.0	3,686	3,003	100.0	100.0

[1]Includes imported cement shipped by domestic and Canadian cement manufacturers and other importers.

Table 15.—Portland cement shipments, by type of customer[1]

(Thousand short tons)

District origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous including own use		Total[2]
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	
1979:															
New York and Maine	227	5.5	674	16.3	2,857	69.3	102	2.5	88	2.1	1	(3)	174	4.2	4,123
Pennsylvania, eastern	599	12.8	1,255	26.9	2,591	55.5	125	2.7	75	1.6	6	0.1	17	.4	4,667
Pennsylvania, western	114	6.2	292	15.9	1,231	66.9	108	5.9	69	3.7	1	(3)	26	1.4	1,841
Maryland and West Virginia	108	4.7	476	20.9	1,534	67.3	81	3.6	71	3.1	2	.1	8	.3	2,280
Ohio	142	7.4	365	19.0	1,359	70.7	37	1.9	11	.6	--	--	6	.3	1,921
Michigan	396	7.0	889	15.6	3,728	65.6	538	9.5	108	1.9	23	.4	--	--	5,683
Indiana	160	6.7	417	17.5	1,653	69.2	100	4.2	55	2.3	2	.1	2	.1	2,389
Illinois	102	5.4	192	10.2	1,460	77.3	125	6.6	9	.5	--	--	1	(3)	1,889
Tennessee	123	9.2	288	21.6	776	58.1	11	.8	38	2.8	79	5.9	19	1.4	1,335
Kentucky, North Carolina, Virginia	112	6.3	201	11.3	1,272	71.7	92	5.2	69	3.9	2	.1	28	1.6	1,775
South Carolina	51	2.8	279	15.2	1,395	76.2	41	2.2	62	3.4	1	.1	--	--	1,831
Florida	437	14.8	399	13.5	1,638	55.4	239	8.1	157	5.3	63	2.1	24	.8	2,957
Georgia	89	6.7	239	17.9	703	52.7	158	11.8	133	10.0	6	.4	7	.5	1,335
Alabama	237	9.2	528	20.5	1,666	64.6	78	3.0	52	2.0	4	.2	12	.5	2,578
Louisiana and Mississippi	255	16.3	194	12.4	779	49.9	135	8.6	51	3.3	97	6.2	52	3.3	1,563
Nebraska and Wisconsin	69	5.7	141	11.6	835	68.6	163	13.4	8	.7	2	.2	--	--	1,218
South Dakota	22	3.3	43	6.4	427	63.7	127	19.0	49	7.3	--	--	2	.3	670
Iowa	93	3.9	470	19.8	1,622	68.4	104	4.4	81	3.4	--	--	2	.1	2,371
Missouri	131	3.0	466	10.5	3,412	77.0	302	6.8	112	2.5	--	--	7	.2	4,430
Kansas	109	5.2	124	5.9	1,617	77.5	75	3.6	133	6.4	--	--	29	1.4	2,086
Oklahoma and Arkansas	195	7.2	240	8.9	1,876	69.4	209	7.7	153	5.7	10	.4	20	.7	2,702
Texas	702	7.5	788	8.4	5,928	63.4	349	3.7	1,209	12.9	113	1.2	264	2.8	9,353
Wyoming, Montana, Idaho	51	4.9	78	7.4	706	67.2	45	4.3	139	13.2	22	2.1	9	.9	1,050
Colorado, Arizona, Utah, New Mexico	220	5.5	541	13.5	2,788	69.8	79	2.0	263	6.6	2	(3)	103	2.6	3,996
Washington	47	2.7	212	12.0	1,282	72.8	53	3.0	101	5.7	1	.1	65	3.7	1,761
Oregon and Nevada	39	4.0	71	7.2	773	78.8	25	2.5	67	6.8	3	.3	3	.3	981
California, northern	271	9.4	492	17.0	1,836	63.4	31	1.1	238	8.2	1	(3)	25	.9	2,894
California, southern	540	7.9	956	14.0	4,932	72.2	126	1.8	244	3.6	7	.1	25	.4	6,830
Hawaii	24	5.1	55	11.7	327	69.7	--	--	37	7.9	1	.2	26	5.5	469
Puerto Rico	582	41.4	123	8.7	616	43.8	--	--	18	1.3	4	.3	64	4.6	1,406
Imports[4]	117	3.9	297	9.9	2,378	79.1	91	3.0	22	.7	85	2.8	15	.5	3,006
Total or average	6,364	7.6	11,785	14.1	55,997	67.2	3,749	4.5	3,922	4.7	538	.7	1,035	1.2	83,390

See footnotes at end of table.

Table 15.—Portland cement shipments, by type of customer[1] —Continued

(Thousand short tons)

District origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscel-laneous including own use		Total[2]
	Quan-tity	Per-cent	Quan-tity	Per-cent	Quan-tity	Per-cent	Quan-tity	Per-cent	Quan-tity	Per-cent	Quan-tity	Per-cent	Quan-tity	Per-cent	
1980:															
New York and Maine	183	5.2	537	15.1	2,526	71.2	78	2.2	59	1.7	1	(3)	166	4.7	3,550
Pennsylvania, eastern	514	12.6	901	22.2	2,515	61.9	61	1.5	55	1.4	7	0.1	13	.3	4,066
Pennsylvania, western	111	7.4	237	15.8	1,013	67.3	90	6.0	40	2.7	--	--	13	.9	1,504
Maryland and West Virginia	89	4.3	414	19.9	1,448	69.6	54	2.6	51	2.5	2	.1	21	1.0	2,079
Ohio	75	4.6	332	20.4	1,145	70.5	56	3.4	5	.3	--	--	12	.7	1,625
Michigan	196	4.2	710	15.3	3,398	73.1	214	4.6	131	2.8	--	--	2	(3)	4,651
Indiana	121	6.8	312	17.6	1,237	69.9	72	4.1	26	1.5	1	.1	--	--	1,769
Illinois	58	3.5	185	11.2	1,278	77.5	116	7.0	12	.7	--	--	--	--	1,649
Tennessee	106	8.1	246	18.9	814	62.4	32	2.5	33	2.5	63	4.8	10	.8	1,304
Kentucky, North Carolina, Virginia	95	6.0	169	10.6	1,148	72.3	71	4.5	78	4.9	2	.1	25	1.6	1,588
South Carolina	49	2.9	280	16.4	1,264	74.2	74	4.3	36	2.1	1	.1	--	--	1,704
Florida	511	14.3	456	12.8	2,057	57.6	288	8.1	180	5.0	65	1.8	17	.5	3,574
Georgia	94	7.6	196	15.9	571	46.4	259	21.0	96	7.8	5	.4	10	.8	1,231
Alabama	230	9.2	487	19.6	1,607	64.5	112	4.5	44	1.8	4	.2	7	.3	2,491
Louisiana and Mississippi	281	17.3	111	6.8	857	52.9	98	6.0	124	7.6	97	6.0	53	3.3	1,621
Nebraska and Wisconsin	43	5.1	92	11.0	564	67.0	123	14.6	11	1.3	1	.1	8	1.0	842
South Dakota	18	3.9	31	6.8	316	68.8	57	12.4	35	7.6	--	--	2	.4	459
Iowa	91	4.6	385	19.3	1,355	67.8	136	6.8	20	1.0	1	.1	10	.5	1,998
Missouri	84	2.4	331	9.4	2,760	78.5	234	6.7	102	2.9	1	(3)	3	.1	3,515
Kansas	91	5.0	138	7.5	1,339	73.0	70	3.8	150	8.2	2	.1	45	2.5	1,835
Oklahoma and Arkansas	186	6.8	236	8.7	1,800	66.0	100	3.7	365	13.4	5	.2	34	1.2	2,726
Texas	515	5.4	719	7.6	5,879	61.8	425	4.5	1,575	16.5	89	.9	315	3.3	9,517
Wyoming, Montana, Idaho	28	2.8	55	5.5	710	70.7	13	1.3	176	17.5	15	1.5	7	.7	1,004
Colorado, Arizona, Utah, New Mexico	209	5.7	430	11.8	2,559	70.2	86	2.4	293	8.0	3	.1	67	1.8	3,647
Washington	59	3.8	176	11.4	1,224	79.2	46	3.0	30	1.9	3	.1	8	.5	1,546
Oregon and Nevada	41	4.3	48	5.0	668	69.6	102	10.6	93	9.7	1	.1	7	.7	960
California, northern	256	10.0	405	15.8	1,616	63.2	49	1.9	207	8.1	1	(3)	22	.9	2,556
California, southern	512	8.2	829	13.3	4,385	70.3	164	2.6	268	4.3	48	.8	35	.6	6,241
Hawaii	23	6.4	51	14.2	266	74.3	--	--	13	3.6	5	1.4	--	--	358
Puerto Rico	367	24.8	121	8.2	896	60.4	--	--	25	1.7	3	.2	70	4.7	1,482
Imports[4]	24	1.5	44	2.8	1,399	88.5	3	.2	110	6.9	--	--	--	--	1,580
Total or average	5,260	7.0	9,664	12.9	50,614	67.8	3,283	4.4	4,443	6.0	426	.6	982	1.3	74,672

[1]Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.

Table 16.—Portland cement shipped from plants in the United States, by type[1]

(Thousand short tons and thousand dollars)

Type	1979			1980		
	Quantity	Value[2]	Average per ton	Quantity	Value[2]	Average per ton
General use and moderate heat (Types I and II)	76,392	3,487,564	$45.65	67,536	3,378,495	$50.03
High-early-strength (Type III)	2,712	123,172	45.42	2,488	125,705	50.52
Sulfate-resisting (Type V)	202	11,197	55.43	245	15,136	61.78
Oil well	1,922	100,935	52.52	2,513	146,766	58.40
White	400	44,125	110.31	309	43,280	140.06
Portland slag and portland pozzolan	997	46,909	47.05	839	44,426	52.95
Expansive	103	5,293	51.39	85	5,446	64.07
Miscellaneous[3]	662	37,151	56.12	659	40,671	61.72
Total or average	83,390	3,856,346	46.24	74,674	3,799,925	50.89

[1]Includes Puerto Rico.
[2]Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.
[3]Includes waterproof cement and low-heat (Type IV).

Table 17.—Average mill value in bulk, of cement in the United States[1]

(Per short ton)

Year	Portland cement	Prepared masonry cement[2]	All classes of cement
1976	$33.86	$42.63	$34.25
1977	36.36	45.03	36.76
1978	40.70	50.53	41.17
1979	46.24	54.59	46.61
1980	50.89	62.11	51.32

[1]Includes Puerto Rico.
[2]Masonry cement made at cement plants only.

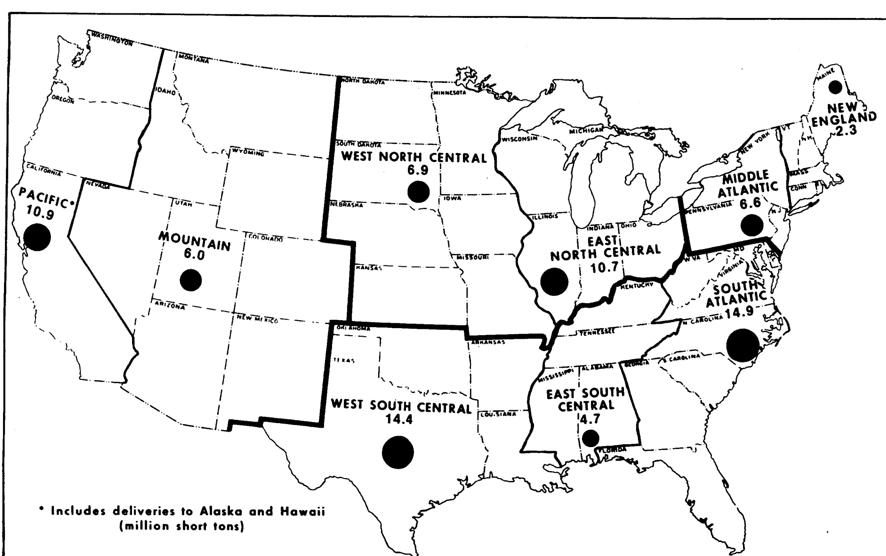

Figure 1.—Shipments of cement by geographic region of destination in 1980.

FOREIGN TRADE

The quantity of cement exported, in 1980, was 0.24% of domestic shipments from mills compared with 0.17% in 1979. In 1980, the United States exported 123,000 tons of cement to Canada and 55,000 tons to Mexico. Shipments to these two countries accounted for 95% of cement exports. Total exports, to 57 countries, were 186,000 tons valued at nearly $17.0 million.

Hydraulic cement and clinker imports decreased 40% to 5.7 million tons valued at $302 million; of this 37% by weight was clinker compared with 50% in 1979. Canada supplied 50% of U.S. imported cement and clinker in 1980 followed by Japan, 12%; Spain, 9%; Mexico, 6%; Bahamas, 6%; and France, 5%. U.S. net import reliance equaled 7% of apparent consumption.

Imports of white nonstaining portland cement increased 41% to 114,000 tons and has almost tripled since 1978. Canada and Spain together accounted for 87% of this tonnage. Exports of white cement from Canada more than doubled.

Table 18.—U.S. exports of hydraulic cement, by country

Country	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Bahamas	2,155	$113	15,904	$351	1,073	$180
Canada	35,207	4,400	88,965	8,034	123,282	9,571
Leeward and Windward Islands	2,581	105	533	32	603	53
Mexico	8,985	2,301	38,785	4,334	54,658	4,927
Netherlands Antilles	26	6	1,252	100	23	2
Peru	1,440	156	2	1	22	9
Trinidad and Tobago	1,858	131	997	81	1,403	165
Other	5,565	1,738	4,408	1,639	5,340	2,090
Total	57,817	8,950	150,846	14,572	186,404	16,997

Table 19.—U.S. imports for consumption of hydraulic cement and clinker, by country

(Thousand short tons and thousand dollars)

Country	1978			1979			1980		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Bahamas	307	9,970	11,090	487	19,929	22,728	298	12,108	13,279
Canada	3,024	85,499	98,608	4,440	137,975	151,247	2,635	90,597	100,330
France	317	9,324	10,518	405	14,425	16,052	251	13,699	14,274
Japan	1,038	28,791	36,207	1,523	52,605	57,822	619	20,822	25,757
Mexico	817	26,973	30,054	525	19,531	22,471	329	13,841	15,924
Norway	208	4,466	5,862	281	7,182	9,760	225	6,193	8,463
Spain	434	12,020	14,831	548	r16,144	21,344	479	22,458	28,461
Sweden	--	--	--	--	--	--	94	3,942	4,222
United Kingdom	302	8,782	11,253	759	26,249	31,636	202	6,797	10,382
Other	150	4,817	6,728	445	8,318	18,104	131	5,116	6,914
Total	6,597	r190,642	225,151	r9,413	r302,358	351,164	5,263	195,573	228,006

rRevised.
[1]C.i.f. cost, insurance, and freight.

Table 20.—U.S. imports for consumption of clinker, by country

(Thousand short tons and thousand dollars)

Country	1978			1979			1980		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Australia	1	69	133	160	3,670	5,430	--	--	--
Canada	1,113	22,827	25,480	1,887	50,531	54,684	800	25,787	27,998
France	314	9,092	10,195	385	13,931	15,262	249	13,554	14,114
Japan	980	25,945	32,973	1,384	40,849	49,594	506	16,797	20,838

See footnotes at end of table.

Table 20.—U.S. imports for consumption of clinker, by country —Continued

(Thousand short tons and thousand dollars)

Country	1978			1979			1980		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Peru	--	--	--	105	2,866	3,631	--	--	--
Spain	324	6,733	8,664	398	9,980	12,159	298	16,270	18,629
United Kingdom	153	3,175	4,348	341	9,911	11,721	--	--	--
Other	83	1,423	1,960	[r]8	135	186	64	1,523	2,163
Total	2,968	69,264	83,753	[r]4,668	131,873	152,667	1,917	73,931	83,742

[r]Revised.
[1]C.i.f. cost, insurance, and freight.

Table 21.—U.S imports for consumption of hydraulic cement and clinker by customs district and country

(Thousand short tons and thousand dollars)

Customs district and country	1979			1980		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Anchorage:						
Canada	20	1,014	1,045	19	1,377	1,498
Japan	(2)	3	4	--	--	--
Total	20	1,017	1,049	19	1,377	1,498
Boston: Canada	(2)	1	1	--	--	--
Buffalo: Canada	765	19,840	23,639	604	17,973	20,783
Chicago:						
Canada	273	7,819	8,451	53	1,842	1,842
Spain	82	1,605	1,851	--	--	--
Total	355	9,424	10,302	53	1,842	1,842
Cleveland:						
Canada	257	8,808	9,744	99	3,097	3,506
Germany, Federal Republic of	(2)	9	13	--	--	--
United Kingdom	(2)	3	6	--	--	--
Total	257	8,820	9,763	99	3,097	3,506
Detroit: Canada	1,186	32,845	34,946	603	18,565	20,135
Duluth:						
Canada	194	6,247	7,095	28	951	1,078
France	20	481	769	--	--	--
United Kingdom	20	485	775	--	--	--
Total	234	7,213	8,639	28	951	1,078
El Paso:						
Canada	(2)	7	8	--	--	--
Mexico	39	2,188	2,189	11	587	586
Sweden	(2)	1	1	--	--	--
Total	39	2,196	2,198	11	587	586
Galveston:						
Mexico	44	1,396	1,712	93	3,391	4,276
Peru	79	2,273	2,762	--	--	--
Spain	69	1,935	2,314	37	1,064	1,283
Total	192	5,604	6,788	130	4,455	5,559
Great Falls: Canada	10	620	738	1	347	414

See footnotes at end of table.

Table 21.—U.S imports for consumption of hydraulic cement and clinker by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1979 Quantity	1979 Value Customs	1979 Value C.i.f.[1]	1980 Quantity	1980 Value Customs	1980 Value C.i.f.[1]
Honolulu:						
Canada	--	--	--	6	250	346
Japan	--	--	--	17	668	755
Total	--	--	--	23	918	1,101
Houston:						
Canada	--	--	--	(2)	4	5
France	--	--	--	(2)	64	66
Mexico	54	1,464	1,732	--	--	--
Spain	28	847	953	176	12,994	14,460
United Kingdom	321	9,462	10,991	(2)	59	68
Total	403	11,773	13,676	176	13,121	14,599
Laredo:						
Canada	2	79	79	--	--	--
Mexico	94	4,463	4,458	100	5,177	5,178
Total	96	4,542	r4,537	100	5,177	5,178
Los Angeles:						
Australia	52	1,356	2,145	--	--	--
Canada	383	12,791	13,791	64	3,592	3,896
Colombia	--	--	--	35	956	1,291
France	36	788	1,198	--	--	--
Germany, Federal Republic of	(2)	38	42	(2)	11	11
Japan	501	15,121	17,628	273	8,497	10,608
Peru	26	991	1,004	--	--	--
Spain	1	140	255	(2)	53	101
Yugoslavia	1	87	169	(2)	55	130
Total	1,000	31,312	36,232	372	13,164	16,037
Miami:						
Bahamas	303	12,393	13,706	255	10,304	11,219
Belgium-Luxembourg	5	372	484	3	219	303
Colombia	31	1,013	1,242	54	1,839	2,535
Denmark	--	--	--	24	944	1,041
France	--	--	--	1	66	69
Mexico	79	3,480	4,055	113	3,799	4,851
Norway	45	1,041	1,457	24	941	942
Spain	65	1,841	2,674	122	3,422	4,879
Total	528	20,140	23,618	596	21,534	25,839
Milwaukee:						
Canada	119	3,853	4,408	60	1,953	2,256
United Kingdom	(2)	2	4	--	--	--
Total	119	3,855	4,412	60	1,953	2,256
New Orleans:						
Bahamas	93	3,868	4,900	--	--	--
Canada	--	--	--	25	802	1,221
Germany, Federal Republic of	--	--	--	(2)	23	30
Greece	11	286	410	--	--	--
Mexico	61	1,829	2,086	--	--	--
Peru	26	594	869	--	--	--
Spain	118	3,382	4,419	28	762	940
United Kingdom	241	6,745	9,141	93	3,024	4,219
Total	550	16,704	21,825	146	4,611	6,410
New York City:						
Italy	--	--	--	(2)	(2)	(2)
Norway	185	4,779	6,489	175	4,586	6,578
Sweden	24	569	714	--	--	--
Total	209	5,348	7,203	175	4,586	6,578
Nogales: Mexico	2	139	139	(2)	42	42

See footnotes at end of table.

Table 21.—U.S imports for consumption of hydraulic cement and clinker by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1979			1980		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Norfolk:						
Germany, Federal Republic of	--	--	--	(2)	1	1
France	58	4,735	5,032	44	4,427	4,559
United Kingdom	--	--	--	(2)	2	2
Total	58	4,735	5,032	44	4,430	4,562
Ogdensburg: Canada	79	1,991	2,186	140	4,129	4,495
Pembina: Canada	228	9,720	10,778	92	4,184	4,711
Philadelphia:						
Canada	(2)	3	2	--	--	--
Germany, Federal Republic of	--	--	--	(2)	7	9
Yugoslavia	1	41	67	--	--	--
Total	1	44	69	(2)	7	9
Port Arthur:						
Mexico	40	752	1,343	--	--	--
Spain	97	2,398	2,935	30	743	990
Total	137	3,150	4,278	30	743	990
Portland, Maine: Canada	22	630	630	14	393	395
Portland, Oreg.:						
Canada	27	1,014	1,102	12	477	503
Japan	131	4,043	5,392	24	803	842
Mexico	15	308	339	--	--	--
Total	173	5,365	6,833	36	1,280	1,345
St. Albans:						
Canada	205	5,795	4,898	275	8,164	7,933
South Africa, Republic of	(2)	5	6	(2)	(2)	1
Yeman Arab Republic	--	--	--	(2)	1	1
Total	205	5,800	4,904	275	8,165	7,935
San Diego:						
Japan	33	882	1,011	--	--	--
Mexico	14	831	831	2	191	191
Panama	24	1,087	1,492	--	--	--
Peru	8	275	421	--	--	--
United Kingdom	55	3,789	4,741	109	3,712	6,093
Total	134	6,864	8,496	111	3,903	6,284
San Francisco:						
Australia	117	2,719	4,050	1	67	113
Canada	150	6,151	7,548	50	2,055	2,588
Japan	318	9,413	12,462	172	6,820	8,503
Mexico	23	716	1,130	--	--	--
Total	608	18,999	25,190	223	8,942	11,204
San Juan:						
Belgium-Luxembourg	7	470	733	10	822	1,234
Colombia	4	237	293	2	147	178
Dominican Republic	(2)	2	4	--	--	--
France	(2)	4	7	(2)	9	15
Italy	(2)	3	6	--	--	--
Japan	(2)	3	4	--	--	--
Spain	9	772	1,428	7	639	1,309
Total	20	1,491	2,475	19	1,617	2,736

See footnotes at end of table.

Table 21.—U.S imports for consumption of hydraulic cement and clinker by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1979			1980		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Seattle:						
Canada	358	13,345	14,466	265	11,646	12,571
Italy	--	--	--	(2)	(2)	(2)
Japan	539	17,925	21,320	131	4,030	5,044
Mexico	19	658	709	(2)	464	532
United Kingdom	(2)	5	11	--	--	--
Total	916	31,933	36,506	396	16,140	18,147
Tampa:						
Bahamas	90	3,668	4,122	44	1,804	2,060
Belgium-Luxembourg	1	96	116	--	--	--
Canada	162	5,404	5,690	225	8,797	10,156
France	292	8,417	9,047	206	9,133	9,565
French West Indies	7	133	184	--	--	--
Mexico	42	1,307	1,748	10	191	268
Norway	51	1,363	1,814	25	666	943
Spain	73	3,075	4,316	78	2,780	4,499
Sweden	22	856	856	94	3,942	4,223
United Kingdom	122	5,759	5,967	--	--	--
Total	862	30,078	33,860	682	27,313	31,714
Savannah:						
Denmark	(2)	7	9	--	--	--
Spain	4	149	198	--	--	--
Total	4	156	207	--	--	--
Baltimore:						
Japan	--	--	--	(2)	5	5
New Zealand	(2)	2	4	--	--	--
Yugoslavia	(2)	7	11	(2)	18	27
Total	(2)	9	15	(2)	23	32
Grand total[3]	9,413	r302,358	351,164	5,263	195,573	228,006

rRevised.
[1]C.i.f. cost, insurance, and freight.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 22.—U.S. imports for the consumption of cement

(Thousand short tons and thousand dollars)

Year	Roman, portland, other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1976	2,122	46,635	962	19,136	23	1,314	3,107	67,085
1977	2,394	62,920	1,613	29,224	31	1,861	4,038	94,005
1978	3,589	119,048	2,968	69,264	40	2,330	6,597	190,642
1979	4,664	165,258	4,668	131,873	81	5,227	9,413	302,358
1980	3,232	115,271	1,917	73,931	114	6,371	5,263	195,573

WORLD REVIEW

During 1980, world cement production increased 1% to 978 million short tons. The world cement industry in 1980 continued to strive to achieve self-sufficiency, overcome shortages, reduce energy consumption, control prices, and find solutions to national uncertainties. European manufacturers hoped for a lessening of government involvement and some considered investing outside the continent to effectively increase productivity and reduce energy cost. Expansion of cement capacity continued in the Middle East causing countries with excess capacity such as Japan and Spain to look elsewhere for markets.

Argentina.—Corporacion Cementera Argentina S.A. brought into production a 2,200-ton-per-day cement production line at Capdeville, in 1980. A 1,760-ton-per-day plant was brought onstream by Juan Minetti S.A. at Cordoba. Calera Avellaneda S.A., Buenos Aires, modified its Olivaria cement plant, increasing production from 1,100 tons to 1,650 tons per day. Cementos Noa S.A. ordered a 1,980-ton-per-day cement plant to be built at Juramento.

Canada.—Canadian cement shipments increased 11% in 1979 to 13 million tons. Domestic markets, especially in Alberta, were strong. Exports of cement and clinker to the United States established new records.

In 1980, Canada Cement Lafarge Ltd. expanded its Exshaw, Alberta, plant by 600,000 tons per year. Ciment Quebec, Inc., replaced the wet-process plant at St. Basile de Portneuf, Quebec, with a Fuller SF 2,000-ton-per-day system. The plant was scheduled to come onstream in 1981. Inland Cement Industries Ltd. at Edmonton, Alberta, was expected to resume production in 1980, after expansion including a four-stage preheater, a flash calciner, a rotary kiln, a clinker cooler, and a blender and conveyor system. St. Lawrence Cement Co., Mississauga, Ontario, expanded its plant to increase its production capacity to 5,000 tons per day.

Ecuador.—La Cemento Nacional C.E.M. was expanding its Cerro Blanco plant to 1,650 tons per day. Empresa Cementos Selvalegre S.A. began operating its new 380,000-ton-per-year plant in the Andes.

France.—Ciments Lafarge France in Lamalle ordered one Polysius roller mill fueled by coal and with a design capacity of 34 tons per hour.

Germany, Federal Republic of.—Dyckerhoff Zementwerke AG modified its Fortuna plant's preheater system, and designed the preheater to use either fuel oil or pulverized coal. The Portland-Zementwerke Heidelberg AG ordered a coal fueled Polysius roller. Breisgauer Portland Zementwerke ordered a coal fueled Polysius roller with a coal transport system and a Poldos kiln feed system.

Hong Kong.—Kaiser Cement Corp., in partnership with local interests, planned to construct and operate a $245 million, 5,000-ton-per-day cement plant in Hong Kong.

India.—Patna Cement Ltd. expanded its plant, adding a 2,700-ton-per-day dry-process line. Narmada Cement Co.'s 1.1-million-ton-per-year plant at Jafarabad was scheduled to start production early in 1981. A contract to supply the main equipment for Mysore Cements Ltd. 1,650-ton-per-day dry-process plant was awarded.

Iraq.—Iraq was to receive electrostatic precipitators, dust-conveying equipment, and a nodulizing plant for its 2.2-million-ton-per-year Kufa plant. Iraq's States Organization of Industrial Design and Construction awarded a $125 million contract to Kawasaki Heavy Industries Ltd. and the Marubeni Corp. to build a 1.1-million-ton-per-year plant at Hit, 90 kilometers west of Baghdad. Kawasaki also was to build a 1.1-million-ton-per-year plant at Al Tamin.

Ireland.—The Cement-Roadstone Holdings Ltd. plans to add 700,000 tons per year capacity to its Limerick cement plant.

Jordan.—Kaiser Engineers, Inc., was to manage the construction of a $100 million plant to be built at Rashidiya in southern Jordan. Basse Sambre ERI signed a $1.2 million contract to supervise the construction of a 110,000-ton-per-year white cement facility near Amman. Jordan Cement Factories Co. Ltd. was to build a 1.1-million-ton-per-year cement plant at the Fuhais works, 25 kilometers northwest of Amman.

Korea, Republic of.—Ssang Yong Cement Industrial Co., Ltd.'s 6-million-ton-per-year program at its Dong Hae plant was completed in 1980. The Union Corp. of Seoul was building a 330-ton-per-day white cement plant 200 kilometers from Seoul.

Malaysia.—Associated Pan Malaysia Cement Sdn. Bhd. expanded its plant at Rawang with the installation of a 1.3-million-ton-per-year dry-process kiln.

Morocco.—Ste. des Ciments Francais was awarded a contract for the construction of a new 1.1-million-ton-per-year cement plant at Casablanca Sud.

Poland.—New large dry-process plants were brought online at Stzelce Opolski, Gorazdze, and Ozarow.

Saudi Arabia.—The Qassim Cement Corp. plant near Buraydah went into production. The $120 million facility had a capacity of 2,200 tons per day. A new 3,300-ton-per-day plant near Ra's Baridi on the Red Sea went into production in 1980.

Spain.—Hornos Ibericosis S.A. built a new 3,300-ton-per-day plant near Carboneras, on the Mediterranean coast. Cementos Portland S.A. had a project to convert facilities at Olazagutia to the Fuller SF process. The Arrigoriaga works of Cementos Rezola S.A. and the Lemona works of S.A. de Cemento Portland de Lemona contracted a study to plan a lump-coal firing preheater system. Cia. Valencia de Cementos Portland S.A. in Alicante ordered two Polysius roller mills. Cia. Valencia in Bunol ordered two Polysius roller mills, including storage, proportioning, and a transport system.

Syria.—The Tartous cement plant added two 1,760-ton-per-day dry-process lines to its Tartous facility, with plans to add two more. A cement plant at Sheikh Said was to begin production from its second 1,650-ton-per-day dry-process line. A dry-process cement plant at Musulmiye was to add two new 1,760-ton-per-day kilns with shaft-type preheaters. The Adra cement plant was being expanded to include an additional 1,100-ton-per-day line.

Thailand.—Siam City Cement Co., Ltd., was adding a new production line to its Tabwang Saraburi plant near Bangkok. A contract was awarded to add a 4,400-ton-per-day production line to the Ta-Luang plant.

Togo.—Société Des Ciments De L'Africa De l'Ouest added two new Polysius precalciner kilns to its plant at Tabligbo. The plant started operations in 1980.

Trinidad and Tobago.—Trinidad, Tobago, and Barbados planned to begin construction of a 306,000-ton-per-year plant in January 1981, in St. Lucy, Barbados.

Tunisia.—A 1.1-million-ton-per-year plant was to be built near Enfida. Société des Cimento Tunisiens planned to build a 1.1-million-ton-per-year plant at Djebel Ouest near Tunis.

United Arab Emirates.—Gulf Cement Co., a joint enterprise of Emirates and Kuwait interest, was completing work on a 1.1-million-ton-per-year plant at Ras al Khaymah. A $100 million contract was awarded to Voest-Alpine AG for a new 570,000-ton-per-year dry-process plant, to become operational in 1983. Union Cement Co. Ltd.'s plant expansion 20 kilometers north of Ras al Khaymah doubled the plant's capacity to 550,000 tons per year. A new plant at Al-Ain, Abu Dhabi, was to go into production in 1981.

United Kingdom.—Deliveries in the United Kingdom fell 8% to 16.3 million tons. Most of the reduction occurred during the second half of the year. Blue Circle Industries Ltd. reduced production in 1980 by closing two plants and three kilns. Rugby Portland Cement Co. Ltd.'s plant, in Rochester, converted from wet to dry process and installed a Polysius, 2,400-ton-per-day grate preheater. Ribblesdale Cement Ltd. was to expand its cement plant near Clitheroe, Lancashire, to a 2,500-ton-per-day dry-process production.

Venezuela.—Cementos Catatumbo C.A. began production at its new cement plant in the State of Zulia, in July 1980. The plant had a rated capacity of almost 2,000 tons per day and was designed with a four-stage preheater kiln equipped with a precalciner.

Yugoslavia.—Fabrika Cementa "Novi Popovac" was expanding the Popovac plant by a 2,200-ton-per-day production line.

Table 23.—Hydraulic cement: World production, by country[1]

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Bahamas	299	[r]77	364	496	600
Canada	10,609	[r]10,626	11,638	12,969	[2]11,571
Costa Rica	399	447	469	483	485
Cuba	2,757	[r]2,928	2,989	2,879	3,065
Dominican Republic	721	[r]950	956	977	990
El Salvador	[r]355	[r]413	573	652	606
Guatemala	[r]491	541	568	632	635
Haiti	[r]271	[r]267	274	[e]300	300
Honduras	[r]280	[r]276	298	685	700
Jamaica	403	367	324	249	275
Mexico	13,871	14,580	15,494	16,731	17,640
Nicaragua	[r]249	[r]249	219	375	385
Panama	[r]312	[r]298	331	514	550
Trinidad and Tobago	[r]262	[r]237	243	238	220
United States (including Puerto Rico)	74,495	80,058	85,480	85,904	76,709
South America:					
Argentina	6,296	6,425	6,783	7,388	[2]7,780
Bolivia	243	[r]294	280	277	287
Brazil	21,105	21,123	24,361	27,425	29,200
Chile	[r]1,061	[r]1,237	1,300	1,491	1,433
Colombia	3,982	3,635	4,578	4,693	4,780
Ecuador	[r]670	[r]687	919	1,211	1,540
Paraguay	171	220	183	177	220
Peru	2,167	2,172	2,226	2,756	3,300
Suriname	[e]55	[r]49	66	68	60
Uruguay	745	[r]772	743	757	760
Venezuela	3,900	3,457	3,777	4,386	[2]4,519
Europe:					
Albania[e]	772	827	992	1,100	1,100
Austria	6,482	6,606	6,322	6,243	6,350
Belgium	8,272	8,558	8,351	8,491	8,500
Bulgaria	4,808	5,142	5,676	5,954	[2]5,907
Czechoslovakia	10,529	10,746	11,248	11,307	[2]11,624
Denmark	2,596	2,545	2,895	2,635	2,200
Finland	2,012	1,887	1,878	1,928	[2]1,984
France	32,401	31,779	30,892	31,774	[2]32,082
German Democratic Republic	[r]12,504	[r]13,340	13,802	13,529	[2]13,717
Germany, Federal Republic of	[r]39,041	[r]36,826	38,958	40,825	39,460
Greece	9,640	11,667	12,434	13,336	14,440
Hungary	4,738	5,093	5,251	5,356	[2]5,132
Iceland	160	153	147	139	140
Ireland	1,730	[r]1,742	1,991	2,281	2,425
Italy	40,044	41,580	41,621	44,247	47,206
Luxembourg	330	[r]321	343	351	342
Netherlands	3,837	[r]4,293	4,319	4,080	3,540
Norway	[r]2,961	[r]2,551	3,460	2,422	[2]2,307
Poland	21,826	23,479	23,920	21,138	[2]20,330
Portugal	4,093	4,736	5,732	5,664	6,130
Romania	14,427	15,295	16,191	17,194	17,200
Spain (including Canary Islands)	27,780	[3]30,859	[3]33,326	[3]30,768	[3]31,370
Sweden	3,163	2,794	2,588	[e]2,579	[2]2,687
Switzerland	3,909	4,022	4,075	4,336	4,300
U.S.S.R	[r]136,958	[r]140,048	139,945	135,605	138,000
United Kingdom	17,394	17,037	17,544	17,791	[2]16,323
Yugoslavia	8,400	8,826	9,588	10,010	[2]10,268
Africa:					
Algeria	1,543	1,959	2,973	[e]4,000	4,400
Angola[e]	[r]329	330	440	440	440
Cameroon	[r]329	400	[e]390	540	550
Cape Verde Islands[e]	4	4	17	17	17
Egypt	3,706	3,590	3,307	3,294	3,300
Ethiopia	164	80	95	102	105
Gabon	118	[r]209	[e]210	106	110
Ghana	[e]720	672	551	236	240
Kenya	[r]1,088	[r]1,262	1,240	1,036	1,400
Liberia	[e]110	[e]110	146	[e]160	155
Libya	1,653	2,756	3,527	3,000	3,100
Madagascar	82	[r]58	73	[e]80	80
Malawi	94	104	103	114	110
Mali	[e]55	[r]39	38	29	29
Morocco	[r]2,562	3,164	3,107	3,400	3,750
Mozambique	239	356	[e]360	301	305
Niger	[r]40	44	[e]45	42	43
Nigeria	1,404	1,587	1,693	[r] [e]2,300	2,750
Senegal	425	364	396	420	420
South Africa, Republic of	7,769	7,245	7,522	7,600	7,700
Sudan	143	151	[e]188	203	200

See footnotes at end of table.

Table 23.—Hydraulic cement: World production, by country[1] —Continued

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Africa —Continued					
Tanzania	266	287	255	309	374
Tunisia	[r]527	631	972	1,527	1,575
Uganda	96	[e]90	[e]90	[e]55	NA
Zaire	720	539	520	[e]500	440
Zambia	[e]424	[e]440	136	175	220
Zimbabwe	595	542	450	437	516
Asia:					
Afghanistan[4]	[e]184	150	[e]140	155	55
Bangladesh	173	338	375	327	385
Burma	257	[r]297	280	428	[2]244
China:					
Mainland	[r]54,343	[r]61,343	71,914	[1]81,461	[2]89,728
Taiwan	[r]9,653	[r]11,392	12,633	13,115	[2]15,501
Cyprus	1,130	[r]1,181	1,220	1,251	1,360
Hong Kong	843	1,134	1,365	1,501	1,545
India	[r]20,609	[r]21,138	21,641	20,133	19,300
Indonesia	[r]1,989	2,952	4,022	4,885	6,479
Iran	[r]6,724	7,998	13,227	[e]9,900	9,900
Iraq	3,007	3,494	[e]5,070	[e]5,620	5,800
Israel	2,204	[r]2,165	2,200	2,116	2,200
Japan	75,742	[r]80,621	93,551	96,787	[2]97,144
Jordan	588	624	622	688	1,000
Kampuchea[e]	55	55	11	--	--
Korea, North	7,700	7,700	7,700	8,800	8,800
Korea, Republic of	13,087	15,648	16,681	18,092	[2]17,230
Kuwait	[r]365	363	685	[r e]695	690
Lebanon	[e]1,878	1,499	1,522	2,239	2,425
Malaysia	1,917	1,959	2,421	2,497	2,755
Mongolia	[r]180	[r]100	183	138	138
Nepal	33	46	40	24	20
Pakistan	3,459	3,489	3,420	3,768	3,750
Philippines[5]	[r]4,957	[r]4,931	5,100	6,519	6,800
Qatar	190	185	229	406	440
Saudi Arabia	1,217	1,397	1,984	[e]2,400	3,860
Singapore[e]	1,490	1,490	1,490	1,490	1,490
Sri Lanka	470	392	634	653	660
Syria	1,224	[r]1,538	1,582	2,036	2,200
Thailand	4,916	[r]5,633	5,614	5,793	5,840
Turkey	[r]13,605	15,248	16,677	15,199	15,650
United Arab Emirates	220	220	220	220	220
Vietnam[e]	815	[r]930	929	804	935
Yemen	[e]66	66	69	55	65
Oceania:					
Australia	5,580	[r]5,536	5,504	5,779	[2]6,058
Fiji Islands	76	85	90	106	110
New Caledonia	60	[r]56	61	66	66
New Zealand	[r]1,101	[r]1,003	880	833	780
Total	[r]834,288	[r]876,546	939,755	963,198	977,626

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 24, 1981.
[2]Reported figure.
[3]Excludes natural cement.
[4]Year beginning Mar. 21 of that stated.
[5]Converted from officially reported data provided in terms of bags of cement. Conversion factor used assumes the bags reported are bags of 94 pounds, but this may be in error for at least a part of the total.

TECHNOLOGY

Cement Manufacture.—Research and development programs in the past decade have been directed toward improving energy efficiency in the manufacture of cement and developing more efficient uses of cement in concrete products and structures.

The National Materials Advisory Board's (National Research Council) Committee on the Status of Cement and Concrete Research and Development in the United States published a report in 1980 which concluded that the U.S. cement and concrete research and development establishment had substantially deteriorated in comparison with its status 20 years ago, and there is little likelihood that this level will be sufficient to anticipate and meet future challenges and changed needs 15 to 20 years ahead.

The manufacture of low-alkali cement from high-alkali raw materials has primarily been confined to the wet or the semiwet process of manufacture and to the use of raw materials suitable for making pellets of sufficient strength. The process was, in most cases, characterized by a very high water demand. Now it can be done by separate precalcining of the raw meal outside the kiln as a purely dry process of cement manufacture. Because of this, all the kiln waste gases can be discharged without necessitating an overall heat consumption of more than 850 to 900 kilocalories per kilogram of clinker. In this way, a minimum alkali content is achieved in the clinker solely by the volatization of the alkali compounds. In addition, raw materials with a high content of sulfur and chloride can be used, and the system can be fired with fuels with a high sulfur content without causing problems in the plant operation.

Recent improvements in concrete production methods include self-contained units for continuous volumetric mixing of concrete; modification of mixing and batching procedures to permit successful incorporation of glass or steel fibers, or of superplasticizers; methods of production of polymer-impregnated concrete to meet special needs for chemical resistance; production of extruded hollow-core panels for floor and wall systems; construction methods for segmental cantilevered box-girder bridges; and special methods for the construction of massive fixed and floating marine storage units.

Widespread development of computer techniques has recently influenced the concrete area, and the development of mathematical models to describe nonlinear triaxial deformation, failure envelopes, creep, and certain moisture and thermal effects have been pursued with some success. Strength concepts have been placed on a statistical basis, and statistical quality control methods have been applied in monitoring concrete production. All of these developments have resulted in significant reductions in the safety factors used in designing concrete structures.

During the past few years, a start has been made toward producing "manufactured" concrete in semi-industrial environments with high production rates and relatively close dimensional tolerances. Intensive vibration and relatively short mixing cycles have been frequently used. Better methods of monitoring the concrete during the processing and early post placement states have been applied.

A variety of cements, based loosely on portland cement, include regulated-set cements, shrinkage-compensating and expansive cements, and some very high early strength cements.

New admixtures, particularly superplasticizers or high-range water reducers, have also been developed in recent years. Most of the products were developed in Europe and Japan and are still being imported into the United States. High-range water reducers are organic admixtures that disperse the cement and drastically reduce the water content needed for mixing and placing concrete. Their use permits stronger and more durable concrete to be made or ordinary concrete to be made with less trouble and expense in placing and consolidation.

Concretes and other composites with various unusual features for special applications have been developed in recent years. A good illustration is shrinkage-compensated concrete used in water impoundment structures, parking garages, and a few large building complexes where crack avoidance was recognized as a primary objective by the designer. Applications have been developed for ferrocement, mortars heavily reinforced with steel wire mesh sheets, especially in small ships and boats.

The major development in structural concrete in recent years has been prestressed concrete. The initial impetus was the postwar shortage and high cost of construction steel in Europe in the 1940's, and European investigators were early leaders. The U.S. concrete industry kept pace in prestressed concrete in some areas, notably prefabricated, prestressed units, and pioneered in others. Nevertheless, the United States has lagged in important areas, particularly in the use of post-tensioned concrete for large structures, and specifically in the cantilevered segmental box-girder bridge. In the early 1970's, changed economic factors led to further rapid progress in the United States, even in areas that previously had been neglected.

A development that originated in Europe and was later applied and refined in the United States is the design and construction of prestressed concrete nuclear reactor vessels. Other recent achievements include very tall concrete buildings (more than 70 stories) using high-strength concrete for columns and, largely in Europe, ocean oil-storage tanks made of concrete. Considerable development has occurred in hyperbolic paraboloid cooling towers, and in lightweight concrete large-span bridges, but unanswered questions remain in both areas. The use of prestressed concrete for piles in ocean ports has now become widespread. Prestressed concrete piling is now used for substantially all structures on the west and gulf coasts of the United States, and its use is spreading to Asia and the Middle East.

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[1]Supervisory physical scientist, Section of Nonmetallic Minerals.
[2]Physical scientist, Section of Nonmetallic Minerals.
[3]Using a preliminary (June 1981) figure of 10.7% increase in 1980 of the U.S. Department of Commerce's Composite Construction Cost Index.

Chromium

By Edward C. Peterson[1]

Domestic consumption of chromium in 1980 fell to its lowest level since 1977, after reaching a near record high in 1979. After a strong showing during the first quarter of the year, consumption of chromium declined sharply owing mainly to the reduced demand for chromium in the steel industry. The chromium market continued weak for the remainder of the year. Despite reduced demands, imports of chromium materials continued strong. Both chromite and ferrochromium prices remained at about 1979 levels as ample supplies and a weak market put pressure on prices.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1976	1977	1978	1979	1980
United States:					
Exports	124	187	23	27	6
Reexports	85	61	29	28	44
Imports for consumption	1,275	1,293	1,013	1,024	982
Consumption	1,006	1,000	1,010	1,209	968
Stocks, Dec. 31: Consumer	1,009	1,338	1,301	907	675
World: Production	r9,362	r10,163	r9,963	r10,511	10,725

rRevised.

Legislation and Government Programs.—In December, the Superfund Act of 1980 was signed into law. Under the new law, which will take effect April 1, 1981, producers and importers of 42 metals and minerals designated as "taxable chemicals" are liable for Federal taxes. These taxes will fund 88% of a 5-year, $1.6 billion "Superfund" to pay for hazardous waste cleanup facilities throughout the United States. The Environmental Protection Agency will be the lead agency in administering the act, but the Internal Revenue Service will be responsible for collection of the tax. The tax on chromite was set at $1.52 per short ton.

Table 2.—Stockpile goals and Government inventories as of December 31

(Thousand short tons)

Material	Stockpile goals	Inventory	
		Stockpile-grade	Nonstockpile-grade
Chromite, metallurgical	3,200	1,957	531
Chromite, chemical	675	242	--
Chromite, refractory	850	391	--
High-carbon ferrochromium	185	402	1
Low-carbon ferrochromium	75	300	19
Ferrochromium-silicon	90	57	1
Chromium metal	20	4	--

New stockpile goals for chromium materials, established in May by the Federal Emergency Management Agency, are shown in table 2. There were no stockpile acquisitions or disposals of chromium materials in 1980.

DOMESTIC PRODUCTION

Although there was no domestic mine production of chromite in 1980, the United States continued to be a major chromite consumer in producing chromium alloys, refractories, and chemicals. The principal producers of these products were as follows:

Company	Plant
Metallurgical industry:	
Chromasco, Ltd	Woodstock, Tenn.
Foote Mineral Co	Keokuk, Iowa, and Graham, W. Va.
Interlake, Inc	Beverly, Ohio.
Macalloy, Inc	Charleston, S.C.
Satralloy Corp	Steubenville, Ohio.
Shieldalloy Corp., Div. of Metallurg, Inc	Newfield, N.J.
SKW	Calvert City, Ky., and Niagara Falls, N.Y.
Union Carbide Corp	Niagara Falls, N.Y., Marietta, Ohio, Alloy, W. Va.
Refractory industry:	
Basic, Inc	Maple Grove, Ohio.
Corhart Refractories Co., Inc	Pascagoula, Miss.
Davis Refractories, Inc	Jackson, Ohio.
General Refractories Co	Baltimore, Md., and Lehi, Utah.
Harbison-Walker Refractories	Hammond, Ind., and Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif., and Columbiana, Ohio.
North American Refractories, Co., Ltd	Womelsdorf, Pa.
Chemical industry:	
Allied Chemical Corp	Baltimore, Md.
American Chrome & Chemical, Inc	Corpus Christi, Tex.
Diamond Shamrock Corp	Castle Haynes, N.C.

Table 3.—Production, shipments, and stocks of chromium ferroalloys and chromium metal

(Short tons)

Year and alloy	Production		Shipments	Producer stocks, Dec. 31
	Gross weight	Chromium content		
1979:				
Low-carbon ferrochromium	34,034	23,304	35,991	4,272
High-carbon ferrochromium	212,935	131,222	193,657	35,934
Ferrochromium-silicon	25,898	9,292	36,009	3,265
Other[1]	21,745	13,214	22,568	5,463
Total	294,612	177,032	288,225	48,934
1980:				
Low-carbon ferrochromium, High-carbon ferrochromium	184,408	115,380	185,480	31,510
Ferrochromium-silicon, Other[1]	54,207	26,935	51,987	12,410
Total	238,615	142,315	237,467	43,920

[1]Includes chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Reduced demand for ferrochromium and increased imports forced domestic producers to either close or operate at reduced levels during various periods of the year in an effort to lower excessive inventories. One plant, the Beverly, Ohio, plant of Globe Metallurgical Division of Interlake, Inc., was closed by a 55-day strike. Domestic ferrochromium production capacity was reduced as one company permanently eliminated 40% of its capacity, while another stopped production of ferrochromium entirely and is producing only ferrochromium-silicon. By yearend, other producers were evaluating their operations to determine whether the market and the ability of domestic producers to compete with imports make it worthwhile to continue production of ferrochromium.

There was continued activity in developing chromium-bearing laterite deposits of northern California and southwestern Oregon. California Nickel Corp. continued evaluation of its properties, and pilot plant testing of a patented process to recover the nickel and cobalt minerals of the ore was started. Previous testing had shown that the chromite content of the ore can be recovered by gravity separation to produce a concentrate. In the same vicinity, Del Norte Chrome Corp., a Canadian-based company, began studies to determine the feasibility of developing its properties, which contain low-grade disseminated ore bodies averaging less than 10% Cr_2O_3. American Chromium Co. continued diamond drilling and geological mapping of its chromite prospects in Siskiyou County, Calif. The company reported that exploration results to date indicate several large mineralized zones where "ore grade chromite" has been encountered on several of the properties.

Atlantic Oil Corp. and Power Resources Corp., both of Denver, Colo., announced the formation of a joint venture to explore mining possibilities for precious and strategic metals, including chromium, in the Western United States. Atlantic Oil will supply the initial $750,000 in venture capital, while Power Resources will conduct the actual exploration.

CONSUMPTION AND USES

Domestic consumption of chromite ore and concentrate was 968,000 tons in 1980. Of the total chromite consumed, the metallurgical industry used 59%; the refractory industry, 16%; and the chemical industry, 25%. The metallurgical industry consumed 573,000 tons of chromite in producing 239,000 tons of chromium alloys and metal. About 38% of the metallurgical-grade ore had a chromium-to-iron ratio of 3:1 and over, 27% had a ratio between 2:1 and 3:1, and 35% had a ratio of less than 2:1.

Chromium has a wide range of uses in the three primary consuming industries. In the metallurgical industry, its principal use was in stainless steel. Of the total chromium alloys consumed, stainless steel accounted for 70%; full-alloy steels, 16%; high-strength low-alloy and electrical steels, 3%; and carbon steels, 1%. Total chromium alloy consumption decreased 22% below that of 1979.

The refractory industry utilized chromium in the form of chromite primarily for manufacturing refractory bricks to line metallurgical furnaces. Consumption of chromite for refractory purposes decreased 20% compared with that of 1979.

The chemical industry consumed chromite for manufacturing sodium and potassium bichromate, which are base materials for a wide range of chromium chemicals. Chromite consumption in this industry decreased less than 1% compared with that of 1979.

Table 4.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (percent)
1976	597	43.4	202	35.0	207	44.8	1,006	42.0
1977	578	41.3	208	36.0	214	44.7	1,000	40.9
1978	534	39.8	237	36.6	239	45.3	1,010	39.9
1979	774	39.9	193	36.2	242	44.9	1,209	40.2
1980	573	37.5	155	34.8	240	45.4	968	39.3

Table 5.—U.S. consumption by end use and form of chromium ferroalloys and metal in 1980

(Short tons, gross weight)

End use	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Other	Total
Steel:					
Carbon	1,408	3,783	1,052	92	6,335
Stainless and heat-resisting	17,323	264,637	15,807	302	298,069
Full-alloy	14,574	46,271	3,895	2,648	67,388
High-strength low-alloy and electric	1,576	6,238	2,316	1,954	12,084
Tool	1,461	2,893	36	2	4,392
Cast irons	1,079	8,603	160	553	10,395
Superalloys	6,745	5,060	138	3,931	15,874
Welding materials (structural and hard-facing)	730	897	--	212	1,839
Other alloys[1]	1,857	1,215	7	2,661	5,740
Miscellaneous and unspecified	1,946	343	9	16	2,314
Total	48,699	339,940	23,420	[2]12,371	424,430
Chromium content	33,093	202,176	8,615	8,609	252,493
Stocks, Dec. 31, 1980	5,432	50,258	2,578	[3]1,935	60,203

[1]Includes magnetic and nonferrous alloys.
[2]Includes 5,635 tons of chromium metal.
[3]Includes 1,107 tons of chromium metal.

STOCKS

Reported consumer stocks of chromite declined for the third successive year in 1980 from 0.91 to 0.68 million tons, with most of the decline in the metallurgical industry. Because of high interest rates and low demand, maximum efforts were made by consumers in 1980 to reduce their inventories. Chromium alloy stocks were mixed; consumer stocks were 3% higher than in 1979, while producer stocks dropped 10%. A considerable tonnage of chromium alloys was in the hands of traders at yearend.

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants decreased from 12,800 tons in 1979 to 11,924 tons in 1980.

Table 6.—Consumer stocks of chromite, December 31

(Thousand short tons)

Industry	1976	1977	1978	1979	1980
Metallurgical	762	900	755	416	219
Refractory	136	174	185	161	134
Chemical	111	264	361	330	322
Total	1,009	1,338	1,301	907	675

Table 7.—Consumer stocks of chromium ferroalloys and chromium metal, December 31

(Short tons, gross weight)

Product	1976	1977	1978	1979	1980
Low-carbon ferrochromium	10,100	6,247	6,455	6,683	5,432
High-carbon ferrochromium	52,553	66,114	69,196	45,465	50,258
Ferrochromium-silicon	3,995	4,777	3,492	3,701	2,578
Other[1]	3,300	2,228	2,618	2,465	1,935
Total	69,948	79,366	81,761	58,314	60,203

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

PRICES

There was little price movement of chromite in 1980. The Soviet chromite price was suspended in February 1978 and it continued to be unquoted at yearend 1980. At the beginning of 1980, the published price of South African Transvaal chromite was $54 to $58 per metric ton. The quotation was lowered in September to $51 to $55 per ton where it remained for the balance of the year. Turkish chromite, 48% Cr_2O_3, 3-to-1 chromium-to-iron ratio, was quoted at $110 per metric ton at Turkish ports in January 1980 where it remained throughout the year.

There were few price changes of ferrochromium during 1980; ample supplies and reduced demand put pressure on any substantial price increases. Chromium alloy and chromium metal prices as published in Metals Week follow:

Material	January 1980	December 1980
	Cents per pound chromium	
U.S. charge chromium (50%-55% chromium)	44.25-45	46.25- 47.5
Imported charge chromium (50%-55% chromium)	42.75-45	45 - 46.25
Imported charge chromium (60%-65% chromium)	48 -52	46 - 50
U.S. charge chromium (66%-70% chromium)	45 -53	48.5 - 52
U.S. low-carbon ferrochromium (0.025% carbon)	95	100
U.S. low-carbon ferrochromium (0.05% carbon)	90	95
Imported low-carbon ferrochromium (0.05% carbon)	89 -95	89 - 95
Simplex (low-carbon ferrochromium)	90	95
	Cents per pound of product	
Ferrochromium-silicon	34.5	34.5
Electrolytic chromium metal	350	425

FOREIGN TRADE

Exports of chromite in 1980 were at the lowest levels since the mid-1960's, while reexports were at the highest level in 3 years. Ferrochromium exports were 31,705 tons in 1980 valued at $22.2 million. Japan (55%) and Canada (18%) were the leading recipients.

Chromium and chromium alloys (wrought and unwrought) and waste and scrap exports totaled 350 tons valued at $3.8 million. Of the 33 countries receiving shipments, the Federal Republic of Germany and the United Kingdom were the principal recipients.

Exports of pigment-grade chromium chemicals totaled 3,027 tons valued at $9.5 million. Japan (20%) and Belgium (15%) were the principal recipients among the 53 countries receiving shipments. Exports of non-pigment-grade chromium chemicals totaled 30,696 tons valued at $32.4 million. The exports went mainly to Canada (23%) and mainland China (17%).

Imports of chromite in 1980 remained strong, decreasing only 4% from the 1979 level. The Republic of South Africa supplied 41% of the total, followed by the U.S.S.R., 17%, and the Philippines 14%. Shipments from the U.S.S.R. were 32% less compared with those of 1979. Shipments received from Albania and the Philippines were also down while imports from Finland, Madagascar, and Turkey rose compared with those of the previous year.

Despite weak demand, imports of ferrochromium were up 23% compared with those of 1979. Of the low-carbon ferrochromium shipments, Sweden supplied 32%; the Republic of South Africa, 29%; and the Federal Republic of Germany, 22%. Six other countries supplied the balance. High-carbon ferrochromium was received from the Republic of South Africa, 80%, and Yugoslavia and Zimbabwe, 7% each. Five other countries supplied the balance.

Ferrochromium-silicon imports totaled 5,100 tons valued at $2.3 million. Zimbabwe accounted for nearly all of the shipments.

Imports of chromium metal (wrought and unwrought) and waste and scrap were 4,075 tons valued at $28.4 million. The United Kingdom supplied 45% and Japan, 39%. Seven other countries supplied the balance.

Imports of chromium-containing pigments in 1980 included chrome yellow, 1,338 tons, and chromium oxide green, 3,908 tons. Total value of these products was $12.4 million. Canada was the major supplier of chrome yellow, and the United Kingdom was the leading supplier of chromium oxide green.

Chromium carbide imports totaled 225 tons valued at $1.6 million. The Federal Republic of Germany supplied 68%, and Japan, 28%.

Imports of chromic acid totaled 43 tons valued at $228,000. Of the four countries supplying imports, Canada accounted for 67%, and the Federal Republic of Germany, 31%.

Sodium chromate and dichromate imports totaled 1,160 tons valued at $945,000. Brazil supplied 95% of the imports. The balance was furnished by four other countries.

Imports of potassium dichromate were 151 tons valued at $145,000. Canada supplied 70%, and the United Kingdom supplied 26%. Three other countries supplied the balance.

Table 8.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1976	124	5,509	85	5,475
1977	187	10,105	61	4,913
1978	23	2,767	29	2,574
1979	27	2,514	28	2,860
1980	6	1,447	44	8,544

Table 9.—U.S. imports for consumption of chromite, by grade and country

(Thousand short tons and thousand dollars)

Year and country	Less than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total		
	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value
1979:												
Albania	11	4	674	95	41	5,787	--	--	--	106	45	6,461
Finland	21	6	668	10	4	442	--	--	--	31	10	1,110
Madagascar	--	--	--	--	--	--	20	10	2,000	20	10	2,000
Philippines	194	62	11,808	--	--	--	--	--	--	194	62	11,808
South Africa, Republic of	10	4	435	269	120	12,382	74	35	3,633	353	159	16,450
Turkey	9	3	540	17	8	1,439	44	21	3,878	70	32	5,857
U.S.S.R	227	88	10,781	23	10	1,137	--	--	--	250	98	11,918
Total	472	167	24,906	414	183	21,187	138	66	9,511	1,024	416	55,604
1980:												
Albania	18	7	1,454	41	18	2,944	27	13	2,420	86	38	6,818
Finland	30	8	1,074	17	8	1,075	--	--	--	47	16	2,149
Madagascar	--	--	--	33	15	2,419	10	5	806	43	20	3,225
Philippines	138	45	11,740	--	--	--	--	--	--	138	45	11,740
South Africa, Republic of	44	17	1,779	276	122	12,783	85	39	4,498	405	178	19,060
Turkey	52	19	2,707	23	10	1,623	18	8	1,794	93	37	6,124
U.S.S.R	80	30	3,791	35	15	1,899	55	31	1,719	170	76	7,409
Total	362	126	22,545	425	188	22,743	195	96	11,237	982	410	56,525

Table 10.—U.S. imports for consumption of ferrochromium, by country

Year and country	Low-carbon ferrochromium (less than 3% carbon) Gross weight (short tons)	Chromium content (short tons)	Value (thousands)	High-carbon ferrochromium (3% or more carbon) Gross weight (short tons)	Chromium content (short tons)	Value (thousands)
1979:						
Belgium-Luxembourg	18	10	$10	--	--	--
Brazil	--	--	--	7,330	4,037	$2,759
France	1,131	808	1,288	--	--	--
Germany, Federal Republic of	3,739	2,672	4,000	111	75	107
Italy	37	27	38	--	--	--
Japan	2,943	1,998	3,522	--	--	--
Norway	321	195	263	221	150	114
South Africa, Republic of	2,645	1,527	1,680	174,320	91,780	70,203
Sweden	8,695	6,133	10,104	4,227	2,717	2,203
Turkey	1,102	750	1,349	2,796	1,820	1,464
Yugoslavia	--	--	--	32,827	21,260	17,487
Total	20,631	14,120	22,254	221,832	121,839	94,337
1980:						
Brazil	--	--	--	5,303	2,855	2,170
France	248	177	265	--	--	--
Germany, Federal Republic of	4,846	3,410	6,056	278	187	291
Italy	19	14	28	--	--	--
Japan	2,632	1,800	3,634	--	--	--
Korea, Republic of	56	37	61	--	--	--
South Africa, Republic of	6,381	4,222	6,023	219,476	123,473	98,797
Spain	--	--	--	2,756	1,485	1,225
Sweden	7,145	5,163	8,527	2,237	1,471	1,267
Turkey	--	--	--	5,485	3,588	3,093
Yugoslavia	55	39	57	20,172	13,157	11,103
Zimbabwe	610	430	677	19,519	12,589	10,213
Total	21,992	15,292	25,328	275,226	158,805	128,159

Tariffs.—The Tokyo Round of Multilateral Trade Negotiations was completed in 1979, resulting in new tariff agreements with the developed nations of the world. Tariff rates for chromium materials at the beginning (January 1, 1980) and ending (January 1, 1987) dates of the staging period, as published in the Tariff Schedules of the United States, Annotated (1980), are shown below.

Item	Number	Most Favored Nation (MFN) Jan. 1, 1980	Most Favored Nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1980
Ore and concentrate	601.15	Free	Free	Free.
Low-carbon ferrochromium	606.22	4% ad valorem	3.1% ad valorem	30% ad valorem.
High-carbon ferrochromium	606.24	0.625 cent per pound of chromium.[1]	No change	25% ad valorem.
Ferrosilicon chromium	606.42	10% ad valorem	10% ad valorem	Do.
Sodium chromate and dichromate	420.98	2.8% ad valorem	2.4% ad valorem	8.5% ad valorem.
Potassium chromate and dichromate	420.08	1.6% ad valorem	1.5% ad valorem	3.5% ad valorem.
Chromium carbide	422.92	5.8% ad valorem	4.2% ad valorem	25% ad valorem.
Pigments:				
Chrome green	473.10	5% ad valorem	5% ad valorem	Do.
Chrome yellow	473.12	do	do	Do.
Chromium oxide green	473.14	4.8% ad valorem	3.7% ad valorem	Do.
Hydrated chromium oxide green	473.16	do	do	Do.
Molybdenum orange	473.18	5% ad valorem	5% ad valorem	Do.
Strontium chromate	473.19	4.8% ad valorem	3.7% ad valorem	Do.
Zinc yellow	473.20	5% ad valorem	5% ad valorem	Do.

[1]Total duty of 4.625 cents per pound on material valued less than 38 cents per pound of chromium through Nov. 15, 1981.

WORLD REVIEW

Despite decreased demand, world mine production of chromite in 1980 was estimated to be 10.7 million short tons, up from 10.5 million tons in 1979. Increased output was recorded in all major chromite producing countries except Finland and Turkey.

The second International Ferroalloy Congress (INFACON-80) was held in Lausanne, Switzerland, in October 1980. The purpose of INFACON-80 was to stimulate technical interchange on all aspects of ferroalloy production. Much of the subject matter concerned chromium. Over 400 delegates from around the world attended. Papers presented at the conference related mostly to energy, environment, and economic aspects of the ferroalloy industry.

Brazil.—A consortium of Japanese ferrochromium producers completed the sale of their 48% interest in Brazil's Mineração Serra de Jacobina (SERJANA) chromite mine to their Brazilian partner Ferroligas da Bahia (FERBASA) for $1.9 million. A $7.3 million advance for the project's mine development by the Japanese will not have to be repaid by the new owners. It was reported that the Japanese pulled out of the project, which was Japan's first captive overseas chromite mine, because of heavy losses incurred since the joint venture was undertaken in 1972.

China, Mainland.—There is little information on China's chromium ore reserves or production. Chinese production to date has been limited to one deposit in Hopeh Province. In 1980, it was reported that a new deposit of chromite was discovered at Saltohai in the far western Xinjiang Uighur Autonomous Region of China. The report stated that chromite was found in commercial quantities, but no other details were included.

France.—Ugine, the French ferrochromium producer, announced that it would cease all ferrochrome production by the end of 1983. High-carbon ferrochrome will probably be phased out by early 1981 when the company's chrome ore contracts expire. It is believed high energy costs and cheap imports were the major reasons for closing the facilities.

Greece.—Hellenic Ferro Alloys, a newly formed subsidiary of the Government-owned Hellenic Industrial and Mining Investment Co., S.A., began construction of a new 33,000-ton-per-year ferrochromium facility at Almyras near Volos, on the east coast of Greece. The new plant will produce high-carbon ferrochromium from chromite produced at the company's Skoumtsa Mine in Macedonia. The cost of the project is estimated at $45 million, with startup scheduled for 1982.

India.—Voest-Alpine of Austria was awarded a $35 million contract by the Indian state-owned Orissa Mining Corp. (OMC) for construction of a 55,000-ton-per-year ferrochromium smelter in Orissa. The facility will produce charge ferrochromium using a new process that reportedly reduces normal electricity consumption by 30%. The ferrochromium will be produced for export and sold through Voest-Alpine.

Japan.—The Japanese ferrochromium industry, like the U.S. industry, continues to suffer from spiraling energy costs, rigid pollution control requirements, and increasing competition from imported ferrochromium materials from the Republic of South Africa. In 1980, over half of the chromite imported, and about 80% of the ferrochromium imports, came from the Republic of South Africa. To combat the high cost of energy, Japanese producers have increased their purchase of high-grade chromite from the Philippines and India. These ores include material grading better than 50% Cr_2O_3, with grades up to 54% to 56% common. In addition to reducing energy costs, these purchases also reduce the industry's reliance on South African imports. It was reported that the Japanese are also seeking import markets for ferrochromium from Brazil, Taiwan, and Yugoslavia.

Nippon Denko, Ltd., expanded its chromium metal capacity of its Tokushima plant. The expansion increased the company's metal production capacity to 1,000 metric tons annually from the current 350 metric tons per year. The expansion was completed in mid-1980. Because of increased demand, Toyo Soda Manufacturing Co. was also expanding its electrolytic metallic chromium capacity at its Yamagata works by 20% to 300 metric tons per month. Plans call for the expansion to be completed by the end of 1981.

Madagascar.—Chromite is the most important mineral mined in Madagascar. In 1980, production was estimated at 165,000 short tons. All mining is carried on by Kraomita Malagasy, a 100% state-owned company. Kraomita, formerly called COM-

IA before nationalization in 1976, was controlled by the French Péchiney-Ugine Kuhlmann group, which began mining operations in 1969.

Production in 1980 was from two sources. In the Andriamena, the larger of the two mines, the chromite graded about 40% Cr_2O_3 and was concentrated to 50% before being transported by road and rail 54 miles to the port at Tamatave for export. The unconcentrated ore at Befandriana averages about 35% Cr_2O_3 and is trucked to Andriamena for concentrating. All of Madagascar's chromite is currently produced for export.

New Caledonia.—Chromite production is scheduled to resume by mid-1982 for the first time in nearly 20 years, at Tiebaghi. Inco, Ltd., is reactivating the mining operation in partnership with two French financial interests. A concentrating plant to be built near the mine is expected to produce about 85,000 metric tons of chromite ore products annually from an anticipated mine production of 110,000 metric tons. The operation will yield 51% chromite concentrates. The deposit, which Inco will develop, is located below a mining operation that Union Carbide Corp. operated until 1962. Exploration work began on the site in 1976. The total cost of the project is expected to be about $14 million.

Norway.—Elkem-Spigerverket A/S, Shieldings Investments, and a group of Norwegian investors signed an agreement in principle to purchase more than half of Union Carbide Corp.'s metal business. Union Carbide will receive about $285 million upon completion of the sale, which includes five U.S. plants, two Canadian operations, and three European plants responsible for producing a variety of ferroalloy products, including specialty chromium. The transaction was expected to be finalized by early 1981.

Papua New Guinea.—A joint venture formed by Nord Resources Corp., (United States) and Mt. Isa Mines (Australia) has found promising indications of chromite, nickel, and cobalt at their Ramu River concession south of the city of Madana. The joint venture, named Nord-Highlands Minerals Venture-1, is conducting detailed metallurgical and process testing of the ore. The study is expected to be completed by mid-1981, at which time the consortium and the Papua New Guinea Government will evaluate the commercial prospects of the ore body. Reserves are estimated to include 5 to 10 million tons of chromite.

Philippines.—Benguet Corp. and Consolidated Mines, Inc., have renewed their operating contract that was due to expire at the end of 1980. Benguet will continue to operate Consolidated Mines' Masinloc refractory chromite mines in Zimbales Province. The new agreement will run for a period of 25 years and will be renewable upon mutual consent of both parties.

Ground breaking for the Philippines' first ferrochromium smelting plant occurred in early December. The $70 million, 52,000-metric-ton-per-year plant is a joint venture between Voest-Alpine of Austria and the Herdis Group of Manila. The facility will be located in Northern Mindanao, and feed for the smelter will come from Acoje Mining Co., a Herdis Group affiliate, which has a 150,000-ton-per-year chromite mine in Zimbales. The facility is expected to come onstream in 1982.

Alamag Processing Corp., a wholly owned subsidiary of Bayer AG of the Federal Republic of Germany, will build a $12 million plant to produce chemical-grade chromite ore concentrates, which Bayer will use in the manufacture of chrome-based chemicals. The facility, expected to begin production in 1983, will have an initial production of 30,000 tons of concentrates annually, increasing to 100,000 tons annually by 1985. Financing will be provided by Bayer along with the German Government. Riopa Mining Services, a Philippine firm, identified as Alamag's mining affiliate, will mine the company's chromite deposits in eastern Samar Province.

Trident Mining and Industrial Corp. has expanded its chromite mining facility on Palawan Island, Western Philippines, to 750 tons per day from 200 tons per day. The expansion involved conversion of the 200-ton-per-day mill to handle 250 tons per day of low-grade ore with an average chromite content of 25% to 30% and building a new 500-ton-per-day mill. The two concentrating plants are now capable of producing 8,000 tons per month of concentrates containing 53% chromite.

South Africa, Republic of.—Chromite production in 1980 was reported at a record 3.8 million tons of ore and concentrates. However, by yearend, the sharp decline in worldwide demand for chromium materials forced many South African producers to reduce production or, in some cases, shut down altogether. A similar situation existed in the ferrochromium industry where producers were operating at about 70% of 1979 levels.

Recent metallurgical and smelting breakthroughs are expected to open the unexploited UG2 chromium-platinum reef in Rustenburg to new mining development. Wheeler Corp. of the United Kingdom has developed a high-temperature plasma furnace that reportedly does not clog up when processing ore from UG2, a problem encountered by smelters using conventional furnaces. The other breakthrough involves the South African National Institute of Metallurgy, which has developed a flotation process that separates chromium fines and produces metals in a concentration four times greater than that obtained in a conventional smelter. Because the reef is 1 to 2 meters wide, its potential for yielding large quantities of chromium and platinum-group metals is considerable. Western Platinum Ltd. is planning a $33 million expansion of its facilities at the reef, and Texasgulf, Inc., is considering developing a mine in the area of the UG2 reef where it holds mineral claims.

Sweden.—In October, Vargön Alloys A/B encountered a complete production stoppage of its 100,000-ton-per-year ferrochromium furnace in Vargön, Sweden. A bottom burn-through halted production, and repairs were not expected to be completed before January 1981. In the meantime, all supply commitments were being met by the company with stockpiled material.

Turkey.—Turkey, the world's sixth largest producer of chromite, has an annual output of about 500,000 tons from eight mines, all of which have beneficiation plants. Production is shared between the private sector and the Government-owned Etibank. There are two ferrochromium plants in the country. In 1980, Outokumpu Oy of Finland and Elkem A/S of Norway signed an agreement with Etibank to supply equipment and engineering services for a 100,000-ton-per-year expansion of the Elazig ferrochromium smelter in central Turkey. The expansion consists of the addition of two submersible electric-arc furnaces that will use Outokumpu's patented smelting process. The cost is estimated at about 120 million Finnish Marks, and the furnaces are expected to be in operation by late 1984.

Zimbabwe.—Union Carbide Corp. and the Zimbabwean Government sales agency, Univex, have agreed as to the method of marketing high-carbon ferrochromium produced at the Rhomet facility. The agreement calls for all European sales commitments of Univex to be assumed by Union Carbide, which manages Rhomet's ferrochromium operation. Rhomet's existing ferrochromium production from its four furnaces is about 120,000 tons per year. Two new furnaces are being added, which will give Union Carbide an annual production total of about 210,000 tons. The first furnace is expected to be onstream in mid-1981, while the second is due onstream in 1982. Union Carbide's chromite mines at Selukwe and Mtorashanga are being expanded by almost 40% to 500,000 tons per year to meet the increased needs of the smelting expansion. The other Zimbabwean ferrochromium producer, the Anglo-American Corp. subsidiary Rhodall (formerly Rhodesian Alloys), plans to expand its production capacity to about 180,000 tons per year by the installation of a new 28-millivolt-ampere, 50,000-ton-per-year furnace. The expansion is expected to be completed in 1982.

Table 11.—Chromite: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Albania[e 3]	915	970	[r]1,090	[r]1,120	1,190
Brazil	205	342	297	375	385
Colombia[e]	6	6	6	6	6
Cuba	21	22	32	31	35
Cyprus	10	16	17	17	18
Egypt	(4)	[r]1	1	(4)	--
Finland	193	186	196	195	193
Greece[5]	38	[e]46	[e]44	[e]60	68
India	443	389	293	341	[e]352
Iran[e]	176	257	218	[e]150	90
Japan	24	20	10	13	15
Madagascar	[r]244	182	152	141	165
New Caledonia	11	9	9	14	14
Pakistan	12	9	12	3	3
Philippines	475	593	592	618	631

See footnotes at end of table.

Table 11.—Chromite: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
South Africa, Republic of	2,656	3,372	3,466	3,634	[6]3,764
Sudan	24	19	20	31	28
Thailand	--	1	(4)	(4)	(4)
Turkey[e 7]	640	560	415	500	440
U.S.S.R.[e]	2,300	2,400	[r]2,550	[r]2,650	2,700
Vietnam[e]	[r]15	[r]14	[r]14	15	17
Yugoslavia	2	2	2	(4)	--
Zimbabwe	952	747	527	597	611
Total	[r]9,362	[r]10,163	9,963	10,511	10,725

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through May 31, 1981.

[2]In addition to the countries listed, Bulgaria, mainland China, and North Korea may also produce chromite, but output is not reported quantitatively and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Figures represent crude ore output, not marketable production.

[4]Less than 1/2 unit.

[5]Exports of direct-shipping ore plus production of concentrates.

[6]Reported figure.

[7]Estimated production of marketable product (direct-shipping ore plus concentrates) based on reported production of run-of-mine ore, which was as follows in thousand short tons: 1976—1,025; 1977—1,006; 1978—(estimated) 700; 1979—(estimated) 900; 1980—(estimated) 800.

TECHNOLOGY

Every year, about 73,000 tons of chromium in scrap metal is lost to the domestic industry because the metal is either not collected, downgraded for use in lower quality materials, or exported. These are the findings of a study sponsored by the Bureau of Mines as part of an effort to establish the extent of the domestic chromium supply that could be exploited in case of adverse changes in international chromium trading and production patterns. The results of the investigation were published by the Bureau in two reports. One report focused on estimating the amount of chromium that could be found in unrecycled superalloys[2] and cast heat- and corrosion-resistant alloys; the other report examined the availability of chromium in wrought stainless steels and heat-resisting alloys.[3] The base years for the studies were 1976 and 1977.

In another study, Bureau of Mines scientists reported the development of a simple, economic, and environmentally safe process of recycling waste etching solutions that contain chromium. The method, using a one-step electrolytic process, minimizes a serious waste disposal problem, is cheaper than conventional recovery and disposal efforts, and conserves a strategic metal. The process is currently being tested in several industrial plants.[4]

The domestic tanning industry is an important consumer of chromium chemicals; however, in the past, tannery wastes have been sources of local pollution. Now, a solution to this problem may have been found. A patented process to remove chromium from tannery plant wastes has been developed by Saco Tanning Corp., a tannery in Saco, Maine. The method, which has been successfully demonstrated in the laboratory by company scientists, is expected to save the company $500,000 annually by reducing its purchases of chromium chemicals used by the leather tanning company. In addition, the process will mean almost no chromium being lost and entering the environment because the chemical wastes will be continuously recycled.

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[1]Physical scientist, Section of Ferrous Metals.

[2]Curwick, L. R., W. A. Petersen, and H. V. Makar. Availability of Critical Scrap Metals Containing Chromium in the United States. Superalloys and Cast Heat- and Corrosion-Resistant Alloys. BuMines IC 8821, 1980, 51 pp.

[3]Kusik, C. L., H. V. Makar, and M. R. Mounier. Availability of Critical Scrap Metals Containing Chromium in the United States. Wrought Stainless Steels and Heat-Resisting Alloys. BuMines IC 8822, 1980, 51 pp.

[4]George, L. C., A. A. Cochran, and D. M. Soboroff. Regeneration of Waste Chromic Acid Etching Solutions in an Industrial-Scale Research Unit. Pres. at 3d Environmental Protection Agency-American Electroplaters Soc. Conf. on Advanced Pollution Control for the Metal Finishing Industry, April 1980. Copies of the presentation may be obtained from the Bureau of Mines, Rolla Research Center, P.O. Box 280, Rolla, MO 65401.

Clays

By Sarkis G. Ampian[1] and Dorothea W. Polk[2]

Clays in 1 or more of 6 classification categories (kaolin, ball clay, fire clay, bentonite, fuller's earth, or common clay and shale) were produced in 45 States and Puerto Rico during 1980. Clay production was not reported in Alaska, Delaware, Hawaii, the District of Columbia, Rhode Island, or Vermont. The States leading in output were Georgia, 8.3 million tons; Texas, 3.8 million tons; Wyoming, 3.1 million tons; North Carolina, 2.9 million tons; and Ohio, 2.7 million tons; followed in order by California and South Carolina. Georgia also led in total value of clay output with $501 million; Wyoming was second with $71.5 million. Compared with 1979 figures, clay production increased in 11 States and value increased in 20 States. Total quantity of clays sold or used by domestic producers in 1980 was 11% lower; total value rose 6% to an alltime high. Increases in value per ton were reported for all clays in 1980 owing to increased labor, fuel, and material costs. The energy crisis, or more specifically, the increasing shortage and cost of fuels, continued to cause considerable concern among clay producers and clay product manufacturers. Industrywide efforts were made both to economize and to obtain standby fuels. The costs of environmental protection equipment and environmental restrictions and rising capital costs also continued to adversely affect production during 1980.

Production of the specialty clays—ball clay, bentonite, fire clay, and fuller's earth—all decreased, largely due to the overall downturn in the economy which lowered demand across the board. A downturn in construction that lowered demand for building materials (brick, lightweight aggregate, vitrified clay pipe, clay floor and wall tile, etc.) was responsible for the decline in production of common clay and shale. In contrast to a 2% increase in production of kaolin were the following decreases: Fire clay, 29%; common clay, 13%; ball clay, 9%; bentonite, 5%; and fuller's earth, 2%.

Kaolin in 1980 accounted for only 16% of the total clay production but accounted for 59% of the value.

Table 1.—Salient clays and clay products statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Domestic clays sold or used by producers:					
Quantity	52,389	53,196	56,822	54,689	48,790
Value	$528,745	$579,170	$717,274	$846,089	$898,947
Exports:					
Quantity	2,487	2,561	2,665	3,205	3,214
Value	$151,953	$160,790	$194,914	$243,722	$263,147
Imports for consumption:					
Quantity	39	36	25	51	34
Value	$1,814	$1,917	$2,082	$3,972	$6,688
Clay refractories shipments: Value	$448,471	$465,442	$497,567	$580,257	$557,386
Clay construction products shipments: Value	$783,644	$993,508	$1,158,278	$1,179,058	$1,061,507

[1]Excludes Puerto Rico.

Table 2.—Clays sold or used by producers in the United States in 1980, by State[1]

(Short tons)

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total	Total value
Alabama	--	W	1,385,485	223,146	--	413,170	[2]2,021,801	[2]$29,831,488
Arizona	W	35,155	W	--	--	--	150,547	1,151,324
Arkansas	--	--	936,609	--	--	213,358	1,149,967	14,402,465
California	W	64,366	2,422,097	W	--	52,001	2,558,413	17,765,630
Colorado	--	36,960	275,354	24,128	--	--	336,442	2,223,278
Connecticut	--	--	92,188	--	--	--	92,188	481,692
Florida	--	--	165,683	--	417,358	30,777	613,818	[3]24,163,771
Georgia	--	--	1,322,574	--	648,802	6,311,407	8,282,783	500,554,800
Idaho	--	W	W	W	--	W	27,345	300,774
Illinois	--	--	439,463	19,758	W	--	[4]459,221	[4]1,918,873
Indiana	--	--	931,765	256	--	--	932,021	1,929,500
Iowa	--	--	753,879	--	--	--	753,879	2,555,129
Kansas	--	30,000	855,780	--	--	--	885,780	2,324,805
Kentucky	W	--	692,303	55,457	--	--	[5]747,760	[5]3,691,921
Louisiana	--	--	379,838	--	--	--	379,838	5,841,314
Maine	--	--	77,924	--	--	--	77,924	173,803
Maryland	W	--	733,152	--	--	--	[5]733,152	[5]2,267,089
Massachusetts	--	--	210,457	--	--	--	210,457	870,273
Michigan	--	--	1,981,957	--	--	--	1,981,957	7,211,572
Minnesota	--	--	93,660	--	--	--	93,660	1,206,310
Mississippi	W	274,998	1,054,446	--	W	--	1,595,557	21,714,159
Missouri	--	--	1,040,718	699,512	--	77,113	1,817,343	16,797,962
Montana	--	606,130	19,062	535	--	--	625,727	22,200,218
Nebraska	--	--	153,781	--	--	--	153,781	456,295
Nevada	--	11,201	W	--	W	W	64,463	2,082,297
New Hampshire	--	--	W	--	--	--	W	W
New Jersey	--	--	52,215	11,239	--	--	63,454	524,683
New Mexico	--	--	59,866	W	--	--	[6]59,866	[6]113,910
New York	W	--	596,182	--	--	--	[5]596,182	[5]2,479,416
North Carolina	--	--	2,851,749	--	--	W	[3]2,851,749	[3]7,307,603
North Dakota	--	--	W	--	--	--	W	W
Ohio	--	--	2,303,746	410,312	--	3,600	2,717,658	11,516,403
Oklahoma	--	--	971,625	--	--	--	971,625	2,249,374
Oregon	--	--	171,690	--	--	--	171,690	321,214
Pennsylvania	--	--	1,340,577	309,014	--	W	[3]1,649,591	[3]12,112,190
Puerto Rico	--	--	290,866	--	--	--	290,866	677,050
South Carolina	--	--	1,552,821	--	W	657,752	[4]2,210,573	[4]25,168,879
South Dakota	--	W	168,664	--	--	--	[2]168,664	[2]283,080
Tennessee	605,584	W	499,809	--	W	--	1,188,120	22,844,243
Texas	W	108,652	3,475,351	56,731	W	W	3,763,435	27,022,341
Utah	--	8,504	348,544	W	W	--	365,156	1,517,212
Virginia	--	--	761,632	--	--	--	761,632	3,172,455
Washington	--	--	301,100	W	--	--	[6]301,100	[6]1,571,409
West Virginia	--	--	290,955	W	--	--	[6]290,955	[6]642,183
Wisconsin	--	--	W	--	--	--	W	W
Wyoming	--	2,877,040	203,644	--	--	--	3,080,684	71,511,898
Undistributed	[7]288,040	[7]131,613	[7]235,626	[7]285,273	[7]467,643	[7]119,815	[8]832,413	[8]22,604,254
Total	893,624	4,184,619	32,494,837	2,095,361	1,533,803	7,878,993	49,081,237	899,624,128

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes Puerto Rico.
[2]Excludes bentonite.
[3]Excludes kaolin.
[4]Excludes fuller's earth.
[5]Excludes ball clay.
[6]Excludes fire clay.
[7]Total of States indicated by symbol W.
[8]Incomplete total; difference included with individual State totals.

Table 3.—Number of mines from which producers sold or used clays in the United States in 1980, by State

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total
Alabama	--	1	29	6	--	6	42
Arizona	1	3	5	--	--	--	9
Arkansas	--	--	16	--	--	5	21
California	1	7	57	1	1	11	78
Colorado	--	1	28	8	--	--	37
Connecticut	--	--	2	--	--	--	2
Florida	--	--	4	--	9	2	15
Georgia	--	--	16	--	8	56	80
Idaho	--	2	1	1	--	1	5
Illinois	--	--	14	1	3	--	18
Indiana	--	--	21	1	--	--	22
Iowa	--	--	16	--	--	--	16
Kansas	--	1	19	--	--	--	20
Kentucky	5	--	10	14	--	--	29
Louisiana	--	--	8	--	--	--	8
Maine	--	--	6	--	--	--	6
Maryland	1	--	8	--	--	--	9
Massachusetts	--	--	3	--	--	--	3
Michigan	--	--	9	--	--	--	9
Minnesota	--	--	2	--	--	--	2
Mississippi	2	4	20	--	2	--	28
Missouri	--	--	17	64	--	13	94
Montana	--	8	11	1	--	--	20
Nebraska	--	--	6	--	--	--	6
Nevada	--	8	1	--	1	1	11
New Hampshire	--	--	1	--	--	--	1
New Jersey	--	--	2	3	--	--	5
New Mexico	--	--	4	2	--	--	6
New York	1	--	12	--	--	--	13
North Carolina	--	--	56	--	--	2	58
North Dakota	--	--	4	--	--	--	4
Ohio	--	--	63	22	--	--	85
Oklahoma	--	--	17	--	--	--	17
Oregon	--	--	10	--	--	--	10
Pennsylvania	--	--	44	38	--	2	84
Puerto Rico	--	--	2	--	--	--	2
South Carolina	--	--	32	--	1	19	52
South Dakota	--	1	2	--	--	--	3
Tennessee	26	--	15	--	1	--	42
Texas	5	7	85	2	3	1	103
Utah	--	3	8	5	1	--	17
Virginia	--	--	24	--	--	--	24
Washington	--	--	21	4	--	--	25
West Virginia	--	--	7	3	--	--	10
Wisconsin	--	--	2	--	--	--	2
Wyoming	--	105	4	--	--	--	109
Total	42	151	744	176	30	119	1,262

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin in 1980 increased 2%, and the value increased 14%. The average unit value for all grades of kaolin in 1980 was $66.90 per ton, $7.33 higher than in 1979. Kaolin was produced at mines in 13 States. Two States, Georgia (80%) and South Carolina (8%), accounted for 88% of the total U.S. production in 1980. Alabama ranked third; Arkansas, fourth; and Missouri, fifth. Output in 1980 increased in Arkansas, Georgia, and Missouri, but declined in Alabama, California, Florida, Idaho, Nevada, North Carolina, Pennsylvania, South Carolina, and Texas.

Kaolin is defined as a white, claylike material approximating the mineral kaolinite. It has a specific gravity of 2.6 and a fusion point of 1,785° C. The other kaolin-group minerals, such as halloysite and dickite, are encompassed.

All Georgia waterwashed kaolin producers again either announced planned increases in production or were presently increasing production during 1980. Anglo-American Clays Corp. started producing kaolin from its new calciner and took delivery of an 84-inch, high-intensity magnetic separator (HIMS) at its Sandersville facility. Engelhard Minerals and Chemicals Corp. included a second 120-inch magnetic separator in its overall $48 million expansion plans at its plant near McIntyre. Freeport Kaolin Co. phased in another calciner and three high-pressure filters, of the seven planned, at its Gordon operation. Three firms installed new energy-efficient spray dryers: Georgia Kaolin Co. as part of its Dry Branch expansion, Nord Kaolin Co. as part of plans to double capacity at its Jeffersonville plant, and Thiele Kaolin Co. as part of its final expansion into waterwashed kaolins. Burgess Pigment Co. canceled plans for a new $12 million kaolin mining and processing facility near Wrens. The plant was scheduled to produce an airfloated kaolin slurry for the conventional kaolin markets. J. M. Huber Corp. also started up magnetic separators at its Huber and Wrens plants. To date, every major Georgia waterwashed kaolin producer has at least one HIMS onstream. HIMS's and spray dryers are the most important pieces of capital equipment to be incorporated into the modern-day waterwashed kaolin flowsheets. The magnetic separator impacts favorably on the reserve picture, while the spray dryers economically produce dust-free and free-flowing kaolin aggregates. In other Georgia kaolin developments, Mulcoa, a division of C E Minerals, which in turn is a part of Combustion Engineering Inc., completed its third plant in Andersonville. Production capacity of refractory-grade calcined aggregates from mixtures of kaolin, bauxitic clay, and bauxite at Andersonville is now in excess of 600,000 tons per year. In addition, Mulcoa has successfully converted one of its kilns to coal-firing.

In acquisition news, Combustion Engineering increased ownership of Georgia Kaolin and American Industrial Clay Corp. from under 50% to 100% by purchasing the parent company, Yara Engineering Corp. W. R. Grace & Co. acquired National Kaolin Products Co. of Aiken, S.C. National Kaolin produces airfloated kaolin for the rubber industry. The Davison Chemical Div. of W. R. Grace will operate the firm and also produce ion exchange products and petroleum catalysts.

Exports of kaolin, as reported by the U.S. Department of Commerce, decreased from 1.583 million tons valued at $125.9 million in 1979 to 1.392 million tons valued at $133.7 million in 1980. The tonnage of kaolin exported in 1980 decreased 12%, while the value rose 6% over that shipped in 1979. The unit value of kaolin exported was attributed to both higher prices and the greater percentage of the higher quality paper-coating grades shipped.

Kaolin, including calcined, was exported to 75 countries. The major recipients were Japan, 29%; Canada, 16%; the Federal Republic of Germany, 15%; Italy, 13%; Mexico, 6%; and other countries, 21%. Of countries listed in 1980, exports to 9 countries increased, and those to 16 countries decreased. Kaolin producers reported the end uses for their exports as follows: Paper coating, 48%; refractories, 22%; rubber, 4%; foundry sand, 3%; and others, including adhesives, ceramics, paint, paper filling, and plastics, 23%.

Kaolin imports in 1980 decreased from 31,456 tons valued at $1,886 million in 1979 to 15,831 tons valued at $1.867 million. The United Kingdom supplied 97.9%; Canada, 1.9%; and three other countries, 0.2%.

Kaolin prices quoted in the trade journals in 1980, with the exception of the calcined and delaminated grade, remained unchanged from those of 1979. Chemical Marketing Reporter, December 29, 1980, quoted prices as follows:

Waterwashed, fully calcined, bags, carload lots, f.o.b. Georgia, per ton	$175.00-$208.00
Paper-grade, uncalcined, bulk, carload lots, f.o.b. Georgia, per ton:	
No. 1 coating	76.00
No. 2 coating	61.00
No. 3 coating	60.00
No. 4 coating	57.00
Filler, general purpose, same basis, per ton	43.00
Delaminated, waterwashed, uncalcined, paint-grade, 1-micrometer average, same basis, per ton	125.00- 163.00
Dry-ground, airfloated, soft, same basis, per ton	25.00
National Formulary, powder, colloidal, bacteria controlled, 50-pound bags, 5,000-pound lots, per pound	.24

The average unit value reported by domestic kaolin producers was $66.90 per ton, an increase of $7.33 above the 1979 value.

Table 4.—Kaolin sold or used by producers in the United States, by State

State	1979 Short tons	1979 Value	1980 Short tons	1980 Value
Alabama	465,510	$20,720,542	413,170	$19,017,072
Arkansas	132,015	6,340,345	213,358	12,847,072
California	60,032	2,086,627	52,001	1,706,901
Florida	30,989	W	30,777	W
Georgia	6,059,109	404,185,621	6,311,407	463,700,320
Missouri	54,856	978,067	77,113	1,450,516
South Carolina	766,976	20,342,400	657,752	20,835,482
Other[1]	191,113	7,666,486	123,415	7,541,246
Total	7,760,600	462,320,088	7,878,993	527,098,609

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Minnesota (1979), Nevada, North Carolina, Ohio (1980), Pennsylvania, Texas, and data indicated by symbol W.

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1979 Short tons	1979 Value	1980 Short tons	1980 Value
Airfloat	[r]1,578,781	[r]$49,857,146	1,558,386	$59,966,953
Calcined[1]	[r]1,537,509	[r]121,875,716	1,656,351	144,921,268
Delaminated	358,293	31,891,253	438,310	40,600,948
Unprocessed	[r]845,298	[r]9,109,832	700,394	8,232,709
Waterwashed	[r]3,440,719	[r]249,586,141	3,525,552	273,376,731
Total	7,760,600	462,320,088	7,878,993	527,098,609

[r]Revised.
[1]Includes both low-temperature filler and high-temperature refractory grades.

Table 6.—Calcined kaolin sold or used by producers in the United States, by kind

State	High temperature Short tons	High temperature Value	Low temperature Short tons	Low temperature Value
1979				
Georgia	676,307	$47,835,984	244,654	$44,089,845
Other[r] [1]	616,548	29,949,887	--	--
Total[r]	1,292,855	77,785,871	244,654	44,089,845
1980				
Georgia	707,446	58,791,366	277,019	50,257,125
Other[1]	671,886	35,872,777	--	--
Total	1,379,332	94,664,143	277,019	50,257,125

[r]Revised.
[1]Includes Alabama, Arkansas, California, Idaho, Pennsylvania, and Texas.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1979		1980	
	Short tons	Value	Short tons	Value
Airfloat	r1,022,374	r$29,710,085	1,067,084	$38,748,311
Calcined[1]	920,961	91,925,829	984,465	109,048,491
Delaminated	358,293	31,891,253	438,310	40,600,948
Unprocessed	359,875	2,483,198	295,996	1,925,839
Waterwashed	r3,397,606	r248,175,256	3,525,552	273,376,731
Total	6,059,109	404,185,621	6,311,407	463,700,320

rRevised.
[1]Includes both low-temperature filler and high-temperature refractory grades.

Table 8.—Georgia kaolin sold or used by producers, by kind and use

(Short tons)

Use	1979				1980			
	Air-float	Unprocessed[1]	Water-washed[2]	Total	Air-float	Unprocessed[1]	Water-washed[2]	Total
Domestic:								
Adhesives	r29,285	--	r15,459	44,744	40,663	--	16,835	57,498
Alum (aluminum sulfate) and other chemicals	200	245,004	8,181	253,385	9,511	219,520	9,252	238,283
Animal feed	W	--	--	W	10,220	--	--	10,220
Asphalt tile and linoleum	38,871	4,670	--	43,541	5,744	6,000	--	11,744
Catalysts (oil-refining)	W	W	W	62,171	--	--	67,082	67,082
China and dinnerware; crockery and earthenware	15,707	3,398	18,830	37,935	25,827	2,096	8,547	36,470
Electrical porcelain	16,894	--	--	16,894	22,741	--	--	22,741
Face brick	267	18,500	55	18,822	289	32,083	--	32,372
Fiberglass and mineral wool	109,807	--	2,393	112,200	69,611	--	56	69,667
Firebrick, block, shapes	536	11,112	--	11,648	352	2,658	--	3,010
Floor and wall tile, ceramic	W	--	W	13,248	W	--	--	W
Flue linings and high-alumina brick	r41,373	r12,865	--	54,238	40,176	4,492	--	44,668
Foundry sand	770	--	--	770	671	--	510	1,181
Glazes, glass, enamels, hobby ceramics	W	--	--	W	W	--	--	W
Grogs and crudes, refractory	18,533	400,270	17	418,820	W	444,748	--	444,748
Ink	W	--	--	W	W	--	--	W
Kiln furniture, mortar, cement	--	W	W	34,681	W	W	--	33,132
Medical, pharmaceutical, cosmetic	W	--	W	2,036	W	--	W	1,990
Paint	r10,702	--	r109,222	119,924	33,262	--	103,426	136,688
Paper coating	r313,884	--	r1,959,999	r2,273,883	65,887	--	2,217,027	2,282,914
Paper filling	r119,593	--	r738,712	858,305	448,736	--	734,193	1,182,929
Plastics	r2,465	--	r53,458	55,923	5,277	--	42,557	47,834
Pottery	7,988	r14,365	--	r22,353	14,203	6,607	--	20,810
Roofing granules	W	--	W	12,646	17,361	--	--	17,361
Roofing and structural tile	r4,995	(3)	--	4,995	434	--	--	434
Rubber	r73,363	--	r16,474	r89,837	66,849	--	10,657	77,506
Sanitary ware	r117,401	W	W	r128,727	111,054	--	69	111,123
Miscellaneous, airfloat:								
Animal oil (1980), fertilizer, gypsum products (1980), oil and grease absorbents, pesticides and related products, pet waste absorbents (1979), textiles (1980), waterproofing and sealing (1980), other, unknown	r31,422	--	--	r31,422	40,280	--	--	40,280

See footnotes at end of table.

Table 8.—Georgia kaolin sold or used by producers, by kind and use —Continued

(Short tons)

Use	1979 Air-float	1979 Unprocessed[1]	1979 Water-washed[2]	1979 Total	1980 Air-float	1980 Unprocessed[1]	1980 Water-washed[2]	1980 Total
Domestic —Continued								
Miscellaneous, unprocessed:								
Common brick (1979), drain tile (1980), flower pots, gypsum products, portland cement (1979), quarry tile (1979), sewer pipe (1979)	--	r23,747	--	r23,747	--	6,263	--	6,263
Miscellaneous, waterwashed:								
Gypsum products, pesticides and related products, waterproofing and sealing, other, unknown	--	--	r66,110	r66,110	--	--	42,569	42,569
Undistributed	r47,378	r26,214	r124,592	r 4 62,076	24,934	18,935	890	4 9,637
Total	r1,001,434	r760,145	r3,113,502	4,875,081	1,054,082	743,402	3,253,670	5,051,154
Exports:								
Paint	r654	--	r29,496	30,150	--	--	25,494	25,494
Paper coating	--	--	580,435	580,435	--	--	691,446	691,446
Paper filling	1,082	--	52,859	53,941	30	--	72,399	72,429
Plastics	--	--	23,324	23,324	--	--	21,997	21,997
Refractories	--	276,037	--	276,037	--	260,040	--	260,040
Rubber	78	--	843	921	78	--	498	576
Undistributed	r19,126	(3)	r200,094	219,220	12,894	--	175,377	188,271
Total	r20,940	r276,037	r887,051	1,184,028	13,002	260,040	987,211	1,260,253
Grand total	r1,022,374	r1,036,182	r4,000,553	6,059,109	1,067,084	1,003,442	4,240,881	6,311,407

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
1 Includes high-temperature calcined.
2 Includes low-temperature calcined and delaminated.
3 Revised to zero.
4 Incomplete total; difference included in totals for specific uses.

Table 9.—South Carolina kaolin sold or used by producers, by kind

Kind	1979		1980	
	Short tons	Value	Short tons	Value
Airfloat	522,262	$18,453,671	457,231	$19,231,850
Unprocessed	244,714	1,888,729	200,521	1,603,632
Total	766,976	20,342,400	657,752	20,835,482

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1979	1980
Airfloat:		
Adhesives	19,937	13,802
Animal feed and pet waste absorbent	2,595	1,444
Ceramics[1]	20,912	23,395
Fertilizers	16,564	20,383
Fiberglass	96,256	105,709
Paint	747	1,146
Paper coating and filling	4,519	4,292
Pesticides and related products	23,059	15,135
Plastics	9,310	11,499
Rubber	244,098	191,059
Other refractories[2]	8,514	7,213
Other uses[3]	4,233	7,268
Exports[4]	71,518	56,612
Total	522,262	458,957
Unprocessed: Face brick; firebrick, block and shapes; miscellaneous	244,714	198,795
Grand total	766,976	657,752

[1]Includes floor and wall tile; glazes, glass, and enamels; pottery; roofing granules; and sanitary ware.
[2]Includes refractory grogs and crudes; refractory mortar and cement.
[3]Includes common brick (1980), crockery and other earthenware, ink, roofing tile (1979), structural tile (1980), and miscellaneous.
[4]Includes ceramics, fertilizers (1979), paper filling, pesticides and related products (1980), plastics (1979), rubber, and miscellaneous.

Table 11.—Kaolin sold or used by producers in the United States, by kind and use

(Short tons)

Use	1979				1980			
	Airfloat	Unprocessed [1]	Water-washed [2]	Total	Airfloat	Unprocessed [1]	Water-washed [2]	Total
Domestic:								
Adhesives	r49,222	W	r15,890	r65,112	54,465	4,376	16,835	75,676
Alum (aluminum sulfate) and other chemicals	425	302,449	46,181	349,055	9,633	332,616	9,252	351,501
Animal feed	7,532	108	5,413	13,053	11,664	5,110	--	16,774
Brick, common and face	982	356,286	55	357,323	1,378	256,576	--	257,954
Catalysts (oil and gas-refining)	W	W	W	62,171	--	--	67,082	67,082
Cement, portland	--	W	W	12,797	--	W	W	18,947
Ceramic (hobby and artware)	W	--	--	W	--	--	--	--
China and dinnerware	12,024	5,988	18,781	36,793	23,829	3,679	8,547	36,055
Crockery and other earthenware	12,063	737	49	12,849	7,922	618	--	8,540
Electrical porcelain	25,797	3,884	--	29,681	31,964	2,373	--	34,337
Fertilizers [3]	16,522	529	10,212	27,263	29,660	11,935	--	41,595
Fiberglass; mineral wool and other insulation	207,222	--	9,291	216,513	176,688	8,176	56	184,920
Firebrick, block, shapes	536	388,737	--	389,273	2,366	199,589	--	201,955
Floor and wall tile, ceramic	22,930	4,390	W	27,320	20,153	3,050	--	23,203
Flue linings and high-alumina brick	r41,373	r12,865	--	54,238	41,099	4,492	--	45,591
Foundry sand	770	--	--	770	1,133	--	510	1,643
Glazes, glass, enamels	373	210	3,018	3,601	60	3,737	--	3,797
Grogs and crudes, refractory	24,270	546,037	17	570,324	4,300	805,561	--	809,861
Gypsum products	963	662	4,957	6,582	2,732	7,613	463	10,808
Ink	W	--	--	W	W	--	--	W
Kiln furniture	2,293	--	--	2,293	2,056	--	--	2,056
Linoleum and asphalt tile	38,871	4,670	--	43,541	5,744	6,000	--	11,744
Medical, pharmaceutical, cosmetic	W	--	W	2,309	W	--	W	1,990
Mortar and cement, refractory	W	35,621	W	36,715	17,395	22,815	--	40,210
Paint	r11,449	--	r157,674	169,123	34,408	26,566	103,426	164,400
Paper coating	r315,601	(4)	r1,959,999	r2,275,600	251,328	--	2,255,278	2,506,606
Paper filling	r122,395	--	r738,712	861,107	229,358	--	734,193	963,551
Pesticides and related products	45,019	634	403	46,056	15,235	32,273	1,326	48,834

Plastics	[r]11,775	--	[r]53,458	65,233	16,776	--	42,557	59,333
Pottery	12,821	[r]18,984	--	[r]31,805	19,001	9,246	--	28,247
Roofing granules	12,980	W	W	14,219	19,152	399	--	19,551
Roofing tile and structural tile	[r]5,645	([4])	--	5,645	--	467	--	467
Rubber	[r]317,540	2,450	[r]22,941	[r]342,931	257,908	8,549	10,657	277,114
Sanitary ware	[r]132,542	W	14,774	[r]147,316	128,080	4,088	69	132,237
Waterproofing and sealing	--	--	706	706	612	--	82	694
Miscellaneous	[r]32,614	[r]55,559	[r]89,572	[r5]98,135	73,581	21,062	890	[5]74,596
Total	[r]1,484,549	[r]1,740,800	[r]3,152,103	6,377,452	1,489,680	1,780.966	3,251,223	6,521,869
Exports:								
Ceramics	2,530	--	4,512	7,042	2,480	--	2,447	4,927
Foundry sand; grogs, crudes, other refractories	310	320,097	--	320,407	308	298,760	--	299,068
Paint	[r]654	--	[r]29,496	30,150	--	--	25,494	25,494
Paper coating	--	--	580,435	580,435	--	--	691,446	691,446
Paper filling	3,006	--	52,859	55,865	5,620	--	72,399	78,019
Plastics	--	--	23,324	23,324	--	--	21,997	21,997
Rubber	47,354	--	843	48,197	44,554	--	498	45,052
Other	[r]40,378	[r]77,256	[r]200,094	317,728	15,744	--	175,377	191,121
Total	[r]94,232	[r]397,353	[r]891,563	1,383,148	68,706	298,760	989,658	1,357,124
Grand total	[r]1,578,781	[r]2,138,153	[r]4,043,666	7,760,600	1,558,386	2,079,726	4,240,881	7,878,993

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Includes high-temperature calcined.
[2]Includes low-temperature calcined and delaminated.
[3]Includes soil conditioners and mulches.
[4]Revised to zero.
[5]Incomplete total; remainder included with totals for specific uses.

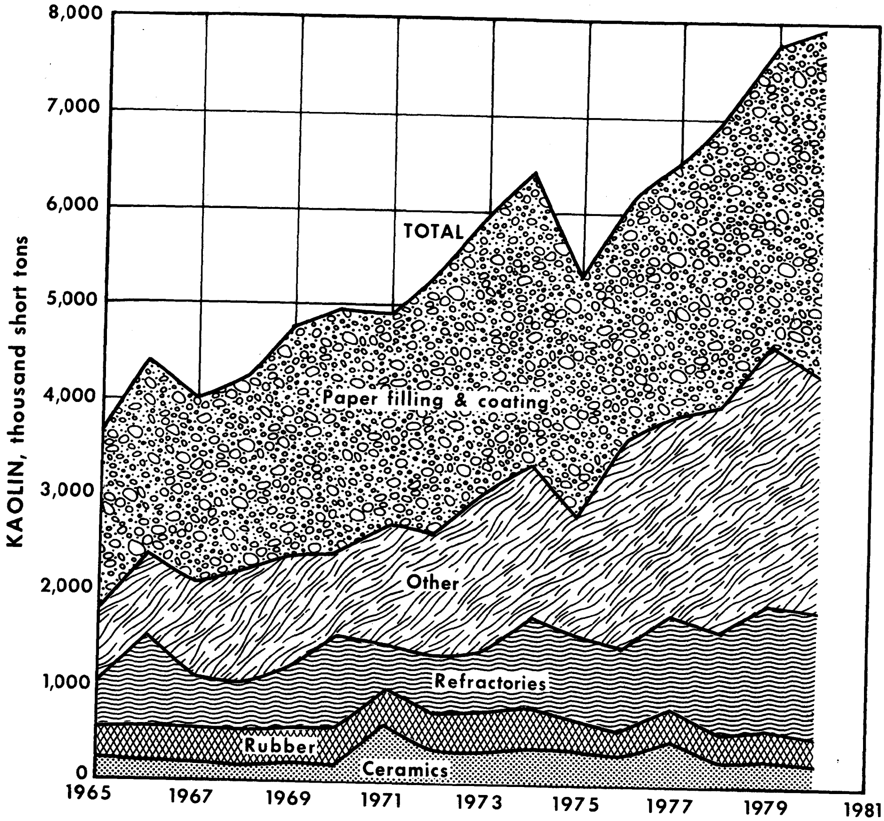

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

BALL CLAY

Reported production for domestically mined ball clay in 1980 decreased 9%, while value increased 3%. Tennessee provided 68% of the Nation's output, followed in decreasing order by Kentucky, Mississippi, Texas, Maryland, New York,[3] California, and Arizona. Production in Kentucky and Mississippi increased over that reported in 1979; production in Maryland and Tennessee decreased; Texas and New York remained about the same.

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware. The clays are of sedimentary origin and consist mainly of the clay mineral kaolinite and sericite micas.

During 1980, Old Hickory Clay Co. and Kentucky-Tennessee Clay Co. completed expansions in their overall production capacities. Old Hickory's expansion at its Mayfield, Ky., facility reportedly increased its production capability about 30%.

The average unit value for ball clay reported by domestic producers rose in 1980 to $30.03 per ton, an increase of $3.57 per ton. Chemical Marketing Reporter, December 29, 1980, listed ball clay prices unchanged from those of 1979, as follows:

Domestic, airfloated, bags, carload lots, Tennessee, per ton	$18.00-$22.00
Domestic, crushed, moisture-repellent, bulk, carload lots, Tennessee, per ton	8.00- 11.25
Imported, airfloated, bags, carload lots, Atlantic ports, per ton	70.00
Imported, lump, bulk, Great Lakes, per ton	40.50

Ball clay exports in 1980 amounted to 211,000 short tons valued at $6.4 million, compared with 169,000 tons worth $5.3 million in 1979. Tonnage and value increased 25% and 21%, respectively, compared with those of 1979. Unit value decreased $0.92 per ton. These shipments were made to 30 countries. The major recipients were Mexico, 66%, and Canada, 24%.

Ball clay imports, largely from Canada and the United Kingdom, decreased in quantity but increased in value from 11,239 tons valued at $666,000 in 1979 to 9,364 tons valued at $1.061 million in 1980.

Table 12.—Ball clay sold or used by producers in the United States, by type and State

Year and State	Airfloat		Unprocessed		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1979						
Tennessee	504,679	$14,662,462	257,458	$5,000,576	762,137	$19,663,038
Other	[1]149,588	[1]4,881,138	[2]75,287	[2]1,575,789	224,875	6,456,927
Total	654,267	19,543,600	332,745	6,576,365	987,012	26,119,965
1980						
Tennessee	374,144	12,419,212	231,440	5,112,716	605,584	17,531,928
Other	[1]208,396	[1]7,701,968	[2]79,644	[2]1,610,230	288,040	9,312,198
Total	582,540	20,121,180	311,084	6,722,946	893,624	26,844,126

[1]Includes Kentucky, Maryland, Mississippi, and Texas.
[2]Includes Arizona, California, Kentucky, Mississippi, New York, and Texas.

Table 13.—Ball clay sold or used by producers in the United States, by kind and use

(Short tons)

Use	1979			1980		
	Airfloat	Unprocessed	Total	Airfloat	Unprocessed	Total
Adhesives	549	--	549	1,614	--	1,614
Animal feed	W	--	W	W	--	W
Brick, face	--	W	W	--	W	W
China and dinnerware	44,476	--	44,476	37,308	--	37,308
Crockery and other earthenware	22,506	--	22,506	13,525	--	13,525
Drilling mud	W	--	W	W	--	W
Electrical porcelain	28,250	6,810	35,060	28,159	--	28,159
Fiberglass and catalysts (oil-refining)	71,213	--	71,213	48,860	--	48,860
Firebrick, block, shapes	W	W	8,471	--	15,255	15,255
Glazes, glass, enamels	W	W	1,644	W	W	2,808
Grogs and crudes, high-alumina; mortar and cement refractories	86,249	2,521	88,770	79,989	19,630	99,619
Kiln furniture	W	W	2,187	W	W	2,505
Paper coating and filling	13,082	--	13,082	13,874	--	13,874
Pesticides and related products	732	--	732	898	--	898
Pottery	105,559	141,502	247,061	129,631	92,150	221,781
Rubber	W	--	W	W	--	W
Sanitary ware	63,632	87,973	151,605	64,265	20,171	84,436
Tile:						
Floor and wall	84,406	29,034	113,440	53,299	37,289	90,588
Other	6,042	--	6,042	--	--	--
Miscellaneous	54,786	15,030	[1]57,514	38,837	68,944	[1]102,468
Exports	72,785	49,875	122,660	72,281	57,645	129,926
Total	654,267	332,745	987,012	582,540	311,084	893,624

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Incomplete total; difference included in totals for specific uses.

FIRE CLAY

Fire clay sold or used by domestic producers in 1980 was reported at 2,095,361 tons valued at $36.0 million. Fire clay is defined as detrital material, either plastic or rocklike, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures of 1,500° C or higher. Fire clay is basically kaolinite but usually contains other materials such as diaspore, ball clay, bauxite clay, and shale. Fire clays commonly occur as underclay below coal seams and are generally used for refractories. Some fire clay was previously reported in other end uses.

In 1980, the Kaiser Refractories Div. of Kaiser Aluminum and Chemical Corp. closed its 90,000-ton-per-year high-alumina and clay-based refractories plant at Frostburg, Md. The Frostburg facility will be used primarily as a distribution center for eastern markets while production is shut down.

Fire clay production was reported in 1980 from mines in 17 States. The first five States in rank—Missouri, Ohio, Pennsylvania, West Virginia, and Alabama—accounted for 90% of the total domestic output.

Exports of fire clay increased from 224,000 tons worth $13.6 million in 1979 to 308,000 tons valued at $17.9 million in 1980. Fire clay exports increased 38% in tonnage and 32% in value. The price of exported fire clay decreased by $2.22 to $58.28 per ton, indicating a larger percentage of standard quality shipped.

Fire clay was exported to 36 countries in 1980, with Mexico, the Federal Republic of Germany, Japan, and Canada receiving 28%, 18%, 15%, and 13%, respectively. No imports of fire clay were reported during 1980.

There are no price quotations in domestic journals for fire clay, but the per-ton value reported by producers ranged from $3.81 to $23.52. The reported average unit value for fire clay produced in the United States increased 7% from $16.09 per ton in 1979 to $17.19 in 1980.

Table 14.—Fire clay sold or used by producers in the United States, by State[1]

State	1979		1980	
	Short tons	Value	Short tons	Value
Alabama	247,257	$4,480,804	223,146	$4,379,015
Colorado	41,897	259,715	24,128	179,599
Illinois	26,519	249,279	19,758	204,298
Indiana	1,062	15,491	256	2,825
Kentucky	60,284	476,735	55,457	475,568
Missouri	799,086	15,193,699	699,512	12,807,753
Montana	503	2,515	535	2,670
New Jersey	15,044	286,234	11,239	222,880
Ohio	673,303	6,290,961	410,312	5,023,064
Pennsylvania	704,714	13,921,224	309,014	7,268,546
Texas	58,398	724,484	56,731	743,454
Other[2]	304,276	5,277,852	285,273	4,712,462
Total	2,932,343	47,178,993	2,095,361	36,022,134

[1]Refractory uses only.
[2]Includes California, Idaho, New Mexico, Utah, Washington, West Virginia.

BENTONITE

Bentonite production in 1980 decreased 5% in tonnage and increased 8% in value over that of 1979. A general decrease was noted in domestic consumption, particularly in foundry sand and animal feed; waterproofing and sealing showed a major increase. An increase was also noted in bentonite exports.

Bentonite was produced in 14 States in 1980. Increased bentonite production was reported for Arizona, Colorado, Montana, Texas, and Utah. Production decreased in Alabama, California, Idaho, Mississippi, Nevada, Tennessee, and Wyoming, and remained the same in Kansas.

Generally, the high-swelling or sodium bentonites are produced chiefly in Wyoming, Montana, and California. The calcium or low-swelling bentonites are produced in the other States.

During 1980, all the major western and southern bentonite producers either announced planned expansion or had expansions underway. With the successful conversion to coal from oil and gas firing in dryers, the industry was exploring the practicality of augmenting coal with wood chips as a fuel.

On December 29, 1979, Chemical Marketing Reporter quoted bentonite prices as rising. Domestic material, 200 mesh, bags, carload lots, f.o.b. mines, was priced from $28 to $30 per ton; and imported Italian, white, high-gel material, bags, 5-ton lots, ex-warehouse, was not listed. The average unit value reported by domestic producers for

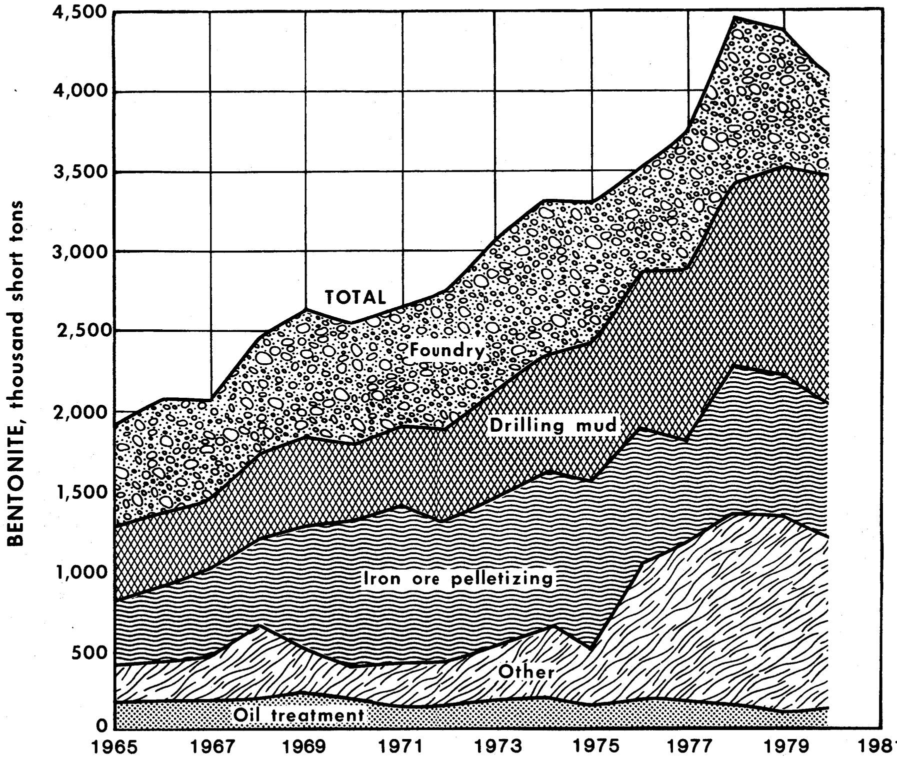

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

bentonite sold or used in 1980 was $27.54, an increase of $3.45 from the $24.09 average of 1979. Per-ton values reported in the various producing States ranged from $8.43 to $70.04, but the average value reported by the larger producers was near the Montana average figure of $36.54.

Bentonite exports in 1980 increased from 853,000 tons in 1979 to 898,000 tons; value increased from $55.3 million in 1979 to $62.2 million in 1980. This increase in value was the result of an increase in the unit value of exported bentonite from $64.77 per ton in 1979 to $69.27 per ton in 1980. This increase in per-ton value of exports was attributed to the return to a larger percentage of the higher cost drilling muds and foundry sand grades shipped. Domestic bentonite producers were facing increased competition in foreign markets. Bentonite from the Greek Island of Milos was being blended with the U.S. clay for pelletizing Canadian taconite ores on a large scale.

Bentonite was exported to 82 countries in 1980. The major recipients were Canada, 46%; the Netherlands, 9%; Singapore and Japan, 7% each; the United Kingdom, 6%; and others, 26%. Domestic bentonite producers reported that the end uses of their exports were drilling mud (53%) and foundry sand (37%), with iron ore pelletizing and others, the remaining (10%).

Bentonite imports in 1980, including chemically activated material, totaled 5,285 tons valued at $2.656 million, compared with 2,577 tons valued at $800,000 in 1979. The 5,130 tons of chemically activated bentonite was imported from four countries, with Canada supplying 51%; the Federal Republic of Germany, 28%; Mexico, 16%; and the United Kingdom, the remaining 5%.

Table 15.—Bentonite sold or used by producers in the United States, by type and State

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1979						
Arizona	W	W	W	W	28,176	$330,564
California	13,550	$391,053	67,610	$4,752,171	81,160	5,143,224
Colorado	1,000	14,100	W	W	W	W
Mississippi	318,078	7,127,584	--	--	318,078	7,127,584
Montana	--	--	385,758	11,362,748	385,758	11,362,748
Nevada	--	--	34,094	612,919	34,094	612,919
Texas	65,824	3,241,749	--	--	65,824	3,241,749
Utah	840	16,800	7,424	31,666	8,264	48,466
Wyoming	--	--	3,285,002	74,405,909	3,285,002	74,405,909
Other	[1]176,200	[1]3,744,269	[2]66,695	[2]827,582	[3]215,719	[3]4,255,387
Total	575,492	14,535,555	3,846,583	91,992,995	4,422,075	106,528,550
1980						
Arizona	35,155	715,682	--	--	35,155	715,682
California	44,935	2,594,650	19,431	787,262	64,366	3,381,912
Colorado	1,510	18,000	35,450	567,200	36,960	585,200
Kansas	--	--	30,000	368,700	30,000	368,700
Mississippi	274,998	6,233,997	--	--	274,998	6,233,997
Montana	--	--	606,130	22,142,532	606,130	22,142,532
Nevada	--	--	11,201	498,813	11,201	498,813
Texas	108,602	7,058,484	50	2,500	108,652	7,060,984
Utah	--	--	8,504	71,708	8,504	71,708
Wyoming	--	--	2,877,040	70,682,075	2,877,040	70,682,075
Other	[1]116,413	[1]2,763,433	[2]15,200	[2]729,960	[3]131,613	[3]3,493,393
Total	581,613	19,384,246	3,603,006	95,850,750	4,184,619	115,234,996

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Idaho, and data indicated by symbol W.
[2]Includes Idaho (1980), Kansas (1979), South Dakota (1980), Tennessee, and data indicated by symbol W.
[3]Incomplete total; difference included with totals for specific States.

Table 16.—Bentonite sold or used by producers in the United States, by type and use

(Short tons)

Use	1979			1980		
	Non-swelling	Swelling	Total	Non-swelling	Swelling	Total
Domestic:						
Adhesives	([1])	1,219	1,219	W	W	3,696
Animal feed	70,234	113,813	184,047	64,057	106,379	170,436
Brick, face	W	--	W	W	--	W
Catalysts (oil refining)	4,511	--	4,511	8,722	--	8,722
Cement, portland	--	W	W	--	W	W
Drilling mud	14,658	1,261,477	1,276,135	59,061	1,374,150	1,433,211
Fertilizers	4,764	--	4,764	--	4,658	4,658
Filtering, clarifying, decolorizing:						
Animal oils and mineral oils and greases	91,044	6,784	97,828	99,930	2,787	102,717
Vegetable oils	18,508	--	18,508	9,242	--	9,242
Foundry sand	300,576	595,697	896,273	228,550	403,530	632,080
Glazes, glass, enamels	--	W	W	--	W	W
Gypsum products	--	W	W	--	--	--
Medical, pharmaceutical, cosmetic	--	3,295	3,295	--	2,451	2,451
Paint	--	13,905	13,905	--	14,111	14,111
Pelletizing (iron ore)	13,504	888,204	901,708	849	861,538	862,387
Pesticides and related products	1,403	2,787	4,190	3,251	2,694	5,945
Pet waste absorbent	--	W	W	W	--	W
Waterproofing and sealing	r2,032	r73,661	75,693	2,160	89,494	91,654
Miscellaneous	r32,763	r201,141	233,904	86,043	126,941	[2]209,288
Total	553,997	3,161,983	3,715,980	561,865	2,988,733	3,550,598
Exports:						
Drilling mud	--	180,067	180,067	1,782	331,302	333,084
Foundry sand	16,964	250,066	267,030	12,646	222,681	235,327
Pelletizing (iron ore)	--	172,515	172,515	--	--	--
Other	4,531	81,952	86,483	5,320	60,290	65,610
Total	21,495	684,600	706,095	19,748	614,273	634,021
Grand total	575,492	3,846,583	4,422,075	581,613	3,603,006	4,184,619

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Revised to zero.
[2]Incomplete total; difference included with total for each specific use.

FULLER'S EARTH

Production of fuller's earth in 1980 decreased 2% both in quantity and value. The unit value assigned by domestic producers decreased $0.17 in 1980 to $51.97 per ton.

Fuller's earth production was reported from operations in nine States. The two top producing States, Georgia (42%) and Florida (27%), accounted for 69% of the domestic production. Georgia, Illinois, and Nevada showed slight gains in production while production in Florida, Mississippi, Tennessee, South Carolina, and Texas decreased slightly. Missouri reported no production for 1980.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate decolorizing and purifying properties.

Production from the region that includes Attapulgus (Decatur County), Ga., and Quincy (Gadsden County), Fla., is composed predominantly of the lath-shaped amphibole clay mineral attapulgite. Most of the fuller's earth produced in other areas of the United States contains varieties of montmorillonite.

In 1980, Oil Dri Corp. completed expansions at its Ochlocknee, Ga., and Ripley, Miss., operations. The Ripley expansion was a major enlargement of its pesticide carrier capacity. Oil Dri and Lowes, Inc., expanded their operations into the west coast markets by acquiring diatomite absorbent producers in Oregon and California, respectively.

Attapulgite, a fuller's earth-type clay, finds wide application in both the absorbent and thickening areas. Mineral thickeners are used in such diverse markets as paints, joint compound cements, polishes, and plastics. The thixotropic properties of attapulgite clays provide the important thickening and viscosity controls necessary for suspending solids.

Prices for fuller's earth were not publicly quoted in 1980, but the value per ton for attapulgite reported by producers ranged from $54.30 to $57.14; montmorillonite prices ranged from $31.90 to $55.

In 1980, fuller's earth was exported to 44 countries; exports increased from 74,000 tons in 1979 to 115,000 tons in 1980. The unit value of exported fuller's earth increased $10.32 to $80.23 per ton. The major recipients were Canada, 44%; the Netherlands, 29%; the United Kingdom, 7%; and other countries, the remaining 20%.

Imports of fuller's earth in 1980 were 298 tons valued at $93,000, all from the United Kingdom.

Table 17.—Fuller's earth sold or used by producers in the United States, by type and State

Year and State	Attapulgite		Montmorillonite		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1979						
Florida	490,843	$31,022,860	--	--	490,843	$31,022,860
Georgia	432,500	23,088,346	188,661	$5,687,180	621,161	28,775,526
Other	[1]35,954	[1]1,710,602	[2]420,289	[2]20,252,976	456,243	21,963,578
Total	959,297	55,821,808	608,950	25,940,156	1,568,247	81,761,964
1980						
Florida	417,358	23,849,643	--	--	417,358	23,849,643
Georgia	425,084	23,081,875	223,718	9,585,352	648,802	32,667,227
Other	[1]83,552	[1]2,375,494	[2]384,091	[2]20,831,653	467,643	23,207,147
Total	925,994	49,307,012	607,809	30,417,005	1,533,803	79,724,017

[1]Includes Nevada and Texas.
[2]Includes Illinois, Mississippi, Missouri (1979), Nevada, South Carolina, Tennessee, and Utah.

Table 18.—Fuller's earth sold or used by producers in the United States, by type and use

(Short tons)

Use	1979 Atta-pulgite	1979 Montmoril-lonite	1979 Total	1980 Atta-pulgite	1980 Montmoril-lonite	1980 Total
Domestic:						
Adhesives	1,014	--	1,014	969	--	969
Animal feed	696	--	696	290	20	310
Drilling mud	81,232	23,578	104,810	158,203	1,453	159,656
Fertilizers	62,434	19,796	82,230	61,185	24,532	85,717
Filtering, clarifying, and decolorizing mineral oils and greases	23,210	--	23,210	22,318	--	22,318
Medical, pharmaceutical, cosmetic	122	--	122	82	--	82
Oil and grease absorbents	279,831	165,174	445,005	235,667	158,796	394,463
Paint	3,902	--	3,902	3,732	--	3,732
Paper filling	746	1,773	2,519	2,503	--	2,503
Pesticides and related products	131,449	67,847	199,296	108,243	72,351	180,594
Pet waste absorbent	202,290	250,177	452,467	169,308	253,875	423,183
Rubber	162	--	162	362	--	362
Miscellaneous	49,411	49,398	98,809	24,651	54,994	79,645
Total	836,499	577,743	1,414,242	787,513	566,021	1,353,534
Exports:						
Drilling mud	109	--	109	6	--	6
Oil and grease absorbents	64,712	20,457	85,169	53,805	24,732	78,537
Pet waste absorbent	37,049	9,100	46,149	70,770	10,741	81,511
Miscellaneous	20,928	1,650	22,578	13,900	6,315	20,215
Total	122,798	31,207	154,005	138,481	41,788	180,269
Grand total	959,297	608,950	1,568,247	925,994	607,809	1,533,803

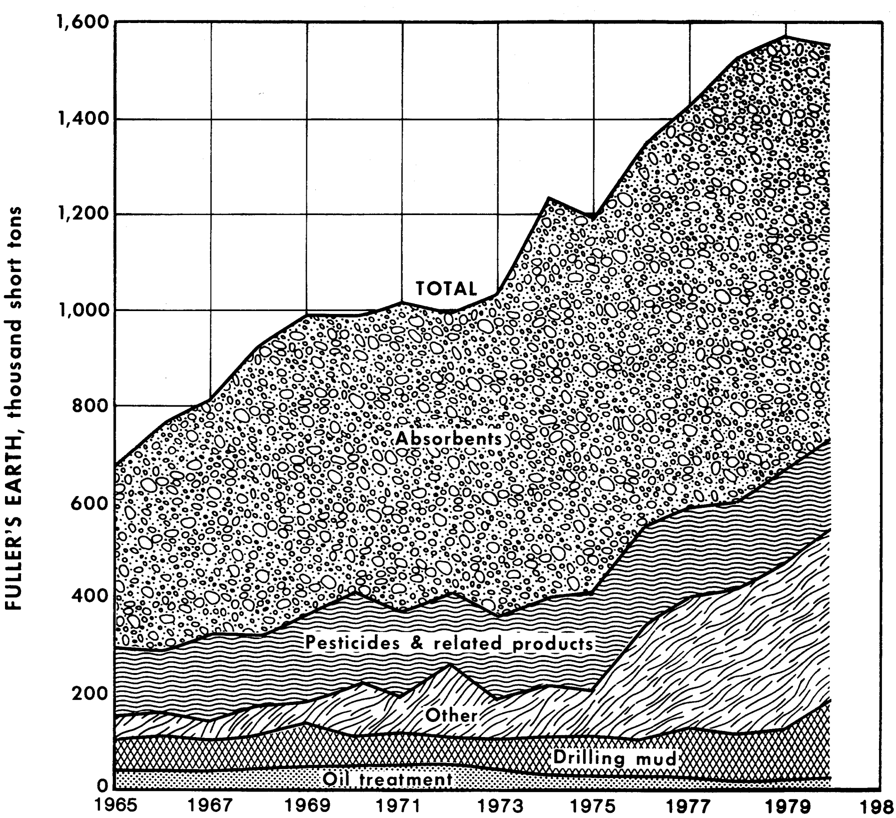

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

COMMON CLAY

Domestic production of common clay and shale in 1980 totaled 32.5 million tons valued at $114.7 million. Common clay and shale represented 66% of the quantity and 13% of the value of the total clays in 1980. Domestic clays and shales are for the most part used by the producer in fabricating or manufacturing products. Less than 10% of the total clay and shale output was sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico in 1980 was $3.53 per short ton, $0.24 more than in 1979. The range in unit value reported for the bulk of the output was from $1.66 to $15.38 per ton.

Common clay is defined as a clay or claylike material which is sufficiently plastic to permit ready mold and vitrification below 1,100° C. Shale is consolidated sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. These materials are used in the manufacture of structural clay products, such as brick and drain tile, portland cement clinker, and bloated lightweight aggregate.

Increased production capacities, new plants, and acquisitions and/or mergers slowed during 1980. Ochs Brick and Tile Co. lit a new 15-brick-wide tunnel kiln and placed onstream an automated plant capable of producing 80,000 bricks per day at its Springfield, Minn., location. Interstate Brick and Tile Co., West Jordan, Utah, started a new $12 million expansion to be completed by mid-1981 to boost production from 110 million brick equivalent per year to 190 million. Included in the enlargement was a new 36-brick-wide by 500-foot-long top-fired tunnel kiln, reportedly the widest in the United States. The kiln was to be equipped for natural gasfiring with provisions for future conversion to solid fuels.

In Texas, Brazos Brick Co., a division of U.S. Brick, Inc., opened a new plant in Mineral Wells capable of producing 225,000 high-quality bricks daily. The automated plant has the facilities for producing both regular- and king-size brick, and it is planned that modular and jumbo-size brick will eventually be added to the product line. Energy conservation was a major consideration in plant design, and the Brazos plant is claimed to use less than 1,000 Btu per pound of brick produced. Texas Industries Inc. added a third kiln to its lightweight aggregate production facility in Dallas. Also in Texas, the Elgin-Butler Brick Co. in Austin entered into an agreement that could lead to the construction of the first commercial lignite briquet gasification plant in the United States. The plant will be designed to produce fuel gas for the brick and ceramic kilns of Elgin-Butler which recover lignite in the process of clay mining in the central part of the State. The plant design was to be completed by May 1981.

In acquisition news, Pacific Coast Building Products, Inc., Sacramento, Calif., announced intention to purchase the H. C. Muddox Co., a locally owned brick and clay products manufacturer, for about $5 million. In 1976, Pacific acquired the Gladding McBean plant in Lincoln, less than 30 miles from Sacramento.

The output of the energy-intensive common clay and shale industry was hindered again by shortages of fuel and labor; also, lower construction rates depressed demand in 1980. Industrywide attention was focusing on coal, sawdust, and woodchip firing in the Northwest and Southeast as a possible escape from the high cost and shortages of oil and gas.

Export data on common clay and shale are not collected by the U.S. Department of Commerce. Most countries have local deposits of either clays or shales that are adequate for manufacturing structural clay products, cement clinker, and lightweight aggregates, and thus have no need to import such materials.

Table 19.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1979 Short tons	1979 Value	1980 Short tons	1980 Value
Alabama	1,858,715	$8,622,506	1,385,485	$6,435,401
Arkansas	912,215	1,345,165	936,609	1,555,393
California	2,389,278	11,388,355	2,422,097	12,580,201
Colorado	479,365	2,457,515	275,354	1,458,479
Connecticut	111,578	434,701	92,188	481,692
Delaware	10,800	8,640	--	--
Florida	159,076	285,014	165,683	314,128
Georgia	1,642,189	4,710,161	1,322,574	4,187,253
Illinois	515,319	2,106,156	439,463	1,714,575
Indiana	1,184,278	2,325,220	931,765	1,926,675
Iowa	869,676	2,883,074	753,879	2,555,129
Kansas	1,060,871	2,635,856	855,780	1,956,105
Kentucky	734,090	2,782,261	692,303	3,216,353
Louisiana	415,516	6,073,392	379,838	5,841,314
Maine	90,030	163,004	77,924	173,803
Maryland	974,831	2,854,067	733,152	2,267,089
Massachusetts	155,547	367,070	210,457	870,273
Michigan	2,072,107	7,429,990	1,981,957	7,211,572
Minnesota	135,474	1,904,984	93,660	1,206,310
Mississippi	1,221,404	3,161,494	1,054,446	3,291,888
Missouri	1,497,161	4,350,426	1,040,718	2,539,693
Montana	38,178	142,530	19,062	55,016
Nebraska	156,144	453,984	153,781	456,295
New Jersey	51,947	272,722	52,215	301,803
New Mexico	74,307	124,242	59,866	113,910
New York	835,581	3,027,177	596,182	2,479,416
North Carolina	3,308,345	8,385,151	2,851,749	7,307,603
Ohio	2,700,331	7,204,029	2,303,746	6,473,395
Oklahoma	948,662	1,999,129	971,625	2,249,374
Oregon	139,188	262,740	171,690	321,214
Pennsylvania	1,763,164	6,178,081	1,340,577	4,843,644
Puerto Rico	259,722	555,757	290,866	677,050
South Carolina	1,504,744	4,149,283	1,552,821	4,333,397
South Dakota	205,469	291,506	168,664	283,080
Tennessee	697,069	1,304,844	499,809	1,171,215
Texas	3,610,246	11,548,394	3,475,351	13,265,270
Utah	340,653	1,076,631	348,544	1,229,612
Virginia	1,058,552	3,512,044	761,632	3,172,455
Washington	338,762	1,549,254	301,100	1,571,409
West Virginia	330,309	591,668	290,955	642,183
Wyoming	186,271	690,193	203,644	829,823
Other[2]	241,639	1,126,707	235,626	1,139,756
Total	37,278,803	122,735,117	32,494,837	114,700,246

[1]Includes Puerto Rico.
[2]Includes Arizona, Idaho, Nevada, New Hampshire, North Dakota, and Wisconsin.

CONSUMPTION AND USES

The manufacture of heavy clay products (building brick, sewer pipe, and drain, roofing, structural, terra cotta, and other tile), portland cement clinker, and lightweight aggregate accounted for 33%, 20%, and 11%, respectively, of the total domestic consumption for 1980. In summary, 64% of all clay produced in 1980 was consumed in the manufacture of these clay- and shale-based construction materials. The utilization of clays in 1980 for heavy clay products and portland cement decreased 18% and 9%, respectively, from that reported in 1979.

Heavy Clay Products.—The value reported for shipments of heavy clay products for 1980 decreased 10% to $1,062 million from the 1979 value of $1,179 million. Trends in the various product categories were less consistent. Thousand-unit counts for building or common face brick decreased 19% in 1980 from that shipped in 1979; shipments of glazed and unglazed ceramic tile and glazed brick decreased 18%; and shipments of clay floor and wall tile increased 3%. The tonnage of unglazed structural tile increased 48%, and vitrified clay sewer pipe and fittings shipped during the year decreased 23%. The value of these shipments decreased 17% for building brick and clay and increased 5% for floor and wall tile. The value decreased 9% for clay sewer pipe and increased 75% for the structural tiles.

Lightweight Aggregate.—Consumption of clay and shale in the making of lightweight aggregate decreased in 1980 to 5.44 million tons. This was a 4% decrease from the 5.68

million tons used in 1979. This small decrease was attributed to a downturn in construction rates, but uses in the newer markets, such as running tracks, golf courses, potting plants, and a host of other horticultural applications, continued growing.

The tonnage of raw material mentioned in tables 20 and 23 for lightweight aggregate production refers only to clay and shale and does not include the quantity of slate and blast furnace slag similarly used. In 1980, 503,436 tons of slate was expanded for lightweight aggregate, a 15% decrease from the 1979 figure of 590,262 tons. The amount of slag used for lightweight concrete aggregate and in block manufacture decreased 76% from 1.538 million tons in 1979 to 369,000 tons in 1980.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, kaolin, and bentonite accounted for 49%, 34%, and less than 1%, respectively, of the total clays used for this purpose. Bentonite was used primarily as a bonding agent in proprietary foundry formulations. Minor tonnages of ball clay, fuller's earth, and common clay and shale (the remaining 16%) were also used, primarily as bonding agents.

The tonnage used for refractories in 1980 constituted 8% of the total clays produced. This slight decrease in the use of clay-based refractories in 1979 continued in 1980, reversing an upward trend that had continued for 7 prior years. The previous increases were due primarily to both the continued expansion in refractory aggregate production and an upsurge in the manufacturing of more conventional brick-type refractories. The decline in 1980 was attributable to the steelmaking decline. Refractory aggregates are used mostly in plastic, gunning, ramming, and castable mixes.

Filler.—All clays are used to some extent as fillers in one or more areas of use. Kaolin, fuller's earth, and bentonite are the principal filler clays. Kaolin was used in the manufacture of a large number of products, such as paper, rubber, paint, and adhesives. Fuller's earth was used primarily in pesticides and fertilizers. Clays in pesticides and fertilizers are used either as carriers, diluents, or prilling agents. Bentonites were used mainly in animal feed.

In 1980, 9% of the clay produced was used in filler applications. Of all the clay used for these purposes, kaolin accounted for 88%; fuller's earth, 6%; and bentonite, 4%. Ball clay, common clay and shale, and fire clay accounted for the remaining 2%. The total amount of kaolin consumed by this end-use category increased 1%. In the individual kaolin categories, a 64% increase was noted for gypsum products, a 16% increase for paper coating, and a 19% decrease in rubber use. Increases were observed for adhesives (17%) and fertilizers (16%), while plastics decreased 9%. Total quantity of fuller's earth used in insecticides and fungicides decreased 9%.

Absorbent Uses.—Absorbent uses for clays consumed 923,878 tons, or 2% of the total 1980 clay production. Demand for absorbents in 1980 decreased 13% from that reported for 1979. Fuller's earth was the principal clay used in absorbent applications; 53% of the entire output was consumed for this purpose. Bentonite was used to a lesser degree. Demand for clays in pet waste absorbent, representing 54% of the 1980 absorbent demand, decreased 7% from that reported for 1979. Demand for use in floor absorbents, chiefly to absorb hazardous oily substances, represented the remaining 46% of absorbent demand and decreased 19% from the 1979 figure.

Drilling Mud.—Demand for clays in rotary-drilling muds increased 15% in 1980 from 1,381,113 tons in 1979 to 1,593,334 tons. The Natural Gas Policy Act of 1978 should continue to spur exploratory gas well drilling. To a lesser degree, oil well drilling has been stimulated both by the oil price increases and by Presidential Executive Order 12287, January 28, 1981, which not only advanced the price deregulation of crude oil, originally scheduled for September 1981, but also freed gasoline and propane from price regulations. This freeing of crude oil prices should also spur expansion and exploration activities. Drilling muds consumed 3% of the entire 1980 clay production. Swelling-type bentonite is the principal clay used in drilling mud mixes, although fuller's earth or nonswelling bentonite is also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used for this purpose. Small amounts of ball clay and kaolin were used in specialized formulations.

Floor and Wall Tile.—Common clay and shale, ball clay, kaolin, and fire clay, in order of demand, were used in manufacturing floor, wall, and quarry tile. This tile end-use category accounted for less than 1% of the total clay production in 1980. Demand in 1980, 279,767 tons, increased 10% from that of 1979.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming hard iron ore pellets.

Demand decreased in 1980 to 862,387 tons. This decrease in the use of bentonite for iron ore pelletizing, reflecting a downturn in taconite pellet production because of lower steel demand, was compounded by inroads made by cheaper foreign bentonites into a traditional U.S. clay market. Of the total bentonite produced in 1980, about 24% of the swelling variety was consumed for this purpose. U.S. deposits continued to be the major source for swelling bentonites.

Ceramics.—The total demand for clays in the manufacture of pottery, sanitary ware, china and dinnerware, and related products (excluding clay flower pots) accounted for 2% of the total 1980 clay output. The total clay demand, principally ball and kaolin clays, decreased from approximately 1,211,539 tons in 1979 to approximately 842,050 tons in 1980.

Table 20.—Clays sold or used by producers in the United States in 1980, including Puerto Rico, by kind and use

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total
Adhesives	1,614	3,696	--	--	969	75,676	75,676	81,955
Alum (aluminum sulfate) and other chemicals	--	20,637	--	--	W	351,501	W	369,346
Animal feed	W	170,436	--	--	310	16,774	W	187,520
Building brick:								
Common	--	--	2,600,227	--	--	30,271	--	2,630,498
Face	W	W	12,283,693	17,914	--	227,683	32,870	12,562,160
Catalysts (oil-refining)	W	8,722	W	--	--	67,082	44,933	120,737
Cement, portland	--	W	9,609,380	--	--	18,947	W	9,630,127
China and dinnerware	37,308	--	--	--	--	36,055	--	73,363
Crockery and other earthenware	13,525	--	5,356	--	--	8,540	--	27,421
Drilling mud	W	1,433,211	--	--	159,656	W	467	1,593,334
Electrical porcelain	28,159	--	W	--	--	34,337	W	62,496
Fertilizers	--	4,658	--	--	85,717	41,595	--	131,970
Fiberglass, mineral wool, other insulation	W	W	--	--	--	184,920	38,942	223,862
Filtering, clarifying, decolorizing:								
Animal oil	--	90,261	--	--	--	W	W	90,261
Mineral oils and greases	--	12,456	--	--	22,318	--	--	34,774
Vegetable oils	--	9,242	--	--	--	--	--	9,242
Firebrick, block, shapes	15,255	W	82,733	1,435,333	--	201,955	W	1,735,276
Flower pots	--	--	32,699	500	--	1,058	1,058	33,199
Flue linings and high-aluminum (minimum 50% Al_2O_3) refractories	9,008	--	73,625	168,295	--	45,591	--	289,350
Foundry sand	--	632,080	W	51,138	--	1,643	W	684,861
Glazes, glass, enamels	2,808	W	--	--	--	3,797	W	6,605
Grogs and crudes, refractory	1,051	W	--	73,543	--	809,861	W	884,455
Gypsum products	--	--	--	--	W	10,808	W	20,481
Ink	--	W	--	--	--	W	--	2,033
Kiln furniture	2,505	--	--	--	--	2,056	--	4,561
Lightweight aggregate:								
Concrete block	--	--	3,554,894	--	--	--	--	3,554,894
Structural concrete	--	W	1,357,060	--	--	--	W	1,357,060
Highway surfacing	--	--	346,107	--	--	--	--	346,107
Other	--	--	179,568	--	--	--	--	179,568
Linoleum and asphalt tile	4,910	--	1,434	--	--	11,744	--	18,088
Medical, pharmaceutical, cosmetic	--	2,451	--	--	82	1,990	--	4,523

See footnotes at end of table.

Table 20.—Clays sold or used by producers in the United States in 1980, including Puerto Rico, by kind and use —Continued

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total
Mortar and cement, refractory	89,560	W	285,449	263,483	W	40,210	51,479	728,481
Oil and grease absorbents	--	W	W	--	394,463	W	28,548	423,011
Paint	--	14,111	W	--	3,732	164,400	W	182,243
Paper coating	787	W	--	--	--	2,506,606	W	2,507,393
Paper filling	13,087	W	--	--	2,503	963,551	W	979,141
Pelletizing (iron ore)	--	862,387	--	--	--	W	W	862,387
Pesticides and related products	898	5,945	W	--	180,594	48,834	W	236,271
Pet waste absorbent	--	W	W	--	423,183	--	77,684	500,867
Plastics	--	W	--	--	W	59,333	2,644	61,977
Plug, tap, and wad	--	--	--	6,046	--	--	--	6,046
Pottery	221,781	--	258,805	12,013	--	28,247	--	520,846
Roofing granules	--	--	W	--	W	19,551	5,012	24,563
Rubber	W	W	--	--	362	277,114	53,335	330,811
Sanitary ware	84,436	--	--	--	--	132,237	--	216,673
Sewer pipe, vitrified	--	--	770,413	W	--	--	W	770,413
Tamping dummies	--	--	4,200	--	--	--	--	4,200
Tile:								
Drain	--	--	185,257	--	--	W	W	185,257
Floor and wall	90,588	W	164,816	W	--	23,203	1,160	279,767
Quarry	--	--	199,777	W	--	--	W	199,777
Roofing	--	--	57,348	--	--	--	--	57,348
Structural	--	--	42,655	--	--	W	W	42,655
Terra cotta	--	--	1,235	--	--	--	--	1,235
Waterproofing and sealing	--	91,654	W	--	--	694	W	96,884
Miscellaneous[2]	135,798	54,637	172,116	16,539	66,982	9,756	--	473,101
Undistributed	10,620	134,014	197,062	34,508	12,663	64,249	118,295	[3]93,446
Exports	129,926	634,021	28,928	16,049	180,269	1,357,124	--	2,346,317
Total	893,624	4,184,619	32,494,837	2,095,361	1,533,803	7,878,993	([4])	49,081,237

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Total of clays indicated by symbol W.
[2]Includes asphalt emulsion, graphite anodes, unknown uses, and data indicated by symbol W.
[3]Incomplete total; difference included with "Miscellaneous."
[4]Included with total for each specific use.

Table 21.—Shipments of principal structural clay products in the United States

Products	1976	1977	1978	1979	1980
Unglazed common and face brick:					
Quantity ... million standard brick	6,973	8,060	8,957	8,020	6,513
Value ... million	$461	$607	$765	$749	$625
Unglazed structural tile:					
Quantity ... thousand short tons	71	50	76	69	102
Value ... million	$3	$3	$4	$4	$7
Vitrified clay and sewer pipe fittings:					
Quantity ... thousand short tons	1,099	1,140	924	847	654
Value ... million	$123	$140	$126	$120	$109
Unglazed, salt-glazed, and ceramic-glazed structural facing tile, including glazed brick:					
Quantity ... million equivalent	62	63	58	56	46
Value ... million	$10	$11	$11	$11	$11
Clay floor and wall tile, including quarry tile:					
Quantity ... million square feet	259	291	299	314	323
Value ... million	$186	$233	$253	$295	$310
Total value[1] ... do	$784	$994	[r]$1,158	$1,179	$1,062

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 22.—Common clay and shale used in building brick production in the United States, by State

State	1979		1980	
	Short tons	Value	Short tons	Value
Alabama	701,542	$1,826,936	717,422	$2,308,673
Arizona and New Mexico	119,248	260,306	137,014	313,567
Arkansas	468,020	760,395	517,645	948,613
California	500,159	1,547,856	511,265	1,661,139
Colorado	447,600	2,325,290	254,542	1,364,979
Connecticut, Florida (1980), New Jersey (1979)	161,578	697,679	143,762	773,345
Delaware	10,800	8,640	--	--
Georgia	1,362,559	4,021,976	1,165,412	3,754,359
Idaho, Montana, Utah	107,135	522,764	85,396	475,020
Illinois	317,504	1,478,969	199,986	930,364
Indiana and Iowa	682,173	1,612,956	416,725	1,110,001
Kansas	220,629	425,635	189,954	394,413
Kentucky	266,955	808,311	186,048	784,326
Louisiana	139,516	273,392	125,838	253,314
Maine, Massachusetts, New Hampshire	149,256	339,722	163,516	803,712
Maryland and West Virginia	461,687	1,721,822	389,866	1,352,104
Michigan, Minnesota, Wisconsin	239,510	2,310,267	192,715	1,839,204
Mississippi	829,356	2,298,697	669,278	2,393,262
Missouri	218,411	672,756	146,700	457,146
Nebraska and North Dakota	165,356	419,284	175,373	477,325
New York	247,409	575,284	168,410	456,833
North Carolina	2,667,030	6,981,229	2,346,506	6,030,305
Ohio	1,400,467	3,519,424	1,036,304	2,584,711
Oklahoma	400,030	793,578	347,268	846,740
Oregon	42,438	73,185	33,300	62,496
Pennsylvania	1,427,168	4,811,100	1,109,867	3,800,961
South Carolina	978,527	2,731,157	753,116	2,223,396
Tennessee	479,281	828,994	279,073	544,007
Texas	1,771,786	5,775,762	1,588,407	5,556,020
Virginia	956,472	1,870,953	634,552	1,419,242
Washington	201,134	801,600	159,058	681,169
Wyoming	43,228	244,061	39,602	248,745
Total	18,183,964	53,339,980	14,883,920	46,849,491

Table 23.—Clay and shale used in lightweight aggregate production in the United States, by State and kind

State	Short tons					Total value
	Concrete block	Structural concrete	Highway surfacing	Other	Total	
1979						
Alabama and Arkansas	999,176	136,471	25,094	--	1,160,741	$5,775,898
California	298,082	299,382	--	67,331	664,795	5,848,595
Illinois, Indiana, Iowa	324,172	--	--	--	324,172	1,029,926
Kansas, Kentucky, Louisiana	466,032	161,738	85,496	7,870	721,136	7,740,970
Massachusetts and Minnesota	121,914	17,483	--	3,979	143,376	1,945,792
Mississippi	121,053	30,830	200,165	--	352,048	772,947
Missouri, Nebraska, North Carolina	364,831	134,000	12,150	--	510,981	1,882,236
Montana	9,475	--	--	--	9,475	15,160
New York	214,750	138,250	--	1,300	354,300	2,053,661
North Dakota, Ohio, Pennsylvania	251,105	638	5,225	--	256,968	939,327
Oklahoma	116,125	67,246	--	--	183,371	361,256
South Dakota, Utah, Washington	195,557	110,199	326	--	306,082	821,426
Texas	234,286	155,324	142,438	61,773	593,821	1,994,794
Virginia	97,000	1,000	--	2,000	100,000	1,638,000
Total	3,813,558	1,252,561	470,894	144,253	5,681,266	32,819,988
1980						
Alabama and Arkansas	610,569	122,118	21,558	--	754,245	3,342,777
California	270,568	311,861	--	66,965	649,394	6,357,224
Florida, Indiana, Iowa	377,492	26,800	10,349	--	414,641	1,217,314
Kansas, Kentucky, Louisiana	495,601	174,531	65,333	5,666	741,131	7,273,748
Maryland, Massachusetts, Minnesota	444,305	46,570	--	7,900	498,775	2,220,016
Mississippi, North Carolina, North Dakota	333,428	141,242	173,753	--	648,423	1,554,774
Montana and New York	168,600	134,750	--	1,500	304,850	1,750,451
Ohio, Oklahoma, Pennsylvania	293,858	75,957	100	--	369,915	858,507
South Dakota, Utah, Virginia	270,045	115,390	--	3,580	389,015	2,538,381
Texas	290,428	207,841	75,014	93,957	667,240	2,292,780
Total	3,554,894	1,357,060	346,107	179,568	5,437,629	29,405,972

Table 24.—Shipments of refractories in the United States, by kind

Product	Unit of quantity	1979 Quantity	1979 Value (thousands)	1980 Quantity	1980 Value (thousands)
CLAY REFRACTORIES					
Superduty fire clay brick and shapes	1,000 9-inch equivalent.	61,538	$79,446	51,188	$49,388
Other fire clay, including semisilica, brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.	do	162,517	89,193	129,646	78,003
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	83,869	135,948	73,210	135,317
Insulating firebrick and shapes	do	49,321	33,049	46,399	35,789
Ladle brick	do	192,965	52,463	162,034	47,168
Sleeves, nozzles, runner brick, tuyeres	do	46,239	35,514	39,312	29,682
Hot-top refractories	Short tons	22,932	6,244	11,261	1,355
Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items.	do	NA	21,843	16,823	23,740
Refractory bonding mortars	do	88,452	25,876	63,661	19,836
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	205,784	44,624	157,500	35,160
Castable refractories	do	153,821	33,084	142,266	34,064
Gunning mixes	do	87,800	15,396	82,297	14,251
Other clay refractory materials sold in lump or ground form.[3 4]	do	92,450	7,577	433,833	53,133
Total clay refractories		XX	580,257	XX	557,386
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent.	44,996	42,059	NA	NA
Magnesite and magnesite-chrome brick and shapes	do	95,670	285,792	67,285	218,364
Chrome and chrome-magnesite brick and shapes	do	10,843	36,603	9,193	34,507
Shaped refractories containing natural graphite	Short tons	25,408	36,435	23,179	34,509
Zircon and zirconia brick and shapes; other carbon refractories: Forsterite, pyrophyllite, dolomite, dolomite-magnesite molten-cast,[5] other brick and shapes.	1,000 9-inch equivalent.	39,624	168,287	17,285	109,237
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	4,651	19,333	3,524	17,106
Other extra-high (over 60%) alumina brick and fused bauxite, fused alumina, dense-sintered alumina shapes.[6]	do	9,043	44,163	2,103	39,972
Silicon carbide brick, shapes, kiln furniture	do	4,842	47,094	1,728	12,102
Refractory bonding mortar	Short tons	33,978	15,626	27,265	15,038
Hydraulic-setting nonclay refractory castables	do	44,098	25,615	44,676	25,887
Plastic refractories and ramming mixes	do	246,915	94,982	215,061	93,725
Gunning mixes	do	403,493	99,147	362,769	97,437
Dead-burned magnesia or magnesite[3 7]	do	630,962	127,198	515,949	130,045
Other nonclay refractory material sold in lump or ground form.[3]	do	665,789	64,441	567,611	57,454
Total nonclay refractories		XX	1,106,775	XX	885,383
Grand total refractories		XX	1,687,032	XX	1,442,769

NA Not available. XX Not applicable.
[1]Heated short of fusion; volatile materials are thus driven off in the presence of chemical changes, giving more stable material for refractory use.
[2]More or less plastic brick and materials which, after the addition of any water needed, are rammed into place.
[3]Materials for domestic use as finished refractories and all exported material.
[4]Including calcined clay, ground brick, and siliceous and other gunning mixes.
[5]Molten cast refractories are made by fusing refractory oxides and pouring the molten material into molds to form finished shapes.
[6]Completely melted and cooled, then crushed and graded for use in a refractory.
[7]Includes shipments to refractory producers for reprocessing in the manufacture of other refractories.

Table 25.—U.S. exports of clays by country and class in 1980

(Thousand short tons and thousand dollars)

Country	Ball clay		Bentonite		Fire clay		Fuller's earth		Kaolin		Clays, n.e.c.		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(2)	5	2	442	(2)	1	(2)	47	17	2,396	2	479	20	3,370
Australia	(2)	2	40	1,922	25	1,406	2	209	12	1,311	4	879	83	5,729
Belgium-Luxembourg	--	--	2	261	5	388	2	254	7	1,007	2	864	18	2,774
Brazil	(2)	30	13	2,689	--	--	(2)	14	6	1,153	2	346	21	4,232
Canada	51	1,552	416	22,502	39	2,555	51	3,729	222	15,788	62	5,782	841	51,908
Chile	(2)	42	8	1,115	--	--	(2)	35	2	403	(2)	43	10	1,638
Colombia	1	42	12	926	4	146	--	--	7	1,037	(2)	94	24	2,245
Ecuador	2	52	1	113	(2)	1	(2)	54	1	131	1	62	5	413
Finland	--	--	5	253	--	--	--	--	(2)	104	(2)	15	5	377
France	(2)	13	1	168	2	256	6	804	33	4,629	7	1,292	49	7,162
Germany, Federal Rebublic of	(2)	19	7	588	55	3,333	1	50	209	16,850	15	1,175	287	22,015
Guatemala	1	60	4	469	(2)	4	(2)	6	2	181	1	106	8	826
Hong Kong	--	--	1	93	--	--	(2)	17	1	70	1	75	3	255
Indonesia	(2)	45	14	711	(2)	4	--	--	1	167	(2)	62	15	989
Italy	--	--	1	490	11	847	1	159	176	17,324	7	707	196	19,527
Japan	3	175	59	4,966	45	3,574	(2)	35	406	38,183	77	8,628	590	55,561
Korea, Republic of	(2)	11	3	553	(2)	1	--	--	17	3,317	1	223	21	4,105
Mexico	140	3,567	10	2,073	87	2,836	(2)	4	88	7,702	28	2,942	353	19,124
Netherlands	--	--	79	4,261	(2)	29	33	2,044	53	4,477	28	1,831	193	12,642
New Zealand	(2)	4	(2)	64	--	--	1	114	1	96	(2)	121	2	401
Peru	--	--	1	163	(2)	7	--	--	5	583	1	63	7	816
Philippines	5	315	1	135	1	29	(2)	4	6	644	2	182	15	1,309
Saudi Arabia	--	--	28	1,246	(2)	10	4	443	--	--	(2)	107	32	1,806
Singapore	--	--	65	3,717	--	--	1	86	(2)	28	1	540	67	4,371
South Africa, Republic of	(2)	17	2	342	--	--	(2)	18	28	3,385	1	370	31	4,132
Spain	--	--	6	507	(2)	32	(2)	4	7	917	(2)	221	13	1,681
Sweden	(2)	10	(2)	33	6	523	(2)	9	12	1,208	4	614	22	2,397
Switzerland	(2)	2	(2)	74	(2)	6	(2)	12	3	533	10	623	13	1,250
Taiwan	1	69	7	981	5	261	(2)	7	27	3,247	7	526	47	5,091
Thailand	--	--	2	232	--	--	--	--	4	332	(2)	24	6	588

Trinidad	--	--	3	331	(2)	5	--	--	(2)	154	(2)	462	3	952
United Arab Emirates	--	--	2	617	--	--	(2)	23	--	--	(2)	161	2	801
United Kingdom	(2)	2	51	3,152	5	596	8	686	5	1,094	12	1,471	81	7,001
Venezuela	2	140	35	2,610	13	799	1	94	23	3,171	7	1,081	81	7,895
Other	5	187	18	3,408	6	301	4	265	11	2,094	7	1,517	51	7,772
Total[1]	211	6,361	898	62,207	308	17,949	115	9,226	1,392	133,716	290	33,688	3,214	263,147

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 26.—U.S. imports for consumption of clays in 1980

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Belgium-Luxembourg	1	$1
Canada	316	23
Germany, Federal Republic of	4	2
United Kingdom	15,510	1,841
Total	15,831	1,867
Fuller's earth, not beneficiated: United Kingdom	277	85
Fuller's earth, wholly or partly beneficiated: United Kingdom	21	8
Bentonite:		
Canada	39	26
Cyprus	1	2
Germany, Federal Republic of	37	14
Hong Kong	7	1
India	15	2
Mexico	52	2
United Kingdom	4	3
Total	155	50
Common blue and other ball clay, not beneficiated:		
United Kingdom	3,268	305
Common blue and other ball clay, wholly or partly beneficiated:		
Canada	2	1
United Kingdom	6,094	755
Total	6,096	756
Other clay, not beneficiated:		
Belgium-Luxembourg	1	1
Canada	83	4
Denmark	7	3
Germany, Federal Republic of	1,544	496
United Kingdom	24	6
Total	1,659	510
Clay, n.e.c., wholly or partly beneficiated:		
Brazil	2	1
Canada	93	15
Germany, Federal Republic of	225	84
Japan	35	33
Mexico	68	5
United Kingdom	1,191	362
Zimbabwe	1	1
Total	1,615	501
Artificially activated clay:		
Canada	2,630	576
France	4	1
Germany, Federal Republic of	1,433	1,416
Mexico	803	206
United Kingdom	260	407
Total	5,130	2,606
Grand total	34,052	6,688

WORLD REVIEW

Abu Dhabi.—A new chemical plant has been opened on Sadiyat Island to produce bentonite and chemicals for use in the offshore drilling industry. The plant was constructed by Abu Drilling Chemicals and Products Co. and is a joint venture with NL Industries Inc. on a 75-25 basis.

Argentina.—A bentonite mining project in San Juan, to be operated by Industrias Petral SRL for 8 months, was approved by the Mining Secretariat. The Government also plans to introduce legislation to assume 80% of mining risks.

Belgium.—English China Clays Ltd. (ECC) was nearing completion of a new $10 million china clay and calcium carbonate slurry processing and distribution center at Lixhe, near Liege. The new center will be used essentially to supply the paper industry.

Canada.—I-XL Industries Ltd., Medicine Hat, Alberta, revealed plans for constructing a new brick plant in Edmonton in conjunction with its Northwest Brick and Tile Div. The company stated that the new plant would cost an estimated $6 million, be ready in early 1981, and have an initial capacity in excess of 40 million bricks per year. The capability of doubling brick capacity by adding a second kiln was incorporated into the plant's design.

China, Mainland.—A mineral deposit containing appreciable reserves of sodium bentonite along with perlite and zeolites was discovered in Jilin Province.

French Guiana.—Tests were being conducted to determine if the high-quality kaolins in the Charvein deposit are suitable for paper filling and coating. The light overburden of the deposit makes it particularly attractive.

Guyana.—The Government's Geological Survey reported that expected final proven kaolin reserves of the Topira deposits and others in the Ituni area, where the overlying bauxite has already been mined, exceed 10 million tons. Bids to carry out a comprehensive preliminary feasibility study of exploiting these kaolins, already closed, have yet to be announced. The study was to include laboratory and small-scale pilot plant testing of representative ores, identification of potential markets, and financial considerations.

India.—Approval for mining and processing of bentonite in the Balmer district was granted to the Rajasthan State Mineral Development Corp. (RSMDC). The present identified reserves in the district were estimated at 4 million tons. A grinding and pulverizing plant and a scientific laboratory costing approximately $200,000 were planned by RSMDC. Other large bentonite deposits have also been located in the Jhalawar District of Rajasthan. It is thought that bentonite reserves totaling over 80 million tons are present in a 25-square-kilometer area.

Indonesia.—A joint venture was planned with foreign business, with the Government holding a minimum 51% interest, for mining bentonite from West Java and Jogjakarta before 1984.

Pakistan.—Proven reserves of 3.5 million tons of china clay have been found by the Pakistan Mineral Development Corp. at Nagar Parkar. A final determination about the project is awaiting a detailed feasibility study.

Portugal.—ECC was assisting Cia. Anglo Portuguesa de Caulines de Viana SARL, a major domestic producer, in exploring the Senhorada Hora kaolin deposits in the Viana do Castelo District in northwest Portugal.

Saudi Arabia.—Sedimentary kaolins of unknown quality were reported near Kashim Radi.

Singapore.—The Singapore, China, Housing and Development Board awarded an $8 million contract to Steetley Engineering and Wakefield Ltd. to develop the biggest automated brickworks in Southeast Asia. The new works, scheduled to come onstream in mid-1981, will provide high-quality facing brick for Singapore's building boom.

South Africa, Republic of.—The discovery of a large sodium-magnesium bentonite deposit 300 kilometers east of Capteown was announced by Cape Bentonite (Pty.) Ltd. of Heidelberg, West Germany. The quality of the bentonite was claimed to be comparable to, if not better than, that of Western bentonites. Tentative estimates from ongoing exploration studies have put reserves of this material in excess of several million tons.

Spain.—Exploration for various industrial minerals, notably attapulgite-sepiolite and kaolin, was reported by Promotora De Recursos Naturales. Large deposits of attapulgite have been located in Guadalajara Province, central Spain, and currently are undergoing technical and economic evaluation. Development of these projects, scheduled for 1981, was to be undertaken as joint ventures with foreign investors. In other attapulgite-sepiolite activities, mining permits were granted to two associated companies in Madrid and Toledo Provinces. Tolsa S.A. already mines clay in Toledo and Caceres Provinces. If production begins in Madrid Province, the processing facilities will probably be situated at Mejorado del Campo. The other company, Minas de Torrejon, was granted permission to enlarge its existing attapulgite-processing facilities at Torrejon el Rubio.

The prospecting and the mining and industrial investigation portions of recovering upwards of 100,000 tons per year from the Vimianzo kaolin deposit in Galicia Province in the northwest were completed by Union Explosivas Rio Tinto (ERT). ERT was examining the financial aspects of developing the deposit.

Sudan.—Several high-purity kaolin deposits have been located on the banks of the River Setit, in eastern Sudan, upstream of El Gira, by the Taha and Yahia El Roubi Mining Co. Proven kaolin reserves in the sediments were estimated at 13 million tons, but development work was expected to substantially increase this figure. The company was investigating possible foreign and domestic markets as well as looking for technical expertise and financial backers for the venture.

Sweden.—A Stockholm-based company,

Hoeganaes, located a local kaolin deposit. The building material and pottery manufacturer maintains that the deposit contains at least several million metric tons of clay. Studies were underway to determine the feasibility of a full-scale mining project and processing plant. Sweden presently imports about 300,000 metric tons per year of kaolin.

United Kingdom.—The long-delayed Brett Bentonite Ltd. sodium-exchange bentonite plant in Oxfordshire started commercial production at the beginning of the year. The new plant, presently operating under its 50,000-ton-per-year capacity, was expected to eventually compete with imports for foundry and civil engineering markets.

ECC planned to ship finished kaolin in a high-density slurry form from a plant to be constructed at a port on the southwest coast, either Par or Fowey. ECC currently pipelines its finished kaolin to Par where it is dried prior to shipping.

Yugoslavia.—The once critical reserve situation in Serbia for various minerals including bentonite, kaolin, fire clay, and other building raw materials was reportedly being overcome. A new deposit of bentonite, with reserves estimated at about 2 million tons, was outlined in the Serbian Topicka Mala Plana. In other bentonite activities, about 25% of the planned 100,000 tons per year of milled clay produced by the Bentomak Mines of Kriva Palanka in Macedonia was targeted for export, mainly to Poland, Austria, Iraq, and Egypt.

Table 27.—Kaolin: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Costa Rica	1	1	1	1	1
Mexico	79	[r]196	198	[e]198	198
United States[3]	[r]6,128	[r]6,489	6,973	7,761	[4]7,879
South America:					
Argentina	92	82	51	146	[4]153
Brazil (beneficiated)	231	286	1,273	[e]1,300	1,400
Chile	74	61	53	65	64
Colombia	838	869	863	903	880
Ecuador	1	[r]5	4	4	4
Paraguay	[e]15	[e]24	39	44	50
Peru	10	12	4	[e]5	6
Venezuela	9	11	25	24	24
Europe:					
Austria (marketable)	79	82	77	87	[4]92
Belgium[e]	130	130	130	130	130
Bulgaria	214	214	219	223	[4]229
Czechoslovakia	601	639	550	565	[4]585
Denmark[e]	25	25	25	22	22
France	302	309	280	[e]275	285
Germany, Federal Republic of (marketable)	487	551	574	613	660
Greece	85	72	55	25	25
Hungary	95	79	75	70	70
Italy:					
Crude	90	90	76	74	[4]74
Kaolinitic earth	29	22	4	NA	[4]29
Poland	104	100	73	54	55
Portugal	70	80	67	60	55
Romania[e]	100	100	100	100	100
Spain (marketable)[5]	[r] [e]155	125	64	66	130
U.S.S.R.[e]	2,400	2,500	2,600	[e]2,800	2,800
United Kingdom	4,241	4,782	4,629	4,899	4,500
Yugoslavia	[e]120	122	198	196	200
Africa:					
Algeria	9	13	19	[e]20	20
Angola[e]	--	1	--	--	--
Burundi	3	[e]3	[e]3	[e]3	3
Egypt	31	54	61	51	55
Ethiopia (including Eritrea)	50	[e]45	35	[e]35	35
Kenya	(6)	1	2	[e]2	2
Madagascar	28	2	3	2	[4]3
Mozambique	1	--	--	(6)	(6)
Nigeria	[e]1	1	[e]2	1	NA
South Africa, Republic of	66	98	135	164	[4]119
Swaziland	1	--	--	--	--
Tanzania[e]	1	1	1	1	1

See footnotes at end of table.

Table 27.—Kaolin: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Asia:					
Bangladesh	2	[7]5	7	9	8
Hong Kong	1	3	[e]3	3	[4]1
India:					
Salable crude	369	385	335	398	[4]384
Processed	114	106	126	121	[4]107
Indonesia	32	[r]42	41	58	70
Iran	220	123	[e]198	176	165
Israel	11	6	7	25	22
Japan	249	[r]249	250	240	235
Korea, Republic of	[r]518	[r]589	606	770	[4]637
Malaysia	29	35	34	36	[r]51
Pakistan	([6])	1	15	17	18
Sri Lanka	5	6	6	6	6
Taiwan	30	32	73	94	[4]88
Thailand	18	27	37	47	50
Turkey	61	65	48	[e]65	55
Oceania:					
Australia	76	98	95	[e]100	100
New Zealand	65	104	37	[e]35	36
Total	[r]18,796	[r]20,153	21,459	23,189	22,971

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 11, 1981.
[2]In addition to the countries listed, mainland China, the German Democratic Republic, Lebanon, Vietnam, and Zimbabwe also produced kaolin, but information is inadequate to make reliable estimates of output levels. Guatemala and Morocco each produced less than 500 tons in each of the years covered by this table.
[3]Kaolin sold or used by producers.
[4]Reported figure.
[5]Excludes unwashed kaolin.
[6]Less than 1/2 unit.
[7]Data for year ending June 30 of that stated.

Table 28.—Bentonite: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Guatemala	[e]10	--	2,858	[r] [e]2,900	2,900
Mexico	61,270	65,223	37,253	[r] [e]39,900	38,600
United States	3,520,381	3,746,487	4,468,000	4,422,075	[3]4,184,619
South America:					
Argentina	145,850	126,585	117,900	173,484	[3]192,011
Brazil	157,871	119,485	184,763	[r] [e]189,600	190,000
Colombia[e]	1,300	1,300	1,300	1,300	1,300
Peru	43,591	45,795	41,022	44,974	45,000
Europe:					
France	19,067	[r]8,888	[e]8,800	[r] [e]9,900	11,000
Greece	349,178	462,363	383,182	625,777	630,000
Hungary	78,427	88,188	90,622	79,366	80,000
Italy	258,648	309,011	260,145	310,851	[3]355,923
Poland[e]	55,000	55,000	55,000	55,000	55,000
Romania[e]	70,000	70,000	72,000	72,000	72,000
Spain	119,213	112,766	119,400	133,025	130,000
Africa:					
Algeria (bentonitic clay)	27,022	26,896	39,313	[e]40,000	40,000
Egypt	4,666	4,201	3,801	[e]3,900	3,900
Morocco	5,141	5,299	5,291	1,118	1,200
Mozambique	[r]3,194	3,025	3,307	1,825	1,650
South Africa, Republic of	43,654	41,029	38,051	51,141	[3]54,910
Tanzania	--	39	22	[4]88	88
Asia:					
Burma	1,053	1,075	1,518	1,594	1,650
Cyprus[5]	5,600	14,550	9,370	7,351	[3]25,353
Iran[e]	55,000	25,800	44,100	22,000	22,000
Israel (metabentonite)	16,535	8,818	7,663	6,930	6,600
Japan[e]	440,000	440,000	440,000	440,000	440,000
Pakistan	823	1,200	999	1,588	1,500
Philippines	2,334	2,512	1,730	1,656	1,200
Turkey	25,970	4,803	9,127	[r] [e]15,400	15,700
Oceania:					
Australia[6]	13,177	6,176	9,439	9,887	10,100
New Zealand (processed)	1,149	[r]2,866	10,803	11,023	11,000
Total	[r]5,525,124	[r]5,799,380	6,466,779	6,775,653	6,625,204

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 10, 1981.
[2]In addition to the countries listed, Austria, Canada, mainland China, the Federal Republic of Germany, and the U.S.S.R. are believed to produce bentonite, but output is not reported and available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.
[4]Exports.
[5]Includes bleaching earths.
[6]Includes bentonitic clay.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Algeria	3,527	[r]4,814	5,343	[e]5,500	5,500
Argentina	3,454	4,551	3,838	6,002	[3]8,166
Australia	10	55	[e]50	55	55
Italy	27,402	6,993	[e]7,700	[e]13,200	13,200
Mexico	22,165	67,648	44,046	[e]45,000	45,000
Morocco (smectite)	40,530	23,176	8,819	15,000	18,500
Pakistan	17,637	19,842	19,842	44,457	33,000
Senegal (attapulgite)	5,100	3,753	7,639	8,000	[3]4,385
South Africa, Republic of	--	--	284	1,013	[3]794
Spain (attapulgite)	[e]40,000	[e]40,000	43,244	68,809	70,000
United Kingdom	221,564	245,815	240,304	242,508	220,000
United States	1,341,582	1,428,326	1,530,000	1,568,247	[3]1,534,000
Total	[r]1,722,971	[r]1,844,973	1,911,109	2,017,791	[3]1,952,600

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Excludes centrally planned economy countries, some of which presumably produce fuller's earth, but for which no information is available. Table includes data available through June 10, 1981.

[2]In addition to the market-economy countries listed, France, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[3]Reported figure.

TECHNOLOGY

The Federal Bureau of Mines published the results of clay-related research conducted at its Tuscaloosa (Ala.) and Reno (Nev.) Research Centers. One Tuscaloosa study developed a dewatering technique that allows for disposal of clay wastes, for reuse of water now lost with clays, and for reclamation of mined land.[4] The technique uses a high-molecular-weight nonionic polyethylene oxide polymer that can both flocculate and dewater materials containing clay wastes. A second work evaluated samples from a clay resource located in Clay County, Ga., for use as a raw material for lightweight aggregate under an agreement with the Georgia Department of Natural Resources.[5] This investigation initially determined the physical properties of clay samples taken from 5-foot increments of drill cores from 11 holes, and then plasticized, extruded, and fired in a rotary kiln. The expanded material had excellent loose pour weights ranging from 30 to 37 pounds per cubic foot.

The Reno Center reported on a bench-scale study of producing alumina from a calcined Georgia kaolin by the hydrochloric acid process.[6] These bench-scale tests, cyclic in nature, determined the composition of recycled leach liquor in the Bureau's proposed clay-HCl leach-HCl sparge process for producing Al_2O_3 from kaolin. The data developed from these tests make it possible to synthesize leach liquors for predetermined steady-state operating conditions when conducting large-scale crystallization tests.

In another Government study, the mineral resources of the Charles M. Russell Wildlife Refuge, Mont., were detailed in a joint Bureau of Mines and U.S. Geological Survey publication.[7] This work included not only the geology of the Refuge, but an evaluation and/or economic appraisal of petroleum, coal, and industrial minerals such as bentonite, kaolin, and lightweight-aggregate-quality shales. Resources of bentonite were estimated at about 3.2 billion tons, with the potential ranging from low to moderate. The highest quality bentonite beds are in the Cretaceous Bearpaw Shale.

An in-depth review of the major industrial minerals, including kaolin, bentonite, chamotte, and other refractory and ceramic clays that are currently being mined in France, was published.[8] The review covered the principal companies recovering and the minerals, the geology, mineralogy, output, production flowsheets, and marketing strategies of the companies. Similar reviews were devoted to Italy,[9] Mexico,[10] Portugal,[11] and Jordan.[12]

The effect of mineralizers—selected calcium and magnesium salts—on the firing shrinkage, microstructure, and strength of kaolin bodies was researched by the combined use of high-resolution scanning microscopy and microprobe analysis (ESCA).[13] The research revealed that the state of dispersion of the mineralizers in the bodies, dependent on the mode of introduction, strongly influenced the physical properties of the ceramic. In another kaolin-related ceramic work, it was shown that the particle shape of the kaolin grog affects the bulk density of aggregates that control the final density of the refractory product.[14] Compact or equiaxed particles gave higher product densities, hence better refractory performance, than bladed or elongated particles.

The application of hectorite clays, beneficiated and nonbeneficiated, as glaze suspension agents, as constituents in ceramic bodies, in weld rod coatings, in foundry products, and in refractory mixes, was highlighted, along with the unique qualities of the clay that make it so versatile.[15]

A comprehensive review cataloged the rapid changes that have taken place in recent years over the broad range of industrial processing that includes drying, calcination, and agglomeration.[16] A second detailed work was devoted to the nonevaporative dewatering of processing slurries.[17] The first effort emphasized the different direct- and indirect-fired rotary, steam-tube, fluidized-bed, spray, flash, and other dryers. The future developments in calcining, rotary kiln systems, and fluidized beds, along with their relative fuel efficiencies, were also discussed, as well as agglomeration and pelletizing. In addition, tables on rotary kiln performance and sizing plus flowsheets and equipment schematic diagrams were illustrated. The dewatering report, similar in scope to the earlier dryer study, explored centrifuge design and applications in a variety of industrially proven dewatering and classification schemes. The domestic kaolin industry, a prime user of centrifuges, was cited in the section on dewatering and classifying.

A popular magazine of the brick, refractories, clay pipe, and expanded aggregate industries, Brick and Clay Record, devoted an entire issue to firing with solid fuel.[18] Industrial applications of sawdust and coal firing, tree harvesting, and biomass fuels—cellulosic material such as wood waste, straw, bagasse, or peat—all featured cost reductions along with production increases as the main advantages over conventional gas and oil fuels.

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[1]Supervisory physical scientist, Section of Nonmetallic Minerals.
[2]Statistical assistant, Section of Nonmetallic Minerals.
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[17]Strom, G. Disc-Type Centrifuging in the Mineral Industry. Eng. and Min. J., v. 181, No. 9, September 1980, pp. 135-141.
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Cobalt

By John T. Kummer[1]

Reported domestic consumption of cobalt in 1980 declined to 15.3 million pounds, about 12% less than that of 1979. Likewise, calculated industrial demand decreased from 18.8 to 17.1 million pounds. Almost all end use applications exhibited a decline in reported consumption, with the most notable exception being a 19% increase in cobalt used to produce superalloys. Owing to the weak demand, U.S. imports of cobalt decreased to 16.3 million pounds, the lowest level since 1975.

Despite the soft market, the producer price of cobalt remained at $25 per pound for the entire year. The dealer or spot price ranged between $18 and $23. In July, Afrimet Indussa Inc., the major dealer for cobalt in the United States, lifted the 70% allocation on its sales to domestic consumers. The allocation, which had been in effect since May 1, 1978, was considered unnecessary because of a buildup in producer stocks.

A plant with the capacity to produce about 1 million pounds per year of extrafine cobalt powder was opened in North Carolina. Properties with the potential for cobalt mine output were under evaluation in California, Idaho, and Missouri. Additions to cobalt production capacity were being made or considered worldwide, primarily in the producing countries of Africa.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1976	1977	1978	1979	1980
United States:					
Consumption	16,482	16,577	19,994	17,402	15,321
Imports for consumption	16,487	17,548	19,029	19,998	16,302
Stocks, Dec. 31: Consumer	3,180	3,738	4,387	3,390	2,540
Price: Metal, per pound	$4.00-$5.40	$5.20-$6.40	$6.40-$20.00	$20.00-$25.00	$25.00
World production, mine[1]	47,218	[r]47,364	56,428	[p]63,256	[e]65,930

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Based on estimated recovered cobalt.

Legislation and Government Programs.—The Government stockpile goal of 85.4 million pounds for cobalt was reaffirmed by the Federal Emergency Management Agency in 1980. The stockpile inventory of cobalt remained at 40.8 million pounds throughout the year.

In July 1980, the Central Idaho Wilderness Act (Public Law 96-312) became law; the act defined the boundaries of the newly created Central Idaho Wilderness Area. Not included in the Wilderness Area was the Blackbird cobalt deposit, which was being considered for redevelopment by Noranda Mines, Ltd. Additional claims held by Noranda extend into a portion of the Wilderness Area designated as a "Special Mining Management Zone." The act would permit exploration and mining in the zone.

On June 28, the Deep Seabed Hard Mineral Resources Act (Public Law 96-283), allowing U.S. companies to begin commercial mining for cobalt-bearing manganese nodules after January 1, 1988, was signed into law. Companies may be licensed for exploration before 1988. Provisions of the bill included the requirements that nodules recovered by U.S. companies be processed domestically and that processing vessels and at least one transport vessel carry the U.S. flag.

DOMESTIC PRODUCTION

There was no domestic mine production of cobalt in 1980. According to AMAX Inc.'s annual report, almost 1 million pounds of cobalt was recovered from imported matte at the firm's Port Nickel refinery in Braithwaite, La. A strike at the refinery of about 420 members of Local 8373 of the United Steel Workers of America ended in January 1980. A new 32-month contract was ratified by a vote of the membership to end the nearly 5-month-long strike.

A facility to produce about 1 million pounds of extra-fine cobalt powder was opened in June in Laurinburg, N.C. The plant is operated by Carolmet, Inc., a wholly owned subsidiary of Metallurgie Hoboken Overpelt, S.A., of Belgium. Feedstock for the $15 million plant is in the form of cobalt broken cathodes imported from Zaire. In making the powder, the cathodes are converted to cobalt oxalate, which is thermally decomposed to yield a sponge. The sponge is then crushed and ground to the required particle size before shipment.

Noranda Mines Ltd. of Canada continued its redevelopment efforts at the Blackbird cobalt deposit near Cobalt, Idaho. During 1980, the firm worked to rehabilitate the existing mine and mill facilities for testing and pilot-scale operations, to construct a water treatment plant, and to complete technical and economic studies for potential full-scale development. An environmental impact statement on the project was to be completed during 1981. Approximately 4 million tons of ore grading 0.7% cobalt, and 1.2% copper have been outlined at the deposit. According to reports, additional feasibility studies would be required before a decision to proceed with construction of a commercial mine could be made. The estimated capital cost of the project exceeded $200 million, including construction of a 1,200-ton-per-day mine and mill complex and a refinery to produce cathode cobalt. A site near Blackfoot, Idaho, about 150 miles southeast of the deposit, was being considered as the refinery site.

Anschutz Mining Co. continued to evaluate the possibility of reopening the Madison Mine property near Fredericktown, Mo. The firm conducted exploratory drilling and was engaged in programs to dewater and rehabilitate the former mine workings. Evaluation of milling, roasting, and refining methods was also undertaken. An economic feasibility study was completed during the year and certain environmental permits obtained. If mining is resumed at the site, production of 1.5 to 2 million pounds of cobalt, in addition to nickel, copper, and lead, was projected.

In Del Norte County, northern California, California Nickel Corp. was considering the development of claims for the recovery of nickel, cobalt, and possibly chromium from low-grade lateritic deposits. At the firm's Gasquet Mountain property, covering an area of about 6,800 acres, exploration has reportedly outlined a processable ore reserve of 36.7 million tons with an average grade of 0.865% nickel, 0.094% cobalt, and 2.0% chromium. A preliminary engineering study for a 5,000-ton-per-day processing plant was completed, with a projected annual production of approximately 30 million pounds of nickel and 2 million pounds of cobalt. Construction of the mine and processing plant, estimated to cost $250 million, was contingent on the results of a feasibility study and acquisition of the necessary financing.

CONSUMPTION AND USES

Reported domestic consumption of cobalt, by end use, decreased approximately 12% from that of 1979. The decline in consumption was attributed to generally lower levels of economic activity and to cobalt's relatively high price throughout the year, which encouraged substitution and conservation by cobalt consumers. The only end uses that experienced an increase in cobalt usage were in the superalloy, welding material, and pigment areas. Reported consumption of cobalt to produce superalloys increased about 19% above that of 1979 and primarily reflected the growth in demand in the aircraft industry. The most significant decreases in cobalt consumption were reported in cutting and wear-resistant materials and magnetic alloys. In magnetic applications, cost considerations apparently stimulated substitution away from cobalt alloys to permanent ferrite magnets, a trend that began in 1979.

Apparent industrial demand, calculated from net imports, secondary production, and change in industry stocks, decreased to 17.1 million pounds, about 9% less than that of 1979. Industrial demand declined for the second consecutive year.

Of the forms of cobalt used by domestic consumers, 71% was as metal, 16% as salts and driers, 8% as purchased scrap, 3% as oxide, and 2% in other forms. A trend towards increased use of scrap has prevailed in recent years. Consumer's stocks of cobalt materials were at a relatively low level throughout the year owing to the decreased demand and greater availability compared with that of 1979.

Table 2.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1979				1980			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	928	928	NA	NA	1,000	1,000	NA	NA
Hydrate (hydroxide)	NA	602	NA	545	NA	220	NA	392
Salts[2] (inorganic compounds)	NA	1,243	NA	1,209	NA	1,092	NA	1,062
Driers (organic compounds)	NA	1,439	NA	1,501	NA	962	NA	1,021
Total	928	4,212	NA	3,255	1,000	3,274	NA	2,475

NA Not available.
[1]Figures on oxide withheld to avoid disclosing company proprietary data.
[2]Various salts combined to avoid disclosing company proprietary data.

Table 3.—U.S. consumption of cobalt, by end use

(Thousand pounds of contained cobalt)

Use	Quantity 1979	Quantity 1980
Steel:		
Stainless and heat-resisting	137	47
Full-alloy	227	116
High-strength, low-alloy	W	W
Tool	413	321
Superalloys	5,276	6,285
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials[1]	2,123	1,344
Welding materials (structural and hardfacing)	444	620
Magnetic alloys	3,266	2,267
Nonferrous alloys	392	150
Other alloys	274	210
Mill products made from metal powder	W	W
Chemical and ceramic uses:		
Pigments	199	282
Catalysts	1,882	1,656
Ground coat frit	554	482
Glass decolorizer	43	40
Other uses[2]	1,791	1,406
Miscellaneous and unspecified	381	95
Total	17,402	15,321

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]Cemented and sintered carbides.
[2]Drier in paints or related usage plus feed or nutritive additive.

Table 4.—U.S. consumption of cobalt, by year and form

(Thousand pounds of contained cobalt)

Form	1976	1977	1978	1979	1980
Metal	11,706	11,547	12,823	12,006	10,825
Oxide	462	426	467	704	441
Purchased scrap	329	507	1,036	1,170	1,183
Salts and driers	3,985	3,778	5,399	[1]3,254	[1]2,475
Other forms	([2])	319	269	268	397
Total	16,482	16,577	19,994	17,402	15,321

[1]Chemical compounds (organic and inorganic) other than oxide.
[2]Included in purchased scrap.

PRICES

Although world demand was soft and supplies plentiful, the listed producer price of cobalt remained at $25 per pound throughout 1980. The $25 price had been in effect since February 1, 1979, having been incrementally increased to that level from $6.40 per pound at the beginning of 1978, partly owing to supply limitations. The above producer prices, quoted by Afrimet Indussa Inc., were f.o.b. Port of New York or Chicago and applied to cobalt granules (shot) or broken cathodes in 551-pound (250-kilogram) drums.

The spot price for cobalt ranged from about $18 to $23 per pound during the year and more closely reflected the weaker market. In addition, it was reported that some producers sold cobalt at discounts to the listed price to encourage sales. The discounted prices were approximately in the range of the prevailing spot price.

FOREIGN TRADE

Exports of unwrought cobalt metal and waste and scrap totaled 1,485,290 pounds, gross weight, with an estimated 583,000 pounds cobalt content and a value of $14,576,477. These exports were shipped to 40 countries, with Japan (456,741 pounds, gross weight), Belgium (369,115 pounds, gross weight), and the Netherlands (130,358 pounds, gross weight) receiving the largest quantities. Exports of wrought cobalt metal totaled 788,493 pounds, gross weight, with a value of $17,363,574. Of the 42 countries to which wrought cobalt was shipped, Ireland, France, the United Kingdom, Sweden, the Netherlands, Mexico, and Canada were the major recipients.

Total imports of cobalt in 1980 were 16,302,000 pounds (contained weight), a decrease of 18% compared with those of 1979. The major sources of cobalt imports were Zaire (38%), Zambia (14%), Japan (8%), Belgium-Luxembourg (8%), Norway (7%), Canada (7%), and Finland (7%). About 92% of all cobalt imports, in terms of cobalt content, were in the form of metal. Material originating in southern Africa, that is imports from Zaire, Zambia, Belgium-Luxembourg (Zairian origin), and Botswana, represented 62% of total cobalt imports during the year.

Table 5.—U.S. imports for consumption of cobalt, by country

(Thousand pounds and thousand dollars)

Country	Metal[1]				Oxide				Other forms[2]				Total content[3]	
	1979		1980		1979		1980		1979		1980			
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	1979	1980
Australia	15	326	2	18	--	--	9	119	43	[4]636	105	[4]1,575	58	114
Belgium-Luxembourg	1,777	47,161	940	27,598	452	8,275	282	5,391	95	1,962	110	2,420	2,206	1,259
Botswana	--	--	--	--	--	--	--	--	358	[4]5,273	397	[4]5,955	358	397
Canada	870	23,336	1,045	24,743	--	--	107	1,879	8	114	4	48	878	1,128
Finland	1,154	30,372	1,090	27,718	--	--	--	--	1	14	--	--	1,155	1,090
France	537	9,431	419	9,271	--	--	--	--	([5])	1	([5])	14	537	419
Germany, Federal Republic of	159	3,538	140	2,453	14	297	1	28	([5])	40	1	57	169	141
Japan	672	18,432	1,243	27,221	4	101	12	205	--	--	17	185	675	1,269
Netherlands	146	5,268	113	1,842	11	346	--	--	--	--	([5])	7	154	113
New Caledonia	--	--	--	--	--	--	--	--	103	[4]1,525	141	[4]2,115	103	141
Norway	927	26,780	1,165	29,299	--	--	--	--	--	--	--	--	927	1,165
South Africa, Republic of	16	405	78	1,872	--	--	--	--	123	[4]1,815	224	[4]3,214	139	302
United Kingdom	236	5,972	206	4,020	2	62	([5])	1	7	59	1	55	244	207
Zaire	8,784	205,367	6,238	147,279	--	--	--	--	--	--	--	--	8,801	6,238
Zambia	3,538	84,699	2,225	54,311	22	348	--	--	--	--	3	9	3,538	2,228
Other	56	1,163	88	938	--	--	3	8	([5])	3	1	23	56	91
Total[6]	18,887	462,250	14,992	358,583	505	9,429	414	7,630	738	11,441	1,004	15,677	19,998	16,302

[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte from Australia, Botswana, New Caledonia, and the Republic of South Africa. Salts and compounds were imported from the remaining countries.
[3]Estimated contained cobalt.
[4]Based on weighted average cobalt metal price of $24.58 per pound for 1979 and $25 per pound for 1980, multiplied by 0.6 (estimated factor for matte) for imports from Australia, Botswana, New Caledonia, and the Republic of South Africa.
[5]Less than 1/2 unit.
[6]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1978	1979	1980
Metal:[1]			
Gross weight	16,488	18,887	14,992
Cobalt content[e]	16,488	18,887	14,992
Value	$167,662	$462,250	$358,583
Oxide:			
Gross weight	1,077	505	414
Cobalt content[e]	797	373	306
Value	$9,190	$9,429	$7,630
Salts and compounds:			
Gross weight	696	370	655
Cobalt content[e]	209	111	197
Value	$2,003	$2,192	$3,572
Other forms:[2]	1,535	627	807
Value	$10,622	$9,249	$12,105
Total content	19,029	19,998	16,302

[e]Estimated.
[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte.

Table 7.—U.S. import duties

Tariff item	Tariff number	Most Favored Nation (MFN)		Non-MFN
		Jan. 1, 1981	Jan. 1, 1987	Jan. 1, 1981
Ore and concentrate	601.18	Free	Free	Free.
Unwrought metal, waste and scrap	632.20	Free	Free	Free.
Alloys, unwrought	632.86	9% ad valorem	9% ad valorem	45% ad valorem.
Chemical compounds:				
Oxide	418.60	1.2 cents per pound	1.2 cents per pound	20 cents per pound.
Sulfate	418.62	1.4% ad valorem	1.4% ad valorem	6.5% ad valorem.
Other	418.68	5.6% ad valorem	4.2% ad valorem	30% ad valorem.

WORLD REVIEW

International.—The ninth session of the Third United Nations Conference on the Law of the Sea (LOS) concluded on August 29, 1980, in Geneva. Although a final LOS treaty did not emerge from the session, some issues regarding deep-seabed mining were resolved. The United States was assured a seat in the 36-member council which would run an International Seabed Authority to regulate ocean mining, and industrialized nations were granted veto power on the council. Several other issues that would affect the potential development of seabed mining capability by private industry were not settled. Another negotiating session was scheduled for March 1981 in New York.

Botswana.—The smelting furnace at the Selebi-Pikwe nickel-copper-cobalt complex was closed for about 2 months during 1980 for overhaul and design modifications. In October, after smelting resumed, output of matte exceeded the new design capacity of 4,400 tons per month. The matte contains 77% to 78% nickel plus copper and about 0.8% cobalt. To reduce energy costs, smelter fuel was changed from oil to pulverized coal. The coal is transported by rail from the Morupule colliery in Botswana.

Ore processing capacity was increased with the opening of a new shaft at the Selebi deposit in June. Construction of a new shaft at the Pikwe deposit was also underway, as open pit operations were terminated during the year. The Selebi-Pikwe mine and mill capacity was approximately 2.3 million tons per year, yielding nearly 800,000 tons of concentrate feed to the smelter. The entire complex is owned and operated by BCL Ltd. (formerly Bamangwato Concessions Ltd.), which is financed by the Botswana Government and Botswana RST Ltd., a firm controlled by AMAX Inc., Anglo American Corp. of South Africa, and public stockholders.

Brazil.—A copper-nickel-cobalt mine and concentrator was being constructed by Metais de Goias, S.A., a State metals company, in Goias State. Operations were projected to begin in 1982; copper sulfate, electrolytic nickel, and about 175 tons of cobalt oxide were to be produced annually.

Canada.—INCO Ltd. announced that an electrolytic cobalt plant would be constructed at its Port Colborne, Ontario, nickel refinery. The $25 million plant was expected to come onstream in late 1982 or early 1983 and will have a capacity of 2 million pounds of cobalt metal per year. The refinery currently produces cobalt oxide that is shipped to the company's plant in Clydach, Wales, for processing into various cobalt compounds. INCO will continue to produce cobalt oxide at its Thompson, Manitoba, refinery.

Sherritt Gordon Mines, Ltd., was engaged in a project to increase cobalt refining capacity at its Fort Saskatchewan, Alberta, refinery. Capacity was to increase about 35% to 900 tons per year of cobalt metal.

Finland.—Outokumpu Oy, the State-owned mining firm, was to increase cobalt production at its Kokkola plant from 1,200 to 1,350 tons in 1980. Although most of the cobalt was produced as a byproduct of copper and nickel mining, the added output was derived from the processing of cobalt-containing residues imported from the German Democratic Republic.

France.—The French Government announced plans for an 18-month program beginning in mid-1980 to buy metals for its national strategic stockpile. The 1.6-billion-franc purchase program would be funded by selling State bonds and obtaining bank loans. According to reports, cobalt was included in a French Government survey of "critical raw materials" which presumably would be candidates for acquisition; however, initial purchases announced did not include cobalt.

Indonesia.—During 1980, no financial commitment for development of the Gag Island nickel-cobalt laterite deposit was made by P.T. Pacific Nikkel Indonesia, a consortium of U.S. and Dutch firms. Although extensive exploration has been completed and mining and ore processing plans prepared, a decision to develop the deposit has been delayed due to increasing capital and operating cost estimates and uncertainty in the nickel market. Capital costs, which had previously been estimated at nearly $1 billion, were reported to have increased about 60% by 1980. The deposit contains an estimated 175 million tons of ore grading 1.64% nickel, 0.12% cobalt, and 35.7% iron.

Japan.—The two Japanese cobalt refineries, owned by Nippon Mining Co., Ltd., and Sumitomo Metal Mining Co., Ltd., operated at near capacity during 1980. Sumitomo's plant produced cobalt metal at a rate of about 139 tons per month, while Nippon Mining's plant output was about 127 tons per month. Nippon Mining also studied the feasibility of producing extra-fine cobalt powder. While the study was being conducted, Nippon Mining arranged for a German firm to produce extra-fine powder on a toll basis. Sumitomo also planned to produce extra-fine powder jointly with Metallurgie Hoboken Overpelt, S.A. of Belgium.

New Caledonia.—Mining feasibility studies were being conducted on nickel-cobalt deposits in northern New Caledonia by Cofremmi, S.A., a French mining firm. Cofremmi is 90% owned by a holding company, which is controlled by AMAX and the Bureau de Rechérches Géologiques et Minières (BRGM); 10% interest is held by Patino N.V. of the Netherlands. Cofremmi awarded a contract for engineering, procurement, and construction management on the potential project, which is in the late stages of predevelopment evaluation. The desposits, located at Poum, Tiebaghi, and Art Island, consist of an estimated 55 million tons of garnierite ores and additional lateritic ore. The garnierite ore, located on Art Island, contains an average 2.5% nickel and cobalt as nickel equivalent. If development does ensue, cobalt output could exceed 1,000 tons per year.

South Africa, Republic of.—Rustenburg Platinum Mines, Ltd., was constructing a new nickel refinery, expected to be onstream during 1981, which would approximately double its output of cobalt sulfate as a byproduct. The firm produces about 500 to 600 tons of cobalt sulfate, which contains about 21% cobalt.

Impala Platinum, Ltd., also planned to build a cobalt refinery at Springs, South Africa, at a cost of $15.9 million. Based on platinum-group metal output by the company, production of cobalt metal could total 175 to 200 tons per year when the facility is completed in 1982. Cobalt production could be increased, reportedly, by modification of its smelting procedures.

Uganda.—Late in 1980, Falconbridge Nickel Mines, Ltd., and the Ugandan Government agreed to discuss the reopening of the Kilembe copper-cobalt mine. Falconbridge had a majority interest in the mine, which produced copper from 1956 to 1977, although the firm sold out its interest in 1975. If an agreement can be negotiated, two feasibility studies would be conducted. One study would involve the possible recovery and marketing of cobalt from pyrite tailings stockpiled at the Kasese concentrator, located near the Kilembe Mine. Several million tons of tailings, reported to grade about 1.4% cobalt, were accumulated while the mine was active. The second study would consider the feasibility of reopening the mine itself, and, presumably, the copper smelter in the town of Jinja, about 300 miles from the mine. The Kilembe deposit has been estimated to grade 1.8% copper and 0.18% cobalt. Cobalt was never recovered while the mine was operating. Although recovery of cobalt from the tailings was considered in the early 1970's, the economic and political situation at the time precluded the necessary investment.

United Kingdom.—A strike by about 600 workers at INCO, Ltd.'s, nickel-cobalt refinery at Clydach, Wales, terminated near the end of February 1980. Operations at the facility had been interrupted since October 17, 1979.

Zaire.—In early July, the Zairian metal marketing agency, Société Zairoise de Commercialization des Minerais (SOZACOM), terminated its allocation program, which had been in effect since May 1, 1978. According to the program, SOZACOM had limited its worldwide customers, including U.S. buyers supplied through Afrimet Indussa, to 70% of their average monthly purchases in 1977. The supply allocations were considered unnecessary owing to the weakening of cobalt demand during the first half of 1980 and consequent buildup of producer inventories.

The French Government agency, BRGM, acquired Amoco Minerals Co.'s 28% interest in Société Minière de Tenke-Fungurume (SMTF) to become the major shareholder in the joint venture company. The Tenke-Fungurume copper-cobalt mine project, on which SMTF has spent over $200 million for basic infrastructure, was to be further evaluated and possibly put into operation by the French agency, Compagnie Générale de Matières Nucleaires (COGEMA). According to reports, a scaled-down operation with annual production of 10,000 tons of copper and 500 tons of cobalt was being considered. Excess capacity of the Zairian mining firm, Générale des Carrières et des Mines (GECAMINES), presumably would be utilized to process the ore if an integrated mining and refining complex was not constructed. Output from the Tenke-Fungurume project was not expected before 1981.

GECAMINES also was involved in projects to increase copper-cobalt mining capacity of its operations. The company brought onstream the Dima concentrator in Kolwezi with about a 5-million-ton-per-year processing capacity.

Zambia.—Zambia's two State-owned mining companies were engaged in projects with the potential to increase cobalt production capacity to about 9,000 tons per year by 1985. Present capacity is approximately 4,000 tons per year. Nchanga Consolidated Copper Mines, Ltd. (NCCM), was constructing a roast-leach-electrowinning cobalt plant at the firm's Rokana facilities. The plant, expected to be in operation by March 1982, has an anticipated capacity of nearly 2,900 tons of cobalt annually, thereby increasing NCCM's total annual output to over 4,000 tons. Capacity at the new refinery may be increased to over 5,000 tons per year by the mid-1980's should a second-stage expansion be undertaken. Feedstock for the plant was to consist of the expanded output of cobalt concentrates from the firm's Rokana and Chingola copper-cobalt mines. NCCM also was having a study conducted to consider the recovery of about 800 tons of cobalt annually by treating slag from the Rokana copper smelter.

Roan Consolidated Mines, Ltd. (RCM), also planned to add over 400 tons per year of cobalt capacity at its Chambishi tankhouse. The addition will increase RCM's annual capacity to about 3,000 tons per year. The plant, which opened in late 1978, operates on cobalt concentrates produced by RCM's Baluba and Chibulumà copper-cobalt mines. A roast-leach-electrowinning process is employed to produce electrolytic cobalt cathodes. Other projects planned at the Chambishi plant include: (1) expansion of the copper electrowinning tankhouse, (2) construction of a sulfuric acid plant, (3) extension of the copper circuit filtration plant to improve copper and cobalt recovery, and (4) installation of a cobalt vacuum refining furnace to reduce lead concentrations in the cobalt cathode. Measures were being taken to reduce the level of lead and other deleterious elements in the cathodes until the vacuum induction furnace was completed, probably by yearend 1981.

Officials of NCCM and RCM agreed to changes in their contract with the Mineworkers Union of Zambia on September 3, thereby averting a threatened strike of laborers at the country's copper-cobalt mines. The agreement included an immediate increase in wages, another increase in 1981, plus other worker benefits.

Table 8.—Cobalt: World production, by country[1]

(Short tons)

Country	Mine output, metal content[2]				Metal[3]			
	1977	1978	1979[p]	1980[e]	1977	1978	1979[p]	1980[e]
Australia[e] [4]	1,100	1,500	1,700	1,760	--	--	--	--
Botswana	[r]180	288	324	320	--	--	--	--
Canada[5]	1,637	1,360	1,522	[6]1,767	506	572	523	518
Cuba[e]	1,800	1,800	1,900	1,900	--	--	--	--
Finland	1,353	1,429	1,281	1,400	1,086	1,016	1,301	1,300
France[7]	--	--	--	--	[r]939	998	850	1,000
Germany, Federal Republic of	--	--	--	--	[r]441	386	424	440
Japan	--	--	--	--	1,205	2,055	2,924	3,140
Morocco	1,119	1,250	1,059	1,100	--	--	--	--
New Caledonia[8]	120	170	230	200	--	--	--	--
Norway	--	--	--	--	777	575	1,051	1,050
Philippines	1,195	1,313	1,366	1,400	--	--	--	--
U.S.S.R.[e]	2,100	2,150	2,000	2,250	[r]3,750	3,900	[r]3,950	4,000
United Kingdom[9]	--	--	--	--	[r]800	720	[r]380	800
United States	--	--	--	--	244	322	464	500
Zaire	[r] [e]11,200	[e]14,660	[e]16,535	17,100	[r]11,260	14,468	15,543	15,980
Zambia[10]	1,878	2,274	3,501	[6]3,648	1,878	2,274	3,501	[6]3,648
Zimbabwe	NA	20	210	120	--	17	204	[6]115
Total	[r]23,682	28,214	31,628	32,965	[r]22,886	27,303	31,115	32,491

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Table includes data available through May 25, 1981.

[2]Figures presented represent recovered cobalt content, whether recovered in the producing country or elsewhere. In addition to the countries listed, Bulgaria, Cyprus, the German Democratic Republic, Greece, Indonesia, Poland, the Republic of South Africa, Spain, and Uganda are known to produce nonferrous metal ores that contain cobalt. Information is inadequate for formulation of reliable estimates of output levels. Other copper and/or nickel-producing nations neither listed in the body of the table nor in the preceeding part of this footnote also may produce ores containing cobalt as a byproduct component, but recovery is small or nil.

[3]Figures presented represent elemental metallic cobalt recovered unless otherwise specified. In addition to the countries listed, Czechoslovakia presumably recovers cobalt from Cuba. Belgium, which in recent years has imported small quantities of partly processed materials containing cobalt, may continue to recover cobalt from such materials, but output is not reported, and available general information is inadequate for formulation of reliable estimates of output levels.

[4]Data series on mine output represents an estimate of that part of total production that is actually recovered. Australia does not report any production of metallic cobalt, but does produce intermediate metallurgical products (cobalt oxide and nickel-cobalt sulfide), with cobalt contents as follows in short tons: 1976—978; 1977—916; 1978—1,286; 1979—Not available; and 1980—Not available.

[5]Actual output is not reported. Data for mine output are total cobalt content of all products derived from ores of Canadian origin, including nickel oxide sinter shipped to the United Kingdom for further processing, and nickel-copper-cobalt matte shipped to Norway for further processing. Data presented for metal output represent the output within Canada of metallic cobalt from ores of both Canadian and non-Canadian origin.

[6]Reported figure.

[7]Production as reported in Annuaire 1979 de Statistique Industrielle, p. 75, which series now conforms closely to that published in Annuaire Minemet Group I Metal 1979, p. 46.

[8]Series revised to reflect estimated actual recovery from ores and intermediate metallurgical products exported from New Caledonia to Japan, France, and the United States. The previously reported quantity either: (1) is among the waste materials of ore concentrating and smelting processes or (2) is included in nickel-cobalt products. The estimated content of total ores mined is as follows, in short tons: 1976—5,036 (revised); 1977—5,036 (revised); 1978—2,794 (revised); 1979—3,417; and 1980—3,300.

[9]Estimated recovery of elemental cobalt in refined cobalt oxides and salts from intermediate metallurgical products originating in Canada.

[10]Mine and smelter output are reported as equal.

TECHNOLOGY

Research on cobalt at the Federal Bureau of Mines was primarily concerned with methods to recover cobalt from domestic resources to reduce import dependence. At the Albany Research Center in Oregon, techniques for the recovery of cobalt, nickel, and copper from low-grade laterites occurring in northern California and southwestern Oregon were being developed. As part of this work, a method was developed to recover cobalt by solvent extraction from reduced and leached lateritic ore.[2] The method permitted solution recycling and resulted in production of a cobalt electrolyte from which metallic cobalt can be electrowon. Solvent extraction and ion exchange techniques to separate and recover cobalt from oxide and sulfide ores were also being investigated at the Albany Research Center.

At the Rolla Research Center in Missouri, work was underway to develop methods to recover cobalt and nickel from Missouri lead ores and concentrates. From this work, a procedure was devised to separate a magnetic fraction (chalcopyrite concentrate) from lead-copper rougher concentrate by wet, high-intensity magnetic separation.[3] The chalcopyrite concentrate was then reground and floated, producing a high-grade copper concentrate and tailing product with over 3.5% cobalt and 5% nickel. The tailing product and lead smelter mattes were subjected to a leach process, followed by caustic purification and sequential precipitations to produce cobalt, nickel, copper, lead, and manganese sulfates, and elemental sulfur. A companion program was concerned with the recovery of cobalt and nickel from Missouri lead smelter mattes, drosses, and slags.

Efforts continued at the Salt Lake City Research Center in Utah to determine techniques for extracting cobalt, nickel, and copper from the arsenical sulfide ore which characterizes the Blackbird District of Idaho. Research at the Twin Cities Research Center (Minnesota) was directed towards optimizing recovery of nickel, cobalt, and platinum group metals from Duluth Gabbro resources located in northern Minnesota. The properties of mischmetal and cobalt and rare-earth element-cobalt magnets were being evaluated at the Reno Research Center in Nevada. These magnets were being considered as possible low-cost substitutes for samarium-cobalt and platinum-cobalt magnets.

The Bureau of Mines published the results of a study to assess the domestic availability of chromium and other alloying elements, including cobalt, from superalloy and cast heat- and corrosion-resistant alloy scrap material.[4] The study, based on 1976 data, considered scrap generation and use patterns to develop a model of material flow circuits within the industries that produce specialty alloys. With regard to cobalt, it was estimated that 5.9 million pounds was lost in 1976 because of down grading or exporting of scrap material containing cobalt and other critical metals.

An official of Certified Alloy Products, Inc., announced that the firm had developed a process to recover nickel, cobalt, molybdenum, and other refractory metals from superalloy scrap.[5] The process involves oxygen lancing of superalloy scrap with a pure nickel lance in an electric arc furnace, followed by vacuum induction melting to produce a usable superalloy product. The method was claimed to oxidize all reactive elements and to remove low-melting-point elements from the scrap charge. Recovery of refractory metals in a standard-specification alloy was said to be nearly complete.

Technologic efforts to reduce cobalt consumption and enhance substitution were widely reported during the year. The metallurgical effects of cobalt in superalloys were reviewed and analyzed.[6] The results indicated that in certain types of superalloys the cobalt content could be decreased while still maintaining acceptable microstructural characteristics and mechanical properties. It was suggested that U.S. demand for cobalt could be reduced by 10% through substitution of nickel or other elements for cobalt in superalloys.

The National Aeronautics and Space Administration (NASA) initiated a study to determine methods to reduce consumption of cobalt and other strategic metals in aerospace applications.[7] The program was expected to continue for about 5 years and involve substantial participation by industry. Recent work was described that indicates the cobalt content in Waspalloy, a superalloy with numerous aerospace uses, could be reduced from the normal 13.5% to about 8% (weight content) without lowering stress rupture performance below minimum standards.[8] Research was also underway to develop cladding methods and composite materials which would conserve use of cobalt-containing superalloys.[9] The work involved techniques to press or fuse thin layers of superalloy cladding onto a base material, such as steel.

Potential for cobalt substitution was also enhanced by development of a new hardfacing alloy containing only 12% cobalt.[10] The alloy, designated "HAYNES Alloy No. 716," was found to have performance qualities similar to the widely used cobalt-based "HAYNES Alloy No. 6," including weldability and wear resistance. Room-temperature hardness and strength of the new alloy was lower than that of Alloy No. 6, but both exhibited similar elevated-temperature (greater than 500° C) properties.

Other applications in which substitution for cobalt-containing materials was examined included the use of ceramics in place of high-temperature alloys[11] and the application of chromium-cobalt-iron permanent magnets in place of the commonly used Alnico (aluminum-nickel-cobalt) magnets.[12]

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[1]Physical scientist, Section of Ferrous Metals.

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Columbium and Tantalum

By Thomas S. Jones[1]

Supplies of columbium and tantalum raw materials, for which the United States remained dependent on imports, improved in 1980. A favorable outlook for assurance of future supplies also developed along with signs of evolution as to the nature of supplies. An important change for columbium was commercialization both in Brazil and in the United States of plants for producing columbium oxide from pyrochlore-based feed material. Brazil also expanded its production of tantalum raw materials, and Australia and Canada gave promise of adding significantly to future tantalum supply. For tantalum, a trend toward upgrading in the source country became evident.

Consumption of columbium advanced much more modestly than in prior years, whereas shipments of tantalum materials by domestic processors declined for the first time since 1975, by 11%. Consumption of columbium as ferrocolumbium and nickel columbium rose to 6.5 million pounds, a 3% increase. Manufacture of superalloys, again the largest demand category for columbium, seemed likely to become a more important user of tantalum in the future. The rise in tantalum raw materials prices was halted after mid-1980 by weakening of both capacitor and cemented carbide markets for tantalum and easing of the supply situation.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1976	1977	1978	1979	1980
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	--	--
Releases from Government excesses (Cb content)[1]	70	--	[2]1	--	--
Consumption of raw materials (Cb content)	2,722	2,427	2,673	2,402	[e]3,000
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium (Cb content)	1,565	1,455	1,566	969	[e]2,020
Consumption of primary products:					
Columbium metal (Cb content)	291	W	W	W	W
Ferrocolumbium and nickel columbium (Cb and Ta content)	3,389	4,389	5,694	6,337	6,503
Exports: Columbium metal, compounds, and alloys (gross weight)	67	75	[e]95	[e]100	[e]120
Imports for consumption:					
Mineral concentrate (Cb content)[e]	2,201	1,551	1,982	1,690	2,320
Columbium metal and columbium-bearing alloys (Cb content)	(3)	2	(3)	[e]4	73
Ferrocolumbium (Cb content)[e]	2,221	2,676	4,159	5,515	5,918
Tin slags (Cb content)[4]	296	880	[5]436	[5]1,133	NA
World: Production of columbium-tantalum concentrates (Cb content)[e]	[r]20,886	[r]19,409	21,269	[p]31,718	[e]32,298

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Includes columbium content in raw materials from which columbium is not recovered and material released as payment-in-kind for upgrading.

[2]Net change in inventory report.

[3]Less than 1/2 unit.

[4]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials in 1977-79.

[5]After deduction of reshipments.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1976	1977	1978	1979	1980
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	--	--
Releases from Government excesses (Ta content)[1]	8	[2](4)	[2]1	--	--
Consumption of raw materials (Ta content)	1,485	1,448	1,571	1,740	[e]1,850
Production of primary metal (Ta content)	1,089	678	974	NA	NA
Consumption of primary products: Tantalum metal (Ta content)	1,098	732	978	NA	NA
Exports:					
Tantalum ore and concentrate (gross weight)	59	118	64	[3]329	[3]468
Tantalum metal, compounds, and alloys (gross weight)	367	470	686	426	524
Tantalum and tantalum alloy powder (gross weight)	219	234	211	296	251
Imports for consumption:					
Mineral concentrate (Ta content)[e]	827	657	596	630	860
Tantalum metal and tantalum-bearing alloys (Ta content)	52	126	137	144	140
Tin slags (Ta content)[4]	431	1,275	[5]676	[5]1,140	NA
World: Production of columbium-tantalum concentrates (Ta content)	[r]748	[r]901	773	[p]1,037	[e]978

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Includes material released as payment-in-kind for upgrading.
[2]Net change in inventory report.
[3]Includes reexports.
[4]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials in 1977-79.
[5]After deduction of reshipments.

Table 3.—Columbium and tantalum materials in Government inventories as of December 31, 1980

(Thousand pounds of columbium or tantalum content)

Material	Stockpile goals	National Defense Stockpile inventory	Defense Production Act (DPA) inventory	Total
Columbium:				
Concentrates	5,600	[1]1,780	--	[2]1,780
Carbide powder	100	21	--	21
Ferrocolumbium	--	[3]931	--	[2]931
Metal	--	45	--	[2]45
Total	([4])	2,777	--	2,777
Tantalum:				
Minerals	8,400	[5]2,551	--	[6]2,551
Carbide powder	--	29	--	[6]29
Metal	--	[7]201	--	[6]201
Total	([4])	2,781	--	2,781

[1]Includes 869,000 pounds in nonstockpile-grade material.
[2]All surplus ferrocolumbium and columbium metal were used to offset columbium concentrates shortfall. Total offset = 1,148,000 pounds.
[3]Includes 333,000 pounds in nonstockpile-grade material.
[4]Overall goals, on a recoverable basis, total 4,850,000 pounds for the columbium metal group and 7,160,000 pounds for the tantalum metal group.
[5]Includes 1,152,000 pounds in nonstockpile-grade material.
[6]All surplus tantalum carbide powder and tantalum metal were used to offset tantalum minerals shortfall. Total offset = 271,000 pounds.
[7]Includes negligible quantity in nonstockpile-grade material.

Legislation and Government Programs.—U.S. Government inventories of columbium and tantalum materials did not change during 1980. There were neither acquisitions nor sales of stockpile excesses. Updated goals were announced by the Federal Emergency Management Agency in May. The overall goal for the columbium-metal group was raised substantially, from 2,661,000 to 4,850,000 pounds of recoverable columbium content. A small part of the total was to be satisfied by inventories of columbium carbide powder, for which a goal did not formerly exist. Otherwise, the goal for the columbium metal group was to be fulfilled by inventories of concentrate. The overall goal for the tantalum metal group was changed insignificantly by rounding the former goal to 7,160,000 pounds of recoverable tantalum content. Individual goals for tantalum carbide powder and for tantalum metal were eliminated. The only goal remaining within the tantalum metal group, that for tantalum minerals, was increased from 5,452,000 to 8,400,000 pounds of contained tantalum.

DOMESTIC PRODUCTION

No domestic mineral production of either columbium or tantalum was reported in 1980. As in 1979, a small quantity of domestic concentrate was reported shipped, evidently from existing mine stockpiles, and several potential columbium and/or tantalum properties, located primarily in the West, were being examined.

Domestic production of ferrocolumbium, expressed as contained columbium, was estimated to have been over twice as great as that of 1979. Value of ferrocolumbium production rose comparatively more, to an estimated $42 million, because of higher average prices for both regular and high-purity grades. The regular grade was somewhat favored over the high-purity grade of ferrocolumbium in the production mix.

Tantalum content of raw materials consumed by processors in production of tantalum compounds and metal was estimated to have exceeded 1.8 million pounds. Consumption of purchased scrap by processors more than doubled to over 100,000 pounds.

Teledyne Wah Chang, Albany Div., started up a plant for large-scale production of columbium oxide, most of which was reportedly for internal use. Nominal plant capacity was 2 million pounds per year of oxide. The manufacturing process consisted of chlorinating ferrocolumbium to produce columbium pentachloride, which was hydrolyzed to oxide that was then kiln-dried.[2]

Cabot Corp. reorganized its Engineered Products Group, effective October 1. Kawecki Berylco Industries, Inc., became Cabot Berylco Inc., the KBI Div. of which included columbium and tantalum manufacturing plants in the United States and Japan (Showa-KBI Co., Ltd.). Also within the Engineered Products Group, the Cabot Mineral Resources Div. had been established earlier in the year with broad responsibilities for raw materials acquisition.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1980

Company	Plant location	Products[1]						
		Metal[2]		Carbide		Oxide/salts		FeCb and/or NiCb
		Cb	Ta	Cb	Ta	Cb	Ta	
Cabot Corp.:								
KBI Div	Boyertown, Pa	X	X	--	--	X	X	--
Do	Revere, Pa	--	--	--	--	--	--	X
Kennametal, Inc	Latrobe, Pa	--	X	X	X	--	X	--
Mallinckrodt, Inc	St. Louis, Mo	--	--	--	--	X	X	--
Metallurg, Inc.:								
Refractory Metals, Inc	Houston, Tex	--	--	X	X	--	--	--
Shieldalloy Corp	Newfield, N.J	--	--	--	--	--	--	X
NRC Inc.[3]	Newton, Mass	--	X	--	--	--	--	--
The Pesses Co	Newton Falls, Ohio	--	--	--	--	--	--	X
H. K. Porter Co., Inc.:								
Fansteel, Inc	Muskogee, Okla	X	X	--	X	X	X	--
Do	North Chicago, Ill	--	X	--	--	--	--	--
Reading Alloys, Inc	Robesonia, Pa	--	--	--	--	--	--	X
Teledyne Inc., Teledyne Wah Chang, Albany Div.	Albany, Oreg	X	X	--	--	X	--	X

[1]Cb, columbium; Ta, tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium.
[2]Includes miscellaneous alloys.
[3]Jointly owned by South American Consolidated Enterprises, S.A., and H. C. Starck Berlin.

CONSUMPTION, USES, AND STOCKS

Reported consumption of columbium as ferrocolumbium and nickel columbium rose by a relatively modest 3%. The overall total of 6.5 million pounds of contained columbium was a record high for the third straight year. Distribution of consumption among end uses was little changed. Demand for columbium in superalloys, up by 6%, exceeded that in high-strength low-alloy (HSLA) steel for the second consecutive year. Columbium consumption as nickel columbium approached 700,000 pounds, over 90% of which was used in superalloys. Use of columbium in all steelmaking increased only by somewhat more than 1%. A 9% increase in consumption reported in the carbon steel end-use category averted a decline in consumption in steelmaking. Consumption in the other categories of steelmaking decreased; steel production was down for all categories, falling overall by nearly one-fifth. Columbium usage per ton of steel produced was thus indicated to have risen significantly for all steelmaking categories.

Columbium continued to be in demand as a microalloying element in high-strength steels both for cars and for oil and gas pipelines. Per car usage of high-strength steel was still increasing in order to save weight and to give stronger structures; high-strength steels with improved formability were announced. Although columbium's lack of domestic availability was a matter of concern, demand for columbium in superalloys was expanding. One factor in the increased demand was greater anxiety over availability of cobalt, another strategic metal, because of which a switch was underway from cobalt-base alloys in jet engines to Inconel 718, a nickel-base alloy with a nominal columbium content of 5%.

Tantalum consumption was down, as reflected in the 11% decrease in overall shipments reported by the Tantalum Producers Association. This was the first year of decline since 1975, both for overall shipments and, as reported by the Electronic Industries Association, for factory sales of capacitors, which were lower by 5%. Softening of the capacitor market, especially in the second half of the year, and manufacture of higher efficiency powders both contributed to lesser demand for powder and anodes. Capacitor production began, however, at the fifth domestic tantalum plant of the Electronics Div. of Union Carbide Corp., in Greenwood, S.C., and construction of a sixth plant, in Shelby, N.C., was announced.

Major segments of the tantalum market also showing declines were mill products and carbides. Use of tantalum in cemented carbides was being reduced through development of coated inserts and of inserts with lower tantalum content. Coating materials included aluminum oxide, titanium nitride, and titanium carbide, alone or in various combinations. Coatings also permitted a lowering of substrate tantalum content. Columbium and/or hafnium substituted to some extent for tantalum in inserts.

Data on aggregate stocks of columbium and tantalum raw materials reported by processors and dealers for 1980 were incomplete at the time this chapter was prepared.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1979	1980	Change (percent)
Columbium products:			
Compounds, including alloys	1,627,800	1,066,550	-34
Metal, including worked products	329,500	344,700	+5
Other	64,200	18,500	-71
Total columbium	2,021,500	1,429,750	-29
Tantalum products:			
Oxides and salts	35,400	48,700	+38
Alloy additive	23,700	8,100	-66
Carbide	190,100	125,730	-34
Powder and anodes	928,200	852,900	-8
Ingot (unworked consolidated metal)	6,600	23,000	+248
Mill products	365,200	318,800	-13
Scrap	151,000	130,900	-13
Other	--	1,700	--
Total tantalum	1,700,200	1,509,830	-11

Source: Tantalum Producers Association.

Table 6.—Consumption, by end use, and industry stocks of ferrocolumbium and nickel columbium in the United States

(Pounds of contained columbium)[1]

End use	1979	1980
Steel:		
Carbon	1,425,132	1,552,338
Stainless and heat-resisting	827,801	824,904
Full alloy	505,084	468,637
High-strength, low-alloy	1,753,172	1,737,627
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	11,935	6,901
Total steel	4,523,124	4,590,407
Superalloys	1,776,880	1,885,935
Alloys (excluding alloy steels and superalloys)	31,932	21,599
Miscellaneous and unspecified	5,398	5,142
Total consumption	6,337,334	6,503,083
Stocks, Dec. 31:		
Consumer	W	W
Producer[3]	W	W
Total stocks	1,614,000	1,964,000

W Withheld to avoid disclosing company proprietary data.
[1]Includes columbium and tantalum in ferrotantalum-columbium, if any.
[2]Withheld to avoid disclosing company proprietary data; included with "Steel: Unspecified."
[3]Ferrocolumbium only.

PRICES

Prices of a wide range of columbium materials were affected by developments in Brazil. As of the second quarter of 1980, the price of Brazilian pyrochlore and of regular grade ferrocolumbium both were advanced by 13%. The price of pyrochlore with 50% to 55% Cb_2O_5, f.o.b. Brazil, was raised to $3.00 per pound of contained pentoxide. The spot price of regular grade ferrocolumbium containing 63% to 68% columbium rose from $5.42-$5.73 to $6.22-$6.35 per pound of contained columbium, f.o.b. shipping point.

Prices declined for high-purity ferrocolumbium, nickel columbium, columbium metal, and columbite concentrates. These declines all were related to the beginning of production of sizable amounts of columbium oxide in Brazil, a new factor in columbium markets that also contributed to a reported drop of about one-third in the price of U.S. produced columbium oxide. Prices for columbium master alloys and metal decreased around midyear; the price for high-purity ferrocolumbium narrowed from $30.15-$35.75 to $30.15-$30.90 per pound of contained columbium. The average spot price for columbite concentrates, per pound of combined columbium and tantalum pentoxides c.i.f. U.S. ports, eased during the year from $10-$12 to $9-$11 in December. However, the year-average price for columbite concentrates was about twice that for 1979.

Most tantalum prices continued rising, but at a less steep rate than in the previous year. The spot market price for tantalite, on the basis of 60% combined tantalum and columbium pentoxides, c.i.f. U.S. ports, started the year at $90 to $95, rose to $115 to $120 within 4 months, but began dropping in late summer to finish the year at $103 to $108 per pound of contained Ta_2O_5. The price advance was somewhat greater for Canadian (Tanco) tantalite, the price of which, per pound of contained pentoxide, was increased from $75 to $102.50 within the first 4 months without being decreased later. Published price quotations for tantalum mill products and powder also went up by midyear, to at least $200 per pound for all items.

FOREIGN TRADE

The estimated trade deficit in columbium and tantalum mètal, alloys, ores, mineral concentrates, and ferrocolumbium rose in 1980 (also including columbium oxide in that year) to $49 million from $16 million in 1979. Contained in these totals were net deficits in columbium materials of $55 million in 1980 and $39 million in 1979, and net surpluses in tantalum materials of $7 million and $22 million, respectively.

Exports and reexports of tantalum ores and concentrates, reported mostly as the former, increased to 468,000 pounds at a value of $15 million in 1980 from 329,000 pounds at a value of $6 million in 1979. The Federal Republic of Germany was the principal recipient in 1980 as opposed to Japan for the previous year. Exports of nickel columbium and ferrocolumbium, mostly as nickel columbium to the Federal Republic of Germany, were reported by the Office of Export Administration to have exceeded 58,000 pounds in 1980.

Imports for consumption from Brazil in 1980 included over 9 million pounds of ferrocolumbium, a 7% increase, and 584,000

Table 7.—U.S. foreign trade in columbium and tantalum metal and alloys, by class and principal country

(Thousand pounds, gross weight, and thousand dollars)

Class	1979		1980		Principal destinations and sources, 1980
	Quantity	Value	Quantity	Value	
EXPORTS[1]					
Tantalum:					
Powder	296	26,060	251	39,880	Japan 62, $11,694; Federal Republic of Germany 62, $10,150; France 43, $6,532; United Kingdom 37, $5,723.
Unwrought, and waste and scrap	336	22,270	399	31,539	Federal Republic of Germany 333, $23,871; Japan 30, $3,560.
Wrought	90	10,363	125	20,896	Japan 48, $7,475; United Kingdom 27, $4,909; Federal Republic of Germany 20, $3,505; France 12, $1,949.
Total exports	XX	58,693	XX	92,315	Federal Republic of Germany, $37,500; Japan, $22,700; United Kingdom, $11,600; France, $9,800.[2]
IMPORTS FOR CONSUMPTION					
Columbium:					
Ferrocolumbium[e]	8,485	25,321	9,104	28,224	All from Brazil.
Unwrought metal, and waste and scrap	1	19	4	16	All from Federal Republic of Germany.
Unwrought alloys	--	--	115	2,561	Do.
Wrought	7	123	([3])	([3])	All from United Kingdom.
Tantalum:					
Waste and scrap	129	2,292	118	3,924	Mexico 61, $1,635; Canada 25, $130; France 16, $608.
Unwrought metal	48	4,657	68	12,387	Federal Republic of Germany 58, $10,305; Belgium-Luxembourg 10, $2,078.
Unwrought alloys	55	5,016	36	4,703	Federal Republic of Germany 36, $4,680.
Wrought	1	138	1	173	Netherlands 1, $70; Austria ([3]), $72.
Total imports for consumption	XX	[4]37,567	XX	51,988	Brazil, $28,200; Federal Republic of Germany, $17,700.[2]

[e]Estimated. XX Not applicable.
[1]For columbium, data on exports of metal and alloys in unwrought and wrought form, including waste and scrap, are not available; included in basket category as of 1978.
[2]Rounded.
[3]Less than 1/2 unit.
[4]Data do not add to total shown because of independent rounding.

Table 8.—U.S. imports for consumption of columbium-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Gross weight	Value	Gross weight	Value
Belgium-Luxembourg[1]	33	167	--	--
Brazil	769	2,436	1,565	4,127
Canada	1,124	2,710	1,446	3,504
China, mainland	273	2,111	430	3,053
Germany, Federal Republic of[1]	131	269	--	--
Malaysia	168	1,463	91	1,043
Netherlands[1]	147	113	--	--
Nigeria	903	3,782	996	8,357
Thailand	15	24	64	198
United Kingdom[1]	1	7	--	--
Uganda	--	--	4	7
Total[2]	3,564	13,083	4,595	20,289

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. imports for consumption of tantalum-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Gross weight	Value	Gross weight	Value
Australia	229	6,627	390	18,133
Brazil	179	4,516	580	19,074
Burundi	--	--	5	193
Canada	679	10,955	505	15,011
China, mainland	--	--	94	2,843
Germany, Federal Republic of[1]	--	--	302	8,388
Malaysia	60	417	106	1,273
Mozambique	25	1,237	9	492
Netherlands[1]	--	--	119	3,433
Rwanda	131	1,499	131	2,875
South Africa, Republic of	2	35	13	497
Spain	83	2,058	36	1,299
Thailand	48	1,110	81	2,204
Uganda	--	--	2	29
United Kingdom[1]	1	35	18	121
Zaire	75	1,201	112	2,601
Zambia	20	444	--	--
Zimbabwe	--	--	7	362
Total[2]	1,532	30,135	2,510	78,829

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

pounds of columbium oxide (a new item from Brazil) at a value of $5.2 million. Estimated data for both ferrocolumbium and columbium oxide were based on entries in nonspecific classes.

Imports for consumption of columbium mineral concentrates were nearly 30% greater than in 1979, chiefly because of more than doubled receipts from Brazil. Value increased by an even greater percentage largely because of a higher unit value for Nigerian columbite. Imports were estimated to contain 1,890,000 pounds of columbium and 140,000 pounds of tantalum, and to again have an average grade of approximately 60% Cb_2O_5 and 4% Ta_2O_5.

Imports for consumption of tantalum mineral concentrates were up by over 60% on a gross weight basis. Imports from Brazil were, after reclassification of considerable quantities originally declared as columbite, roughly triple those in 1979 and even exceeded those from Canada, which has been the largest source in recent years. Average unit value for overall imports was higher by 60%. Imports were estimated to contain 720,000 pounds of tantalum and 140,000 pounds of columbium. The average grade of 35% Ta_2O_5 and 25% Cb_2O_5 gave a significantly lower Ta_2O_5-to-Cb_2O_5 ratio than in immediately previous years.

Data on receipts of raw materials other than mineral concentrates were incomplete.

Duty-free treatment of synthetic tantalum-columbium concentrates from most-favored-nations was made permanent through enactment of Public Law 96-467 effective October 17, 1980, with retroactivity available to July 1, 1980. Duty on synthetic concentrates had been suspended from November 8, 1977, through June 30, 1980. Public Law 96-467 also established a new tariff class, 603.67, for imports of synthetic concentrates. The only 1980 data in this class were imports of 39,600 pounds at a value of $824,000 in December, all from the Federal Republic of Germany; these figures are not included elsewhere in this chapter.

In August 1980, the U.S. International Trade Commission reaffirmed, after considering corrections to import statistics, its October 1976 determination that, as of that date, imports of tantalum electrolytic fixed capacitors from Japan during January 1975 through June 1976 were not, and were not likely to be, injuring an industry in the United States.

WORLD REVIEW

World production of columbium and tantalum minerals is detailed in table 10; the table does not include tantalum (and columbium) contained in tin slags. Tantalum contained in tin slags produced in 1976, 1977, 1978, and 1979 was, in thousand pounds, 742, 822, 790, and 987, respectively, according to data of the Tantalum Producers International Study Center (TIC). No data were available for the U.S.S.R. for either minerals or slag. Exclusive of the U.S.S.R., the TIC data were believed to represent over 90% of the recoverable tantalum contained in tin slags produced in 1976-79. Also not included in table 10 was any additional recovery of tantalum from tin slags produced many years ago. Sizable inventories of such old slags have been identified throughout tin-producing areas of Southeast Asia and were regarded by industry sources as vital to world tantalum supply during the next few years. In many instances the Ta_2O_5 content of old slags was rated as less than 2%, thus making eventual utilization uncertain. Quantities of old slags considered to contain over 5% Ta_2O_5 shipped from Thailand in 1977 and in 1979 were in the vicinity of 1,000 metric tons, whereas shipments in 1978 approached 5,000 metric tons. Data were not available as to further disposition of these shipments.

Australia.—For fiscal years ending June 30, Greenbushes Tin N.L. reported increased operations in 1980 compared with those in 1979: Production of tantalite concentrates (nominal 40% Ta_2O_5), 108 versus 89 metric tons; Ta_2O_5 content of concentrates, 95,000 versus 85,000 pounds; ore processed, 1.50 versus 1.33 million cubic meters. As of mid-1980, Greenbushes began regular production of tin by electric furnace smelting and coproduction of tantalum-bearing slags. Greenbushes also started construction of a tailings retreatment plant at its facilities in Western Australia. The plant was to become operational by early 1981. Exploration of deposits elsewhere in western areas of Australia by Greenbushes and by other companies gave promising indications of tantalum.

Late in the year, Greenbushes signaled a greatly increased potential to contribute to world tantalum supply by announcing delineation of new, relatively large tantalum resources northwest of its present open pit operation for mining eluvial pegmatite. Several years of diamond drilling to depths of over 300 meters have disclosed existence of hard-rock pegmatite containing significant concentrations of tin and tantalum as well as low-grade columbium mineralization. This new resource was projected to contain 4 to 10 million pounds of tantalum at Ta_2O_5 grades of 0.07% to 0.06%, and perhaps 20 million pounds of tantalum at 0.04% Ta_2O_5 grade. Based on these findings, Greenbushes outlined an expansion program leading to annual production of 800,000 pounds of Ta_2O_5 (equivalent basis) in 1985. The company was seeking financial arrangements and long-term sales contracts for the expansion. Addition of the tin smelter and the tailings plant was seen as raising annual output in any event to 200,000 pounds of Ta_2O_5 as of 1982.

Brazil.—Companhia Brasileira de Metalurgia e Mineraçao (CBMM), which has been mining about 2,500 tons per day of pyrochlore ore on a two-shift basis for an annual ore production of 875,000 tons, progressed with its expansion program for ore treatment facilities. Nominal capacity of these facilities to treat 800,000 tons per year of ore containing an average of 3% Cb_2O_5 in order to produce 27,600 tons per year of 60% Cb_2O_5 concentrate was being increased to 44,000 tons per year of concentrate in 1981 and 60,000 tons per year in 1982. These data were given in a review of CBMM's operations at its Araxá complex in Minas Gerais State.[3]

CBMM moved further into provision of only upgraded forms of columbium by inaugurating commercial shipments of technical-grade (98% minimum Cb_2O_5) columbium oxide in January and by ending exports of concentrate as of yearend 1980. The company was reported to be considering future production of columbium metal. CBMM's production of 16,900 short tons of ferrocolumbium was nearly 90% of total Brazilian production. At 19,300 tons, Brazil's total production was 26% greater than in 1979.

Metallurg, Inc., increased its involvement in tin and tantalite mining and smelting in Brazil by acquiring Companhia Industrial Fluminense. Equipment for upgrading tantalum raw materials was reportedly being installed in the acquired plant of Fluminense at Sao Joao del Rei, Minas Gerais State.

Canada.—As reported by Teck Corp., Ltd., for fiscal years ending September 30, production of columbium oxide at the Niobec Inc. mine at St. Honoré, Quebec, was virtually unchanged: 5,440,159 pounds in 1980 versus 5,444,826 pounds in 1979. Tons of ore milled (657,074 versus 627,628) and recovery (66% versus 65%) were up slightly, whereas Cb_2O_5 grade of ore (0.63% versus 0.67%) and reserves (10,347,000 tons at 0.65% Cb_2O_5 versus 10,523,000 tons at 0.66% Cb_2O_5) declined somewhat. A 30% expansion of milling facilities was completed; production of columbium oxide was reported to be an option under consideration for utilization of the coming enlarged output.

Tantalum Mining Corp. of Canada Ltd. (Tanco) completed an expansion program at its Bernic Lake, Manitoba, operation. Milling capacity was raised to 1,000 from 750 tons per day, which allowed retreatment of tailings and stockpiling of mined ore during the summer and an increase of mill throughput during the winter. Results with the modified mill circuit were below expectations, with overall recovery dropping to 62% from 70%, and further tests were being conducted. In the mine, introduction of an electric-hydraulic drill jumbo in place of a pneumatic jumbo lowered drilling costs and improved productivity and the working environment. Production statistics for 1980 were 162,000 tons of ore milled having a Ta_2O_5 grade of 0.136% and 35,000 tons of tailings reprocessed having a Ta_2O_5 grade of 0.055%; in 1979, 181,000 tons of ore were milled at a Ta_2O_5 grade of 0.137%. Quantity of Ta_2O_5 in concentrates produced was down 14% in 1980, to 298,000 pounds versus 344,000 pounds in 1979. Exploration drilling disclosed no major discoveries. Reserves (stated as proven, probable, and possible) at yearend were thus reported to have dropped to 2.8 from 3.0 million pounds of contained tantalum, and tantalum contained in stored tailings dropped to 910,000 from 960,000 pounds.

A significant new tantalum-columbium resource for possible future development was indicated by exploration at a property in the vicinity of Great Slave Lake, 65 miles southeast of Yellowknife, Northwest Territories. Placer Development Ltd. made an agreement to take over exploration and development on this property, formerly owned 70% by Highwood Resources Ltd. and 30% by Calabras (Canada) Ltd. Initial findings suggested the deposit could contain from 20 to 60 million pounds of tantalum at a grade of over 0.03% Ta_2O_5 and around 10 times as much columbium at a grade of 0.4% Cb_2O_5 or better.

China, Mainland.—Much interest was shown in China's still undefined columbium and tantalum potential. A variety of raw materials and upgraded forms of both columbium and tantalum were identified as available for export. Japan reported purchases of potassium tantalum fluoride from China, as well as a request by the Chinese for technical assistance in developing a process for production of ferrocolumbium as a byproduct of iron ore from Inner Mongolia. Exchange of technology for raw materials was a topic of various discussions between the United States and Chinese officials and firms. A joint 3-year exploration program for columbium, tantalum, and tin deposits was begun by geologists of the Federal Republic of Germany and of China. The initial target area was the Wangxiang area of east Hunan Province in central China.

Nigeria.—Production of columbite as a byproduct of tin mining by Amalgamated

Table 10.—Columbium and tantalum: World production of mineral concentrates by country[1]

(Thousand pounds)

Country[2]	Gross weight[3] 1976	1977	1978	1979[p]	1980[e]	Columbium content[4] 1976	1977	1978	1979[p]	1980[e]	Tantalum content[4] 1976	1977	1978	1979[p]	1980[e]
Argentina:															
Columbite	([5])	1	([5])	1	1	[5]([6])	[6]1	[5]([6])	[5]([6])	([5])	[5]([6])	[5]([6])	[5]([6])	[5]([6])	([5])
Tantalite	([5])	([5])	([5])	([5])	([5])	([5])	([5])	[5]([6])	[5]([6])	([5])	[5]([6])	[5]([6])	[5]([6])	[5]([6])	([5])
Australia: Columbite-tantalite[7]	[r]260	[r]346	306	379	420	[r]52	[r]69	61	76	84	[r]86	[r]114	101	125	140
Brazil:															
Columbite-tantalite	436	303	448	825	880	98	56	83	153	160	128	95	141	260	280
Pyrochlore	41,894	34,421	39,412	63,733	66,000	[6]17,571	[6]14,436	[6]16,529	[6]26,729	27,700	--	--	--	--	--
Burundi: Columbite-tantalite	9	[e]10	--	--	5	2	2	--	--	--	2	2	--	--	--
Canada:															
Pyrochlore	[e]5,505	[e]9,220	[e]9,087	[r] [e]9,231	[6]8,560	[6]2,309	[6]3,866	[6]3,811	[6]3,872	[6]3,591	--	--	--	--	--
Tantalite	[e]520	595	624	640	[6]520	15	17	17	18	14	[6]231	[6]265	[6]278	[6]287	[6]229
Malaysia: Columbite-tantalite	101	99	51	88	95	43	39	13	22	24	12	15	4	7	8
Mozambique:															
Columbite[e]	4	5	5	5	NA	1	1	1	1	NA	2	2	2	2	NA
Microlite	123	88	88	[e]70	NA	5	4	4	3	NA	68	48	48	40	NA
Tantalite[e]	62	80	80	70	NA	8	13	13	10	NA	27	33	30	25	NA
Nigeria:															
Columbite	1,561	1,898	1,468	1,250	1,220	687	773	646	550	537	89	175	88	75	73
Tantalite	2	[r]2	2	2	2	1	([5])	([5])	([5])	([5])	1	2	1	1	1
Portugal: Tantalite	11	7	18	[e]11	11	3	2	4	3	3	3	2	4	3	3
Rwanda: Columbite-tantalite	100	142	107	104	110	29	44	33	35	35	24	30	19	20	20
Thailand:															
Columbite	--	73	141	842	440	--	16	32	191	100	--	13	23	138	165
Tantalite	15	90	--	55	90	3	18	--	18	18	4	24	--	14	23
Uganda: Columbite-tantalite[e]	5	5	5	5	NA	1	1	1	1	NA	1	1	1	1	NA
Zaire: Columbite-tantalite	174	183	40	106	90	48	41	11	29	25	46	56	9	22	19
Zimbabwe: Columbite-tantalite[e]	90	90	90	65	65	10	10	10	7	7	24	24	24	17	17
Total	50,872	47,658	51,972	77,482	78,509	[r]20,886	[r]19,409	21,269	31,718	32,298	[r]748	[r]901	773	1,037	978

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes columbium and tantalum-bearing tin ores and slags. Table includes data available through May 25, 1981.
[2]In addition to the countries listed, mainland China, Spain, Namibia, the U.S.S.R., and Zambia also produce or are believed to produce columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.
[3]Data on gross weight generally have been presented as reported in official sources of the respective countries, divided into concentrates of columbite, tantalite, pyrochlore, and microlite where information is available to do so, and reported in groups such as columbite and tantalite where it is not.
[4]Unless otherwise specified, data presented for metal content are U.S. Bureau of Mines estimates.
[5]Less than 1/2 unit.
[6]Reported in official country sources.
[7]Series revised; data on exports published in previous editions replaced by actual production as reported by Western Australia, the only State mining columbium and tantalum minerals.

Tin Mines of Nigeria Ltd. (ATMN), Bisichi-Jantar (Nigeria) Ltd., Gold and Base Metal Mines of Nigeria, Ltd., and Vectis Tin Mines Ltd. declined by 3%. The combined totals for the group were, in metric tons, 553 in 1980 and 571 in 1979. Virtually all production was by Bisichi-Jantar and ATMN. Profitability of ATMN was adversely affected both by mining difficulties and by an increase in the minimum wage rate. Terms were reached for transfer of 60% of equity in Bisichi-Jantar and in Gold and Base Metal Mines to Nigerian interests, as required by the Government.

Thailand.—Steps taken would lead to production of tantalum in upgraded form by mid-1983 and alter the commercial pattern of movement for a significant proportion of world tantalum supply. After several proposals and counterproposals, including one involving Thailand Smelting and Refining Co., Ltd. (Thaisarco), the Thai Government granted Thai Tantalum Industrial Corp. (TTIC) exclusive rights to production of tantalum oxide for the next 8 years. The Government furthermore ruled that commencing a year before TTIC's plant would become operational, tin slags could no longer be exported; that is, presumably as of sometime in 1982. TTIC's proposal to manufacture tantalum oxide from Thai tin slags was also accompanied by its further proposal to upgrade low-grade tin slags from elsewhere in Southeast Asia. Technical assistance was to be furnished TTIC by Hermann C. Starck Berlin, whereas ownership was to be local. Financial backing for TTIC and a definite arrangement whereby TTIC was to be supplied with Thaisarco's output of slag were still to be worked out.

Other developments affecting tantalum supply included Thaisarco's decision to begin paying a premium for tantalum in tin concentrates in recognition of the current high value of tantalum. Thai Pioneer Enterprise Ltd. had a tin smelter under construction that was expected to be operational early in 1981. Initial production was to be about 4,000 metric tons of tin annually, with concentrate feed to come from central and northern Thailand. The tin smelter of Thai Present Co. remained in the planning stage, the proposed site having been changed to Phuket in southern Thailand.

United Kingdom.—Murex, Ltd., with a plant at Rainham (near London), was sold by BOC International Ltd. to SKW Trostberg AG of the Federal Republic of Germany. The acquisition was expected to further a modernization program underway at Murex, which has been a producer of columbium and tantalum mill shapes, ferrocolumbium, and nickel columbium.

TECHNOLOGY

Innovations in extraction of columbium and tantalum that were patented included processes for producing columbium oxide from pyrochlore ores and for obtaining columbium-tantalum values from raw materials high in titania.[4]

Investigations of the properties of columbium-bearing steels included determination in an HSLA steel of the relative contributions to strengthening of the effects of grain refinement, precipitation and substructure, and solid solution. For a low-carbon steel with columbium and vanadium additions, it was shown that the same 80 ksi strength level could be produced by either hot-strip or plate mill processing. For both methods of processing, grain refinement was the primary strengthening factor; effects due to precipitation and substructure were somewhat more important than those due to solid solution in producing additional strengthening.[5]

The columbium-carbon relationship necessary in 26 Cr-1 Mo ferritic stainless steels low in interstitial content to provide resistance to intergranular corrosion was determined. For such steels when stabilized with columbium, avoidance of corrosion was found to depend on keeping a minimum value for the columbium-to-carbon ratio. The ratio itself was a function of carbon content but not of nitrogen content.[6]

The Bureau of Mines investigated vacuum roll-bonding to iron of, among various possible cladding materials, a columbium high-temperature alloy (Cb-10Ti-5Zr) and commercially pure tantalum. With a mill operating in a vacuum at a residual gas pressure of 2×10^{-5} torr, the columbium alloy as well as tantalum were successfully bonded to iron in one pass at temperatures of about 1,000° C.[7]

Development of a new tantalum-bearing superalloy by Pratt & Whitney Aircraft Corp. made probable a significant increase in tantalum consumption in aerospace applications. Tantalum was specified in this superalloy, at a relatively high nominal tantalum content of 12%, because it gave high creep strength and oxidation resistance. Also important in the development program was establishing procedures for casting the superalloy in single crystal form on a production basis. Use of this superalloy as turbine blade material was foreseen for forthcoming commercial and military jet engines.[8]

A trend away from use of tantalum, columbium, and other strategic metals in aerospace applications was, however, the objective of a research program proposed by the National Aeronautics and Space Administration, under the title "Conservation of Strategic Aerospace Materials—COSAM."[9]

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[1]Physical scientist, Section of Ferrous Metals.

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Copper

By W. C. Butterman[1]

World mine production of copper fell about 1% in 1980 to 7.62 million tons,[2] while production of refined copper increased 1% and consumption of refined copper dropped 3%. Most of the decline in world mine production could be ascribed to the 5-month labor strike in the United States. The United States remained the largest producer of mined copper, followed closely by Chile and the U.S.S.R., and then by Canada, Zambia, Zaire, Peru, Poland, and 58 other countries. The daily price of copper peaked in February at $1.45 per pound, then dropped quickly to the level preceding the rise; the average price per pound for domestic delivered wire bar in 1980 was $1.02, compared with $0.93 in 1979 and $0.66 in 1978.

Table 1.—Salient copper statistics

	1976	1977	1978	1979	1980
United States:					
Ore produced ---- thousand metric tons--	257,401	235,844	239,247	264,790	218,715
Average yield of copper -----percent--	0.51	0.52	0.51	0.49	0.47
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines ---------- metric tons--	1,456,561	1,364,374	1,357,586	1,443,556	1,168,311
Value --------- thousands--	$2,234,975	$2,009,297	$1,990,323	$2,960,676	$2,638,020
Smelters --------- metric tons--	1,325,629	1,265,008	1,269,981	1,313,224	994,479
Percent of world total -------	17	16	16	16	13
Refineries -------- metric tons--	1,290,673	1,280,035	1,327,373	1,411,518	1,121,897
From foreign ores, matte, etc., as reported by refineries ------------do----	105,764	77,281	121,684	103,858	88,957
Total new refined, domestic and foreign ----------do----	1,396,437	1,357,316	1,449,057	1,515,376	1,210,854
Secondary copper recovered from old scrap only ----------------do----	380,225	409,928	501,650	604,301	613,458
Exports: Refined -------------do----	101,502	46,745	91,923	73,677	14,489
Imports, general:					
Unmanufactured -----------do----	485,084	468,769	546,389	328,323	542,363
Refined ----------------do----	346,113	354,506	414,697	215,161	458,112
Stocks, Dec. 31: Producers:					
Refined ----------------do----	172,000	212,000	153,000	64,000	49,000
Blister and materials in solution -do----	291,000	314,000	263,000	275,000	272,000
Total ---------------do----	463,000	526,000	416,000	339,000	321,000
Consumption:					
Refined copper ------------do----	1,807,008	1,982,162	2,189,301	2,158,442	1,862,096
Apparent consumption, primary copper ---------------do----	1,656,000	1,625,000	1,831,000	1,746,000	1,669,000
Apparent consumption, primary and old copper (old scrap only) ------do----	2,036,000	2,035,000	2,333,000	2,350,000	2,282,000
Price: Weighted average, cents per pound ---	69.6	66.8	66.5	93.3	102.4
World:					
Production:					
Mine ------- thousand metric tons--	[r]7,525	[r]7,756	7,633	7,675	7,617
Smelter ----------------do----	[r]7,840	[r]8,135	8,023	8,060	7,953
Price: London, average cents per pound ----	63.92	59.44	61.88	90.07	99.25

[r]Revised.

Legislation and Government Programs.—In May 1980, the Federal Emergency Management Agency updated goals for several materials in the national defense stockpile, including copper. All goals were rounded to emphasize that they are targets affected by changing conditions, rather than precisely fixed quantities. Thus, the goal for copper was reduced from 1.18 million tons to 0.9 million tons. At yearend, copper in the stockpile totaled only 26,352 tons, mostly in refined shapes, but including 6,125 tons of brass scrap.[3]

The first of eight annual staged reductions in tariffs negotiated during the Tokyo Round of multilateral trade negotiations went into effect on January 1, 1980, and affected 37 classes of unwrought copper, copper scrap, and brass-mill products.

The Environmental Protection Agency (EPA), on July 20, 1980, promulgated final effluent limitations guidelines for existing primary copper smelting and refining operations and for metallurgical acid plants. The guidelines, promulgated under sections 301 and 304 of the Clean Water Act, U.S.C. 1311 and 1314, represented the degree of effluent reduction attainable by the application of the best practicable control technology currently available, and were, in effect, amendments of an interim final regulation (sic) that had been promulgated in 1975.[4]

The Solid Waste Disposal Act, amended Public Law 96-482, which provided that solid waste disposal associated with surface mining be regulated under the Surface Mining Control and Reclamation Act, Public Law 95-87, 1977, instead of under hazardous waste legislation, was extended for another 2 years.[5]

Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510, commonly known as "superfund" legislation, 3 copper compounds were among the 42 chemicals and petroleum products designated as hazardous. The production of these three compounds—cupric sulfate, cupric oxide, and cuprous oxide—was to be taxed at the rates of $1.87, $3.59, and $3.97 per short ton, respectively. The taxes, to be levied over the period April 1, 1981, to September 30, 1985, were to be used to build a hazardous substance response fund to cover the costs of cleaning up abandoned disposal sites and spills of hazardous substances.[6]

DOMESTIC PRODUCTION

Primary Copper.—The longest labor strike in the U.S. copper industry since 1968 began on July 1, 1980, and lasted 20 weeks. At its maximum extent, in August, it immobilized 10 major companies that normally account for 85% of domestic mine production and 89% of refinery production. As a result, domestic mine production decreased 0.28 million tons in 1980 to 1.17 million tons, while refinery production from ores decreased 0.30 million tons to 1.21 million tons. Refinery production from scrap rose slightly, so that total refinery production decreased 0.29 million tons to 1.73 million tons. The relatively high production rates of the first half of the year kept the industry's production declines from being greater.

Mine Production.—Copper was mined in 17 States in 1980, with Arizona, Utah, New Mexico, and Montana accounting for 94% of the total. Arizona, which alone produced 65% of the total, normally produces more copper than any foreign nation except Chile, but in 1980, because of the labor strike, its output dropped below that of the third-ranking national producer, the U.S.S.R.

Surface mines yielded 81% of U.S. primary copper, and underground mines, 19%. Of the top 25 producing mines, 21 were surface mines and 22 were mines in porphyry deposits. Eighty-two percent of the copper was extracted from ores that had been concentrated by flotation, and another 17% was recovered by leaching of ores and tailings. The remainder came from the very small amount of direct-smelting ore and from other base metal ores. Of the leached copper, about 70% was recovered by precipitation on iron and 30% by electrowinning. The average yield of all copper ores, except those treated by leaching in dumps or in place, was 10.4 pounds per ton of ore or 0.47%.

The value of byproduct gold and silver became very important to the economics of several copper mines in 1980, as prices of those metals reached historic highs. Revenues from gold and silver averaged $1.85 per ton of ore or $0.18 per pound of copper. Molybdenum, the price of which had nearly tripled in the last 5 years, was also a very important source of revenue at some mines.

Mines operated by the principal copper-mining companies are listed below, with some numerical data from published sources.

Mines operated in 1980 by principal U.S. producers

Company	Mines	Production (thousand metric tons)	Reserves (million metric tons)
Anaconda Copper Co	Berkeley and Carr Fork	NA	NA.
Anamax Mining Co	Twin Buttes	[1]101	312, grade 0.68% Cu.
ASARCO Incorporated	Mission, Sacaton, San Xavier, Silver Bell.	35	277, grade 0.64% Cu.
	Eisenhower	[2]10	133, grade 0.64% Cu.
Cities Service Co	Copperhill, Miami Leach, Pinto Valley.	NA	NA.
Copper Range Co	White Pine	[3]25	NA.
Cyprus Mines Corp	Bagdad and Pima	NA	NA.
Duval Corp	Esperanza, Mineral Park, Sierrita, Battle Mountain.	125	456, grade 0.28% Cu.
Inspiration Consolidated Copper Co	Christmas (Pit)	6	11, grade 0.62% Cu.
	Inspiration area mines	33	241, grade 0.55% Cu.
	Ox Hide	([4])	
Kennecott Minerals Co	Chino, Ray, Utah Copper	304	2,540,[5] grade 0.57% Cu.
Magma Copper Co	Magma	98	6, grade 5.50% Cu.
	San Manuel	NA	593,[6] grade 0.72% Cu.
Phelps Dodge Corp	Metcalf, Morenci, New Cornelia, Tyrone.	[7]243	1,600,[8] grade 0.68% Cu.
UV Industries, Inc	Continental	NA	NA.

NA Not available.
[1]Includes copper processed from Eisenhower Mine ore.
[2]Asarco is the operating partner in Eisenhower Mining Co. Production figure represents Asarco's share, which in this table is also included in Twin Buttes production.
[3]First 9 months.
[4]Less than 1/2 unit.
[5]Includes reserves in Nevada.
[6]Includes Kalamazoo ore body.
[7]Includes 3,000 tons from leaching at Bisbee.
[8]All Phelps Dodge properties, including the Safford ore body.

Anaconda Copper Co.'s Carr Fork Mine in Utah, in its first full year of operation, experienced startup problems, including a serious hoisting mishap, which kept output below expectations. A deep-drilling program at Butte found a substantial tonnage of copper-molybdenum ore at, and adjacent to, the Berkeley Mine.

ASARCO Incorporated's Sacaton Mine remained in operation during the labor strike; output was 14,600 tons. Two shafts to be completed in 1981 were begun at Sacaton to allow underground development. Asarco replaced the truck fleet at its Mission Mine with more fuel-efficient, 170-ton trucks and installed new large-volume ore flotation cells, which are more efficient in mineral recovery and more economical in use of power. Development continued at the Troy silver-copper mine in Montana, which was expected to produce about 18,000 tons of copper in concentrates annually and to be onstream by the end of 1981.

Cities Service Co. continued the development of its Miami East underground mine, scheduled for startup in 1982, and the construction of a second solvent-extraction electrowinning plant at the Pinto Valley Mine.

Cyprus Mines Corp. began an expansion program at the Bagdad Mine in 1980 to increase production by about 30% to 77,000 tons per year by 1982. Certain inactive mill facilities at the Pima Mine were rehabilitated, increasing milling capacity by 75% to nearly 30,000 tons per day.

Duval Corp. ranked third in domestic mine production in 1980, its mines having been affected only 5 days by the strike. The electrowinning plant at the company's Battle Mountain gold-copper mine in Nevada reached full production status in 1980.

The initial phases of modernization of the concentrator at Inspiration Consolidated Copper Co. were completed in 1980. Inspiration also put into operation its ferric cure leach system, a means of producing efficient leach solutions quickly.

Kennecott Minerals Co. announced a modernization program at its Chino Mine, involving a new concentrator, new milling equipment, and the elimination of rail haulage. At midyear, Kennecott and Mitsubishi Corp. of Japan announced a joint venture to implement the project. On March 2, 1981, the assets of Kennecott's Chino Mines Div. were transferred to Chino Mines Co., owned two-thirds by Kennecott and one-third by Mitsubishi. The modernization program was expected to increase copper production 70% by 1983, at a cost in excess of $365 million. Kennecott also began sinking a shaft next to its Bingham Canyon, Utah, open pit mine, to explore a high-grade underground deposit of copper, gold, silver, and molybdenum. The company also started up a new solvent-extraction plant having a capacity of 100 tons per day at its Ray Mine in Arizona.

Magma Copper Co.'s San Manuel Mine was closed for 16 days in May and June by a timber fire which broke out in a mined-out haulage drift. Magma continued to develop the Kalamazoo ore body, adjacent to the San Manuel deposit; production was scheduled for 1983.

The Lakeshore Mine, near Casa Grande, Ariz., now owned by Noranda Lakeshore Mines, Inc., was restarted in the second half of 1980 after being idle for 3 years. Noranda restricted its production in 1980 to the oxide ore; the sulfide ore process was reported to require further development.

Exxon Corp. continued exploration of its Pinos Altos copper-zinc prospect, near Silver City, N. Mex. Superior Mining Co. continued test drilling of a copper-zinc ore body on Bald Mountain near Ashland, Maine. Quintana Minerals Corp. and Phibro Mineral Enterprises, Inc., announced that they would begin development of an open pit copper mine at Copper Flats, near Hillsboro, N. Mex. Production at the rate of 18,000 tons per year was scheduled for 1982.

Smelter Production.—Because of the strike, domestic smelter output fell 25% to 1.1 million tons. Sixteen primary copper smelters, in nine States, operated in 1980. Many of the smelters awaited expensive modification in order to achieve continuous control of sulfur dioxide emissions and meet the deadline of January 1, 1983, for full compliance with emissions limitations. Some were expected to qualify for a 5-year extension of the use of the current dispersion techniques under EPA's Nonferrous Smelter Order (NSO) program. A few of the older smelters were reported to face closure in the 1980's because it would not be economically feasible to modify them to meet emission regulations.

Anaconda announced on September 29 that its smelter at Anaconda, Mont., idled by the strike, would be closed permanently, stating that the plant could not be retrofitted to meet environmental standards and be cost competitive with modern, large-scale smelters. The company then signed a 7-year contract with six Japanese smelters to process 390,000 tons or more of its concentrates per year. The Anaconda smelter had operated under variances from State environmental regulations since 1972. It accounted for nearly 10% of domestic smelter capacity.

Asarco installed secondary exhaust hoods on the converters at its Hayden, Ariz., smelter, and planned to install them over the next 2 years at its Tacoma, Wash., smelter. The hoods improved working conditions and permitted higher operating rates; they were expected to effectively increase production by 8% at the Tacoma plant.

Inspiration continued engineering work on converters and gas-handling systems at its smelter in Arizona, with the goal of bringing the plant into full compliance with sulfur dioxide emission regulations.

Kennecott applied for an NSO for its smelter at Hurley, N. Mex. The smelter presently captures 60% of the sulfur in its feed material; State and Federal regulations require removal of 87% to 90%.

Refinery Production.—Production of refined copper in 1980 was 1.5 million tons, 79% derived from ore and 21% from scrap. Fourteen refineries operated in 12 States.

Anaconda closed its Great Falls, Mont., refinery in September when it shut down its smelter at Anaconda. Asarco closed its Tacoma, Wash., refinery at yearend, with the advent of expanded capacity at its new, more efficient refinery at Amarillo, Tex. The Tacoma refinery had been on a standby basis since January 1979. The closure of these two refineries reduced U.S. refining capacity by 15% or 370,000 tons per year.

Copper Range Co. announced that it would build a 55,000-ton-per-year electrolytic refinery at its White Pine, Mich., mine to replace its fire refinery there. The new refinery was scheduled to be onstream before the end of 1982.

Copper Sulfate.—Copper sulfate was produced from electrolytic refinery solutions, blister copper, and secondary metal by seven companies listed below. Production declined 11% in 1980. About 41% went to agricultural uses; 56% to industrial uses; and 3% to other uses.

Company	Plant location
The Anaconda Company	Great Falls, Mont.
Chevron Chemical Co.	Richmond, Calif.
Cities Service Co.	Copperhill, Tenn.
CP Chemicals Inc	Sewaren, N.J.
Madison Industries Inc	Old Bridge, N.J.
Phelps Dodge Refining Corp	Laurel Hill, N.Y., and El Paso, Tex.
Van Waters & Rogers Inc	Wallace, Idaho, and Midvale, Utah.

Byproduct Sulfuric Acid.—Sulfuric acid was produced at 13 domestic copper smelters from the sulfur dioxide contained in offgases. Output in 1980, at 2.1 million tons, was lower than that of 1979 because of the labor strike.

Secondary Copper and Brass

Domestic recovery of copper in all forms from all classes of purchased scrap totaled 1.44 million tons in 1980. Copper-base scrap was the source of 98% of the total and was 57% new scrap and 43% old scrap. Brass mills accounted for 34% of the copper recovered from copper-base scrap, secondary smelters and refiners for 39%, and primary smelters and refiners for 22%. The remaining 5% was reclaimed at foundries and chemical plants. Of the major categories of copper and copper-alloy products derived from scrap, unalloyed copper comprised 39%; brass-mill products, 43%; and brass and bronze ingots, 15%.

CONSUMPTION

Consumption of refined copper declined 14% in 1980 to 1.86 million tons. Of this, nearly all went to wire rod mills (70%) and brass mills (27%), and the shapes used most were cathodes (52%) and wire bars (31%).

STOCKS

Producer and consumer stocks of refined copper followed opposite trends in 1980. Primary producer stocks dropped to a low of 20,000 tons at midyear; stocks at brass mills reached a high of 45,000 tons at midyear; and stocks at wire rod mills peaked at 113,000 tons in July. Total refined stocks, including those at Commodity Exchange, Inc., increased 21% in 1980.

PRICES

The copper price underwent a sharp 3-month rise beginning in December 1979 and peaking in February 1980; by April, the price had come back down to the level preceding the rise. It rose more slowly to a secondary high in July, then dropped gradually the rest of the year. The January average price for domestic delivered wire bar was $1.19 per pound; the February average was $1.34; and the December average was $0.89. The 1980 average was $1.02.

FOREIGN TRADE

The United States was again a net importer of copper in 1980, as imports of unwrought copper increased sharply. Refined copper comprised 84% of imports, and blister copper, 9%. Of the imported refined copper, most came from Canada, Chile, and Japan. Exports consisted mainly of scrap and ore and concentrates and went to more than 40 countries.

WORLD REVIEW

Most of the decline in world mine production in 1980 could be ascribed to the 5-month labor strike in the United States. The United States continued to lead the world in mine production with 15% of the total, followed by Chile, the U.S.S.R., Canada, Zambia, Zaire, Peru, Poland, and 58 other countries. According to the World Bureau of Metal Statistics, world consumption of refined copper declined 3% to 9.53 million tons. Stocks of refined copper in the market economy countries decreased for the third consecutive year, falling by 160,000 tons to 703,000 tons. Yearend stocks were equivalent to about 1 month of consumption. However, stocks rose at the warehouses of Commodity Exchange Inc. of New York and of the London Metal Exchange.

Since 1976, the major copper-producing and consuming countries have participated in a series of meetings held by the United Nations Conference on Trade and Development to discuss the causes of copper market instability and to consider possible solutions. Proposals generally have involved stabilization by means of a copper buffer stock alone or a buffer stock in conjunction with controls on production and exports. Essentially no progress was made in 1980 as the Seventh Preparatory Meeting adjourned without reaching substantive conclusions; the question of further preparatory work on copper was referred to the Ad Hoc Intergovernmental Committee for the Integrated Programme for Commodities.

The 16th session of the Conference of Ministers of the Intergovernmental Council of Copper Exporting Countries was held in Lusaka, Zambia, July 21-23.

Canada.—Copper was produced at about 3 dozen mines at which it was the principal product, and at 1 dozen mines at which it was an important coproduct. Copper was produced in the 2 territories and in 7 of the 10 Provinces; British Columbia led with 39% of total production; Ontario had 33%; Quebec had 14%; Manitoba had 9%; and Yukon, New Brunswick, Newfoundland, Saskatchewan, and Northwest Territories together accounted for the remaining 5%.

Details on the operation of individual mines and on exploration and development activities were published in the Canadian Minerals Yearbook.

Chile.—About 85% of production came from the four mines operated by the Government-owned Corporación del Cobre de Chile (Codelco), and the remainder came from seven privately owned mines. Of Codelco's four mines, Chuquicamata was reported to have produced 510,000 tons of copper; El Teniente, 270,000 tons; El Salvador, 80,000 tons; and Andina, 50,000 tons.

The Chilean Copper Commission announced plans for a 50% increase in Chile's copper production by 1990. It was expected that most of the expansion would be realized in the last 5 to 6 years of the decade, and that most, if not all, new mines established in the future would be in the private sector. Total investment in copper production for the decade was projected to be $6.5 billion, of which part would be required for expansion of facilities at Codelco's four mines to compensate for an anticipated decline in ore grade. Average ore grade at the four mines in 1980 was 1.68% copper, but grade was expected to fall to 1.13% copper by 1990.

Codelco announced plans to invest $1.5 billion in 1981-85, of which about $600 million would be for expansion of capacity. At Chuquicamata, mine and concentrator capacity was to be expanded by 37% to 96,000 tons of ore per day, and the smelter and leaching facilities were to be modified. At El Teniente, a new 25,000-ton-per-day concentrator was being installed, and capacity was expected to be augmented by about 23% to 320,000 tons of copper per year. Capacity at El Salvador was to be increased 15% to 90,000 tons of copper per year, and capacity at the Potrerillos smelter-refinery was to be increased by 30%. Output at Andina was to be increased 40% to 70,000 tons of copper per year.

Cia. Minera Disputada de las Condes (owned by Exxon Corp.) was reportedly studying the possibility of expanding output at its Los Bronces Mine as much as tenfold to 250,000 tons of copper per year. Anaconda was exploring the deposit called Los Pelambres, reported to contain 200 million tons of copper ore. Exploradora Donña Inés and a consortium of Canadian and U.S. companies were exploring the Quebrada Blanca deposit, which was estimated to have resources of 150 million tons of ore, grading more than 1% copper. Noranda Mines Ltd. had been exploring the Andacollo deposit but withdrew when it could not secure financing for development of the 200-million-ton deposit. Empresa Nacional de

Minería announced that Andacollo would be put up for bids again soon.

Peru.—Output of the largest producer was cut by several weeks of labor strikes. More than 90% of the total was accounted for by about 10 producers. Southern Peru Copper Corp.'s Cuajone and Toquepala Mines produced 73% of the total, while the mines of Empresa Mineral del Centro del Perú (Centromín) and the Cerro Verde Mine of Empresa Minera del Perú (Minero Peru) together produced another 16%.

Southern Peru Copper planned to increase capacity at Toquepala by 10,000 tons per day to 55,000 tons per day in 1981 and to 65,000 tons per day by 1983.

The Aguila Mine, located 400 kilometers north of Lima, attained full production in 1980. It was reported that a new flash smelter would be built to process concentrates from the Aguila and other mines of the region. The smelter, which was to be in Chimbote, was to have a capacity of 150,000 tons per year.

Centromín continued work on the fourfold expansion of its Cobriza Mine to 10,000 tons of ore per day, scheduled for completion in 1981. Minero Peru planned an expansion of its Cerro Verde Mine.

Empresa Estatal Minera Asociada Tintaya, S.A., a company formed by Minero Peru to develop the Tintaya copper deposit in southern Peru, near Cuzco, was evaluating proposals on the project from five foreign groups. Tintaya was scheduled for production in 1983.

Development of the Antamina copper deposit as a joint venture of Minero Peru and Geomin of Romania continued. Difficulty in obtaining financing was experienced, and after organizational changes were made, a new reduced goal of 10,000 tons of ore per day was set. Reserves at Antamina are estimated at 166 million tons, grading 1.6% copper.

Amax Exploration, Inc., of Denver, continued its drilling program on the PASHPAP copper-molybdenum deposit in the Province of Huaylas, in northern Peru.

Poland.—Mine output came principally from the Lubin, Polkowice, and Rudna Mines, located in the sedimentary Kupferschiefer beds of southwest Poland.

Zaire.—Copper was produced by two companies, the Government-owned La Générale des Carrières et des Mines du Zaire (Gécamines), and a joint Government-private Japanese company, Société de Development Industriel et Minière du Zaire (Sodimiza).

Gécamines produced most of Zaire's copper from its 10 mines and was able to raise output in spite of a persisting shortage of expatriate employees and difficult transportation and supply problems. With the installation of primary crushers and ore conveyors, the Dikuluwe and Mashamba Mines were fully commissioned. The Dima concentrator also became fully operational in 1980. A new 125,000-ton-per-year flash smelter and a 90,000-ton-per-year electrolytic refining unit were scheduled to come onstream at Luilu, near Kolwezi, in 1982. Expansion of the Lubumbashi smelter and plant was also planned.

Sodimiza increased production from its Musoshi and Kinsenda Mines by about 15% in 1980. Concentrates were shipped to Japan for smelting.

Société Minière de Tenke-Fungurume conducted feasibility studies on the Tenke-Fungurume deposit.

Zambia.—Copper was produced by the two Government-controlled companies, Nchanga Consolidated Copper Mines Ltd. (NCCM) and Roan Consolidated Mines Ltd. (RCM). NCCM operated five mines—Nkana, Bwana Mkubwa, Chingola, Konkola, and Kansanshi—and accounted for about two-thirds of the national total. RCM operated five mines—Mufulira, Luanshya, Baluba, Chambishi, and Chibuluma—and accounted for the other one-third of national production.

In general, the Zambian copper industry continued to experience difficulties with rising costs, difficult and costly transportation arrangements, shortages of spare parts and skilled personnel, and the cumulative effects of shortfalls in capital investment over the years.

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[1]Physical scientist, Section of Nonferrous Metals.
[2]In this chapter, tons refer to metric tons.
[3]Federal Emergency Management Agency, Office of Public Affairs. News Release 80-16, May 2, 1980.
[4]Federal Register. V. 45, No. 129, July 2, 1980, pp. 44926-44935.
[5]U.S. Senate, Committee on Environment and Public Works. News Release, Oct. 3, 1980.
[6]Federal Register. V. 45, No. 228, Nov. 24, 1980, pp. S14988-S15009.

Table 2.—Copper produced from domestic ores, by source

(Thousand metric tons)

Year	Mine	Smelter	Refinery
1976	1,457	1,326	1,291
1977	1,364	1,265	1,280
1978	1,358	1,270	1,327
1979	1,444	1,313	1,412
1980	1,168	994	1,122

Table 3.—Copper ore and recoverable copper produced, by mining method

(Perçent)

Year	Open pit		Underground	
	Ore	Copper[1]	Ore	Copper[2]
1976	90	84	10	16
1977	90	83	10	17
1978	90	85	10	15
1979	88	84	12	16
1980	87	81	13	19

[1]Includes copper from dump leaching.
[2]Includes copper from in-place leaching.

Table 4.—Mine production of recoverable copper in the United States, by month

(Metric tons)

Month	1979	1980
January	106,944	123,744
February	106,270	116,321
March	121,688	129,183
April	123,084	127,003
May	129,412	128,445
June	119,641	119,428
July	115,976	49,179
August	128,235	33,915
September	124,716	47,992
October	130,503	75,572
November	121,015	101,409
December	116,072	116,120
Total	1,443,556	1,168,311

Table 5.—Mine production of recoverable copper in the United States, by State

(Metric tons)

State	1976	1977	1978	1979	1980
Arizona	929,338	838,037	891,404	946,002	757,314
California	340	200	W	W	W
Colorado	2,205	1,720	1,191	362	461
Idaho	3,050	3,676	3,888	3,618	3,103
Maine	1,602	1,213	--	--	--
Michigan	39,650	38,442	W	W	W
Missouri	10,024	10,648	10,819	13,021	13,576
Montana	82,655	78,202	67,326	69,854	37,749
Nevada	52,762	60,837	20,453	W	W
New Mexico	156,362	149,412	127,828	164,281	149,394
Oregon	--	5	W	2	--
Tennessee	10,097	5,613	11,289	W	W
Utah	168,244	176,111	186,330	193,082	157,775
Other[1]	231	259	37,057	53,335	48,941
Total[2]	1,456,561	1,364,374	1,357,586	1,443,556	1,168,311

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Includes Alaska, California, Michigan, Oregon, and Washington (1978); California, Michigan, Nevada, Tennessee, and Washington (1979); and California, Michigan, Nevada, and Tennessee (1980).
[2]Data may not add to totals shown because of independent rounding.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1980, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore, copper precipitates.
2	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
3	Sierrita	Pima, Ariz	Duval Corp	Copper ore.
4	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore, copper precipitates.
5	Twin Buttes	Pima, Ariz	Anamax Mining Co	Copper ore.
6	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Copper ore, copper precipitates.
7	San Manuel	do	Magma Copper Co	Copper ore, copper tailings.
8	Bagdad	Yavapai, Ariz	Cyprus Bagdad Copper Co	Copper ore.
9	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore, copper precipitates.
10	Pinto Valley	Gila, Ariz	Cities Service Co	Do.
11	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
12	White Pine	Ontonagon, Mich	White Pine Copper Div	Copper ore.
13	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co.	Copper ore, copper precipitates.
14	Eisenhower	Pima, Ariz	Eisenhower Mining Co	Copper ore.
15	Pima	do	Cyprus Pima Mining Co	Do.
16	New Cornelia	do	Phelps Dodge Corp	Do.
17	Continental	Grant, N. Mex	UV Industries, Inc	Do.
18	Esperanza	Pima, Ariz	Duval Corp	Copper ore, copper precipitates.
19	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
20	Metcalf	Greenlee, Ariz	Phelps Dodge Corp	Copper ore, copper precipitates.
21	Sacaton Unit	Pinal, Ariz	ASARCO Incorporated	Copper ore.
22	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore, copper precipitates.
23	Silver Bell	Pima, Ariz	ASARCO Incorporated	Do.
24	Copperhill (3 mines).	Polk, Tenn	Cities Service Co	Copper-zinc ore.
25	Mission	Pima, Ariz	ASARCO Incorporated	Copper ore.

Table 7.—Mine production of recoverable copper in 1980, by method of treatment

Method of treatment	Ore treated (thousand metric tons)	Recoverable copper		Remarks
		Metric tons	Percent yield	
Copper ore:				
By concentration	206,670	953,156	0.46	See table 9.
By smelting	111	420	.38	See table 10.
By leaching	11,934	85,101	.71	See table 11.
Total or average	218,715	1,038,677	.47	
Tailings, dump, in-place material by leaching	--	107,980	--	See table 11.
Miscellaneous from cleanup, tailings, noncopper ores	--	21,654	--	
Total	XX	1,168,311	XX	

XX Not applicable.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States in 1980, by State, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand metric tons)	Recoverable metal content: Copper, Metric tons	Copper, Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per metric ton of ore
Arizona	141,971	605,206	0.43	71,533	5,640,703	$1.13
Montana	8,217	32,825	.40	11,541	1,612,034	4.91
New Mexico	22,208	129,683	.58	W	W	W
Utah	29,232	140,615	.48	W	W	W
Other[1 2]	5,153	45,247	.88	182,673	3,383,772	3.21
Total or average	206,781	953,576	.46	265,747	10,636,509	1.85

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Includes data for Idaho, Michigan, Nevada, New Mexico, Tennessee, and Utah.
[2]Includes copper-zinc ore.

Table 9.—Copper ore concentrated[1] in the United States in 1980, by State, with content in terms of recoverable copper

State	Ore concentrated (thousand metric tons)	Recoverable copper content: Metric tons	Percent
Arizona	141,894	604,823	0.43
Montana	8,216	32,798	.40
New Mexico	22,176	129,673	.58
Utah	29,232	140,615	.48
Other[2]	5,153	45,247	.88
Total or average	[3]206,670	953,156	.46

[1]Includes following methods of concentration: "Dual process" (leaching followed by concentration), "LPF" (leach-precipitation-flotation), and froth flotation.
[2]Includes copper-zinc ore.
[3]Data do not add to total shown because of independent rounding.

Table 10.—Copper ore shipped directly to smelters[1] in the United States in 1980, by State, with content in terms of recoverable copper

State	Ore shipped to smelters: Metric tons	Recoverable copper content: Metric tons	Percent
Arizona	77,545	383	0.49
Montana	1,077	27	2.51
New Mexico	31,941	11	.03
Total or average	110,563	[2]420	.38

[1]Primarily smelter fluxing material.
[2]Data do not add to total shown because of independent rounding.

Table 11.—Copper precipitates (leached from dump and in-place material or tailings) shipped directly to smelters, and copper ore leached (heap, vat, or tank) in the United States in 1980, by State, with content in terms of recoverable copper

State	Precipitates shipped (metric tons)	Recoverable copper content (metric tons)	Ore leached (metric tons)	Recoverable copper content (metric tons)	Percent
Arizona	114,403	[1]66,971	[2]11,934,450	85,101	0.71
Montana	7,494	4,669	--	--	--
New Mexico	19,833	19,711	--	--	--
Utah	22,136	16,630	--	--	--
Total or average	163,866	[3]107,980	11,934,450	85,101	.71

[1]Includes copper from newly generated tailings.
[2]Includes 7,985,638 metric tons of ore leached for electrowinning.
[3]Data do not add to total shown because of independent rounding.

Table 12.—Copper ore smelted and copper ore concentrated in the United States and average yield in copper, gold, and silver

Year	Smelting ore		Concentrating ore		Total				
	Thousand metric tons	Yield in copper (percent)	Thousand metric tons[1] [2]	Yield in copper (percent)	Thousand metric tons[1]	Yield in copper (percent)	Yield per metric ton in gold (ounce)	Yield per metric ton in silver (ounce)	Value per metric ton in gold and silver
1976	236	0.32	234,391	0.50	257,401	0.51	0.0014	0.058	0.43
1977	272	.31	217,861	.51	235,844	.52	.0016	.061	.52
1978	258	.22	224,893	.50	239,247	.51	.0016	.056	.62
1979	199	.30	248,722	.49	264,790	.49	.0016	.057	1.12
1980	111	.38	206,670	.46	218,715	.47	.0013	.051	1.85

[1]Includes some ore classed as copper-zinc and minor amount of tailings.
[2]Excludes tank or vat and heap leaching. (See tables 7 and 11.)

Table 13.—Copper produced by primary smelters in the United States

(Metric tons)

Year	Domestic	Foreign	Secondary	Total
1976	1,325,629	66,557	46,307	1,438,493
1977	1,265,008	36,962	44,846	1,346,816
1978	1,269,981	18,397	54,216	1,342,594
1979	1,313,224	22,383	60,231	1,395,838
1980	994,479	13,918	44,876	1,053,273

Table 14.—Primary and secondary copper produced by primary refineries and electrowinning plants in the United States

(Metric tons)

	1976	1977	1978	1979	1980
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,107,800	1,052,505	1,124,585	1,207,626	935,883
Electrowon	94,294	126,512	98,416	98,801	101,545
Fire refined	88,579	101,018	104,372	105,091	84,469
Total	1,290,673	1,280,035	1,327,373	1,411,518	1,121,897
From foreign ores, etc.:[1]					
Electrolytic[2]	105,764	77,281	121,684	103,858	88,957
Electrowon	W	W	W	W	W
Fire refined	--	W	W	W	W
Total refinery production of primary copper	1,396,437	1,357,316	1,449,057	1,515,376	1,210,854
SECONDARY					
Electrolytic[2]	254,983	240,552	293,437	298,344	315,062
Electrowon	W	W	W	W	W
Fire refined	6,909	W	W	W	W
Total secondary	261,892	240,552	293,437	298,344	315,062
Grand total	1,658,329	1,597,868	1,742,494	1,813,720	1,525,916

W Withheld to avoid disclosing company proprietary data; included in "Electrolytic."

[1]The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.

[2]Includes electrowon and fire-refined quantities indicated by symbol W.

Table 15.—Copper cast in forms at primary refineries in the United States

	1979		1980	
	Thousand metric tons	Percent	Thousand metric tons	Percent
Billets	57	3	100	7
Cakes	93	5	65	4
Cathodes	968	54	827	54
Ingots and ingot bars	78	4	62	4
Wire bars	580	32	432	28
Other forms	38	2	40	3
Total	1,814	100	1,526	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Metric tons)

Year	Production		Shipments[1]	Stocks, Dec. 31
	Quantity	Copper content		
1976	29,141	7,639	27,607	7,763
1977	27,306	7,199	28,084	6,985
1978	31,881	8,551	31,208	7,658
1979	35,005	9,286	33,802	8,861
1980	31,010	8,445	34,135	5,736

[1]Includes consumption by producing companies.

Table 17.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Metric tons)

Year	Copper plants[2]	Lead plants	Zinc plants[3]	Total
1976	2,069,825	132,333	725,542	2,927,700
1977	2,138,567	127,898	669,304	2,935,769
1978	2,484,111	202,935	686,275	3,373,321
1979	2,513,035	282,704	773,836	3,569,575
1980	2,097,692	[4]410,266	560,784	3,068,742

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrite concentrates.
[3]Excludes acid made from native sulfur.
[4]Includes acid processed at molybdenum plants in order to conceal company proprietary data.

Table 18.—Secondary copper produced in the United States

(Metric tons)

	1976	1977	1978	1979	1980
Copper recovered as unalloyed copper	354,463	364,721	437,120	516,271	534,556
Copper recovered in alloys[1]	684,512	720,704	810,115	1,036,254	902,871
Total secondary copper[1]	1,038,975	1,085,425	1,247,235	1,552,525	1,437,427
Source:					
New scrap	658,750	675,497	745,585	948,224	823,969
Old scrap	380,225	409,928	501,650	604,301	613,458
Percentage equivalent of domestic mine output	71	80	92	108	123

[1]Includes copper in chemicals, as follows: 1976—3,635; 1977—3,283; 1978—2,911; 1979—3,004; and 1980—2,869.

Table 19.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1979	1980
KIND OF SCRAP		
New scrap:		
Copper-base	926,025	803,527
Aluminum-base	21,937	20,247
Nickel-base	237	173
Zinc-base	25	22
Total	948,224	823,969
Old scrap:		
Copper-base	587,935	598,591
Aluminum-base	16,181	14,610
Nickel-base	121	127
Tin-base	5	5
Zinc-base	59	125
Total	604,301	613,458
Grand total	1,552,525	1,437,427
FORM OF RECOVERY		
As unalloyed copper:		
At primary plants	298,344	315,062
At other plants	217,927	219,494
Total	516,271	534,556
In brass and bronze	976,402	850,188
In alloy iron and steel	3,086	2,317
In aluminum alloys	53,608	47,306
In other alloys	154	191
In chemical compounds	3,004	2,869
Total	1,036,254	902,871
Grand total	1,552,525	1,437,427

Table 20.—Copper recovered as refined copper in alloys and in other forms from copper-base scrap processed in the United States

(Metric tons)

Recovered by—	From new scrap		From old scrap		Total	
	1979	1980	1979	1980	1979	1980
Secondary smelters	242,517	239,675	346,280	301,327	588,797	541,002
Primary copper producers	139,636	87,281	158,708	227,781	298,344	315,062
Brass mills	520,413	453,017	31,201	29,868	551,614	482,885
Foundries and manufacturers	21,334	21,467	50,867	38,833	72,201	60,300
Chemical plants	2,125	2,087	879	782	3,004	2,869
Total	926,025	803,527	587,935	598,591	1,513,960	1,402,118

Table 21.—Production of secondary copper and copper-alloy products in the United States

(Metric tons)

Item produced from scrap	1979	1980
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	298,344	315,062
Refined copper by secondary smelters	200,115	200,021
Copper powder	17,411	13,203
Copper castings	401	6,270
Total	516,271	534,556
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	21,964	21,145
Leaded red brass and semired brass	136,416	120,869
High-leaded tin bronze	26,449	19,884
Yellow brass	12,488	11,892
Manganese bronze	10,277	8,105
Aluminum bronze	7,684	8,337
Nickel silver	3,113	2,707
Silicon bronze and brass	4,527	3,769
Copper-base hardeners and master alloys	18,135	15,430
Total	241,053	212,138
Brass-mill products	692,136	598,672
Brass and bronze castings	51,555	38,858
Brass powder	1,197	877
Copper in chemical products	3,004	2,869
Grand total	1,505,216	1,387,970

Table 22.—Composition of secondary copper-alloy production

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1979	216,135	4,513	9,566	10,281	479	79	241,053
1980	194,113	2,949	6,366	8,250	404	56	212,138
Secondary metal content of brass-mill products:							
1979	551,614	471	3,658	133,593	2,773	27	692,136
1980	482,885	366	3,003	110,734	1,661	23	598,672
Secondary metal content of brass and bronze castings:							
1979	42,110	1,423	3,166	4,750	47	59	51,555
1980	31,272	1,174	2,382	3,848	105	77	38,858

[1]About 95% from scrap and 5% from other than scrap (1979); and about 96% from scrap and 4% from other than scrap (1980).

Table 23.—Stocks and consumption of purchased copper scrap in the United States in 1980

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
SECONDARY SMELTERS						
No. 1 wire and heavy copper	2,104	49,174	4,882	44,345	49,227	2,051
No. 2 wire, mixed heavy and light copper	11,630	257,790	131,583	126,198	257,781	11,639
Composition or red brass	2,194	57,758	10,470	45,829	56,299	3,653
Railroad-car boxes	194	1,548	--	1,488	1,488	254
Yellow brass	3,768	41,348	6,776	34,895	41,671	3,445
Cartridge cases and brass	72	167	--	149	149	90
Auto radiators (unsweated)	3,602	61,118	--	60,971	60,971	3,749
Bronze	1,587	17,583	3,062	14,430	17,492	1,678
Nickel silver and cupronickel	605	2,832	357	2,536	2,893	544
Low brass	445	3,443	1,057	2,303	3,360	528
Aluminum bronze	146	446	354	76	430	162
Low-grade scrap and residues	12,188	226,674	177,767	50,420	228,187	10,675
Total	38,535	719,881	336,308	383,640	719,948	38,468
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	8,392	110,723	32,672	82,223	114,895	4,220
No. 2 wire, mixed heavy and light copper	10,981	150,184	43,999	113,345	157,344	3,821
Refinery brass } Low-grade scrap and residues	18,734	4,234	32	4,095	4,127	22,226
Low-grade scrap and residues		175,469	41,793	130,291	172,084	
Total	38,107	440,610	118,496	329,954	448,450	30,267
BRASS MILLS[1]						
No. 1 wire and heavy copper	11,794	185,338	156,460	28,878	185,338	12,318
No. 2 wire, mixed heavy and light copper	2,846	44,280	43,059	1,221	44,280	2,135
Yellow brass	21,600	247,867	247,867	--	247,867	19,864
Cartridge cases and brass	10,519	61,205	61,087	118	61,205	10,346
Bronze	480	4,414	4,414	--	4,414	775
Nickel silver and cupronickel	3,670	13,934	13,934	--	13,934	3,756
Low brass	3,012	50,932	50,932	--	50,932	3,724
Aluminum bronze	19	235	235	--	235	6
Total[1]	53,940	608,205	577,988	30,217	608,205	52,924
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	3,388	30,580	14,290	16,636	30,926	3,042
No. 2 wire, mixed heavy and light copper	686	7,553	4,147	3,399	7,546	693
Composition or red brass	697	11,855	212	11,660	11,872	680
Railroad-car boxes	707	6,284	--	6,140	6,140	851
Yellow brass	433	10,039	5,398	4,725	10,123	349
Auto radiators (unsweated)	680	4,351	1,433	3,142	4,575	456
Bronze	900	524	356	199	555	869
Nickel silver and cupronickel	10	442	31	407	438	14
Low brass	53	1,239	1,134	107	1,241	51
Aluminum bronze	80	878	32	854	886	72
Total	7,634	73,745	[2]27,033	[2]47,269	74,302	7,077
GRAND TOTAL						
No. 1 wire and heavy copper	25,678	375,815	208,304	172,082	380,386	21,631
No. 2 wire, mixed heavy and light copper	26,143	459,807	222,788	244,163	466,951	18,288
Composition or red brass	2,891	69,613	10,682	57,489	68,171	4,333
Railroad-car boxes	901	7,832	--	7,628	7,628	1,105
Yellow brass	25,801	299,254	260,041	39,620	299,661	23,658
Cartridge cases and brass	10,591	61,372	61,087	267	61,354	10,436
Auto radiators (unsweated)	4,282	65,469	1,433	64,113	65,546	4,205
Bronze	2,967	22,521	7,832	14,629	22,461	3,322
Nickel silver and cupronickel	4,285	17,208	14,322	2,943	17,265	4,314
Low brass	3,510	55,614	53,123	2,410	55,533	4,303
Aluminum bronze	245	1,559	621	930	1,551	240
Low-grade scrap and residues[3]	30,922	406,377	219,592	184,806	404,398	32,901
Total	138,216	1,842,441	1,059,825	791,080	1,850,905	128,736

[1]Brass-mill stocks include home scrap; purchased scrap consumption is assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.
[2]Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 2,198 tons new and 814 tons old.
[3]Includes refinery brass.

Table 24.—Consumption of copper and brass materials in the United States, by principal consuming group

(Metric tons)

Year and item	Primary producers	Brass mills	Wire rod mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1979:						
Copper scrap	486,045	703,138	--	88,831	795,212	2,073,226
Refined copper[1]	--	610,177	1,499,596	42,418	6,251	2,158,442
Brass ingot	--	4,050	--	[2]237,444	--	241,494
Slab zinc	--	127,628	--	2,770	11,006	141,404
Miscellaneous	--	--	--	180	--	180
1980:						
Copper scrap	448,450	608,205	--	74,302	719,948	1,850,905
Refined copper[1]	--	511,627	1,308,922	36,580	4,967	1,862,096
Brass ingot	--	6,087	--	[2]207,631	--	213,718
Slab zinc	--	90,413	--	2,311	6,102	98,826
Miscellaneous	--	--	--	180	--	180

[1]Detailed information on consumption of refined copper will be found in table 28.
[2]Shipments to foundries by smelters and change in stocks at foundries.

Table 25.—Foundry consumption of brass ingot in the United States, by type

(Metric tons)

Type	1976	1977	1978	1979	1980
Tin bronzes	30,043	34,649	35,951	35,242	30,327
Leaded red brass and semired brass	88,661	97,095	106,053	107,596	95,138
Yellow brass	21,016	23,841	21,368	21,138	17,780
Manganese bronze	5,166	5,296	7,430	7,724	6,287
Hardeners and master alloys	3,071	3,484	4,398	5,913	5,446
Nickel silver	2,040	2,096	2,330	2,315	2,579
Aluminum bronze	5,374	6,122	7,071	7,267	6,727
Total	155,371	172,583	184,601	187,195	164,284

Table 26.—Foundry consumption of brass ingot in the United States in 1980, by type, refined copper, and copper scrap, by geographic division and State

(Metric tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	Yellow brass	Manganese bronze	Hardeners and master alloys	Nickel silver	Aluminum bronze	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:										
Connecticut	524	1,864	922	27			238	4,193	292	716
Massachusetts	225	1,730	422	186	541	396	97	2,739	795	169
Maine, New Hampshire, Rhode Island, Vermont	240	1,826	89	275				2,670		
Total	989	5,420	1,433	488	541	396	335	9,602	1,087	885
Middle Atlantic:										
New Jersey	741	1,048	205	108			163	2,330	3,327	5,646
New York	926	6,611	1,202	231	1,051	690	171	9,196		
Pennsylvania	6,577	5,963	1,164	544			1,314	17,183	3,880	5,899
Total	8,244	13,622	2,571	883	1,051	690	1,648	28,709	7,207	11,545
East North Central:										
Illinois		11,153	854	560			1,393	14,912	375	9,898
Indiana	4,183	7,215	682	216	1,289	91	25	12,401	438	
Michigan		3,510	540	883			355	5,636	6,132	3,017
Ohio	10,258	9,169	3,095	955	1,049	278	557	22,430	6,002	8,706
Wisconsin		5,237	1,715	168			153	10,204		3,774
Total	14,441	36,284	6,886	2,782	2,338	369	2,483	65,583	12,947	25,395
West North Central:										
Iowa, Kansas, Minnesota	127	2,211	998	514	84	4	114	4,013	3,993	12,376
Missouri, Nebraska, South Dakota	61	1,358	757	158			245	2,618		
Total	188	3,569	1,755	672	84	4	359	6,631	3,993	12,376

Table 26.—Foundry consumption of brass ingot in the United States in 1980, by type, refined copper, and copper scrap, by geographic division and State —Continued

(Metric tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	Yellow brass	Man-ganese bronze	Hardeners and master alloys	Nickel silver	Alumi-num bronze	Total brass ingot	Refined copper con-sumed	Copper scrap con-sumed
South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	331	393	514	71	1	952	57	1,856	2,955	3,778
North Carolina, South Carolina, Virginia, West Virginia	110	7,225		79			266	8,143		
Total	441	7,618	514	150	1	952	323	9,999	2,955	3,778
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	1,757	10,207	1,747	429			1,243	14,406		4,288
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,124	8,394	1,109	174	114	138		13,026	7,165	3,106
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	337	400	235	36			14	1,026		571
Pacific:										
California	1,641	9,525	1,530	673	1,317	30	322	13,438	893	8,332
Oregon and Washington	165	99						1,864		1,014
Total	1,806	9,624	1,530	673	1,317	30	322	15,302	893	9,346
Grand total	30,327	95,138	17,780	6,287	5,446	2,579	6,727	164,284	36,247	71,290

Table 27.—Primary refined copper supply and withdrawals on domestic account

(Metric tons)

	1976	1977	1978	1979	1980
Production from domestic and foreign ores, etc	1,396,437	1,357,316	1,449,057	1,515,376	1,210,854
Imports[1]	346,113	354,506	414,697	215,161	458,112
Stocks, Jan. 1[1]	187,000	172,000	212,000	153,000	64,000
Total available supply	1,929,550	1,883,822	2,075,754	1,883,537	1,732,966
Copper exports[1]	101,502	46,745	91,923	73,677	14,489
Stocks, Dec. 31[1]	172,000	212,000	153,000	64,000	49,000
Total	273,502	258,745	244,923	137,677	63,489
Apparent withdrawals on domestic account[2]	1,656,000	1,625,000	1,831,000	1,746,000	1,669,000

[1]May include some copper refined from scrap.
[2]Excludes copper, if any, delivered to industry from national stockpile sales.

Table 28.—Refined copper consumed by class of consumer

(Metric tons)

Year and class	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1979:							
Wire rod mills	812,345	673,575	W	W	--	13,676	1,499,596
Brass mills	272,059	28,335	74,333	105,573	129,462	415	610,177
Chemical plants	--	--	--	--	--	415	415
Secondary smelters	2,052	--	4,039	--	--	160	6,251
Foundries	2,618	W	7,898	--	W	1,402	11,918
Miscellaneous[1]	9,945	W	5,813	W	W	14,327	30,085
Total	1,099,019	701,910	92,083	105,573	129,462	30,395	2,158,442
1980:							
Wire rod mills	714,050	560,904	W	W	--	33,968	1,308,922
Brass mills	233,695	22,107	54,076	84,251	117,370	128	511,627
Chemical plants	--	--	--	--	--	333	333
Secondary smelters	1,333	--	2,654	--	--	980	4,967
Foundries	2,510	W	6,795	--	W	1,601	10,906
Miscellaneous[1]	8,585	W	4,076	W	W	12,680	25,341
Total	960,173	583,011	67,601	84,251	117,370	49,690	1,862,096

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

Table 29.—Stocks of copper in the United States, December 31

(Metric tons)

Year	Blister and materials in process of refining[1]	Refined copper				
		Primary producers	Wire rod mills	Brass mills	Other[2]	New York Commodity Exchange
1976	291,000	172,000	104,000	32,000	6,000	182,000
1977	314,000	212,000	106,000	31,000	6,000	167,000
1978	263,000	153,000	63,000	28,000	7,000	163,000
1979	275,000	64,000	44,000	25,000	[r]9,000	90,000
1980	272,000	49,000	50,000	22,000	10,000	163,000

[r]Revised.
[1]Includes copper in transit from smelters in the United States to refineries therein.
[2]Includes secondary smelters, chemical plants, foundries, and miscellaneous plants.

Table 30.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1979[1]

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	47.07	58.82	65.46	68.93	63.14	59.05
No. 1 composition scrap (red brass)	45.18	54.97	59.84	62.62	57.41	57.29
No. 1 composition ingot (85-5-5-5)	80.18	90.85	94.91	97.24	93.82	92.00

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	57.79	58.85	62.03	62.89	62.25	65.00	60.94
No. 1 composition scrap (red brass)	55.55	56.18	58.80	59.76	59.30	61.89	57.37
No. 1 composition ingot (85-5-5-5)	92.00	92.00	92.00	96.00	96.00	96.00	92.75

[1]Data not available for 1980.

Source: Metal Statistics, 1980.

Table 31.—Average monthly quoted prices of electrolytic copper for domestic delivered, in the United States and for spot copper at London

(Cents per pound)

Month	1979				1980			
	Domestic delivered		London spot[1]		Domestic delivered		London spot[1]	
	Cathode	Wire bar	Cathode	Wire bar	Cathode	Wire bar	Cathode	Wire bar
January	75.47	76.57	73.83	75.24	118.07	119.39	114.00	117.89
February	88.13	89.70	87.33	88.16	132.85	133.81	126.71	132.29
March	95.34	96.72	92.40	92.94	105.05	106.04	100.45	104.55
April	97.32	98.32	95.29	95.20	93.62	94.85	90.96	93.91
May	90.40	91.23	85.91	87.34	92.16	93.48	90.79	92.82
June	87.23	88.24	82.57	85.15	91.66	92.71	88.26	90.96
July	85.77	86.77	80.06	82.25	102.24	103.56	95.80	98.68
August	90.17	91.34	86.18	89.61	99.72	100.71	91.09	94.39
September	94.55	95.85	92.04	95.01	97.99	98.86	90.30	93.41
October	97.99	99.11	92.61	94.09	98.45	99.47	89.70	92.75
November	98.54	99.71	92.63	94.76	95.81	96.98	89.00	91.16
December	105.41	106.45	97.00	100.38	88.10	89.13	83.21	85.17
Average	92.19	93.33	88.25	90.07	101.31	102.42	96.09	99.25

[1]Based on average monthly rates of exchange.

Source: Metals Week.

Table 32.—Average weighted prices of copper delivered

(Cents per pound)

Year	Domestic copper	Foreign copper
1976	69.6	63.5
1977	66.8	59.3
1978	66.5	61.9
1979	93.3	90.0
1980	102.4	99.2

Source: Metals Week.

Table 33.—U.S. exports of copper, by class and destination

Year and destination	Ore and concentrates (copper content)		Ash and residues[1] (copper content)		Refined		Scrap		Blister and precipitates	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1979	44,565	$66,155	5,215	$9,415	73,677	$128,703	54,080	$70,624	7,445	$9,515
1980:										
Africa	--	--	--	--	138	320	18	30	14	38
Bangladesh	--	--	--	--	--	--	--	--	--	--
Belgium-Luxembourg	51	50	3,107	8,495	589	1,211	5,591	7,808	21	49
Brazil	--	--	--	--	1,451	3,401	1,166	2,084	1	12
Canada	2,683	1,686	348	476	2,865	5,132	8,705	12,957	424	989
Chile	--	--	--	--	--	--	57	85	--	--
China:										
Mainland	3,012	5,399	--	--	--	--	--	--	--	--
Taiwan	--	--	--	--	300	583	3,062	4,168	29	110
Colombia	--	--	--	--	--	--	18	20	--	--
Costa Rica	--	--	--	--	1	3	--	--	--	--
El Salvador	--	--	--	--	--	--	--	--	--	--
Finland	1,775	1,947	--	--	1	2	--	--	--	--
France	19	35	--	--	1,851	4,770	184	277	11	28
German Democratic Republic	1,710	3,204	--	--	--	--	57	97	--	--
Germany, Federal Republic of	2,744	5,086	151	1,201	799	1,665	9,883	15,315	1	2
Guatemala	--	--	--	--	150	499	--	--	--	--
Haiti	--	--	--	--	--	--	--	--	--	--
Honduras	--	--	--	--	--	--	--	--	--	--
Hong Kong	--	--	--	--	--	--	167	319	(2)	3
Iceland	--	--	--	--	--	--	--	--	--	--
India	--	--	97	173	126	217	4,304	5,399	--	--
Indonesia	--	--	--	--	--	--	--	--	--	--
Israel	--	--	--	--	10	37	--	--	3	10
Italy	--	--	--	--	1,428	3,047	2,588	3,093	7	11
Japan	77,813	146,561	1,974	3,992	812	1,873	6,435	10,416	2,063	3,383
Jordan	--	--	--	--	--	--	--	--	--	--
Korea, Republic of	7,396	15,378	--	--	--	--	2,916	5,114	854	1,754
Mexico	10	9	14	22	918	1,306	6,912	11,876	324	729
Netherlands	--	--	--	--	644	1,261	2,196	3,491	2	3
Norway	--	--	--	--	--	--	130	246	--	--
Oceania	--	--	--	--	5	13	--	--	5	10
Philippines	--	--	--	--	--	--	--	--	(2)	2
Romania	2,951	7,135	(2)	1	--	--	--	--	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	22	101

See footnotes at end of table.

Table 33.—U.S. exports of copper, by class and destination —Continued

Year and destination	Ore and concentrates (copper content)		Ash and residues[1] (copper content)		Refined		Scrap		Blister and precipitates	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1980 —Continued										
Singapore	--	--	--	--	3	$7	--	--	14	$36
Spain	38	$94	466	$251	74	166	5,472	$7,777	--	--
Sweden	--	--	--	--	128	282	216	389	--	--
Trinidad	--	--	--	--	--	--	--	--	--	--
United Arab Emirates	--	--	--	--	--	--	--	--	--	--
United Kingdom	--	--	722	863	1,950	4,841	903	1,708	4	9
Venezuela	--	--	--	--	--	--	--	--	1	14
Yugoslavia	6,624	16,790	--	--	--	--	--	--	--	--
Other	--	--	--	--	246	463	245	391	2	4
Total[3]	106,825	203,375	6,881	15,474	14,489	31,099	61,225	93,059	3,802	7,296

Year and destination	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[4]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1979	8,527	$25,480	656	$2,342	8,530	$27,207	81,616	$302,321	19,460	$40,462
1980:										
Africa	500	1,696	4	29	301	1,639	5,041	19,095	186	358
Bangladesh	1	4	--	--	13	48	362	1,068	--	--
Belgium-Luxembourg	4	23	55	408	43	298	309	4,860	755	1,908
Brazil	26	122	15	129	29	73	346	2,387	482	996
Canada	1,358	4,529	1,007	3,102	463	2,206	15,661	55,679	4,464	11,195
Chile	9	35	--	--	36	162	324	1,622	39	74
China:										
Mainland	--	--	1	2	48	580	232	1,711	--	--
Taiwan	34	165	119	366	221	1,438	1,105	9,399	43	86
Colombia	64	273	18	71	15	50	719	2,710	--	--
Costa Rica	241	724	1	4	6	43	25	115	1,620	3,837
El Salvador	--	--	1	8	123	868	20	105	495	1,088
Finland	70	254	1	2	(2)	3	23	206	--	--
France	1,317	4,750	1	3	45	253	451	9,324	3,894	8,994
German Democratic Republic	--	--	--	--	--	--	--	--	--	--
Germany, Federal Republic of	4,169	12,291	301	1,379	21	194	822	12,861	2,742	5,300
Guatemala	52	180	--	--	33	76	149	639	1	1
Haiti	(2)	2	--	--	40	157	635	2,287	1	2
Honduras	6	29	(2)	2	41	195	838	2,293	2	13
Hong Kong	24	114	(2)	2	12	51	270	1,847	--	--

Iceland	1	2	--	--	115	249	24	105	--	--
India	(2)	3	2	8	109	307	123	1,292	388	901
Indonesia	3	19	(2)	3	5	33	420	2,039	2	3
Israel	423	1,294	6	18	30	231	847	5,150	2	6
Italy	1,774	6,170	1	12	19	202	353	4,940	8,150	18,395
Japan	21	44	6	30	57	328	393	6,628	300	1,055
Jordan	37	131	--	--	45	214	346	887	--	--
Korea, Republic of	1	10	--	--	55	134	272	3,757	17	41
Mexico	1,539	3,849	77	275	1,883	8,424	15,107	51,946	5,315	12,383
Netherlands	490	1,565	2	18	9	76	402	5,954	1,637	3,898
Norway	--	--	--	--	2	19	69	1,147	--	--
Oceania	33	108	2	13	98	501	549	5,218	35	168
Philippines	12	53	1	8	35	189	457	3,260	61	133
Romania	--	--	--	--	--	--	28	310	--	--
Saudi Arabia	877	2,918	12	62	1,436	4,859	9,659	40,683	20	65
Singapore	18	71	3	14	19	196	988	5,832	9	34
Spain	779	2,541	--	--	2	17	84	814	(2)	2
Sweden	196	637	--	--	11	84	90	2,093	1,540	4,242
Trinidad	3	16	--	--	12	61	318	1,631	--	--
United Arab Emirates	144	493	--	--	238	782	394	2,456	--	--
United Kingdom	1,966	7,371	71	238	41	251	1,661	17,112	4,645	10,393
Venezuela	294	1,052	87	209	172	646	1,295	6,029	3,974	8,585
Yugoslavia	--	--	--	--	--	--	43	452	--	--
Other	1,166	4,742	51	294	408	1,734	3,844	19,063	251	605
Total[3]	17,652	58,284	1,843	6,708	6,295	27,868	65,098	317,008	41,071	94,760

[1]Includes matte.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Excludes copper wire cloth: 1979—308,386 square feet ($1,044,000), and 1980—301,046 square feet ($771,950).

Table 34.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper alloy scrap			
	1979		1980		1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	61	$81	18	$19	1,018	$869	55	$74
Belgium-Luxembourg	2,600	2,937	5,591	7,808	10,951	13,561	14,497	23,496
Brazil	735	1,049	1,166	2,084	1,624	2,253	2,010	2,937
Canada	12,306	15,257	8,705	12,957	10,553	12,571	12,002	13,766
Finland	11	12	--	--	1,425	2,273	1,609	2,861
France	16	18	184	277	113	191	250	567
German Democratic Republic	170	230	57	97	37	58	18	23
Germany, Federal Republic of	6,693	8,901	9,883	15,315	15,774	18,240	22,300	30,799
Hong Kong	183	259	167	319	742	840	1,492	1,628
India	2,627	3,077	4,304	5,399	11,060	12,902	7,083	8,374
Italy	146	165	2,588	3,093	862	984	4,845	4,957
Japan	4,189	5,508	6,435	10,416	18,954	23,824	17,753	26,428
Korea, Republic of	14,380	21,867	2,916	5,114	20,732	28,769	7,446	11,062
Mexico	3,319	4,535	6,912	11,876	1,964	1,652	3,355	3,636
Netherlands	599	718	2,196	3,491	1,431	1,981	1,444	2,322
Singapore	194	115	--	--	43	52	--	--
Spain	3,636	2,871	5,472	7,777	11,367	8,569	18,742	22,567
Sweden	288	365	216	389	1,202	1,852	560	965
Switzerland	--	--	18	32	71	87	163	263
Taiwan	1,027	1,511	3,062	4,168	3,991	3,846	10,843	13,714
Thailand	54	70	18	35	236	261	164	222
Turkey	--	--	81	130	--	--	752	1,176
United Kingdom	680	858	903	1,708	2,505	3,457	2,102	3,676
Other	166	221	332	557	337	581	284	465
Total[1]	54,080	70,624	61,225	93,059	116,992	139,673	129,767	175,981

[1]Data may not add to totals shown because of independent rounding.

Table 35.—U.S. imports[1] of unmanufactured copper (copper content), by class and country

Year and country	Ore and concentrates		Matte		Blister		Refined		Scrap		Total[2]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1979	22,433	$39,426	414	$543	68,137	$121,786	215,161	$408,826	22,178	$33,730	328,323	$604,310
1980:												
Argentina	--	--	--	--	--	--	500	1,076	--	--	500	1,076
Australia	1,361	2,298	--	--	4,077	11,146	--	--	--	--	5,438	13,444
Austria	--	--	--	--	--	--	--	--	126	238	126	238
Canada	2,142	4,033	326	480	3,953	9,597	130,873	286,909	15,122	29,667	152,416	330,685
Chile	27	49	439	900	19,227	38,790	106,568	230,598	358	713	126,618	271,049
Dominican Republic	--	--	--	--	--	--	--	--	839	1,504	839	1,504
El Salvador	--	--	--	--	--	--	--	--	299	573	299	573
France	--	--	--	--	--	--	36	75	158	470	194	545
Germany, Federal Republic of	--	--	--	--	--	--	403	845	53	167	456	1,012
Guatemala	--	--	--	--	--	--	--	--	130	219	130	219
Japan	--	--	--	--	2,721	5,831	104,732	236,736	1	2	107,454	242,569
Mexico	22	23	--	--	927	3,254	2,611	6,344	4,700	5,845	8,261	15,467
Norway	--	--	--	--	--	--	485	1,068	--	--	485	1,068
Panama	--	--	--	--	--	--	--	--	425	619	425	619
Peru	1,306	1,804	--	--	16,034	32,130	35,176	73,473	--	--	52,516	107,407
Philippines	8,898	19,283	--	--	--	--	--	--	30	50	8,927	19,333
South Africa, Republic of	--	--	--	--	--	--	2,173	4,976	1	1	2,174	4,978
Venezuela	--	--	--	--	--	--	--	--	189	394	189	394
Yugoslavia	--	--	--	--	--	--	4,542	9,261	--	--	4,542	9,261
Zaire	--	--	--	--	--	--	5,003	11,201	--	--	5,003	11,201
Zambia	--	--	--	--	--	--	64,857	138,481	--	--	64,857	138,481
Other	(3)	(3)	--	--	25	88	153	314	336	401	515	803
Total[2]	13,756	27,489	765	1,379	46,963	100,837	458,112	1,001,357	22,768	40,863	542,363	1,171,926

[1]Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 36.—Copper: World mine production, by country[1]

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada[2]	730.9	759.4	659.4	636.4	[3]710.1
Cuba	[r]2.9	2.6	2.8	2.8	3.0
Guatemala	[r]3.5	[r]2.5	2.1	1.8	[3].8
Honduras	.4	.5	.6	1.4	1.0
Mexico	89.0	89.7	87.2	107.1	175.4
Nicaragua[4]	[r].8	[r].3	[e].1	--	--
United States[2]	1,456.6	1,364.4	1,357.6	[3]1,443.6	[3]1,168.3
South America:					
Argentina	.3	.2	.3	.2	[3].2
Bolivia	5.1	[r]3.2	2.9	1.8	[3]1.9
Brazil	.1	([5])	([5])	5.0	4.7
Chile	1,005.2	1,056.2	1,035.5	1,060.6	[3]1,067.7
Colombia	[r].3	.9	.4	.3	.4
Ecuador	.3	[r]1.0	.8	1.2	1.2
Peru	220.3	341.0	366.4	400.4	[3]365.3
Europe:					
Albania[e]	10.0	10.0	11.5	[r]14.0	15.3
Austria	1.1	--	--	--	--
Bulgaria	57.0	57.0	58.0	58.0	58.0
Czechoslovakia[e]	[r]4.9	[r]5.4	4.7	6.2	5.6
Finland	41.7	46.7	46.9	41.1	36.8
France	.5	.3	.6	.6	.5
German Democratic Republic[e]	16.0	17.0	16.0	15.0	15.0
Germany, Federal Republic of[2 6]	1.6	1.2	.8	.9	[3]1.3
Greece[5]	2.6	3.5	1.5	--	--
Hungary	1.3	1.0	.5	.3	.3
Ireland[4]	4.1	4.9	4.8	4.9	[3]4.2
Italy[6]	.9	.7	.5	.5	[3].6
Norway[6]	31.1	29.1	28.3	28.0	[3]28.9
Poland[2]	267.0	289.3	321.0	325.0	[3]346.1
Portugal[6]	[r].4	[r].3	.3	.5	.5
Romania[2]	23.0	27.0	27.0	27.0	27.0
Spain[6 7]	35.6	48.3	42.2	43.3	[3]41.5
Sweden	44.9	44.8	47.6	45.8	[3]42.8
U.S.S.R.[e 2 6]	800.0	830.0	865.0	885.0	900.0
United Kingdom	.6	.4	.1	--	--
Yugoslavia[4]	120.1	116.2	123.3	111.4	134.0
Africa:					
Algeria	.4	.3	.2	.2	.2
Botswana[8]	11.9	11.8	14.6	14.6	[3]15.6
Congo (Brazzaville)[4]	.4	1.1	.8	1.0	1.3
Ethiopia[e]	.4	--	--	--	--
Mauritania	9.4	7.6	1.8	--	--
Morocco[4]	4.9	4.8	4.7	7.0	5.7
Mozambique[e]	--	--	.1	.2	.2
Namibia	43.5	49.2	37.7	41.9	[3]38.6
South Africa, Republic of	196.9	208.3	209.3	190.6	215.0
Uganda	7.0	4.0	1.3	--	--
Zaire	444.4	481.6	423.8	400.0	[3]459.4
Zambia	708.9	656.0	643.0	588.3	[3]595.8
Zimbabwe	[r]41.3	34.8	33.8	29.6	27.0
Asia:					
Burma[8]	.1	([5])	.1	.1	.1
China:					
Mainland[e]	[r]180.0	[r]195.0	[r]200.0	[r]200.0	200.0
Taiwan	2.0	2.0	.8	.8	1.2
Cyprus[6]	8.0	6.8	5.8	6.0	6.0
India	[r]29.3	31.2	26.0	26.5	22.0
Indonesia	69.1	61.6	58.9	60.2	[3]58.0
Iran[e]	6.0	[r]13.5	20.0	5.3	3.6
Israel	2.5	--	--	--	([5])
Japan[4]	81.6	81.4	72.0	59.1	[3]53.2
Korea, North[e 2]	15.0	15.0	15.0	15.0	15.0
Korea, Republic of	2.3	1.7	.7	.5	[3].4
Malaysia	18.2	23.0	26.4	23.6	25.9
Mongolia	--	--	4.0	[e]4.0	4.0
Nepal	--	([5])	([5])	--	--
Philippines	237.6	272.8	263.4	300.5	324.0
Turkey	29.8	33.4	31.3	24.3	22.7

See footnotes at end of table.

Table 36.—Copper: World mine production, by country[1] —Continued

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
Oceania:					
Australia	218.5	221.6	222.1	234.7	[3]216.8
Papua New Guinea	175.8	182.3	198.6	170.8	[3]146.8
Total	[r]7,525.3	[r]7,755.8	7,632.9	7,674.9	7,616.9

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data presented represent copper content (recoverable, where indicated) of ore mined wherever possible. If such data are not available, the figures presented are the nonduplicative total copper content of ores, concentrates, matte, metal, and/or other copper-bearing products measured at the least stage of processing for which data are available. Table includes data available through June 29, 1981.
[2]Recoverable.
[3]Reported figure.
[4]Copper content of concentrates produced.
[5]Less than 1/2 unit.
[6]Includes copper content of cupriferous pyrite.
[7]Excludes an unreported quantity of copper in iron pyrite which may or may not be recovered.
[8]Copper content of matte produced.

Table 37.—Copper: World smelter production[1]

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada:					
Primary	457.6	481.6	[e]410.3	[e]374.5	463.0
Secondary	31.0	18.7	[e]15.0	[e]10.0	19.0
Total	488.6	500.3	425.3	384.5	[2]482.0
Mexico, primary	85.2	87.5	87.0	83.8	85.5
United States:					
Primary	1,392.2	1,302.0	1,288.4	1,335.6	[2]1,008.4
Secondary	46.3	44.8	54.2	60.2	[2]44.9
Total	1,438.5	1,346.8	1,342.6	1,395.8	[2]1,053.3
South America:					
Argentina, primary[e]	.1	.1	.1	.1	.1
Brazil, primary	.4	--	--	--	--
Chile, primary	856.3	888.4	927.4	946.9	[2]953.1
Peru, primary	188.4	321.1	318.9	379.6	350.0
Europe:					
Albania, primary[e]	9.0	9.0	9.5	[r]9.7	9.9
Austria:					
Primary	.9	--	--	--	--
Secondary	12.1	12.1	12.1	13.2	11.0
Total	13.0	12.1	12.1	13.2	11.0
Belgium-Luxembourg:					
Primary[e]	14.0	13.0	9.0	[r]1.5	1.5
Secondary[e]	58.0	48.6	46.9	47.8	50.0
Total[e]	72.0	61.6	55.9	[r]49.3	51.5
Bulgaria:					
Primary[e]	57.0	57.0	[r]61.0	[r]61.0	61.0
Secondary[e]	3.0	3.0	3.0	3.0	3.0
Total[e]	60.0	60.0	[r]64.0	[r]64.0	64.0
Czechoslovakia:					
Primary[e]	6.9	7.4	6.7	8.2	7.6
Secondary[e]	3.1	2.6	3.3	1.8	2.4
Total[e]	10.0	10.0	10.0	10.0	10.0
Finland:					
Primary	51.5	61.5	53.7	55.3	49.2
Secondary	[e]9.5	10.6	10.0	9.9	10.0
Total	61.0	72.1	63.7	65.2	[2]59.2

See footnotes at end of table.

Table 37.—Copper: World smelter production[1] —Continued

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
Europe—Continued					
France, secondary	2.2	5.3	6.4	7.0	7.0
German Democratic Republic, primary	16.0	18.0	17.0	19.0	19.0
Germany, Federal Republic of:					
Primary	193.7	189.6	165.8	158.2	160.0
Secondary	50.8	58.4	55.7	92.5	90.0
Total	244.5	248.0	221.5	250.7	250.0
Hungary:					
Primary	(3)	(3)	(3)	(3)	--
Secondary	[r]1.1	[r].8	.3	.1	.1
Total	[r]1.1	[r].8	.3	.1	.1
Norway, primary	23.4	26.6	20.1	27.3	[2]33.7
Poland, primary and secondary	281.2	311.0	337.0	341.0	363.5
Portugal:					
Primary	2.8	3.3	2.8	3.0	3.0
Secondary	.1	.1	.2	.4	.5
Total	2.9	3.4	3.0	3.4	3.5
Romania:					
Primary	40.5	41.4	38.9	40.0	40.0
Secondary	5.0	4.0	4.0	4.0	4.0
Total	45.5	45.4	42.9	44.0	44.0
Spain:					
Primary	92.5	99.5	95.5	90.3	95.0
Secondary	20.0	18.0	17.0	18.0	20.0
Total	112.5	117.5	112.5	108.3	115.0
Sweden:					
Primary	46.5	46.7	53.2	51.7	[2]45.7
Secondary	15.5	15.0	13.8	12.9	[2]10.7
Total	62.0	61.7	67.0	64.6	[2]56.4
U.S.S.R.:					
Primary	840.0	850.0	865.0	885.0	905.0
Secondary	80.0	85.0	90.0	95.0	95.0
Total	920.0	935.0	955.0	980.0	1,000.0
Yugoslavia:					
Primary	[e]99.0	97.4	107.5	108.7	110.0
Secondary	[e]65.1	68.4	87.7	71.3	72.0
Total	164.1	165.8	195.2	180.0	182.0
Africa:					
Namibia, primary	36.1	[r]53.4	45.9	42.7	48.5
South Africa, Republic of, primary	168.0	188.4	189.4	176.4	[2]180.8
Uganda, primary	7.0	8.3	--	--	--
Zaire, primary	413.0	443.0	390.7	370.1	[2]425.7
Zambia, primary	[r]705.9	[r]650.5	658.9	582.1	617.0
Zimbabwe, primary	23.5	28.0	26.2	26.0	24.0
Asia:					
China:					
Mainland, primary and secondary[e]	[r]180.0	[r]195.0	[r]200.0	[r]200.0	200.0
Taiwan, primary	11.7	11.5	13.0	14.3	17.0
India, primary	24.8	23.5	19.6	24.1	[2]28.5
Iran, primary	4.0	7.0	6.0	.7	.8
Japan:					
Primary	769.4	848.4	854.5	853.7	861.0
Secondary	89.4	103.9	56.0	67.7	68.8
Total	858.8	952.3	910.5	921.4	[2]929.8
Korea, North:					
Primary[e]	15.0	15.0	15.0	15.0	15.0
Secondary[e]	5.0	5.0	5.0	3.0	3.0
Total[e]	20.0	20.0	20.0	18.0	18.0

See footnotes at end of table.

Table 37.—Copper: World smelter production[1] —Continued

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
Asia —Continued					
Korea, Republic of:					
Primary	13.6	19.2	17.3	20.0	21.0
Secondary	17.3	23.7	37.6	41.2	42.0
Total	30.9	42.9	54.9	61.2	63.0
Turkey:					
Primary[e]	27.1	30.9	25.6	21.6	16.6
Secondary[e]	.6	.6	.6	.6	.6
Total[e]	27.7	31.5	26.2	22.2	17.2
Oceania:					
Australia:					
Primary	167.3	167.7	164.4	167.1	[2]171.4
Secondary	3.0	4.1	2.8	6.3	[2]7.1
Total	170.3	171.8	167.2	173.4	[2]178.5
Grand total	[r]7,839.6	[r]8,134.6	8,022.9	8,060.1	7,952.6
Of which:					
Primary	6,860.3	[r]7,095.9	6,964.3	6,953.2	6,828.0
Secondary	[r]518.1	[r]532.7	521.6	565.9	561.1
Undifferentiated	[r]461.2	[r]506.0	537.0	541.0	563.5

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table has been revised in general format to include total production of copper metal at the unrefined stage, whether produced by thermal, electrolytic, or electrowinning methods, and whether derived from ore, concentrates, or matte (primary) and/or scrap (secondary). To the extent possible, primary and secondary output of each country is shown separately. In some cases, total smelter production is officially reported, but the distribution between primary and secondary has been estimated. In instances where copper is recovered in a single step from raw material to refined product, the amount recovered has been included. Table includes data available through June 29, 1981.

[2]Reported figure.

[3]Revised to zero.

Table 38.—Copper: World refinery production[1]

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada:					
Primary[e]	479.5	479.8	420.3	377.3	475.2
Secondary[e]	31.0	29.0	26.0	20.0	30.0
Total[e]	510.5	508.8	446.3	397.3	[2]505.2
Mexico:					
Primary[e]	67.4	67.1	70.0	[r]76.8	80.6
Secondary[e]	8.0	6.0	5.0	[r]5.0	5.0
Total[e]	75.4	73.1	75.0	[r]81.8	[2]85.6
United States:					
Primary	1,396.4	1,357.3	1,449.1	1,515.4	[2]1,210.9
Secondary	340.3	349.6	420.1	498.4	[2]515.1
Total	1,736.7	1,706.9	1,869.2	2,013.8	[2]1,726.0
South America:					
Argentina, primary	1.5	--	--	--	--
Brazil, secondary	[r]39.3	[r]45.9	45.0	50.0	50.0
Chile, primary	632.0	676.0	749.1	779.5	810.7
Peru, primary	135.6	188.1	182.8	230.8	231.0
Europe:					
Albania, primary[e]	7.0	7.0	7.0	[r]7.5	7.7
Austria:					
Primary[e]	8.6	9.7	15.5	16.3	15.0
Secondary[e]	20.0	22.0	16.0	16.5	16.3
Total[e]	28.6	31.7	31.5	32.8	31.3

See footnotes at end of table.

Table 38.—Copper: World refinery production[1] —Continued

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
Europe —Continued					
Belgium-Luxembourg:					
Primary[e]	359.0	408.7	332.6	[r]318.8	321.5
Secondary[e]	66.0	56.0	56.0	[r]50.0	52.0
Total[e]	425.0	464.7	388.6	[r]368.8	373.5
Bulgaria, primary and secondary[e]	[r]58.0	[r]58.0	[r]62.0	[r]62.0	62.0
Czechoslovakia, primary and secondary	22.1	23.1	23.8	24.6	[2]25.6
Finland:					
Primary[e]	34.1	32.8	32.7	33.0	30.5
Secondary[e]	4.0	10.0	10.0	10.0	10.0
Total[e]	38.1	42.8	42.7	43.0	40.5
France:					
Primary	19.3	22.3	20.7	22.0	23.0
Secondary	20.0	[r]22.1	20.6	23.3	23.3
Total	39.3	[r]44.4	41.3	45.3	[2]46.3
German Democratic Republic, primary and secondary[e]	50.0	51.0	49.0	51.0	51.0
Germany, Federal Republic of:					
Primary[e]	285.6	276.2	[r]246.6	[r]234.5	227.0
Secondary[e]	161.0	164.0	158.0	148.0	147.0
Total[e]	446.6	440.2	[r]404.6	[r]382.5	374.0
Hungary, primary and secondary	10.6	[r]12.1	13.1	12.0	12.0
Italy:					
Primary[e]	4.8	4.0	3.5	[r]2.6	2.0
Secondary[e]	22.0	16.0	14.0	[r]13.0	13.0
Total[e]	26.8	20.0	17.5	[r]15.6	15.0
Norway:					
Primary	17.8	[r]21.2	15.7	21.0	25.8
Secondary	6.2	[r]1.3	5.6	6.0	6.0
Total	24.0	[r]22.5	21.3	27.0	31.8
Poland, primary and secondary	270.1	306.6	332.2	335.8	357.3
Portugal, primary	2.8	3.4	3.0	3.4	3.6
Romania, primary and secondary	[e]38.0	40.0	40.5	42.0	42.0
Spain:					
Primary[e]	110.9	130.0	117.0	119.4	127.7
Secondary[e]	31.0	29.0	30.0	25.0	30.0
Total[e]	141.9	159.0	147.0	144.4	[2]157.7
Sweden:					
Primary	55.6	47.7	53.2	49.7	46.7
Secondary	7.3	14.0	11.2	12.0	9.0
Total	62.9	61.7	64.4	61.7	[2]55.7
U.S.S.R.:					
Primary[e]	760.0	790.0	810.0	830.0	945.0
Secondary[e]	160.0	160.0	170.0	170.0	170.0
Total[e]	920.0	950.0	980.0	1,000.0	1,115.0
United Kingdom:					
Primary	51.5	44.4	46.2	48.5	[2]68.4
Secondary	85.7	77.8	79.4	73.2	[2]94.1
Total	137.2	122.2	125.6	121.7	[2]162.5
Yugoslavia:					
Primary	121.6	93.0	103.9	99.2	100.0
Secondary	14.9	50.5	46.9	38.3	31.3
Total	136.5	143.5	150.8	137.5	[2]131.3

See footnotes at end of table.

Table 38.—Copper: World refinery production[1] —Continued

(Thousand metric tons)

Continent, country, and metal origin	1976	1977	1978	1979[p]	1980[e]
Africa:					
South Africa, Republic of, primary[3]	95.6	145.9	149.1	150.8	140.9
Zaire, primary	66.0	98.7	102.8	103.2	[2]144.2
Zambia, primary	694.2	648.0	627.7	563.6	607.3
Zimbabwe, primary	23.5	28.2	34.2	30.9	27.0
Asia:					
China:					
Mainland, primary and secondary[e]	[r]240.0	[r]260.0	[r]270.0	[r]280.0	280.0
Taiwan, secondary	11.7	11.5	14.5	13.7	[2]19.5
India, primary[3]	20.9	22.8	17.6	30.3	[2]17.0
Iran, primary[e]	7.0	7.0	6.0	3.0	.8
Japan:					
Primary	769.8	848.4	854.5	853.7	[2]889.5
Secondary	94.6	85.3	104.6	130.0	[2]124.8
Total	864.4	933.7	959.1	983.7	[2]1,014.3
Korea, North, primary and secondary[e]	25.0	25.0	25.0	[r]22.0	22.0
Korea, Republic of:					
Primary	30.9	42.9	52.4	52.1	[2]64.4
Secondary	[e]10.0	[e]10.0	[e]13.0	11.0	[2]14.7
Total	40.9	52.9	65.4	63.1	[2]79.1
Turkey, primary	28.3	25.3	30.1	22.2	20.0
Oceania:					
Australia:					
Primary	160.3	152.0	152.6	138.2	[2]144.8
Secondary	28.0	[r]32.7	21.9	35.6	[2]21.1
Total	188.3	[r]184.7	174.5	173.8	[2]165.9
Grand total	[r]8,322.3	[r]8,646.4	8,789.3	8,912.1	9,042.3
Of which:					
Primary	6,447.5	[r]6,677.9	6,705.9	6,733.7	6,808.2
Secondary	[r]1,161.0	[r]1,192.7	1,267.8	1,349.0	1,382.2
Undifferentiated	[r]713.8	[r]775.8	815.6	829.4	851.9

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table has been revised in general format to include total production of refined copper, whether produced by thermal, electrolytic, or electrowinning methods, and whether derived from primary unrefined copper or from scrap. To the extent possible, primary and secondary output of each country is shown separately. In some cases, total refinery production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through June 30, 1981.

[2]Reported figure.

[3]Although only primary production is reported, an unknown but small additional output of secondary refined copper may have been produced.

Diatomite

By A. C. Meisinger[1]

Total value of processed diatomite sold or used in 1980 established a new record high of $100.6 million, although the quantity sold or used declined 4% to 689,000 tons, compared with 1979 production. Production came from four Western States, with California operations accounting for more than half of the 1980 output.

U.S. diatomite exports of 173,000 tons totaled 25% of domestic production in 1980 compared with 24% in 1979. Diatomite imported in 1980 declined 44% in quantity (295 tons) from that in 1979. Mexico was again the major source of the imports.

Demand for diatomite as a filtration medium remained strong in 1980 and was 66% of total sales, compared with 65% the previous year. The use of diatomite as fillers accounted for 21% of the domestic market in 1980, the same as in 1979.

Continuing cost increases for processing and transporting diatomite products in 1980 were reflected in the average unit value increase of 16%, or $146 per ton compared with $126 per ton in 1979.

DOMESTIC PRODUCTION

Although 1980 output of diatomite by U.S. producers decreased 4% in quantity (689,000 tons) from the record high of 717,000 tons in 1979, value of sales established a new record high of $100.6 million for an 11% increase over the previous year's record value of $90.3 million.

Domestic production in 1980 was in 9 plants processing from 11 mining operations in 4 Western States: California, Nevada, Oregon, and Washington. Diatomite operations in California accounted for more than half of the total 1980 production.

Principal producers in 1980 were Johns-Manville Sales Corp., with operations at Lompoc, Calif.; Grefco, Inc. (Dicalite Div.), at Lompoc, Calif., and Mina (Basalt), Nev.; Eagle-Picher Industries, Inc. (Minerals Div.), at Sparks and Lovelock, Nev.; and Witco Chemical Corp. (Inorganic Specialties Div.) at Quincy, Wash. Other producers during the year were Excel-Mineral Co. in California; Cyprus Diatomite Co. (formerly Cyprus Industrial Minerals Co.) in Nevada; and Oil-Dri Production Co. (formerly Oil-Dri West) in Oregon. No further development activity was reported during the year at the diatomite property of the American Exploration and Management Co. in Rio Arriba County, N. Mex.

Table 1.—Diatomite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Domestic production (sales)	631	648	651	717	689
Total value of sales	$54,981	$63,870	$72,429	$90,323	$100,610

CONSUMPTION AND USES

Apparent domestic consumption of diatomite in 1980 (sales, plus imports, minus exports) totaled 516,000 tons compared with 547,000 tons in 1979. Demand for diatomite as a filtration medium in 1980 continued to account for most (66%) of the total sales, although the quantity sold or used for this application declined from 463,000 tons in 1979 to 453,000 tons. Diatomite used as fillers decreased slightly from 151,000 tons in 1979 to 149,000 tons and accounted for 21% of total sales in 1980. Other uses of diatomite in 1980 were abrasives, absorbents, catalysts, fertilizer coatings, insulation, and lightweight aggregates, which together accounted for 13% of the total quantity sold or used by domestic producers.

Table 2.—Diatomite sold or used,[1] by principal use

(Percent of U.S. production)

Use	1976	1977	1978	1979	1980
Filtration	60	59	63	65	66
Fillers	W	W	23	21	21
Insulation	5	5	3	3	3
Other	35	36	11	11	10

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes exports.

PRICES

The weighted average value reported by producers for processed diatomite sold or used in 1980 was $146.02 per ton, a 16% increase over the 1979 weighted average value. Higher fuel, labor, transportation, and packaging costs in 1980 continued to increase the value of processed diatomite products indicated in table 3.

Table 3.—Average annual value per ton[1] of diatomite, by use

Use	1978	1979	1980
Abrasives	$172.26	$174.09	W
Fillers	102.51	118.22	$132.56
Filtration	122.18	136.52	158.88
Insulation	81.68	94.67	103.47
Miscellaneous[2]	76.07	87.81	101.79
Weighted average	111.23	125.91	146.02

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Based on unrounded data.
[2]Includes absorbents, abrasives (1980), admixtures and silicates (1978-79), catalysts (1979-80), fertilizer coatings, light weight aggregates (1978, 1980), and pozzolan additive (1978-79).

FOREIGN TRADE

The quantity of processed diatomite exported in 1980 was 173,000 tons, a slight increase over that exported in 1979. The total value of exports, however, was significantly higher in 1980, $32.2 million compared with $26.5 million in 1979, a 22% increase. The quantity of diatomite exported in 1980 represented 25% of U.S. production compared with nearly 24% in 1979. Diatomite was exported to 80 countries in 1980, and the following 5 countries received 56% of the total exports: Canada, 30,400 tons; Japan, 22,000 tons; the Federal Republic of Germany, 18,200 tons; Australia, 14,000 tons; and the United Kingdom, 12,100 tons.

Imports of diatomite declined 44%, from 528 tons in 1979 to 295 tons. Approximately 91% of this came from Mexico, compared with 99% in 1979. Value of imports from Mexico (U.S. Customs declared average value at U.S. ports of entry) in 1980 was $83,545, compared with $83,314 in 1979.

[1]Industry economist, Section of Nonmetallic Minerals.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value[1]
1977	152	18,876
1978	153	21,463
1979	170	26,496
1980	173	32,238

[1]U.S. Customs.

Table 5.—Diatomite: World production, by country[1]

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	[r]3	[r]1	2	2	2
Costa Rica	1	1	1	1	1
Mexico	29	26	25	[e]25	25
United States	631	648	651	717	[2]689
South America:					
Argentina	15	14	8	10	9
Brazil (marketable)	6	12	13	18	20
Chile	(3)	1	6	1	1
Colombia	1	1	[e]1	[e]1	1
Peru	[e]20	21	18	[e r]21	22
Europe:					
Austria	2	(3)	1	--	--
Denmark:					
Diatomite[e]	23	28	28	28	28
Moler[e 4]	[r]175	[r]175	[r]175	[r]140	140
France	232	227	[e]220	[e]220	240
Germany, Federal Republic of	58	55	52	54	55
Iceland[5]	25	23	22	23	23
Italy	20	[e r]21	[e]21	[e]21	22
Portugal	3	4	3	[e]3	4
Romania[e]	45	45	45	45	45
Spain	[e]19	31	24	30	30
Sweden	(3)	--	--	--	--
U.S.S.R.[e]	[r]230	[r]235	[r]240	[r]250	250
United Kingdom	4	2	2	2	2
Africa:					
Algeria	5	5	4	[e]4	4
Egypt	(3)	(3)	(3)	3	3
Kenya	3	3	2	[e]2	2
South Africa, Republic of	1	1	1	1	(3)
Asia:					
Korea, Republic of	15	25	21	26	22
Thailand	--	(3)	1	4	3
Turkey	9	[e]10	[e]10	[e]10	10
Oceania:					
Australia	2	1	3	1	1
New Zealand	3	1	(6)	(6)	--
Total	[r]1,580	[r]1,617	1,600	1,663	1,654

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 23, 1980.
[2]Reported figure.
[3]Less than 1/2 unit.
[4]Series revised to reflect estimated diatomite content of moler produced.
[5]Exports.
[6]Revised to zero.

Feldspar, Nepheline Syenite, and Aplite

By Michael J. Potter[1]

Total U.S. feldspar output in 1980 (including soda, potash, and mixed varieties) was 710,000 tons. Feldspar was mined in six States, with North Carolina in the lead, followed by Connecticut and Georgia. The other producing States were California, Oklahoma, and South Dakota. Shipments went to at least 31 States and to foreign destinations such as Canada and Mexico. Aplite of glassmaking quality was produced only in Virginia; output figures are not released, but the tonnage produced was approximately 10% less than in 1979. Imports of crude and ground nepheline syenite in 1980 totaled 504,000 short tons, which was 6% less than that of the previous year.

The 1980 end-use distribution of total feldspar in the United States indicated that 57% went into glassmaking and 39% into pottery. The remaining 4% was used in other applications such as enamels, sanitary ware, and fillers. In South Dakota, plans to produce feldspar were announced by Concepts West, Inc., of Rapid City. In Virginia, one of the two aplite operations ceased in mid-1980 (International Minerals & Chemical Corp. (IMC), near Piney River).

Optimistic forecasts have been given for the 1980's for the major outlets of feldspar (glass containers and ceramics). Favorable outlooks are also expected for other end uses, such as porcelain enamel and glass fiber.

Legislation and Government Programs.—According to provisions of the Tax Reform Act of 1969, which continued in force throughout 1980, the depletion rate allowed on feldspar production (both domestic and foreign operations) was 14%.

Table 1.—Salient feldspar and nepheline syenite statistics

	1976	1977	1978	1979	1980
United States:					
Feldspar produced[1] short tons	739,700	734,000	735,000	740,000	710,000
Value thousands	$17,530	$17,190	$18,200	$21,500	$23,200
Exports short tons	6,140	6,200	10,330	12,300	13,000
Value thousands	$352	$394	$853	$1,025	$896
Imports for consumption short tons	93	242	39	266	404
Value thousands	$18	$8	$3	$31	$133
Imports for consumption, nepheline syenite short tons	501,200	502,600	548,000	536,000	504,000
Value thousands	$8,823	$9,135	$10,446	$10,846	$11,264
Consumption, apparent[2] (feldspar plus nepheline syenite) thousand short tons	1,235	1,231	1,273	1,264	1,201
World production (feldspar) do	[r]3,083	[r]3,228	[r]3,425	[r]3,782	3,782

[r]Revised.
[1]Includes hand-cobbed feldspar, flotation-concentrate feldspar, and feldspar in feldspar-silica mixtures; includes potash feldspar (8% K_2O or higher).
[2]Measured by quantity produced plus imports, minus exports (rounded figures).

FELDSPAR

DOMESTIC PRODUCTION

Soda feldspar is defined commercially as containing 7% Na_2O or higher, while potash feldspar contains 10% K_2O or higher. Hand-cobbed or hand-sorted feldspar is usually obtained from pegmatites (coarse-grained, igneous dike rock) and is relatively high in K_2O compared with Na_2O. Feldspar flotation concentrates can be classified as either soda, potash, or "mixed" feldspar, depending on the relative amounts of Na_2O and K_2O present. Feldspar-silica mixtures (feldspathic sand) can either be a naturally occurring material, such as sand deposits, or a processed mixture obtained from flotation.

The data for potash feldspar in tables 1-6 were collected from the three U.S. producers of this material, and some of this feldspar contained less than 10% K_2O (8% to 10% K_2O). Therefore, in order that potash feldspar data could be published and company data maintained as proprietary, the data in tables 1-6 are for a K_2O content of 8% or higher.

Feldspar was mined in six States in 1980, led by North Carolina and followed in descending order by Connecticut, Georgia, California, Oklahoma, and South Dakota. The combined output of the first four States named amounted to 95% of the U.S. total.

Most of the feldspar used in glassmaking is ground no finer than 20 to 40 mesh, and substantial tonnages of feldspathic sands (feldspar-quartz mixtures) enter into glass furnace feeds with no further reduction in particle size. Feldspar to be used in ceramic and filler applications is usually pulverized to minus 200 mesh or finer. In 1980, 11 U.S. companies operating 12 plants produced feldspar in 6 States for shipment to destinations in at least 31 States and foreign destinations such as Canada and Mexico. North Carolina had five plants, California had three, and the other producing States (except Oklahoma) had one plant each: Connecticut, Georgia, and South Dakota.

In South Dakota, plans to produce feldspar (and mica) were announced by Concepts West, Inc., of Rapid City. Feldspar is to be shipped by rail and truck to a mill purchased by the company in Bonneville, Wyo.

Table 2.—Feldspar produced in the United States[1]

(Thousand short tons and thousand dollars)

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures[2]		Total[3]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1976	28	321	601	13,610	111	3,600	740	17,530
1977	23	309	568	12,600	142	4,280	734	17,190
1978	26	400	568	13,240	140	4,550	735	18,200
1979	20	238	580	16,460	140	4,770	740	21,500
1980	14	229	566	18,240	130	4,780	710	23,200

[1]Includes potash feldspar (8% K_2O or higher).
[2]Feldspar content.
[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

In 1980, there continued to be no significant consumption of run-of-mine feldspar. The majority of users acquired their supplies already ground and sized by the feldspar producers, although some manufacturers of pottery, soaps, and enamels continued to purchase feldspar for grinding to their preferred specifications in their own mills. A substantial portion of the material classified as feldspar-silica mixtures serves in glassmaking without additional processing.

In 1980, 57% of total feldspar consumed in the United States was used in glassmaking (including container glass, flat glass, and fiber glass) and 39% was used in pottery. The remaining 4% was used in other applications, including glazes, enamels, sanitary ware, rubber products, and electrical insulators.

Potash feldspar data appear in tables 5 and 6 and are based on a K_2O content of 8% or higher.

There appears to be a trend back to porcelain enamel, which utilizes feldspar. One major factor is the increase in the cost of energy. Porcelain enamel is far less energy intensive than paints and plastics, which had been making inroads in kitchen appliances.[2] Good growth in the housing industry and a favorable appliance replacement market during the next several years will mean good news for porcelain enamel.[3] Glass fiber, another feldspar outlet, is expected to do well in the 1980's, in spite of the unsettled market conditions in 1980.[4] Optimistic outlooks for the next decade are also given for glass containers[5] and ceramics.[6]

Table 3.—Feldspar sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Hand-cobbed:				
Pottery	W	W	W	W
Other	20	1,260	15	995
Total	20	1,260	15	995
Flotation concentrate:				
Glass	304	7,250	298	7,870
Pottery	W	W	W	W
Other	281	10,660	266	10,990
Total	585	17,910	564	18,860
Feldspar-silica mixture:[2]				
Glass	102	3,590	106	4,790
Pottery	W	W	W	W
Other	38	1,840	25	1,620
Total	140	5,430	131	6,410
Total:				
Glass[3]	406	10,840	404	12,660
Pottery	312	12,220	276	11,390
Other[4]	27	1,540	30	2,220
Total[5]	744	24,600	710	26,300

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Feldspar content.
[3]Includes container glass, flat glass, and fiber glass.
[4]Includes enamel, sanitary ware, filler, electrical insulators, etc., and unknown; totals for "Quantity" and "Value" do not correspond to the sums of the subtotals of the three "Other" categories above.
[5]Data may not add to totals shown because of independent rounding.

Table 4.—Destination of shipments of feldspar sold or used by producers in the United States, by State[1]

(Short tons)

State	1977	1978	1979	1980
Alabama	(2)	35,500	13,900	21,100
Arkansas	5,500	5,200	W	W
California	(2)	(2)	r(2)	(3)
Connecticut	(2)	23,800	21,600	18,400
Florida	(2)	20,000	23,600	32,800
Georgia	(2)	35,800	69,000	64,700
Illinois	37,000	47,600	43,700	36,600
Indiana	30,800	32,600	25,300	26,700
Kentucky	10,100	10,200	13,100	12,800
Louisiana	16,200	19,200	16,900	14,600
Maryland	5,000	6,500	7,600	5,100
Massachusetts	18,400	W	W	11,100
Michigan	800	2,500	4,000	2,700
Mississippi	20,800	22,000	17,600	15,600
Missouri	7,600	4,200	7,600	4,900
New Jersey	45,100	50,400	59,600	64,600
New York	20,600	21,400	22,000	23,100
Ohio	63,300	59,200	64,400	56,400
Oklahoma	34,300	33,600	31,700	31,000
Pennsylvania	53,700	55,400	52,900	46,200
South Carolina	NA	W	17,700	15,600
Tennessee	21,700	19,700	19,400	18,300
Texas	39,400	38,800	40,400	35,000
West Virginia	37,000	38,200	59,800	55,400
Other[4]	267,200	153,200	r112,200	97,300
Total	[5]735,000	735,000	744,000	710,000

rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Data are incomplete; included with "Other."
[3]Data are incomplete; Bureau of Mines estimate is 40,000 tons or more; included with "Other."
[4]Includes North Carolina, Rhode Island, Wisconsin, other States, States indicated by symbol W or footnote 2, exports to foreign destinations, and unknown.
[5]Data do not add to total shown because of independent rounding.

Table 5.—Potash feldspar sold or used by producers in the United States, by use[1]

Use	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Pottery	77,500	$4,079	69,500	$4,050
Other[2]	16,600	592	15,500	700
Total	94,100	4,671	85,000	4,750

[1]K_2O content of 8% or higher.
[2]Includes glass, enamel, sanitary ware, etc.

Table 6.—Destination of shipments of potash feldspar sold or used by producers in the United States, by State[1]

(Short tons)

State	1977	1978	1979	1980
Illinois, Indiana, Wisconsin	W	14,900	15,500	13,400
Maryland, New York, West Virginia	27,300	27,500	29,500	28,200
Massachusetts	1,100	W	1,400	W
Ohio	12,100	12,100	12,000	10,700
Pennsylvania	11,100	12,000	9,000	8,200
Texas	600	400	W	400
Other States	34,600	18,300	18,600	18,150
Mexico	W	1,500	2,900	1,600
Canada	3,800	4,600	5,200	4,300
Other destinations	100	--	--	50
Total	90,700	91,300	94,100	85,000

W Withheld to avoid disclosing company proprietary data; included with "Other States."
[1]K_2O content of 8% or higher.

PRICES

Engineering and Mining Journal, December 1980, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade:

North Carolina:	
20 mesh, flotation	$25.50
40 mesh, flotation	41.00
200 mesh, flotation	38.25
Georgia:	
40 mesh, granular	41.00
200 mesh	58.00
Connecticut:	
20 mesh, granular	30.25
200 mesh	41.75

Feldspar prices were quoted by Industrial Minerals (London), December 1980, as follows (converted from pounds sterling per metric ton to dollars per short ton, using an exchange rate of £1.00=US$2.40):

Ceramic grade, powder, 200 mesh, bagged, ex-store, United Kingdom	$152-$163
Sand, 2 to 3 millimeters, ceramic and/or glass grade, c.i.f. main European port	74- 91

FOREIGN TRADE

In 1980, U.S. exports classified as feldspar, leucite, and nepheline syenite (but presumably all or mostly feldspar) amounted to 13,000 tons valued at $895,600. This was 6% higher in tonnage than in 1979. Chief recipients of the exported material were Canada, 47%; Mexico, 31%; and the Dominican Republic, 6%. The remaining 16% was shared among 11 other countries.

In addition to feldspar and nepheline syenite, U.S. imports in 1980 of "Other mineral fluxes, crushed" totaled 470 tons with a value of $152,840. Also, there were 195 tons of material with a value of $13,819 classified as "Other crude natural mineral fluxes."

The tariff schedule in force throughout 1980 for most favored nations provided for a 3.4% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty-free.

Table 7.—U.S. imports for consumption of feldspar

(Short tons)

Country	1979		1980	
	Quantity	Value	Quantity	Value
Crude:				
Brazil	1	$1,500	--	--
Canada	(1)	400	232	$111,693
Mexico	48	4,520	--	--
Ground, crushed, or pulverized:				
Germany, Federal Republic of	--	--	1	796
Norway	141	13,549	103	10,401
Sweden	76	11,094	68	9,837

[1]Less than 1/2 unit.

WORLD REVIEW

France.—Producers and output of feldspar in France were discussed in a journal article.[7]

Imports of nepheline syenite were 40,500 tons in 1978 and 51,700 tons in 1979. Most of the material was from Norway and the rest from Canada. French feldspar exports were 57,800 tons in 1978 and 57,000 tons in 1979; shipments went largely to Belgium-Luxembourg and Spain.[8]

Norway.—Trial production of alumina from anorthosite took place at the Institute of Atomic Energy, near Oslo, Norway. However, it could be at least 10 years before actual commercial production of alumina from anorthosite would take place because of problems associated with processing and high production costs. A decision was to be made during the year on whether to introduce a pilot project.[9]

Portugal.—Information on pegmatite minerals (including feldspar) was included in a journal article. Also discussed was information on producers of feldspar (and quartz). One of the main producers, Unimil Minerais Ltda., was to enter a joint venture with Minas do Zêzere S.A.R.L. The project involves a deposit of around 1 million tons, with an approximate composition of 60% feldspar, 30% quartz, and 10% mica. Tests were carried out and samples sent to Portuguese ceramics companies for testing. If the results were favorable, it was hoped for a go-ahead with the project, with initial plans calling for around 20,000 tons per year of feldspar-quartz product for the Portuguese ceramics industry. If early results were encouraging there was the possibility of a later increase in production and the export of some material.[10]

Spain.—During 1980, there was an indication that Promotora de Recursos Naturales, of Spain, may build three plants to treat feldspar in the Provinces of Segovia and Salamanca.[11]

Sweden.—The only feldspar producer in Sweden, Forshammars Bergverk, completed a major expansion and modernization program at its operation near Örebro in the south-central part of the country. The investment in the project was around $3.7 million and raised total grinding capacity to about 70,000 tons per year. The company will now be able to enter the field of custom grinding for the first time.

The feldspar supply to the plant comes from a deposit containing measured reserves of 770,000 tons and indicated reserves of 4 million tons. The company's products include mixed feldspar and quartz. Potash feldspar is also produced at the Forshammar operation and comes from two mines in northern Sweden.[12]

United Kingdom.—Feldspar imports in 1980 were 131,000 tons; principal countries of origin and quantities supplied were Norway, 59%; Finland, 25%; and Sweden, 14%. Nepheline syenite imports in 1980 were 52,000 tons and mainly came from Norway, 68%, and Canada, 24%.[13]

Yugoslavia.—A new facility of the Feldspat Enterprise in Prokuplje, Serbia, was to begin operation. Output is slated to be around 20,000 tons per year of finely ground feldspar (also 33,000 tons per year of quartz and 16,000 tons per year of mica).[14]

Table 8.—Feldspar: World production by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Guatemala	[e]22	14	17	12	13
Mexico	81	126	141	[e]140	140
United States	740	734	735	740	[3]710
South America:					
Argentina	75	47	46	46	47
Brazil[4]	[r]93	[r]106	114	401	405
Chile	1	3	1	(5)	(5)
Colombia	39	29	29	32	33
Peru	4	5	11	[e]10	10
Uruguay	1	2	3	3	3
Venezuela	72	29	77	98	99
Europe:					
Austria	4	4	3	7	8
Finland	75	79	79	75	75
France	207	212	232	215	220
Germany, Federal Republic of	463	434	425	411	408
Italy	201	235	277	325	325
Norway[6]	42	78	66	[e]78	77
Poland[e]	33	44	44	44	44
Portugal	15	17	19	[e]29	29
Romania[e]	64	66	66	66	66
Spain[7]	100	103	128	128	138
Sweden	49	58	59	[r e]55	55
U.S.S.R.[e]	310	320	330	340	340
United Kingdom (china stone)[e]	55	55	55	55	55
Yugoslavia	28	62	53	62	60
Africa:					
Egypt	2	3	4	4	4
Kenya	1	2	1	1	1
Madagascar	--	(5)	(5)	(5)	(5)
Mozambique[e]	1	1	1	(8)	--
Nigeria[e]	6	6	6	6	6
South Africa, Republic of	51	56	58	52	55
Zambia	1	1	(5)	(5)	(5)

See footnotes at end of table.

Table 8.—Feldspar: World production by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Asia:					
Burma	2	2	2	2	2
Hong Kong	3	4	3	1	[9]20
India	61	60	57	55	55
Japan[10]	45	47	46	41	40
Korea, Republic of	29	54	76	95	88
Pakistan	3	4	16	16	16
Philippines	17	[r]18	19	19	19
Sri Lanka	4	4	3	4	4
Thailand	14	19	36	29	28
Turkey	64	83	83	[e]80	79
Oceania: Australia	5	2	4	5	5
Total	[r]3,083	[r]3,228	3,425	3,782	3,782

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 27, 1981.
[2]In addition to the countries listed, mainland China, Czechoslovakia, Romania, and the Territory of South-West Africa (Namibia) produce feldspar, but output is not officially reported and available general information is inadequate for the formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Series revised to exclude production of leucite and sodalite; data presented now consist only of that material reported by Brazil under the heading of "Feldspar." Data represent the sum of (1) run-of-mine production for direct sale and (2) salable beneficiated product; total run-of-mine feldspar production was as follows in thousand short tons: 1976—[r]94; 1977—[r]110; 1978—[r]109; 1979—[r]408; 1980—[e]410.
[5]Less than 1/2 unit.
[6]Described in source as lump feldspar; does not include nepheline syenite as follows in thousand short tons: 1976—[r]239; 1977—231; 1978—256; 1979, not available; 1980, not available.
[7]Includes pegmatite.
[8]Revised to zero.
[9]Includes feldspar sand, a byproduct from kaolin washing, not reported (and presumably not produced) in prior years; of the total, approximately one-fifth is feldspar and four-fifths is feldspar sand.
[10]In addition, the following quantities of aplite were produced in thousand short tons: 1976—395; 1977—435; 1978—[r]416; 1979—435; 1980—[e]420.

TECHNOLOGY

A four-step, bench-scale process was developed that can remove at least 92% of the soluble fluoride from feldspar flotation process wastewaters at a projected cost of $0.93 per ton of feldspar. The initial capital expenditure for a 180,000-ton-per-year plant would be about $200,000.[15]

Laboratory tests were carried out by the Federal Bureau of Mines to investigate the feasibility of recovering potash feldspar and glass sands from molybdenite tailings. The feldspar concentrates from the test results contained in excess of 0.10% Fe_2O_3; however, a high-quality glass sand was produced.[16]

A patent was granted for extraction of alumina from anorthosite or other aluminum silicate ore. The ore is leached with sulfuric acid. In a later step the purified leach solution is treated with gaseous hydrogen chloride.[17]

Two other patents dealt with improved frother reagents for use in froth flotation beneficiation of metal ores and nonmetallic minerals, including feldspar.[18]

NEPHELINE SYENITE

Nepheline syenite is a quartz-free, light-colored rock that, although resembling medium-grained granite in texture, consists principally of nepheline and alkali feldspars, usually in association with minor amounts of other minerals. Large quantities of nepheline syenite (after processing to remove contaminants, especially iron-bearing minerals) are consumed in making glass and ceramics. There is no domestic production of nepheline syenite in grades suitable for these purposes, and U.S. needs are wholly supplied by imports.

In Canada, two firms mine nepheline syenite from the deposit at Blue Mountain, Ontario: Indusmin, Ltd., and International Minerals & Chemical Corp. (Canada) Ltd. Canadian production in 1978, the last year for which an estimate is available, totaled approximately 638,000 tons valued at $13.1 million.

Other than Canada, only two countries are known to produce significant quantities of nepheline syenite—Norway with 267,000 tons in 1979, and the U.S.S.R. where, although production figures are not released, the mineral is known to serve the customary applications of the glass and ceramics industries and also as a major source of cell-feed alumina for electrolytic aluminum plants.

In Mexico, the highly diversified mineral-producing company, Industrias Peñoles S.A. de C.V., was said to be developing reserves of alumina contained in about 3 billion tons of nepheline syenite near Ciudad Victoria in the State of Tamaulipas. Technology for a 300,000-ton-per-year plant is being derived from the U.S.S.R. Investment capital for the entire project is estimated to involve some $590 million.[19]

In Brazil, the company Austral Mineração Serviços Ltda., was understood to be developing a nepheline syenite mine and processing plant near Rio de Janeiro. Commissioning was scheduled for the latter part of 1980.[20]

The price range quoted for imported nepheline syenite in Ceramic Industry magazine, January 1981, was from $18 to $138 per ton, depending upon grade, purity, grind, packaging, transportation, quantity sold, and other factors. Industrial Minerals (London), December 1980, quoted price ranges as follows (converted from Canadian dollars and pounds sterling per metric ton to dollars per short ton):

Canadian:	
Glass grade, 30 mesh, bulk, car lots-truck lots, per short ton.	$18-$21
Ceramic grade, 200 mesh, bagged, 10-ton lots, per short ton.	35- 39
Norwegian:	
Glass grade, 32 mesh (Tyler), bulk, per short ton, c.i.f. main European port.	78
Ceramic grade, 325 mesh (Tyler), bagged, per short ton, c.i.f. main European port.	120

In early March 1981, the American Paint & Coatings Journal quoted paint-grade nepheline syenite in 50-pound bags, carload lots, f.o.b. Ontario, at $67 to $76 per ton.

Table 9.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	178	$4	547,845	$10,442
1979	2,260	28	533,700	10,818
1980	6,760	71	497,580	11,193

APLITE

Aplite is another rock of granitic texture containing quartz mixed with varying proportions of soda or lime-soda feldspar; it is usually not suitable for use in ceramics but, if sufficiently low in iron, finds ready acceptance in the manufacture of glass, especially container glass. Japan, with an annual production of 400,000 to 500,000 tons, is the world's foremost producer of aplite.

Aplite of glassmaking quality was produced in the United States in 1980 only from two open pit operations in central Virginia. The Feldspar Corp. mined aplite near Montpelier, Hanover County, and treated the material by wet-grinding, classification, and spiraling to remove biotite, ilmenite, and rutile, followed by dewatering, drying, and high-intensity magnetic separation to eliminate iron-bearing minerals. IMC operated an aplite mine near Piney River, Nelson County. The ferruginous material from this dry-ground ore was removed by a high-intensity magnetic process. On June 30, 1980, this IMC operation ceased.

Domestic output in 1980 was approximately 10% lower in tonnage than in the previous year. Specific annual data on aplite production, sales, and value are not released for publication. Aplite prices are not commonly quoted in trade journals, but the product traditionally commands a somewhat lower per-ton price than feldspar. Industrial Minerals (London), December 1980, gave a value of around $20 per ton for glass grade, bulk, 100% plus 200 mesh, f.o.b. Montpelier, Va.

[1]Physical scientist, Section of Nonmetallic Minerals.
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[5]Ceramic Industry. Glass, The Natural Choice for the 80's. V. 115, No. 2, August 1980, pp. 51-53.

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Podobnik, D. M., and G. H. Harris (assigned to The Dow Chemical Co.). Froth Flotation. Can. Pat. 1,085,975, Sept. 16, 1980.

[19]Clarke, G. Mexico's Industrial Minerals—Gathering Momentum. Ind. Miner. (London), No. 153, June 1980, p. 28.

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Ferroalloys

By Frederick J. Schottman[1]

The domestic and world ferroalloy industry suffered from weak demand and lower production in 1980. The ferroalloy industry is dependent on its major customer, the iron and steel industry, which had lower production in most industrialized countries. Production continued to shift away from the industrialized countries to the developing ferroalloy industries in countries with ore resources or low-cost electrical power.

Legislation and Government Programs.—Revised goals for the national defense stockpile were announced, replacing goals set in 1976. In a new policy, goals were set first for groups of materials, such as ore and alloys, containing a stockpile element, and then a desired mix of materials in each group was set.

Goals for many ferroalloy-element groups were increased, but goals for several specific ferroalloys were reduced. The goal for the chemical and metallurgical chromium group was raised 10% to 1,353,000 short tons of chromium, but goals for high-carbon and low-carbon ferrochromium were reduced to 185,000 and 75,000 short tons, respectively. The goal for ferrochromium-silicon was increased to 90,000 short tons. The goal for the columbium group was raised 82% to 2,425 short tons, but the goal for ferrocolumbium remained at zero. The new goal for the chemical and metallurgical manganese group was up 5% to 1,500,000 short tons of manganese. Medium-carbon ferromanganese and silicomanganese goals were reduced to zero. The new tungsten goal was up 12% to 25,333 short tons, but the ferrotungsten goal was lowered to zero. Both the group and ferroalloy goals for vanadium were reduced. The group goal was lowered 31% to 8,700 short tons of vanadium, and the ferrovanadium goal was lowered 90% to 1,000 short tons of vanadium.

Table 1.—Government inventory of ferroalloys, December 31, 1980

(Thousand short tons)

Alloy	Stockpile grade	Nonstockpile grade	Total
Ferrochromium:			
High-carbon	402	1	403
Low-carbon	300	19	319
Ferrochromium-silicon	57	1	58
Ferrocolumbium (contained columbium)	.3	.2	.5
Ferromanganese:			
High-carbon	600	--	600
Medium-carbon	29	--	29
Ferrotungsten (contained tungsten)	.4	.6	1
Silicomanganese	24	--	24

So-called superfund legislation was enacted to provide for the cleanup of toxic waste dumps and spills. Most of the cost will be paid by taxes on industrial feedstocks, including chromite used by ferrochromium producers.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States[1]

	1979				1980			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese[2]	317,102	80	330,487	$180,828	189,472	80	194,347	$99,626
Silicomanganese	165,049	66	166,933	69,164	188,317	66	161,568	70,329
Ferrosilicon[3]	857,099	60	853,196	516,332	686,377	61	681,420	442,567
Chromium alloys:								
Ferrochromium:								
High-carbon	212,935	62	193,657	106,570	184,408 (High-carbon and Low-carbon combined)	63	185,480	125,101
Low-carbon	34,034	69	35,991	43,457				
Ferrochromium-silicon	25,898	36	36,009	23,166	54,207 (Ferrochromium-silicon and Other alloys combined)	50	51,987	54,831
Other alloys[4]	21,745	61	22,568	52,625				
Total	294,612	60	288,225	[5]225,817	238,615	60	237,467	179,932
Ferrocolumbium	749	66	766	17,464	1,558	65	1,266	34,491
Ferrophosphorus	87,322	22	78,355	11,760	116,482	24	85,371	13,060
Other[6]	153,124	XX	153,005	296,266	126,351	XX	124,823	290,947
Grand total	1,875,057	XX	1,870,967	1,317,631	1,547,172	XX	1,486,262	1,130,952

XX Not applicable.
[1]Does not include alloys consumed in the making of other ferroalloys.
[2]Includes fused-salt electrolytic low- and medium-carbon ferromanganese (massive manganese).
[3]Includes silicon metal and miscellaneous silicon alloys.
[4]Includes chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.
[5]Data do not add to total shown because of independent rounding.
[6]Includes ferroaluminum, ferroboron and other complex boron additive alloys, ferromolybdenum, ferronickel, ferrotitanium, ferrotungsten, ferrovanadium, ferrozirconium, spiegeleisen, silvery iron, and other miscellaneous alloys.

DOMESTIC PRODUCTION

Domestic production of ferroalloys decreased in 1980 because of weak demand and continued competition from imports. The decline was part of a long-term trend toward greater reliance on imported ferroalloys, particularly for ferromanganese and ferrochromium. The number of active producers of manganese and chromium ferroalloys was again reduced. Ohio Ferro-Alloys Corp. discontinued production of manganese ferroalloys. In the latter part of the year, Chromium Mining & Smelting Corp. and Satralloy, Inc., shutdown ferrochromium production for an indefinite period.

Cabot Corp. sold its silicon metal plant at Springfield, Oreg., to Dow Corning Corp. The plant had one furnace with a capacity of 9,000 tons per year. Some of the silicon metal from the plant will be used as feed material in Dow Corning's electronic-grade silicon and silicon chemicals businesses.

Union Carbide Corp., the largest and most diversified domestic producer of ferroalloys, reached an agreement in principle to sell most of its ferroalloy operations in the United States, Canada, and Europe to groups led by Elkem A/S of Norway. The sale would include most of Union Carbide's silicon, manganese, and chromium ferroalloys production facilities. It would not include the ferrochromium plants in the Republic of South Africa and Zimbabwe, nor would it include Union Carbide's vanadium and tungsten operations. Earlier in the year, Union Carbide closed its ferrosilicon plant in Sheffield, Ala.

The Ferroalloys Association reported that its member companies used 8.0 billion kilowatt-hours of electricity in 1980, down from 9.9 billion in 1979.

Table 3.—Producers of ferroalloys in the United States in 1980

Producer	Plant location	Products[1]	Type of furnace
FERROALLOYS (EXCEPT FERROPHOSPHORUS)			
Alabama Alloy Co., Inc	Bessemer, AL	FeSi	Electric.
Aluminum Co. of America, Northwest Alloys, Inc.	Addy, WA	Si, FeSi	Do.
Autlan Manganese Corp	Mobile, AL	SiMn	Do.
AMAX Inc., Climax Molybdenum Co. Div	Langeloth, PA	FeMo	Metallothermic.
Cabot Corp., KBI Div. Penn Rare Metal Div.	Revere, PA	FeCb	Do.
Chromasco Ltd., Chromium Mining & Smelting Corp. Div.	Woodstock, TN	FeCr, FeSi	Electric.
Dow Corning Corp	Springfield, OR	Si	Do.
Engelhard Minerals & Chemicals Corp., Minerals and Chemicals Div.	Strasburg, VA	FeV	Metallothermic.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH; Graham, WV; Keokuk, IA	FeSi, FeV, silvery pig iron, other.[2]	Electric.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, OR	FeNi, FeSi	Do.
Silicon Div	Wenatchee, WA	Si, FeSi	Do.
Interlake, Inc., Globe Metallurgical Div	Beverly, OH; Selma, AL	FeCr, FeCrSi, Si, FeSi, SiMn.	Do.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div	Bridgeport, AL	FeSi	Do.
	Kimball, TN	do	Do.
Macalloy Inc	Charleston, SC	FeCr, FeCrSi	Do.
Metallurg, Inc., Shieldalloy Corp	Newfield, NJ	FeAl, FeB, FeCb, FeTi, FeV, other.[2]	Metallothermic.
Ohio Ferro-Alloys Corp	Montgomery, AL; Philo, OH; Powhatan Point, OH	FeB, FeMn, FeSi, Si, SiMn.	Electric.
Pennzoil Co., Duval Corp	Sahuarita, AZ	FeMo	Metallothermic.
Pesses Co., The	Newton Falls, OH; Solon, OH; Pulaski, PA; Fort Worth, TX	FeAl, FeB, FeCb, FeMo, FeNi, FeTi, FeV, FeW, other.[2]	Electric and metallothermic.
Reactive Metals and Alloys Corp	West Pittsburg, PA	FeTi, other[2]	Electric.
Reading Alloys, Inc	Robesonia, PA	FeCb, FeV	Metallothermic.
Reynolds Metals Co	Sheffield, AL	Si	Electric.
Satra Corp., Satralloy, Inc. Div	Steubenville, OH	FeCr, FeCrSi	Do.
SEDEMA S.A., Chemetals Corp	Kingwood, WV	FeMn	Fused-salt electrolytic.
SKW Alloys, Inc	Calvert City, KY; Niagara Falls, NY	FeMn, FeSi, SiMn	Electric.
South African Manganese Amcor, Ltd. Roane Ltd	Rockwood, TN	FeMn, SiMn	Do.
Teledyne, Inc., Teledyne Wah Chang, Albany Div	Albany, OR	FeCb	Metallothermic.
Union Carbide Corp., Metals Div	Alloy, WV; Ashtabula, OH; Marietta, OH; Niagara Falls, NY; Portland, OR; Sheffield, AL	FeB, FeCr, FeCrSi, FeMn, FeSi, FeV, FeW, Si, SiMn, other.[2]	Electric.
Union Oil Co. of California, Molycorp, Inc	Washington, PA	FeB, FeMo, FeW	Electric and metallothermic.
FERROPHOSPHORUS			
Electro-Phos Corp	Pierce, FL	FeP	Electric.
FMC Corp., Industrial Chemical Div	Pocatello, ID	do	Do.
Monsanto Co., Monsanto Industrial Chemicals Co.	Columbia, TN	do	Do.
	Soda Springs, ID	do	Do.
Occidental Petroleum Corp., Hooker Chemical Co., Industrial Chemicals Group	Columbia, TN	do	Do.
Stauffer Chemical Co., Industrial Chemical Div.	Mt. Pleasant, TN; Silver Bow, MT; Tarpon Springs, FL	do	Do.

[1]FeAl, ferroaluminum; FeB, ferroboron; FeCb, ferrocolumbium; FeCr, ferrochromium; FeCrSi, ferrochromium-silicon; FeMn, ferromanganese; FeMo, ferromolybdenum; FeNi, ferronickel; FeP, ferrophosphorus; FeSi, ferrosilicon; FeTi, ferrotitanium; FeV, ferrovanadium; FeW, ferrotungsten; Si, silicon metal; SiMn, silicomanganese.

[2]Includes specialty silicon alloys, zirconium alloys, and miscellaneous ferroalloys.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1980[1]

(Short tons of alloys)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	601,584	92,196	[2]116,903	400	9,124	910
Stainless and heat-resisting	14,173	5,456	[2]47,457	1,432	(3)	29
Other alloy	159,486	41,261	[2]60,266	814	1,632	329
Tool	669	42	[2]2,927	(3)	--	--
Unspecified	752	1,015	41,131	10	10	--
Total steel	776,664	139,970	268,684	2,656	10,766	1,268
Cast irons	16,375	11,695	236,320	101	4,135	W
Superalloys	425	W	430	W	--	W
Alloys (excluding alloy steels and superalloys)	16,139	2,576	71,941	171	90	77
Miscellaneous and unspecified	4,868	1,576	75,039	117	2,040	124
Total	814,471	155,817	652,414	3,045	17,031	1,469
Percent of 1979	81	90	82	75	61	87

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]FeMn, ferromanganese including spiegeleisen and manganese metal; SiMn, silicomanganese; FeSi, ferrosilicon including silicon metal, silvery pig iron, and inoculant alloys; FeTi, ferrotitanium; FeP, ferrophosphorus including other phosphorus materials; FeB, ferroboron including other boron materials.
[2]Part included in "Unspecified."
[3]Included in "Unspecified."

Table 5.—Consumption by end use of ferroalloys as alloying elements in the United States in 1980[1]

(Short tons of contained elements)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	3,493	67	--	1,114	776	--
Stainless and heat-resisting	173,576	578	52	40	413	24,533
Other alloy	48,168	1,217	29	3,406	[2]1,103	3,339
Tool	2,759	279	145	653	--	(3)
Unspecified	(4)	(4)	--	4	3	--
Total steel[5]	227,996	2,141	226	5,217	2,295	27,872
Cast irons	6,385	1,230	--	54	--	229
Superalloys	11,682	223	W	29	943	955
Alloys (excluding alloy steels and superalloys)	4,833	314	7	[5]10	11	814
Miscellaneous and unspecified	1,597	69	14	28	3	49
Total	252,493	3,977	247	5,338	3,252	29,919
Percent of 1979	78	90	63	88	103	75

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]FeCr, ferrochromium including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum including calcium molybdate; FeW, ferrotungsten including melting base self-reducing tungsten; FeV, ferrovanadium including other vanadium-carbon-iron ferroalloys; FeCb, ferrocolumbium including nickel columbium; FeNi ferronickel.
[2]Part included in "Unspecified."
[3]Included with "Other alloy."
[4]Included in "Miscellaneous and unspecified."
[5]With minor exceptions as denoted by footnote 4.

CONSUMPTION AND USES

Total consumption of ferroalloys in 1980 was about 20% lower than in 1979. In general, consumption patterns for ferroalloys followed the production patterns for steel. Consumption of alloys used predominantly in stainless steel, such as ferrochromium, ferronickel, and ferrotitanium, was down by a greater percentage than consumption of alloys used predominantly in grades of steel other than stainless.

Demand for silicon ferroalloys in making cast iron, normally ferrosilicon's largest end use, was down 28%, largely because of lower cast iron demand by the automotive industry. The fraction of manganese in ferroalloys that was consumed as silicomanganese increased somewhat in 1980. Consumption of ferromolybdenum showed a relatively small decrease in 1980 because consumption in 1979 had been limited by a shortage of molybdenum. Also, some molybdenum bearing products such as drill pipe for the oil

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States at yearend

(Short tons)

	Producer		Consumer		Total	
	1979 (gross weight)	1980 (gross weight)	1979 (gross weight)	1980 (gross weight)	1979 (gross weight)	1980 (gross weight)
Manganese ferroalloys[1]	61,023	72,654	193,967	175,303	254,990	247,957
Silicon alloys[2]	116,404	120,795	55,129	43,015	171,533	163,810
Ferrochromium[3]	48,861	43,920	58,314	60,203	107,175	104,123
Ferroboron[4]	W	W	402	305	402	305
Ferrophosphorus[5]	67,042	104,852	3,964	2,631	71,006	107,483
Ferrotitanium[6]	W	W	595	659	595	659
Total	293,330	342,221	312,371	282,116	605,701	624,337
	1979 (contained element)	1980 (contained element)	1979 (contained element)	1980 (contained element)	1979 (contained element)	1980 (contained element)
Ferrocolumbium[6]	151	W	662	W	813	W
Ferromolybdenum[7]	310	1,249	936	754	1,246	2,003
Ferronickel	W	W	2,467	2,051	2,467	2,051
Ferrotungsten[8]	W	W	75	54	75	54
Ferrovanadium[9]	1,062	1,593	879	770	1,941	2,363
Total	1,523	2,842	5,019	3,629	6,542	6,471

W Withheld to avoid disclosing company proprietary data.
[1]Includes ferromanganese, silicomanganese, and manganese metal.
[2]Includes ferrosilicon, miscellaneous silicon alloys, and silicon metal.
[3]Includes other chromium alloys and chromium metal.
[4]Consumer totals include other boron materials.
[5]Consumer totals include other phosphorus materials.
[6]Consumer totals include nickel columbium.
[7]Consumer totals include calcium molybdate.
[8]Consumer totals include melting base self-reducing tungsten.
[9]Includes other vanadium-iron-carbon ferroalloys.

and gas industry were in strong demand.

Low concentrations of vanadium, columbium, and boron can improve the mechanical properties of steel with relatively low added materials cost. Consumption of the ferroalloys containing these elements declined relatively little in 1980, compared with consumption of other ferroalloys, and in the case of ferrocolumbium there was a small increase. High-strength low-alloy steels containing columbium and vanadium were increasingly being used to reduce materials cost and to produce lighter weight, more efficient products.

PRICES

Weak demand limited price increases for most ferroalloys, despite rising production costs. Producer prices for ferromanganese, silicomanganese, and ferrosilicon did not increase during the year, but silicon metal prices were raised about 5% in January. A midyear price increase for ferrosilicon announced by two companies was rescinded. Ferrochromium and ferronickel prices rose during the first half of the year, but discounting was reported later in the year when demand fell.

Producers of ferromolybdenum were able to raise prices despite reduced demand because their prices had lagged behind free market prices during the shortage of 1979. The price of ferrovanadium was raised about 9% at the beginning of the year to $7.75 per pound of vanadium. Late in the year, several price increases for ferrosilicon and vanadium alloys were announced, to be effective at the beginning of 1981.

Alloy	End of year price[1]	
	1979	1980
Charge chromium (66% to 70%)	$0.46	$0.485
Low-carbon ferrochromium, 0.02% maximum carbon ("Simplex")	.90	.95
Standard 78% ferromanganese, per long ton of alloy	490.00	490.00
Ferromolybdenum, lump	8.40	11.52
Ferronickel	2.95	3.40
Ferrosilicon, 50%	.42	.42
Ferrosilicon, 75%	.4625	.4625

[1]Per pound contained, except as noted otherwise. If range of prices was quoted, the lowest price is shown.

FOREIGN TRADE

The trade deficit for ferroalloys was down slightly in 1980 to $493 million, from $515 million in 1979 despite higher prices. The quantity of exports on a gross weight basis increased by 13% to over one-ninth of imports. The value of exports was about one-sixth that of imports.

Total imports of ferroalloys and ferroalloy metals declined because of weaker U.S. demand. An exception to the pattern was the chromium group of ferroalloys for which imports increased 25%.

The Republic of South Africa and Zimbabwe together provided almost half of the imported ferroalloys and ferroalloy metals in 1980. These two countries shipped 90% of the chromium ferroalloy imports, and the Republic of South Africa shipped 33% of manganese ferroalloy imports. Europe was the source of a third of imports, principally ferromanganese. More than half of the imports from Europe were ferromanganese from France. Norway and Yugoslavia were other important European suppliers of ferroalloys. Almost one-seventh of imports came from countries of the Western hemisphere. Canada, Brazil, and Mexico were leading suppliers.

At the request of the Ferroalloys Association, the U.S. Department of Commerce dropped an investigation of subsidies given to the Brazilian ferroalloy industry by the Brazilian Government. The association explained that in December 1979, the Brazilian Government had announced changes that eliminated about 90% of the subsidies. In a similar case, countervailing duties were imposed on imports from Spain at the beginning of 1980. The extra duties were 2.4% ad valorem on medium-carbon ferromanganese and 3.36% ad valorem on high-carbon ferromanganese, high-carbon ferrochromium, silicomanganese, and 60% to 80% ferrosilicon.

Table 7.—U.S. exports of ferroalloys

Alloy	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ferrocerium and alloys	19	$214	42	$273	17	$196
Ferrochromium	19,397	10,727	14,762	14,558	31,705	22,233
Ferromanganese	9,433	4,769	25,344	19,252	11,686	7,657
Silicomanganese	4,782	1,568	5,243	2,627	6,489	3,468
Ferromolybdenum	733	6,721	840	10,029	880	17,104
Ferrophosphorus	4,168	696	37,292	3,678	44,692	6,778
Ferrosilicon	11,900	7,871	22,357	14,740	27,488	18,572
Ferrovanadium	1,309	9,986	879	7,881	802	6,995
Ferroalloys, n.e.c	13,937	9,356	6,441	12,616	4,710	10,130
Total[1]	65,678	51,908	113,200	85,655	128,470	93,133

[1]Data may not add to totals shown because of independent rounding.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1979			1980		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Manganese alloys:						
Ferromanganese containing less than 1% carbon	2,238	1,955	$1,998	3,957	3,483	$3,455
Ferromanganese containing over 1% and less than 4% carbon	52,538	42,588	30,249	38,409	31,121	23,747
Ferromanganese containing 4% or more carbon	766,437	594,192	224,596	563,336	438,795	184,163
Ferrosilicon-manganese (Mn content)	94,671	62,608	34,756	74,975	49,158	29,291
Spiegeleisen	--	--	--	2,850	([1])	177
Total manganese alloys[2]	915,884	701,343	291,599	683,528	522,557	240,833

See footnotes at end of table.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals —Continued

Alloy	1979 Gross weight (short tons)	1979 Content (short tons)	1979 Value (thousands)	1980 Gross weight (short tons)	1980 Content (short tons)	1980 Value (thousands)
Ferrosilicon:						
8%-30% silicon	4,491	666	$ 575	1,187	184	$ 126
30%-60% silicon, over 2% magnesium	12,127	5,768	7,169	5,523	2,706	5,293
30%-60% silicon, n.e.c	14,350	7,298	7,137	14,108	6,971	7,621
60%-80% silicon, over 3% calcium	(3)	(3)	(3)	8,373	6,020	6,217
60%-80% silicon, n.e.c.[3]	82,122	60,352	42,540	41,729	30,993	23,271
80%-90% silicon	463	389	200	97	80	55
Over 90% silicon	--	--	--	135	124	56
Total ferrosilicon	113,553	74,473	57,621	71,152	47,078	42,639
Chromium alloys:						
Ferrochromium containing 3% or more carbon	221,831	121,838	94,337	275,227	158,806	128,162
Ferrochromium containing less than 3% carbon	20,631	14,120	22,254	21,993	15,293	25,328
Ferrosilicon-chromium	42	3	21	5,082	1,967	2,313
Total chromium alloys	242,504	135,961	116,612	302,302	176,066	155,803
Ferronickel	62,593	18,776	91,340	51,742	16,667	104,156
Other ferroalloys:						
Ferrocerium and other cerium alloys	62	(1)	680	72	(1)	902
Ferromolybdenum	31	23	636	23	15	243
Ferrophosphorus	6	(1)	8	4	(1)	10
Ferrotitanium and ferrosilicon titanium	964	(1)	2,702	623	(1)	1,679
Ferrotungsten and ferrosilicon tungsten	368	285	5,228	272	223	4,039
Ferrovanadium	737	517	5,967	327	263	3,477
Ferrozirconium	2,013	(1)	2,046	981	(1)	1,222
Ferroalloys, n.e.c.[4]	4,477	(1)	26,067	4,826	(1)	30,942
Total other ferroalloys[2]	8,658	XX	43,334	7,128	XX	42,513
Total ferroalloys[2]	1,343,192	XX	600,506	1,115,854	XX	585,944
Metals:						
Manganese	6,683	(1)	5,545	7,915	(1)	8,032
Silicon (96%-99% silicon)	19,936	(1)	16,833	15,887	(1)	15,607
Silicon (99%-99.7% silicon)	7,050	6,987	6,646	5,370	5,322	5,760
Chromium	3,661	(1)	19,889	4,075	(1)	28,367
Total ferroalloy metals	37,330	XX	48,913	33,247	XX	57,766
Grand total[2]	1,380,522	XX	649,419	1,149,101	XX	643,711

XX Not applicable.
[1]Not recorded.
[2]Data may not add to totals shown because of independent rounding.
[3]Prior to 1980, no distinction was made between high-calcium ferrosilicon and regular ferrosilicon with 60% to 80% silicon.
[4]Principally ferrocolumbium.

WORLD REVIEW

World consumption and production of ferroalloys was lower in 1980 than in 1979 because of reduced steel production. Production increased in a few countries such as Brazil and Iceland, which have developing ferroalloy industries. However production was lower in the United States, Japan, the Republic of South Africa, and most European countries.

Australia.—Kaiser Aluminum and Chemical Corp. (Australia) Ltd. announced plans for a silicon metal plant with an initial capacity of 30,000 tons per year. The plant would be built at Geelong, Victoria, and start production in 1983.

Colombia.—Construction continued on the Cerro Matoso S.A. ferronickel project. The plant is expected to begin production in early 1982 and to reach an output of 25,000 tons of nickel per year in 1984.[2]

Dominican Republic.—Falconbridge Dominicana C. por A. shutdown its ferronickel operation for the second half of 1980 because of weak demand for nickel. The company was hurt financially by the rising price of oil for the energy-intensive processing of lateritic ore.

Greece.—Hellenic Ferroalloys, established by the Greek Government's Hellenic Industrial Mining & Investment Co., is to build a ferrochromium plant at Tsiggeli, Almyros. The $37 million plant is to have an annual capacity of 33,000 tons per year. The plant is part of a planned complex comprising mines, ferroalloy plants, and a stainless steel plant.[3]

India.—Production of ferroalloys continued to be restrained by the unavailability of hydropower because of drought. Late in the year more power became available in some parts of the country and full power was restored for most ferrosilicon production.

Orissa Mining Corp., jointly with foreign participation by Outokumpu Oy of Finland and Vöest-Alpine AG of Austria, agreed to form a new company, OMC Alloys, to build a 55,000-ton-per-year ferrochromium plant at Bamnipal. The plant will use Outokumpu technology to pelletize and smelt low-grade chrome ore fines. The plant is planned to start operation in 1983. Ferroalloys Corp. was installing a 16-megavolt-ampere furnace for various alloys and was planning a 55,000-ton-per-year charge chrome plant to be built in Orissa.[4]

Japan.—Production of ferroalloys in 1980 was almost equal to that in 1979. However, power costs rose sharply and the Japanese ferroalloys industry became less economically competitive with imports. Continuing the trend to less Japanese ferrosilicon production, Japan Metals & Chemicals Ltd. announced that it was eliminating 18,000 tons per year of capacity.[5]

Norway.—A proposed Norwegian Government energy policy may weaken the Norwegian ferroalloy industry by more than doubling the price of purchased electrical power. It would also apply a tax on power generated by a company's own power stations to bring the cost up to that of purchased power. The Government plan also expects less power to be available than the metallurgical industry says is needed for future expansion.[6] Following the release of the energy plan, Elkem A/S delayed a decision on construction of a fourth ferrosilicon furnace at Salten Verk.

Philippines.—A 57,000-ton-per-year ferrochromium plant was being built for Ferrochrome Philippines Inc. at Tagaloan, Oriental Misamis. Ferrochrome Philippines is a joint venture of the Herdis Group and Vöest-Alpine AG.[7]

South Africa, Republic of.—After a decade of growth in which ferroalloy production increased more than fourfold, production in 1980 was slightly lower than that in 1979. Producers were forced to cut back production in the second half of the year because of weak demand in their export markets.

Turkey.—Etibank General Management will triple the capacity of its ferrochromium plant at Elazig to 165,000 tons per year. The expansion will be completed in 1984.[8]

Venezuela.—Fesilven, formerly Venbozel, faced possible liquidation because of continued financial losses and the reluctance of the firm's owners to put up additional capital. Nobel Bozel of France, which had a 75% interest in the company when it was founded in 1973, gave up its remaining 30% interest in Fesilven, leaving that company entirely Venezuelan owned. The Fesilven plant started production in 1976 and had a capacity of 66,000 tons per year of 75% ferrosilicon.

Zimbabwe.—Ferroalloys from Zimbabwe were again openly traded after the end of years of international trade sanctions against the former Southern Rhodesia. Union Carbide Corp. resumed control of its Union Carbide Rhomet (Private) Ltd. subsidiary after the new internationally recognized government took power.

TECHNOLOGY

Most refined medium- and low-carbon ferromanganese has been produced using a two-stage process involving reduction of manganese ore by the silicon in silicomanganese. A new version of the process has been developed by Uddeholms AB and Asea AB of Sweden. The process injects powdered manganese ore and lime through a tuyere into molten silicomanganese in an induction-heated furnace.[9] A different process for the production of refined ferromanganese was introduced in several countries in recent years. The process decarburizes high-carbon ferromanganese by top blowing with oxygen. This operation is analogous to steelmaking in the basic oxygen furnace.[10]

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[1]Physical scientist, Section of Ferrous Metals.

[2]Financial Times (London). Nickel: A New Force in the World Market. No. 28287, Oct. 6, 1980, p. 22.

[3]Engineering & Mining Journal. Greece Drives to Expand Production of Key Minerals by Mid-1980's. V. 181, No. 4, April 1980, p. 49.

[4]Metal Bulletin. New FeCr Plant in Orissa. No. 6526, Sept. 26, 1980, p. 25.

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Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1]

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
Argentina: Electric furnace:					
Ferromanganese	26	31	28	32	31
Silicomanganese	7	7	11	15	13
Ferrosilicon	19	17	11	7	9
Other	1	1	1	2	1
Total	53	56	51	56	54
Australia: Electric furnace:[5]					
Ferromanganese	55	78	105	106	106
Silicomanganese	16	26	(6)	--	--
Ferrosilicon	8	21	21	21	21
Total	79	125	126	127	127
Austria: Electric furnace, undistributed	9	8	8	10	9
Belgium: Electric furnace, ferromanganese[7]	93	61	96	99	94
Brazil: Electric furnace:					
Ferromanganese	109	142	130	147	[8]155
Silicomanganese	70	83	117	141	[8]148
Ferrosilicon	50	66	80	74	[8]120
Silicon metal	6	5	6	6	[8]14
Ferrochromium	[r]72	73	69	93	[8]103
Ferrochromium-silicon	[r]4	5	5	8	[8]9
Ferronickel	11	12	12	13	[8]12
Other	22	23	32	42	[8]47
Total	[r]344	409	451	524	[8]608
Bulgaria: Electric furnace:					
Ferromanganese[e 9]	36	33	31	31	31
Ferrosilicon[e]	28	21	19	18	18
Other[e]	1	1	1	1	1
Total	65	55	51	50	50
Canada: Electric furnace:					
Ferromanganese[e 9]	88	66	77	55	80
Ferrosilicon	94	126	143	[r]105	[8]153
Silicon metal	22	25	31	29	[8]33
Other[e 10]	60	13	25	[r]20	25
Total	264	[e]230	[e]276	209	291
Chile: Electric furnace:					
Ferromanganese	9	5	6	6	6
Silicomanganese	2	(11)	(11)	(11)	(11)
Ferrosilicon	5	3	2	6	5
Other	1	1	(11)	1	1
Total	17	9	8	13	12

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
China:[e]					
Mainland: Furnace type unspecified:					
Ferromanganese[9]	210	255	340	375	375
Ferrosilicon	110	120	165	180	180
Silicon metal	5	5	9	10	15
Ferrochromium	65	80	100	100	100
Other[10]	30	40	46	55	55
Total	420	500	660	720	725
Taiwan: Electric furnace, ferrosilicon	26	27	33	41	[8]39
Colombia: Electric furnace ferrosilicon[12]	1	--	--	--	--
Czechoslovakia:					
Blast furnace, undistributed	2	--	--	--	--
Electric furnace:					
Ferromanganese[e 9]	77	110	110	110	108
Ferrosilicon[e]	30	39	39	36	34
Silicon metal[e]	4	5	6	6	6
Ferrochromium[e]	33	33	33	31	30
Other[e 10]	10	11	13	10	9
Total[13]	156	198	201	193	187
Dominican Republic: Electric furnace, ferronickel	[r]71	[r]72	41	73	46
Egypt: Electric furnace:					
Ferrosilicon	--	5	[e]5	--	--
Other	5	--	--	--	--
Total	5	5	[e]5	--	--
Finland: Electric furnace, ferrochromium	44	37	49	54	55
France:					
Blast furnace:					
Spiegeleisen	[r]2	10	7	10	[8]11
Ferromanganese	402	395	430	485	[8]518
Electric furnace:					
Silicomanganese[14]	13	23	21	14	[8]22
Ferrosilicon	261	266	219	300	[8]284
Silicon metal	45	47	46	61	60
Ferrochromium[15]	112	[r]112	102	105	[8]95
Other[16]	[r]125	[r]139	143	157	[8]135
Total	[r]960	[r]992	968	1,132	1,125
German Democratic Republic:					
Blast furnace, spiegeleisen	--	--	4	--	--
Electric furnace:					
Ferromanganese[e 9]	88	98	88	88	86
Ferrosilicon[e]	25	22	34	33	32
Silicon metal[e]	3	3	4	4	4
Ferrochromium[e]	32	26	28	23	22
Other[e 10]	22	21	23	22	21
Total[13]	170	170	181	170	165
Germany, Federal Republic of:					
Blast furnace:					
Ferromanganese	243	193	231	257	[8]220
Ferrosilicon	100	96	86	87	[8]71
Electric furnace:					
Ferromanganese[e 9]	66	55	17	[r]33	28
Ferrosilicon[e]	66	55	33	[r]55	55
Ferrochromium[e]	66	61	55	66	66
Other[e 10]	65	60	48	[r]56	55
Total	606	520	470	554	495
Greece: Electric furnace, ferronickel	67	39	61	[e]60	80
Hungary: Electric furnace:					
Ferromanganese[9]	3	3	3	[e]3	3
Ferrosilicon	8	8	8	[e]8	8
Silicon metal[e]	2	2	2	2	2
Total[13]	13	13	13	13	13
Iceland: Electric furnace, ferrosilicon	--	--	--	17	[8]28

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
India: Electric furnace:					
Ferromanganese	194	213	243	208	[8]179
Silicomanganese	([11])	3	3	3	[8]5
Ferrosilicon	59	49	58	56	[8]47
Silicon metal	([17])	1	([11])	1	[8]3
Ferrochromium	19	20	24	25	[8]18
Ferrochromium-silicon	6	5	4	4	[8]4
Other	([11])	[r]12	4	3	[8]1
Total	278	[r]303	336	300	257
Indonesia: Electric furnace, ferronickel	19	24	22	20	20
Italy:					
Blast furnace:					
Spiegeleisen	3	7	3	3	[8]6
Ferromanganese	69	64	68	74	[8]67
Electric furnace:					
Ferromanganese	17	19	31	24	24
Silicomanganese	46	44	47	60	50
Ferrosilicon	87	84	75	89	79
Silicon metal	19	18	16	[e]17	[e]17
Ferrochromium	50	44	41	47	45
Ferrochromium-silicon	([17])	--	([11])	([17])	--
Other[18]	[15]7	9	8	12	[8]16
Total[18]	298	289	289	326	304
Japan: Electric furnace:					
Ferromanganese	697	581	502	709	[8]669
Silicomanganese	411	368	334	499	[8]478
Ferrosilicon	345	321	298	363	[8]349
Silicon metal	49	41	16	17	[8]17
Ferrochromium	511	440	302	421	[8]471
Ferrochromium-silicon	12	[r]13	10	19	[8]18
Ferronickel	[r]219	247	219	335	[8]308
Other	[r]18	23	22	17	[8]17
Total	2,262	[r]2,034	1,703	2,380	[8]2,327
Korea, North: Furnace type unspecified:					
Ferromanganese[e 9]	44	62	72	72	77
Ferrosilicon[e]	22	25	33	33	33
Other[e 10]	11	13	15	15	22
Total[e]	77	100	120	120	132
Korea, Republic of: Electric furnace:					
Ferromanganese	[e 19]32	[e 19]40	[e 19]52	[e 19]78	[8]60
Ferrosilicon	[19]38	[19]30	[19]34	[19]44	[8]33
Other[e 20]	1	1	1	[r]2	27
Total	71	71	87	124	[8]120
Mexico: Electric furnace:					
Ferromanganese	60	110	118	135	136
Silicomanganese	19	30	37	34	40
Ferrosilicon	20	25	27	27	29
Ferrochromium	4	3	5	5	4
Other	([11])	([11])	1	1	1
Total	103	168	188	202	210
New Caledonia: Electric furnace, ferronickel	173	[e]127	[e]89	[e]92	93
Norway: Electric furnace:					
Ferromanganese	384	269	301	372	[8]316
Silicomanganese	186	140	147	203	[8]180
Ferrosilicon	306	246	293	372	[8]339
Silicon metal[e]	63	56	70	77	94
Ferrochromium	35	25	17	13	[8]13
Ferrochromium-silicon	1	([11])	1	1	([8 11])
Other	34	34	33	33	[8]7
Total[13]	1,009	770	862	1,071	949

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
Peru: Electric furnace:					
Ferromanganese	--	--	1	1	1
Ferrosilicon	([11])	([11])	1	1	1
Total	([11])	([11])	2	2	2
Philippines: Electric furnace, ferrosilicon[e 21]	8	17	15	20	22
Poland:					
Blast furnace:					
Spiegeleisen	9	12	8	10	9
Ferromanganese	128	136	131	133	132
Electric furnace:					
Ferromanganese[e 9]	50	55	55	55	53
Ferrosilicon[e]	57	61	58	57	55
Silicon metal[e]	12	12	12	12	11
Ferrochromium[e]	55	55	55	55	53
Other[e 10]	19	21	18	15	13
Total[13]	330	352	337	337	326
Portugal: Electric furnace:					
Ferromanganese[e 22]	61	61	86	83	82
Silicomanganese[e 22]	2	5	17	17	19
Ferrosilicon[e]	[r]25	[r]26	[r]33	[r]28	28
Silicon metal[e]	--	15	[r]22	[r]35	36
Other[e]	[r]([11])	[r]([11])	[r]([11])	[r]([11])	([11])
Total[13]	[r e]88	[r e]107	158	163	165
South Africa, Republic of: Furnace type unspecified:					
Ferromanganese	[e]386	[e]441	[r e]507	[r e]862	[8]842
Silicomanganese[e]	24	28	33	[r]38	32
Ferrosilicon	[e]87	[e]110	[r e]133	[r e]176	[8]172
Silicon metal[e]	25	31	36	39	36
Ferrochromium	[e]386	[e]419	[r e]529	[r e]612	[8]623
Ferrochromium-silicon[e]	24	32	34	[r]39	33
Other[e 23]	([11])	([11])	[r]1	1	1
Total[13]	932	1,061	1,273	1,767	[8]1,739
Spain: Electric furnace:					
Ferromanganese	147	156	148	162	169
Silicomanganese	100	70	120	131	133
Ferrosilicon	62	75	108	137	154
Silicon metal[e]	7	18	22	22	22
Ferrochromium	22	18	15	22	21
Other	([11])	([11])	([11])	1	1
Total[13]	338	337	413	475	500
Sweden: Electric furnace:					
Silicomanganese	8	--	--	--	--
Ferrosilicon	41	25	1	--	--
Silicon metal	20	14	10	[e]18	18
Ferrochromium	128	148	183	209	208
Ferrochromium-silicon	7	9	5	32	22
Other	3	2	2	2	3
Total[13]	207	198	201	261	251
Switzerland: Electric furnace:					
Ferrosilicon[e]	6	6	6	6	6
Silicon metal[e]	3	3	3	3	3
Total[e]	9	9	9	9	9
Thailand: Electric furnace:					
Ferromanganese	2	1	1	2	([8 11])
Ferrosilicon	1	--	2	3	([8 11])
Total	3	1	3	5	([8 11])
Turkey: Electric furnace:					
Ferromanganese[e]	--	1	1	1	1
Ferrosilicon[e]	--	3	3	3	3

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
Turkey: Electric furnace —Continued					
Ferrochromium[e]	28	38	44	[r]33	36
Total[e]	28	42	48	[r]37	40
U.S.S.R.:					
Blast furnace:					
Spiegeleisen	[r]110	110	80	[e]80	80
Ferromanganese	[r]770	[r]770	580	[e]570	570
Other	[r]110	[r]110	110	[e]110	110
Electric furnace:[24]					
Ferromanganese[e]	[r]570	[r]610	[r]870	[r]900	880
Silicomanganese[e]	28	33	33	33	35
Ferrosilicon[e]	661	661	683	694	695
Silicon metal[e]	50	52	52	63	65
Ferrochromium[e]	[r]530	[r]700	[r]730	[r]760	770
Ferrochromium-silicon[e]	[r]11	[r]11	[r]11	[r]11	11
Other[16]	193	198	204	204	204
Total	[r]3,033	[r]3,255	3,353	3,425	3,420
United Kingdom:					
Blast furnace, ferromangese	134	107	76	151	132
Electric furnace, undistributed[e]	18	16	18	18	18
Total	152	123	94	169	150
United States: Furnace type unspecified:[25]					
Ferromanganese	483	334	273	317	[8]189
Silicomanganese	129	120	142	165	[8]188
Ferrosilicon	732	776	703	[r]712	[8]559
Silicon metal	129	118	116	145	[8]127
Ferrochromium	215	217	195	269	[8 26]239
Ferrochromium-silicon	54	53	24	26	([26])
Other[27]	168	136	213	[r]241	[8]244
Total[28]	1,910	1,754	1,666	1,875	[8]1,547
Uruguay: Electric furnace, ferrosilicon	([11])	([11])	([11])	([11])	--
Venezuela: Electric furnace:					
Ferromanganese	--	--	--	1	2
Silicomanganese	--	--	--	1	2
Ferrosilicon	3	[r e]12	31	43	24
Total	3	[r e]12	31	45	28
Yugoslavia: Electric furnace:					
Ferromanganese	24	60	41	50	49
Silicomanganese	29	10	31	32	32
Ferrosilicon	[29]109	61	66	75	73
Silicon metal	([29])	30	34	35	33
Ferrochromium	47	40	57	72	71
Ferrochromium-silicon	8	6	9	7	7
Other	4	2	3	4	3
Total	221	209	241	275	[8]268
Zimbabwe: Electric furnace:					
Ferromanganese[e]	NA	NA	NA	3	3
Ferrochrome[e]	205	220	220	[r]220	220
Total	205	220	220	223	223
Grand total[28]	[r]15,220	[r]15,109	15,509	17,838	17,305
Of which:					
Blast furnace:					
Spiegeleisen[30]	124	139	102	103	106
Ferromanganese[30]	[r]1,746	[r]1,665	1,516	1,670	1,639
Other[31]	[r]210	[r]206	196	197	181
Undistributed	2	--	--	--	--
Total blast furnace	[r]2,082	[r]2,010	1,814	1,970	1,926
Electric furnace:[32]					
Ferromanganese[33]	[r]2,888	[r]2,858	3,141	3,494	3,352
Silicomanganese[33 34]	[r]1,090	[r]990	1,093	1,386	1,377
Ferrosilicon	[r]3,400	3,409	3,473	3,840	3,687

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by furnace type, alloy type, and country[1] —Continued

(Thousand short tons)

Country,[2] furnace type,[3] and alloy type[4]	1976	1977	1978	1979[p]	1980[e]
Of which —Continued					
Electric furnace:[32] —Continued					
Silicon metal	464	501	513	602	616
Ferrochromium[35]	[r]2,659	[r]2,809	2,853	3,235	[26]3,263
Ferrochromium-silicon[35]	[r]127	[r]134	103	147	[26]104
Ferronickel[36]	[r]560	[r]521	444	593	559
Other[36]	[r]800	[r]761	857	917	910
Undistributed	27	24	26	28	27
Total electric furnace	[r]12,015	[r]12,007	12,503	14,242	13,895
Furnace type unspecified:					
Ferromanganese and total[32]	1,123	1,092	1,192	1,626	1,483

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Table includes data available through June 21, 1981.

[2]In addition to the countries listed, Romania is known to produce electric furnace ferroalloys, but output is not reported quantitatively and no basis is available for estimation.

[3]To the extent possible, ferroalloy production of each country has been separated according to the furnace type from which production is obtained; production derived from metallothermic operations is included with electric furnace production.

[4]To the extent possible, ferroalloy production of each country has been separated so as to show individually the following major types of ferroalloys: Spiegeleisen, ferromanganese, silicomanganese, ferrosilicon, silicon metal , ferrochromium, ferrochromium-silicon, and ferronickel. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically but which definitely exclude those listed previously in this footnote have been reported as "Other." For countries for which one or more of the individual ferroalloys listed separately in this footnote have been inseparable from some other ferroalloys owing to the nation's reporting system, such deviations are indicated by individual footnote. In instances where ferroalloy production has not been subdivided in sources, and where no basis is available for estimation of individual component ferroalloys, the entry has been reported as "Undistributed."

[5]Data for year ending Nov. 30 of that stated.

[6]Revised to zero.

[7]Reported as blast furnace ferromanganese and spiegeleisen but believed to be electric furnace output.

[8]Reported figure.

[9]Includes silicomanganese.

[10]Includes ferrochromium-silicon and ferronickel, if any was produced.

[11]Less than 1/2 unit.

[12]Colombia is reported to also produce ferromanganese, but output is not reported quantitatively and no basis is available for estimation.

[13]Total for 1976-79 represents an estimate for silicon metal plus a reported total for all other types.

[14]Includes silicospiegeleisen.

[15]Includes ferrochromium-silicon, if any was produced.

[16]Includes ferronickel, if any was produced.

[17]Included with "Other," if any was produced.

[18]Series excludes calcium silicide.

[19]It appears likely that the Republic of Korea produced silicomanganese during 1976-80; during 1976-79, silicomanganese output presumably was included in reported output, but whether it was included with ferromanganese or with ferrosilicon is not clear; in 1980, it presumably was included with "Other."

[20]Estimates for 1976-79 represent ferrotungsten only, figure for 1980 presumably includes silicomanganese as well as other unspecified ferroalloys, possibly ferrochromium, but available information is inadequate to permit distribution by type.

[21]Based on exports; additional quantities may be consumed in the Philippines.

[22]Estimated figures included for the first time in this edition; based on reported exports and an allowance for domestic use.

[23]Ferrovanadium only; other minor ferroalloys may be produced, but no basis is available for estimation.

[24]Soviet production of electric furnace ferroalloys is not reported; estimates provided are based on crude source material production and availability for consumption (including estimates) and upon reported ferroalloy trade, including data from trading partner countries.

[25]U.S. production of ferromanganese cannot be separated by furnace type in order to conceal corporate proprietary information. Similarly, spiegeleisen and ferronickel production cannot be separately reported. All U.S. ferroalloy production except a portion of ferromanganese output is from electric furnaces or metallothermic operations.

[26]United States output of ferrochromium-silicon included with ferrochromium in order to conceal corporate proprietary information.

[27]Includes spiegeleisen and ferronickel.

[28]Data may not add to totals shown because of independent rounding.

[29]Silicon metal apparently included with ferrosilicon.

[30]Spiegeleisen for the Federal Republic of Germany is included with blast furnace ferromanganese.

[31]Includes the following quantities specifically identified as ferrosilicon: 1976—100; 1977—96; 1978—86; 1979—87; 1980—71. The remainders are not identified except that they are not spiegeleisen or ferromanganese.

[32]Although furnace type has not been specified for any ferroalloy production for mainland China, North Korea, the Republic of South Africa, and the United States, all output of these countries has been included under electric furnace (and metallothermic) output except for their production of ferromanganese, which is reported separately below.

[33]Ferromanganese includes silicomanganese (if any was produced) for countries carrying footnote 9 on ferromanganese data line.

[34]Includes silicospiegeleisen for France.

[35]Ferrochromium includes ferrochromium-silicon (if any was produced) for countries carrying footnote 15 on ferrochromium data line.

[36]"Other" includes ferronickel production for France, Norway, the U.S.S.R., and the United States.

Fluorspar

By David E. Morse[1]

Domestic shipments of finished fluorspar declined for the fourth consecutive year in 1980. Fluorspar output failed to exceed 100,000 tons for the first time since 1938, primarily because of the temporary closure, from September 1979, of the Minerva Mines in Illinois, which were sold by Allied Chemical Corp. to Inverness Mining Co. in May 1980. Byproduct fluosilicic acid (H_2SiF_6) recovery by domestic plants producing phosphoric acid also declined in 1980. H_2SiF_6 augments fluorspar as a source of fluorine in the chemical industry. Reported consumption of fluorspar was down sharply in response to the drop in domestic steel production in 1980. The United States continued to depend on foreign sources to supply over 85% of its fluorspar requirements. Mexico remained the major supplier of metallurgical- and acid-grade fluorspar; the Republic of South Africa was a significant source of acid-grade material in 1980. Lesser amounts of fluorspar were received from mainland China, Italy, Spain, and Kenya.

Table 1.—Salient fluorspar statistics[1]

	1976	1977	1978	1979	1980
United States:					
Production:					
Mine production short tons	611,133	613,000	447,876	407,054	372,092
Material beneficiated do	574,678	538,000	447,560	355,655	321,219
Material recovered do	182,582	164,600	124,947	106,099	88,831
Finished (shipments) do	188,270	169,489	129,428	109,299	92,635
Value f.o.b. mine thousands	$17,927	$16,479	$13,261	$12,162	$12,611
Exports short tons	4,923	6,642	8,267	14,454	17,865
Value thousands	$764	$975	$978	$1,339	$1,660
Imports for consumption short tons	895,254	971,355	916,703	1,021,085	899,219
Value[2] thousands	$64,881	$69,457	$67,569	$80,090	$94,103
Consumption (reported) short tons	1,273,498	1,162,336	1,203,448	1,135,451	976,644
Consumption (apparent)[3] do	1,120,970	1,191,000	1,062,988	1,090,665	1,017,559
Stocks, Dec. 31:					
Domestic mines:					
Crude do	88,905	204,466	121,329	166,619	213,204
Finished do	14,870	12,243	4,322	5,400	8,930
Consumer do	277,783	226,320	201,158	226,423	182,853
World: Production do	[r]4,765,598	[r]4,877,730	5,136,189	5,057,995	5,124,341

[r]Revised.
[1]Does not include fluosilicic acid and imports of hydrofluoric acid and cryolite.
[2]F.o.b. foreign port in 1974; c.i.f. U.S. port in 1975-78.
[3]Apparent consumption includes finished shipments plus imports, minus exports, minus consumer stocks increase.

Legislation and Government Programs.—In May 1980, the Federal Emergency Management Agency (FEMA) announced new stockpile goals for fluorspar. The goal for acid-grade fluorspar was reduced from 1,594 to 1.4 million tons; the metallurgical-grade goal was also reduced from 1,914 to 1.7 million tons. The stockpile goals were adjusted by FEMA to reflect a declining usage of fluorspar by the various consuming industries. No acquisition plans for bringing stockpile inventories up to these levels were announced.

The ban on the sale and manufacture of "nonessential" aerosol products containing chlorofluorocarbons (CFC's), which was instituted in April 1979, continued in effect. The ban was instituted because of the uncertainty in the role of CFC's in the depletion of stratospheric ozone. In the October 7, 1980, Federal Register, the Environmental Protection Agency (EPA) announced an advance notice of intention to institute tighter controls on the production and use of all CFC's.

As in previous years, a 22% depletion allowance was granted against Federal income tax applied to the mining of domestic fluorspar reserved, compared with a 14% allowance for foreign reserves.

DOMESTIC PRODUCTION

Shipments of finished fluorspar from domestic mining operations fell to 92,635 short tons in 1980, the lowest output reported since 1938, and the fourth consecutive year of declining shipments. Illinois was the leading producing State in 1980, accounting for well over 90% of all U.S. shipments. Statistics on shipments of fluorspar by State and by grade are withheld to avoid revealing company proprietary data.

In Illinois, the Inverness Mining Co. acquired the Minerva Mines from Allied Chemical Corp. in May 1980. Allied had ceased operating the properties in September 1979, but made shipments from stocks until the sale was finalized. Inverness resumed mining and milling operations shortly after the sale, and by yearend was producing fluorspar, barite, and sphalerite concentrates. Inverness made improvements in both the flotation plant circuitry and in the tailings disposal system; crude ore was produced from the Spivy and Minerva No. 1 Mines.

Ozark-Mahoning Co., the nation's largest fluorspar producer, maintained a high production level from its mines and plants in Pope and Hardin Counties, Ill. Ozark completed its new Denton shaft in northeast Hardin County, with production expected to begin in 1981. The company was ahead of planned schedule in sinking the Henson shaft in Pope County and planned to have it in production in 1982.

The only other active fluorspar producer in Illinois was the Hastie Trucking and Mining Co. which operated a small, heavy media concentrator near Cave-in-Rock. Hastie's primary products were metallurgical gravel spar and construction aggregate.

Frontier Spar Corp. of Salem, Ky., kept its Babb-Barnes Mine and mill in a care and maintenance status. No production of fluorspar was reported from Kentucky for the second consecutive year. In Tennessee, U.S. Borax and Chemical Corp. was evaluating its fluorspar property near Sweetwater (Monroe County), after completing a 490-foot exploration drift.

In the west, J. Irving Crowell, Jr. and Sons operated its Crowell-Daisy Mine near Beatty, Nev. D & F Minerals Co. continued operations at its Paisano Mine, south of Alpine, Tex. Small unreported amounts of fluorspar were produced in Utah, Idaho, and New Mexico during 1980. Inspiration Development Co. purchased the Bayhorse manto fluorspar deposit near Challis, Idaho. Mine development and mill construction were dependent on studies planned for 1981. A. C. Miller and Co. acquired the Roberts Mining Co. open pit mine and heavy media plant near Darby, Mont. Resumption of operations was contingent on the results of a study on ore potential scheduled for 1981.

Reported production of fluorspar briquets for use in steel furnaces was nearly 130,000 tons; 1979 production was about 200,000 tons. The 1980 decline was a direct result of the drop in domestic steel output. Fluorspar briquets, made mostly from imported concentrates, vary in calcium fluoride (CaF_2) content from 25% to 95% and contain various combinations of manganese dioxide, ferric oxide, alumina, dolomite, hydrated lime, flue dust, feldspar, soda ash, olivine, ilmenite, and mill scale sweepings along with binding agents.

Eleven plants processing 6.9 million tons of phosphate rock for the production of phosphoric acid recovered nearly 58,000 tons of H_2SiF_6 in 1980 compared with 69,500 tons in 1979. Total H_2SiF_6 shipments were 39,361 tons in 1980; 70% was used for the manufacture of aluminum fluoride and cryolite, 21% for water fluoridation chemicals, 9% for other chemical products. The H_2SiF_6 shipments were equivalent to 64,000 tons of acid-grade fluorspar.

CONSUMPTION AND USES

Different grades of fluorspar are required depending on the end use. Acid-grade fluorspar, containing greater than 97% CaF_2, is used as feedstock in the manufacture of hydrofluoric acid (HF), a key ingredient in the aluminum and fluorchemical industries. Ceramic-grade fluorspar, containing 85% to 95% CaF_2, is used in the ceramics industry for the production of glass and enamel. Metallurgical-grade fluorspar (met-spar), containing between 60% and 85% or more CaF_2, is used primarily by the iron and steel industry as a neutral flux. Traditionally, U.S. steelmakers have used met-spar containing a minimum of 70% effective CaF_2; however, lower grade material and briquets have gained widespread usage.

The HF and steel industries accounted for 60% and 37%, respectively, of the 1980 reported fluorspar demand. The American Iron and Steel Institute (AISI) reported that raw steel production was 112,101,423 tons in 1980, 23.8 million tons less than 1979. Comparing the AISI data with fluorspar consumption data received by the Bureau of Mines from the steel producers, the calculated fluorspar consumption rate for the domestic steel industry was 6.51 pounds per tons in 1980. On the basis of furnace type, the average fluorspar consumption per ton of raw steel was as follows:

Type of furnace	Fluorspar consumption (pounds per ton)		
	1978	1979	1980
Open hearth	11.3	9.3	8.90
Basic oxygen	8.18	8.10	7.08
Electric	5.79	5.35	4.20
Industry average	8.12	7.59	6.51

Eight companies operating 11 plants produced HF in 1980. Data collected by the U.S. Department of Commerce, Bureau of the Census, indicated the HF "produced and withdrawn from system" amounted to 206,000 short tons on an anhydrous basis in 1980 compared with 194,000 short tons in 1979. Imports of 70% HF augmenting domestic production amounted to 98,730 short, tons in 1980 and 101,000 short tons in 1979. The CFC production in 12 plants by 5 producing companies was a major end use for HF. According to data collected by the U.S. International Trade Commission on select CFC's, the 1980 production of F-11 was 75,542 tons, F-12 output was 143,791 tons, and F-22 production was 109,408 tons. Compared with production in 1979, F-11 production dropped 10%, F-12 output increased 0.6%, and F-22 output increased 3%. The major uses of CFC's were refrigerants, foam-blowing agents, and fluorinated solvents. The use of CFC's as propellants in aerosol sprays was restricted to essential products and by and large had been replaced by hydrocarbons and carbon dioxide.

The production of fluorine chemicals used in the reduction of alumina to primary aluminum by the Hall process was another major end use of HF. Six major companies accounted for most of the domestic production of aluminum fluoride and synthetic cryolite used by the aluminum industry. Domestic primary aluminum production was 5,129,700 tons in 1980. An estimated 48 pounds of fluorine was consumed for each ton of aluminum produced, amounting to about 123,000 tons of fluorine. H_2SiF_6 supplemented fluorspar as a source of fluorine; the fluorine content in H_2SiF_6 shipped to consumers for the manufacture of fluorine chemicals used in aluminum production was 21,800 tons in 1980.

HF was consumed in the concentration of the uranium isotope U-235 for use in nuclear energy. The U_3O_8 concentrate from ore is reacted with HF to produce UF_4, which is then converted to gaseous UF_6 through the addition of fluorine gas. HF was consumed in diverse applications, including stainless steel pickling, petroleum alkylation, glass etching, oil and gas well treatment, and in the manufacturing of a host of fluorine chemicals used in dialectrics, metallurgy, wood preservatives, pesticides, mouthwashes, and decay-preventing dentifrices, plastics, and water fluoridation.

In September, a $50 million expansion of Allied Chemical Corp.'s HF plant at Geismar, La., was approved by the corporation's directors.[2] The expansion, when completed in 1982, would raise the capacity from 50,000 to 95,000 tons of HF annually.

In the ceramics industry, fluorspar was used in the production of flint glass, white or opal glass, and enamels. Fluorspar acts both as a flux and as an opacifier in these uses. Fluorspar was used in the manufacture of fiberglass, was added directly in small amounts in aluminum production, and was used in the melt shop by the foundry industry and by cement and brick producers.

Table 2.—Reported domestic consumption of fluorspar, by end use and grade

(Short tons)

End use or product	Containing more than 97% CaF_2		Containing not more than 97% CaF_2		Total	
	1979	1980	1979	1980	1979	1980
Hydrofluoric acid	588,538	587,380	--	--	588,538	587,380
Glass and fiber glass	7,106	6,103	4,346	4,241	11,452	10,344
Enamel and pottery	302	220	1,130	404	1,432	624
Welding rod coatings	666	551	899	746	1,565	1,297
Primary aluminum and magnesium	843	549	234	--	1,077	549
Iron and steel castings	--	--	11,131	10,047	11,131	10,047
Open-hearth furnaces	--	--	89,094	58,107	89,094	58,107
Basic oxygen furnaces	W	--	337,237	242,778	337,237	242,778
Electric furnaces	13,350	13,372	76,205	50,510	89,555	63,882
Other uses or products	1,529	--	2,841	1,636	4,370	1,636
Total	612,334	608,175	523,117	368,469	1,135,451	976,644
Stocks, Dec. 31	80,355	91,892	146,068	90,961	226,423	182,853

W Withheld to avoid disclosing company proprietary data.

Table 3.—Reported consumption of subacid grades of fluorspar in 1980, by end use and form

(Short tons)

End use or product	Containing not more than 97% CaF_2		
	Flotation concentrates	Lump or gravel	Briquets or pellets
Chemicals and allied products: Welding fluxes	654	W	W
Glass, ceramic, bricks:			
Glass	4,094	--	--
Other glass, clay products	404	--	--
Primary metals:			
Steel mills:			
Open-hearth furnaces	--	56,994	680
Basic oxygen furnaces	5,440	120,413	116,279
Electric furnaces	1,082	42,473	6,955
Other steel furnaces	--	--	--
Iron and steel foundries	51	5,570	4,426
Other identified end uses	1,059	1,809	85
Total	12,784	227,259	128,425

W Withheld to avoid disclosing company proprietary data; included with "Other identified end uses."

Table 4.—Fluorspar (domestic and foreign) consumed in the United States, by State

(Short tons)

State	1978	1979	1980
Alabama, Kentucky, Tennessee	83,377	91,441	76,974
Arizona, Colorado, Utah	31,372	34,196	28,601
Arkansas, Kansas, Louisiana, Missouri	247,775	203,398	157,291
California	36,433	30,727	20,330
Connecticut, Massachusetts, New York, Rhode Island	31,174	22,948	16,915
Illinois	48,519	51,672	31,022
Indiana	75,244	61,837	49,347
Iowa and Wisconsin	915	1,007	257
Michigan	41,933	46,885	21,397
New Jersey	25,234	19,731	20,555
Ohio	137,041	136,188	95,200
Oregon and Washington	1,053	982	682
Pennsylvania	122,247	101,950	92,053
Texas	238,580	252,951	305,667
West Virginia	46,831	45,340	39,249
Other States[1]	35,720	34,197	21,104
Total	1,203,448	1,135,451	976,644

[1]Includes Delaware, Georgia, Maryland, North Carolina, Oklahoma, and Virginia.

STOCKS

The 1980 yearend mine stocks of finished fluorspar totaled 8,930 short tons, 65% higher than that at yearend 1979. Consumer stocks decreased from 226,423 tons in 1979 to 182,853 tons in 1980; the 1980 decrease in consumer stocks was for subacid-grade material. Government stockpiles of strategic and critical fluorspar remained unchanged and included 895,984 short tons of acid-grade fluorspar (of which 630 tons were considered nonstockpile grade) and 411,738 tons of metallurgical-grade fluorspar (of which 116,863 tons were of nonstockpile grade).

PRICES

Domestic producers reported increases of 29.7% and 4%, for the average value of acid-grade and metallurgical-grade shipments respectively, during 1980. Mexican fluorspar prices were raised 25% on January 1 and 12% on July 1. Yearend price quotations by the Engineering and Mining Journal are presented in table 5; price quotations serve as a general guide, but do not necessarily reflect actual transactions.

HF prices escalated nearly 30% in 1980 because of increased costs for both acid-grade fluorspar and sulfur. Yearend price quotations were 65 cents per pound, f.o.b. plant, tank cars for anhydrous HF; for aqueous HF, 70% in drums or tanks, f.o.b. plant, prices were quoted as $50 to $51 per 100 pounds. Yearend fluorochlorocarbon price quotations are given in the accompanying table:

Fluoro-carbon number	Chemical name	Chemical formula	Price (cents per pound)[1]
F-11	Trichloro-fluoromethane	CCl_3F	47
F-12	Dichloro-difluoromethane	CCl_2F_2	54
F-22	Chloro-difluoromethane	$CHClF_2$	87
F-113	Trichloro-trifluorethane	$CCl_2F\text{-}CClF_2$	72
F-114	Dichlor-tetrafluorethane	$CClF_2\text{-}CClF_2$	81

[1]Bulk, tanks, delivered.

Yearend prices for cryolite and aluminum fluoride were $550 per ton and 17.5 cents per pound, respectively, in bulk, ex-works.

Table 5.—Prices of domestic and imported fluorspar

(Dollars per short ton)

	1979	1980
Domestic, f.o.b. Illinois-Kentucky:		
Metallurgical: 70% effective CaF_2 briquets	91	110
Ceramic, variable calcite and silica:		
88% to 90% CaF_2	100	100
95% to 96% CaF_2	109	140
97% CaF_2	121.5	165-175
Acid, dry basis, 97% CaF_2:		
Carloads	117	160-171
88% effective CaF_2 briquets	111	168-179
European and South African:[1] Acid, term contracts	130-145	140-175
Mexican:[2]		
Metallurgical:		
70% effective CaF_2, f.o.b. vessel, Tampico	69.45	97.25
70% effective CaF_2, f.o.b. cars, Mexican border	66.70	93.39
Acid, bulk: 97 +%, Mexican border	84.14	121.79

[1]C.i.f. east coast, Great Lakes, and Gulf ports.
[2]U.S. import duty, insurance, and freight not included.

Source: Engineering and Mining Journal, December 1979 and 1980.

FOREIGN TRADE

U.S. fluorspar exports totaled 17,865 tons in 1980, 3,411 tons greater than exports in 1979. Domestic exports are not reported by grade; exports may have been acid-, ceramic-, or metallurgical-grade fluorspar and may include briquets manufactured from domestic ore. Synthetic cryolite exports totaled 19,073 tons valued at $9.16 million in 1980.

U.S. imports of fluorspar declined 12% from 1979 to 899,219 tons in 1980. Acid-grade imports were down only 2,100 tons, while imports of subacid-grade material dropped nearly 120,000 tons or 31% compared with 1979. Imports from Mexico, the largest foreign supplier, totaled 545,164 tons in 1980 or 60.6% of all fluorspar imports; Mexico supplied 678,057 tons, 66% of total imports in 1979. The Republic of South Africa supplied 27% of the 1980 total or 242,546 tons, Italy supplied 3.8% or 34,261 tons, and mainland China supplied 3.1% or 27,623 tons.

U.S. imports of cryolite increased 25% to 17,085 tons; mainland China, Canada, and Denmark were the leading sources of imported cryolite in 1980. HF imports declined 2% to 98,730 tons, but increased nearly 37% in value (c.i.f.) to $94.9 million. Canada and Mexico continued to be the major suppliers of imported HF in 1980. Data on exports and imports of aluminum fluoride were not available.

Table 6.—U.S. exports of fluorspar

Country	1979		1980	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Canada	13,941	$1,260,788	16,767	$1,515,532
Chile	38	3,849	--	--
Dominican Republic	190	40,621	462	69,666
Ghana	--	--	96	11,385
Israel	12	1,212	--	--
Japan	39	3,900	--	--
Malaysia	13	1,270	--	--
Mexico	18	1,811	--	--
Peru	--	--	13	1,302
South Africa, Republic of	21	5,760	--	--
Suriname	--	--	95	13,914
Taiwan	--	--	22	4,265
United Kingdom	113	11,295	247	24,695
Venezuela	69	8,938	163	18,811
Total	14,454	1,339,444	17,865	1,659,570

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1978 Quantity (short tons)	1978 Value (thousands) Customs	1978 Value (thousands) C.i.f.	1979 Quantity (short tons)	1979 Value (thousands) Customs	1979 Value (thousands) C.i.f.	1980 Quantity (short tons)	1980 Value (thousands) Customs	1980 Value (thousands) C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE									
Canada:									
Cleveland	--	--	--	--	--	--	6,554	$640	$693
El Paso	--	--	--	1,029	$52	$85	1,953	87	162
Laredo	--	--	--	78	6	6	147	15	15
Total	--	--	--	1,107	58	91	8,654	742	870
Greenland: El Paso	--	--	--	77	6	6	--	--	--
Italy: Galveston	43,679	$3,267	$3,718	36,203	2,920	3,443	34,261	3,939	4,673
Germany, Federal Republic of: Laredo	--	--	--	--	--	--	448	27	27
Kenya:									
Detroit	17,320	1,221	1,531	11,168	483	900	--	--	--
Houston	--	--	--	15,681	908	1,139	16,949	1,506	2,188
Total	17,320	1,221	1,531	26,849	1,391	2,039	16,949	1,506	2,188
Mexico:									
Buffalo	--	--	--	--	--	--	11	2	3
Detroit	588	64	64	214	9	11	--	--	--
El Paso	104,860	5,594	8,657	93,074	4,993	7,707	90,413	8,889	9,514
Galveston	--	--	--	--	--	--	10,417	1,191	1,331
Laredo	215,738	16,369	16,606	222,514	17,450	17,504	207,159	19,682	19,712
Los Angeles	--	--	--	77	6	6	--	--	--
New Orleans	--	--	--	--	--	--	5,664	616	724
Pembina	--	--	--	77	6	6	--	--	--
Philadelphia	--	--	--	12,932	1,068	1,129	11,581	1,194	1,336
San Diego	--	--	--	77	6	6	--	--	--
San Francisco	--	--	--	77	6	6	--	--	--
Total	321,186	22,027	25,327	329,042	23,544	26,375	325,245	31,574	32,620
Morocco: Cleveland	5,770	393	466	--	--	--	2,976	400	401

See footnotes at end of table.

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district —Continued

Country and customs district	1978			1979			1980		
	Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)	
		Customs	C.i.f.		Customs	C.i.f.		Customs	C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE—Continued									
South Africa, Republic of:									
Detroit	--	--	--	12,995	$743	$1,060	--	--	--
Galveston	--	--	--	7,388	509	714	9,121	$964	$1,205
Houston	--	--	--	16,933	1,173	1,554	11,902	1,126	1,447
Laredo	19,570	$1,163	$1,476	9,868	590	772	6,058	598	780
New Orleans	140,180	9,156	11,614	156,078	10,866	14,987	192,406	17,570	22,711
Philadelphia	--	--	--	8,140	563	597	8,637	920	1,074
Total	159,750	10,319	13,090	211,402	14,444	19,684	228,151	21,178	27,217
Spain:									
Cleveland	25,228	1,692	2,170	23,411	2,108	2,425	13,289	1,788	2,008
New Orleans	4,939	358	415	--	--	--	6,910	922	1,171
Philadelphia	9,555	721	843	10,910	871	921	--	--	--
Total	39,722	2,771	3,428	34,321	2,979	3,346	20,199	2,710	3,179
United Kingdom: Milwaukee	--	--	--	--	--	--	(1)	1	1
Grand total	587,427	39,998	47,560	639,001	45,342	54,984	636,883	62,077	71,177
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE									
Canada:									
Buffalo	--	--	--	--	--	--	150	12	15
El Paso	--	--	--	600	12	12	248	15	15
Laredo	--	--	--	190	13	13	--	--	--
Total	--	--	--	790	25	25	398	27	30

Mexico:									
Baltimore	4,645	304	315	38,834	2,397	2,918	17,558	1,336	1,787
Buffalo	15,913	928	1,038	16,624	1,023	1,231	3,428	270	295
Detroit	--	--	--	--	--	--	76	6	6
El Paso	49,356	1,622	1,622	43,248	1,399	1,399	29,755	2,135	2,261
Galveston	--	--	--	123	8	8	--	--	--
Laredo	158,870	9,440	9,441	175,137	11,488	11,546	130,779	11,147	11,178
Mobile	--	--	--	--	--	--	8,812	753	822
New Orleans	13,201	785	861	65,501	4,266	4,819	19,800	1,552	1,739
Philadelphia	4,778	324	390	9,548	638	769	9,711	809	971
Total	246,763	13,403	13,667	349,015	21,219	22,690	219,919	18,008	19,059
China, mainland: New Orleans	--	--	--	--	--	--	27,623	2,011	2,681
South Africa, Republic of:									
Baltimore	6,778	464	589	--	--	--	2,755	167	215
Chicago	2,464	136	166	1,311	80	154	--	--	--
New Orleans	40,257	2,299	2,929	30,968	1,768	2,237	11,640	728	940
Total	49,499	2,899	3,684	32,279	1,848	2,391	14,395	895	1,155
Spain: Baltimore	33,014	2,515	2,658	--	--	--	--	--	--
Germany, Federal Republic of: Milwaukee	--	--	--	--	--	--	1	1	1
Grand total	329,276	18,817	20,009	382,084	23,092	25,106	262,336	20,942	22,926

[1]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of 70% hydrofluoric acid

Country	1979 Quantity (short tons)	1979 Value, c.i.f. (thousands)	1980 Quantity (short tons)	1980 Value, c.i.f. (thousands)
Canada	39,453	$22,563	37,498	$32,659
France	137	198	65	264
Germany, Federal Republic of	266	393	257	496
Japan	1,664	1,538	5,445	4,681
Mexico	58,597	43,539	55,045	56,218
Netherlands	41	60	57	87
Spain	--	--	111	115
Sweden	22	5	--	--
Switzerland	13	17	--	--
United Kingdom	963	1,208	252	401
Total	101,156	69,521	98,730	94,921

Table 9.—U.S. imports for consumption of cryolite[1]

Country	1979 Quantity (short tons)	1979 Value, c.i.f. (thousands)	1980 Quantity (short tons)	1980 Value, c.i.f. (thousands)
Canada	5,320	$2,179	5,291	$2,272
China:				
Mainland	590	257	5,725	2,986
Taiwan	--	--	291	160
Denmark	2,436	1,575	2,741	2,055
Germany, Federal Republic of	2,954	1,716	3	3
Greenland	160	101	40	18
Hong Kong	--	--	557	249
Israel	--	--	12	8
Japan	2,173	1,318	2,353	1,626
Netherlands	58	49	51	47
Sweden	--	--	21	17
Switzerland	1	([2])	1	1
Total	13,692	7,195	17,086	9,442

[1]Only the material from Denmark is natural cryolite; all other material is synthetic.
[2]Less than 1/2 unit.

WORLD REVIEW

World production of fluorspar increased 1.1% in 1980 to 5.1 million tons. Mexico, with nearly 20% of the world total, remained the world's leading producer and was followed by the U.S.S.R., the Republic of South Africa, Mongolia, mainland China, Spain, and France (in order of volume). Fluorspar was produced commercially in over 30 nations worldwide.

Canada.—In British Columbia, Eaglet Mines, Ltd., conducted surface exploration and a diamond drill coring program on its fluorite property near Quesnel Lake. Although the full extent of the mineralized body had not been determined, it extends at least 4,000 feet in length; in addition to fluorite, some zones of the ore body contain silver values, barite, rare-earth minerals, and minor lead sulfide. Eaglet did not announce any plans to develop the property for commercial operation in 1980.[3]

Allied Chemical Corp. expanded the capacity of its Amherstburg, Ontario, HF plant an additional 10,000 tons late in the year.[4]

China, Mainland.—The United States received 27,623 tons of metallurgical-grade fluorspar valued at $97.10 per ton (c.i.f.) from China in 1980. Exports of met-spar to Japan increased nearly 20,000 tons compared with exports in the previous year.

Italy.—Fluorspar production in Italy is centered in Sardinia where Mineria Silius S.p.A. is by far the largest producer. Soricon S.p.A. planned to bring the Pianciano fluorspar project to the development stage. The bedded, pyroclastic, lacustrine deposit contained 7.1 million tons of ore averaging 43.9% fluorite. However, the fine grained size (averaging 2 micrometers) presented a processing problem, which the new test plant has been designed to correct.[5]

Mexico.—Compania Minera Las Cuevas S.A. completed underground development work and expanded milling facilities by adding a third bank of flotation cells to increase its capacity to 200,000 metric tons per year of acid-grade fluorspar and 175,000 metric tons per year of met-spar. Las Cuevas was the world's largest fluorspar producer in 1980, and the company planned to make further capital expenditures to upgrade and expand present facilities.[6]

An excellent summary of the makeup and the functions of the Mexican Fluorspar Institute (Instituto Mexicano de la Fluorita) was published.[7]

South Africa, Republic of.—Production and exports of fluorspar exceeded 500,000 tons in 1980. South Africa reportedly has the world's largest fluorspar reserves; the bulk of South Africa's reserves are associated with the acidic phase of the Bushveld Igneous Complex in the Transvaal.[8] The two largest fluorspar producers were Marico Fluorspar (Pty.) Ltd. (formerly owned by United States Steel International Corp. and sold to Philipp Bros.) and Buffalo Fluorspar (Pty.) Ltd. controlled by General Mining, with annual production capacities of 170,000 and 160,000 metric tons, respectively. Two other large fluorspar producers, each with annual capacities of 100,000 metric tons were Chemspar Ltd. and Vergenoeg Mining Co. (Pty.) Ltd.[9]

United Kingdom.—In Derbyshire, S.P.O. Minerals planned to have their new Golcona barite/fluorspar/lead milling operation "fully operational" by April 1981. The first ore was put through the first-stage heavy media circuit on December 3, 1980, and the grinding and flotation circuit was expected to be operating by yearend. The company expected to market met-spar, drilling and filler-grade barite, and lead concentrates.[10]

Table 10.—Fluorspar: World production, by country[1]

(Short tons)

Country[2] and grade[3]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada, acid grade[e] [4]	70,500	65,600	--	--	--
Mexico:[5]					
Acid grade	[r]496,206	445,624	560,795	563,200	567,700
Ceramic grade	[r]64,995	41,695	59,462	48,400	60,600
Metallurgical grade	[r]394,946	314,738	420,583	451,900	385,700
Total	[r]956,147	[r]802,057	1,040,840	1,063,500	1,014,000
United States (shipments):					
Acid grade	116,300	100,605	74,880	W	W
Metallurgical grade	71,970	68,884	54,548	W	W
Total	188,270	169,489	129,428	109,299	[6]92,635
South America:					
Argentina:					
Acid grade[e]	13,253	14,482	8,845	9,722	9,300
Metallurgical grade[e]	30,924	33,790	20,637	22,686	21,600
Total	44,177	48,272	29,482	32,408	30,900
Brazil:[7]					
Direct shipping ore, grade unspecified (sales)	61	14,509	513	117	NA
Beneficiated product (output):					
Acid grade	34,287 (acid, ceramic, and metallurgical grades combined)	30,071	34,363	82,443 (acid, ceramic, and metallurgical grades combined)	NA
Ceramic grade		524	--		NA
Metallurgical grade		28,359	33,247		NA
Total	34,348	73,463	68,123	82,560	82,700
Uruguay, grade unspecified	55	83	125	[e]85	95
Europe:					
Czechoslovakia:[e] [4]					
Acid grade	51,500	[2]53,000	53,000	53,000	53,000
Metallurgical grade	51,500	53,000	53,000	53,000	53,000
Total	103,000	106,000	106,000	106,000	106,000

See footnotes at end of table.

Table 10.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1976	1977	1978	1979[p]	1980[e]
Europe —Continued					
France:[e] [8]					
Acid and ceramic grade	208,000	[r]193,000	207,000	186,000	183,000
Metallurgical grade	129,000	[r]119,000	128,000	135,000	132,000
Total	[r]337,000	312,000	335,000	321,000	315,000
German Democratic Republic:[e] [4]					
Acid grade	25,000	27,600	27,600	27,600	27,600
Metallurgical grade	75,000	82,400	82,400	82,400	82,400
Total	100,000	110,000	110,000	110,000	110,000
Germany, Federal Republic of (marketable):[4]					
Acid grade[e]	63,701	83,086	75,142	62,672	62,500
Metallurgical grade[e]	7,078	9,232	8,349	6,963	6,900
Total	70,779	92,318	83,491	69,635	69,400
Greece, grade unspecified	[r]551	551	672	397	440
Italy:					
Acid grade	193,192	158,000	143,320	148,094	133,400
Ceramic grade	9,205	14,544	14,969	7,589	2,200
Metallurgical grade	29,983	32,209	30,314	45,809	24,200
Total	232,380	204,753	188,603	201,492	159,800
Romania, metallurgical grade[e] [4]	17,000	22,000	22,000	22,000	22,000
Spain:					
Acid grade	244,688	233,497	222,121	171,164	215,000
Metallurgical grade	71,293	108,727	109,999	41,469	160,000
Total	315,981	342,224	332,120	212,633	375,000
Sweden:[4]					
Acid grade[e]	2,015	1,464	--	--	--
Metallurgical grade[e]	1,649	1,197	--	--	--
Total	3,664	2,661	--	--	--
U.S.S.R.:[e] [4]					
Acid grade	260,000	265,000	270,000	275,000	275,000
Metallurgical grade[e]	280,000	287,000	292,000	298,000	298,000
Total	540,000	552,000	562,000	573,000	573,000
United Kingdom:[9]					
Acid grade	147,710	115,743	143,300	114,640	88,000
Metallurgical grade	31,967	25,353	17,637	13,228	10,000
Unspecified	59,524	[r]72,752	47,400	41,888	32,000
Total	239,201	[r]213,848	208,337	169,756	130,000
Africa:					
Egypt, grade unspecified	1,716	1,548	2,464	751	750
Kenya:					
Acid grade	[e]70,535	116,575	103,278	[e]98,000	98,000
Metallurgical grade	[e]12,168	20,111	14,189	[e]12,000	12,000
Total	82,703	136,686	117,467	[e]110,000	110,000
Morocco, acid grade	56,714	[r]44,092	59,700	65,000	66,100
South Africa, Republic of:					
Acid grade	232,449	258,656	328,038	426,930	496,000
Ceramic grade	43,543	72,378	16,432	9,344	10,000
Metallurgical grade	44,469	55,523	89,042	60,991	45,000
Total	320,461	386,557	433,512	497,265	551,000
Tunisia, acid grade	38,094	31,809	36,661	37,267	37,500
Zambia, grade unspecified	3	[e]11	84	--	55
Zimbabwe, metallurgical grade[e] [4]	220	220	220	220	220
Asia:					
China, mainland, metallurgical grade[e] [4]	385,000	440,000	440,000	440,000	440,000

See footnotes at end of table.

Table 10.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1976	1977	1978	1979[p]	1980[e]
Asia —Continued					
India:					
Acid grade	10,702	9,997	10,668	11,607	[6]13,612
Metallurgical grade	4,708	6,768	4,794	7,234	[6]9,808
Total	15,410	16,765	15,462	18,841	[6]23,420
Korea, North, metallurgical grade[e 4]	33,000	44,000	44,000	44,000	44,000
Korea, Republic of, metallurgical grade	22,344	14,309	12,531	9,315	[6]5,396
Mongolia, metallurgical grade[4]	[r e]355,000	[r e]369,000	[r e]502,000	[r e]496,000	496,000
Pakistan, grade unspecified	11	--	369	461	330
Thailand:[10]					
Acid grade	58,777	60,435	60,627	62,362	69,000
Metallurgical grade	141,679	213,093	193,490	195,914	188,000
Total	200,456	273,528	254,117	258,276	257,000
Turkey, metallurgical grade	1,413	1,886	1,381	6,834	6,600
Grand total	[r]4,765,598	[r]4,877,730	5,136,189	5,057,995	5,124,341

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 6, 1981.

[2]In addition to the countries listed, Bulgaria is believed to have produced fluorspar, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.

[3]An effort has been made to subdivide production of all countries by grade (acid, ceramic, and/or metallurgical). Where this information is available in official reports of the subject country, the data have been entered without qualifying notes; where a secondary source has been used to subdivide production by grade, the source for the basis of this subdivision has been identified by footnote. Where no basis for subdivision is available, the entry has been identified with the notation "grade unspecified."

[4]Information on grade obtained from Bundesanstalt Für Bodenforschung Hannover and Deutsches Institut Für Wirtschaftsforschung Berlin. Untersuchungen über Angebot and Nachfrage Mineralischer Rohstoffe 4. Flusspat, March 1974, p. 39.

[5]Figures adjusted from those reported by Instituto Mexicano de la Fluorita to rationalize sales of submetallurgical-grade ores to an average marketable product basis.

[6]Reported figure.

[7]Official Brazilian sources list crude ore mined as follows in short tons: 1976—54,448; 1977—171,916; 1978—139,147; 1979—179,874; 1980—180,000 (estimated).

[8]Data for 1976-77 are marketed production estimated from domestic consumption and trade data. Data do not take into account changes in stocks. Total run-of-mine production (direct-shipping plus ore destined for concentration) was as follows in short tons: 1976—744,000; 1977—586,000; 1978—583,800 (revised); 1979—513,300 (revised); 1980—519,000 (estimated).

[9]Includes material recovered from lead-zinc mine dumps.

[10]Acid-grade material listed for Thailand is beneficiated product resulting from processing of reported low-grade material; metallurgical-grade material is run-of-mine material reported under the term "high grade." Recorded production of low-grade material was as follows in short tons: 1976—79,184; 1977—51,246; 1978—92,875; 1979—177,730; 1980—187,000 (estimated).

TECHNOLOGY

The role of CFC's in the depletion of stratospheric ozone continued to be a subject of controversy. In August, the Alliance for Responsible CFC Policy was formed to curb the EPA's plans to further limit the production and use of CFC's. According to the alliance, the data used to support the EPA's contention for expanded regulation of CFC's are wrong. The EPA's policy for further regulation was based on the results of two 1979 reports issued by the National Academy of Sciences.[11]

Grumman Aerospace Corp. was evaluating the Spectronix Automatic Fire Extinguishing (SAFE) System for military vehicles under contract with the U.S. Army. The system developed by Spectronix Ltd. of Israel dispenses a fire retardant within tanks and/or troop carriers within 0.06 second of the detection of penetration of a projectile. The fire suppressant is monobromotrifluoromethane which acts rapidly so that fire and explosion overpressure never reach levels that harm the crew.[12]

A patent was granted for a method to produce water-resistant pellets of fluorspar, iron oxide ore, manganese ore, or chromium ore. Particulate ore is mixed with sodium carbonate and water to form a plastic mass which is formed into pellets and heated to drive off the water. The resulting pellets are relatively hard and moisture resistant.[13] A patent was granted for an improved collector for use in the froth flotation of phosphate rock, barite, fluorspar, scheelite, or iron oxide. The collector was comprised of a tall fatty oil (70% to 99% by weight) and an anionic perfluorsulfonate. Reagent consumption is reduced, and high recovery rates at high grade are effected.[14]

In 1979, a British patent was granted for the removal of bismuth, antimony, and arsenic impurities in blister copper by volatilization. The molten impure copper is contacted with sulfur hexafluoride (SF_6) gas under conditions to form gaseous fluorides of the impurities, and the gaseous fluorides are discharged while the copper is molten.[15]

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[1]Physical scientist, Section of Nonmetallic Minerals.
[2]The Wall Street Journal. Allied Chemical Sets $50 Million Outlay to Expand Facility. V. 196, No. 62, Sept. 28, 1980, p. 20.
[3]The Northern Miner. V. 66, No. 22, Aug. 7, 1980, pp. 1, 7.
[4]Work cited in footnote 2.
[5]Industrial Minerals. Pianciano Onstream by 1981. No. 148, January 1980, p. 29.
[6]——. Focus on Las Cuevas. No. 153, June 1980, pp. 36-37.
[7]——. The Mexican Fluorite Institute. No. 153, June 1980, pp. 41-42.
[8]South African Mining and Engineering Yearbook. Thompsons Publications, South Africa (Pty.) Ltd., Johannesburg, Republic of South Africa, 1980, p. 64.
[9]Work cited in footnote 8.
[10]Industrial Minerals. S.P.O. Speeds Ahead. No. 160, January 1981, pp. 14-15.
[11]Chemical and Engineering News. Alliance Fights Limits on Chlorofluorocarbons. V. 59, No. 9, Mar. 2, 1981, p. 8.
[12]——. Newscripts. V. 59, No. 49, Dec. 8, 1980, p. 86.
[13]Ground, E. R. (assigned to International Minerals and Chemical Corp.). Mineral Ore Pellets. U.S. Pat. 4,199,348, Apr. 22, 1980.
[14]Wang, S. S., E. L. Smith, Jr., and E. F. Huliganga (assigned to American Cynamid Co.). Process for Froth Flotation of Non-Sulfide Minerals. U.S. Pat. 4,186,083, Jan. 29, 1980.
[15]French, R. O. (assigned to Kennecott Copper Corp.) Removal of Arsenic, Antimony and Bismuth From Molten Copper With Sulfur Hexafluoride. U.S. Pat. 4,010,030, Mar. 1, 1977, U.K. Pat. 1,553,237, Sept. 26, 1979.

Gallium

By Benjamin Petkof[1]

Domestic gallium consumption exceeded 10,000 kilograms in 1980. Gallium recovered from domestic sources supplied a significant portion of U.S. consumption. Imports provided the remainder. Data on world gallium consumption and production were not available. Gallium in metal or metallic compounds was used primarily in the manufacture of electronic devices.

Table 1.—Salient gallium statistics in the United States

(Kilograms)

	1976	1977	1978	1979	1980
Production	W	NA	NA	NA	NA
Imports for consumption	4,920	2,884	3,721	6,401	6,175
Consumption	8,880	8,789	8,908	9,461	10,460
Price per kilogram	$750-$800	$500-$600	$500-$600	$510	$510-$630

NA Not available. W Withheld to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

The Aluminum Co. of America, using proprietary technology at its Bauxite, Ark., alumina plant, recovered gallium as a byproduct of its alumina production process. Eagle-Picher Industries, Inc., produced gallium metal, oxide, and trichloride from zinc production residues at its Quapaw, Okla., facility. Production data were not available. Based on consumption and import data, total domestic output of gallium metal appeared to have increased over that of 1979.

CONSUMPTION

Gallium consumption reached a record high level of over 10,000 kilograms in 1980. Over 90% of consumption was used in the manufacture of electronic devices. Increased consumption was noted in the manufacture of alloys, and in research and development.

General acceptance by the public of various electronic devices that use gallium-based components increased the demand for gallium. Continued use and development of items, such as fiber-optic light transmission cables actuated by gallium-based light-emitting diodes and lasers and gallium-based bubble memories for computers, were expected to continue the high levels of demand for gallium and gallium compounds.

Table 2.—Consumption of gallium, by end use

(Kilograms)

End use	1978	1979	1980
Specialty alloys	5	5	14
Electronics[1]	8,305	8,782	9,635
Research and development	584	617	754
Unspecified uses	14	57	57
Total	8,908	9,461	10,460

[1]Light-emitting diodes, semiconductors, and other electronic devices.

STOCKS

Consumer stocks of gallium metal for 1979 and 1980, both commercial and high-purity grades, are shown in table 3. Stocks at yearend 1980 were slightly higher than those at yearend 1979.

Table 3.—Stocks, receipts, and consumption of gallium[1]

(Kilograms)

Purity	Beginning stocks[2]	Receipts	Consumption	Ending stocks[2]
1979:				
97.0%-99.9%	108	5	7	106
99.99%	15	34	45	4
99.999%	5	70	72	3
99.9999%-99.99999%	1,748	9,101	9,337	1,512
Total	1,876	9,210	9,461	1,625
1980:				
97.0%-99.9%	106	13	15	104
99.99%	4	14	15	3
99.999%	3	74	73	4
99.9999%-99.99999%	1,637	10,485	10,357	1,765
Total	1,750	10,586	10,460	1,876

[1]Consumers only.
[2]Ending stocks for 1979 do not equal 1980 beginning stocks because of reported beginning stock adjustments.

PRICES

The American Metal Market quoted the price for 99.999% purity metal at $510 per kilogram, in 100-kilogram lots, from January 1980 to October 1980. In October, the quoted price increased to $630 per kilogram and stayed at that level for the remainder of the year.

FOREIGN TRADE

Data on the exports of gallium metal are not reported separately but are included in the export category "base metals and alloys, not elsewhere classified, wrought or unwrought, waste and scrap." Significant quantities of gallium and gallium compounds are exported as parts of manufactured gallium-based electronic and electrical components and equipment.

U.S. imports of gallium in 1980 declined slightly in quantity and value from those of 1979. Switzerland and Canada were the major sources of U.S. imports. The average price of imported metal increased from $417.37 per kilogram in 1979 to $427.08 per kilogram in 1980.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1979 Kilograms	1979 Value	1980 Kilograms	1980 Value
Canada	450	$203,431	1,449	$675,911
China:				
Mainland	--	--	409	119,288
Taiwan	--	--	11	2,775
Czechoslovakia	53	16,201	--	--
France	--	--	232	90,521
Germany, Federal Republic of	218	85,716	561	233,107
Hungary	59	17,526	--	--
Italy	--	--	--	--
Japan	41	22,452	13	14,861
Netherlands	41	17,180	--	--
Switzerland	5,498	2,289,820	3,444	1,470,558
United Kingdom	41	19,228	56	30,214
Total	6,401	2,671,554	6,175	2,637,235

WORLD REVIEW

Data on consumption and production of gallium for the rest of the world were not available. However, nations with well developed electronic and electrical industries probably consumed significant quantities of gallium. Based on the quantity of gallium imported by the United States during 1979 and 1980, it was thought that the rest of the world's gallium production in 1980 was about the same as that of 1979.

TECHNOLOGY

The triple-point temperature of high-purity gallium metal was determined to be 29.77406° C using platinum resistance thermometry. Gallium samples from three commercial sources were used for this determination.[2]

Thermal properties of gallium such as thermal diffusivity, heat capacity, and thermal and electrical conductivity were investigated, and the results in the temperature range 1,200° to 2,000° K were given.[3]

The conditions for the acid extraction of gallium from mica and pegmatite ores were investigated. Extraction required temperatures above 200° C for a period greater than 2 hours. It was necessary to dissolve the mica to release gallium trapped in the mica lattice.[4]

A laboratory magnetohydrodynamic (MHD) electric generator, that used the motion of a liquid-metal conducting fluid in a magnetic field to generate electricity, was developed. This liquid-metal MHD required only a low-temperature heat source and could operate with metals such as mercury, sodium-potassium, or gallium. A system efficiency of 12% to 15% was claimed.[5]

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[1]Physical scientist, Section of Nonferrous Metals.

[2]Mangum, B. W., and D. D. Thorton. Determination of the Triple-Point Temperature of Gallium. Metrologia, v. 15, No. 4, October 1979, pp. 201-215.

[3]Branchilla, S. N., D. K. Palchaev, and L. P. Filipov. Thermal Properties of Liquid Gallium, Indium and Thallium at High Temperatures. High Temp., v. 17, No. 3, May-June 1979, pp. 426-428.

[4]Baldwin, W. G., E. Bock, A. Chow, H. D. Gesser, D. W. McBride, and O. Vaielya. Acid Extraction of Gallium From Ores. Hydromet., v. 5, Nos. 2-3, February 1980, pp. 213-225.

[5]Chemical Week. A Pilot Test for Liquid-Metal MHD. V. 128, No. 7, Feb. 16, 1981, p. 41.

Gem Stones

By Staff, Section of Nonmetallic Minerals,
Ceramics and Refractories Unit

The value of gem stones and mineral specimens produced in the United States during 1980 was estimated to have decreased more than 15% to $6.9 million from the 1979 value of $8.2 million. All types of gem stones production, except for opal, decreased during the year. Amateur collectors accounted for much of the activity in many States. Commercial operators produced rough jade, jasper, agate, sapphire, turquoise, opal, peridot, emerald, onyx, obsidian, and tourmaline, which they sold mainly to wholesale or retail outlets and also to jewelry manufacturers.

DOMESTIC PRODUCTION

Mines and collectors in 40 States produced gem materials with an estimated value of $1,000 or more in each State in 1980. Ten States supplied 89% of the total value, as follows: Arizona, $3.1 million; Maine, $900,000; Nevada, $900,000; Oregon, $450,000; California, $210,000; Wyoming, $190,000; Texas, $160,000; New Mexico, $150,000; Washington, $150,000; and Arkansas, $140,000.

Park authorities at the Crater of Diamonds Park in Pike County, Ark., reported that approximately 75,000 people visited the park in 1980 and found 582 diamonds. The largest was a 5.2-carat stone of undetermined value. Most of the stones are off-white to brown; however, yellow, pink, and green stones are also found. The decrease in attendance during the year, reflecting a general nationwide decrease in tourism, was compounded by the heat wave which affected the region; however, "dig for fee" operations remained popular.

CONSUMPTION

Domestic gem stone output went to amateur and commercial rock, mineral, and gem stone collections, objects of art, and jewelry. Apparent consumption (domestic production plus imports minus exports and reexports) in 1980 was $1,791 million, 38% more than that of 1979.

PRICES

A sampling of prices that colored-stone dealers in various U.S. cities charged their cash customers during December 1980 follows:

Gem stone	Carat weight	Price range per carat 1980	Median price per carat[1]	
			December 1979	Early December 1980
Amethyst	10	$14- $28	$15	$15
Aquamarine	5	55- 300	168	168
Cat's eye (chrysoberyl)	2	290-1,500	850	850
Citrine	10	8- 18	12	12
Emerald:				
Medium to better	1	1,600-5,000	3,150	3,500
Commercial	1	225-2,500	900	900
Garnet, green (tsavorite, demantoid)	1	425-1,250	600	725
Opal, black	3	350- 750	500	500
Opal, white	5	60- 125	75	75
Peridot (variety of olivine)	5	45- 90	65	55
Ruby:				
Medium to better	1	950-4,500	1,830	2,750
Commercial	1	350-1,800	590	850
Sapphire:				
Medium to better	1	475-2,500	750	1,200
Commercial	1	150- 900	225	425
Star sapphire:				
Sky-blue	5	80- 900	250	250
Grey	5	25- 150	100	100
Tanzanite (blue-violet zoisite)	5	500-1,200	500	590
Topaz	5	150- 265	245	245
Tourmaline, green	5	40- 145	70	75
Tourmaline, pink	5	40- 150	80	80

[1]Jewelers' Circular-Keystone, v. 151, No. 2, February 1980, p. 196; v. 152, No. 1, January 1981, p. 126. These figures represent a sampling of net prices that colored stone dealers in various U.S. cities charged their cash customers during the month.

A sampling of prices that diamond dealers in various U.S. cities charged their customers in December 1980 follows:

Carat weight	Description, color[1]	Clarity[2] (GIA terms)	Price range per carat 1980	Median price per carat[3]	
				December 1979	Early December 1980
0.04-0.08	G-I	VS_1	$450- $755	$587	$570
.04- .08	G-I	SI_1	350- 615	540	520
.09- .16	G-I	VS_1	475- 849	640	655
.09- .16	G-I	SI_1	375- 681	595	585
.17- .22	G-I	VS_1	725- 1,710	980	1,080
.17- .22	G-I	SI_1	600- 1,510	895	975
.23- .28	G-I	VS_1	950- 1,970	1,220	1,385
.23- .28	G-I	SI_1	771- 1,720	1,090	1,150
.29- .35	G-I	VS_1	1,000- 2,270	1,400	1,550
.29- .35	G-I	SI_1	800- 1,905	1,120	1,375
.46- .55	G-I	VS_1	1,600- 3,215	1,950	2,738
.46- .55	G-I	SI_1	1,050- 2,645	1,540	1,950
.69- .79	G-I	VS_1	2,000- 5,200	2,605	3,556
.69- .79	G-I	SI_1	1,400- 3,450	2,103	2,530
1.00-1.15	D	FL	42,000-54,000	37,000	[4]53,000
1.00-1.15	E	VVS_1	16,000-24,000	17,000	[4]23,000
1.00-1.15	G	VS_1	6,000- 9,000	6,100	[4]8,600
1.00-1.15	H	VS_2	4,000- 6,500	4,650	[4]5,650
1.00-1.15	I	SI_1	2,500- 3,900	3,170	[4]3,550

[1]Gemological Institute of America (GIA) color grades: D—colorless; E—rare white; G-I—traces of color.
[2]Clarity: FL—no blemishes; VVS_1—very, very slightly included; VS_1—very slightly included; VS_2—very slightly included, but more visible; SI_1—slightly included.
[3]Jewelers' Circular-Keystone, v. 151, No. 2, February 1980, p. 194; v. 152, No. 1, January 1981, p. 124. These figures represent a sampling of net prices that diamond dealers in various U.S. cities charged their customers during the month.
[4]Representative of early November 1980 sales. December sales are nonrepresentative.

FOREIGN TRADE

The following section contains foreign trade statistics tables 1-6 for 1979 and 1980. Table 7 contains world production statistics for 1976-80.

Table 1.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1979 Quantity (carats)	1979 Value (millions)	1980 Quantity (carats)	1980 Value (millions)
Exports:				
Belgium-Luxembourg	33,589	$110.5	31,797	$95.9
Canada	5,503	4.9	7,041	5.1
France	4,606	26.2	5,112	31.0
Hong Kong	73,854	243.1	69,927	240.5
Israel	23,966	21.4	21,164	16.2
Japan	35,792	72.0	28,039	64.2
Switzerland	18,249	104.2	24,110	127.3
United Kingdom	4,349	14.1	5,068	19.5
Other	13,573	26.7	18,385	43.6
Total	213,481	623.1	210,643	643.3
Reexports:				
Belgium-Luxembourg	354,873	86.4	333,186	119.2
France	9,688	8.3	6,922	6.9
Hong Kong	12,812	22.1	36,345	40.6
India	126,763	3.2	199,201	6.7
Israel	295,662	63.9	262,625	93.2
Japan	10,528	11.3	61,579	7.3
Netherlands	53,468	8.9	42,987	6.8
Switzerland	13,076	27.6	18,323	44.6
United Kingdom	94,273	24.7	109,024	18.4
Other	10,884	5.1	43,918	54.2
Total	982,027	261.5	1,114,110	397.9

Table 2.—U.S. imports for consumption of diamond (cut but unset), by kind and country

Kind and country	1979 Quantity (carats)	1979 Value (millions)	1980 Quantity (carats)	1980 Value (millions)
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	557,859	$187.0	531,251	$223.6
India	769,769	172.9	854,526	198.9
Israel	676,353	241.9	787,535	322.8
South Africa, Republic of	20,655	13.8	34,751	25.6
Switzerland	13,277	7.0	9,528	4.6
Other	72,890	28.5	53,202	22.9
Total	2,110,803	651.1	2,270,793	798.4
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	127,277	138.1	155,280	242.2
India	5,390	2.1	5,155	2.7
Israel	77,190	66.3	89,015	117.8
Netherlands	2,794	2.6	2,555	4.9
South Africa, Republic of	9,545	19.8	28,638	43.1
Switzerland	5,181	10.7	3,678	16.6
United Kingdom	4,551	7.8	5,475	15.4
Other	3,602	4.2	6,309	14.9
Total	235,530	251.6	296,105	457.6

Table 3.—U.S. imports of precious and semiprecious gem stones, by kind and country

Kind and country	1979 Quantity (carats)	1979 Value (millions)	1980 Quantity (carats)	1980 Value (millions)
Emerald:				
Brazil	94,237	$4.8	240,198	$7.5
Colombia	205,129	45.1	81,910	55.7
France	6,215	1.0	5,073	1.5
Germany, Federal Republic of	21,511	2.5	38,618	3.0
Hong Kong	126,097	8.0	56,073	8.6
India	1,673,987	14.4	3,025,578	18.6
Israel	71,718	13.8	88,234	21.2
Switzerland	13,352	6.8	27,310	12.0
United Kingdom	5,188	2.6	6,032	7.2
Other	59,797	6.1	31,864	6.1
Total	2,277,231	105.1	3,600,890	141.4
Ruby:				
Burma	NA	.3	NA	.8
Germany, Federal Republic of	NA	.4	NA	.9
Hong Kong	NA	2.1	NA	13.5
India	NA	1.7	NA	3.1
Israel	NA	.4	NA	.5
Sri Lanka	NA	.3	NA	.9
Switzerland	NA	1.0	NA	3.3
Thailand	NA	23.0	NA	58.1
United Kingdom	NA	.2	NA	1.3
Other	NA	.6	NA	2.6
Total	NA	30.0	NA	85.0
Sapphire:				
Burma	NA	.4	NA	.3
Germany, Federal Republic of	NA	.4	NA	.6
Hong Kong	NA	1.4	NA	4.9
India	NA	.9	NA	1.6
Sri Lanka	NA	3.4	NA	6.8
Switzerland	NA	1.2	NA	1.7
Thailand	NA	15.0	NA	31.8
United Kingdom	NA	.2	NA	.8
Other	NA	1.3	NA	2.4
Total	NA	24.2	NA	50.9
Other:				
Rough, uncut:				
Australia	NA	1.6	NA	2.0
Brazil	NA	3.1	NA	4.5
Colombia	NA	1.8	NA	1.8
Israel	NA	.6	NA	.1
Kenya	NA	.8	NA	.5
South Africa, Republic of	NA	3.3	NA	3.2
Switzerland	NA	3.0	NA	3.5
Zambia	NA	1.8	NA	1.9
Other	NA	3.2	NA	2.8
Total	NA	19.2	NA	20.3
Cut but unset:				
Australia	NA	2.4	NA	2.4
Brazil	NA	11.2	NA	17.4
Germany, Federal Republic of	NA	5.3	NA	7.9
Hong Kong	NA	17.2	NA	17.1
Taiwan	NA	.5	NA	1.0
Other	NA	7.7	NA	11.1
Total	NA	44.3	NA	56.9

NA Not available.

Table 4.—Value of U.S. imports of synthetic and imitation gem stones, by country

(Million dollars)

Country	1979	1980
Synthetic, cut but unset:		
Austria	5.1	0.9
France	4.0	.8
Germany, Federal Republic of	2.8	7.5
Japan	.3	.3
Korea, Republic of	.9	5.3
Switzerland	3.8	2.1
Taiwan	.5	.9
Other	5.2	1.9
Total	22.6	19.7
Imitation:		
Austria	8.2	8.5
Czechoslovakia	1.3	.8
Germany, Federal Republic of	3.1	3.1
Japan	.3	.3
Switzerland	.1	.8
Other	.8	.2
Total	13.8	13.7

Table 5.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1979		1980	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut	2,120	956,340	[1]1,594	995,212
Cut but unset	2,347	902,755	2,567	1,255,983
Emeralds: Cut but unset	2,277	105,064	3,601	141,413
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	3,511	NA	3,544
Rubies and sapphires: Cut but unset	NA	53,513	NA	226,426
Marcasites	NA	134	NA	136
Pearls:				
Natural	NA	2,453	NA	3,829
Cultured	NA	39,655	NA	77,375
Imitation	NA	1,321	NA	1,965
Other precious and semiprecious stones:				
Rough and uncut	NA	19,198	NA	20,323
Cut but unset	NA	44,319	NA	56,927
Other n.s.p.f	NA	4,763	NA	7,430
Synthetic:				
Cut but unset[2]	20,223	22,579	17,848	19,714
Other	NA	1,485	NA	1,277
Imitation gem stones	NA	13,814	NA	13,689
Total	XX	2,170,904	XX	2,825,243

NA Not available. XX Not applicable.
[1]Includes 16,544 carats of other natural diamond, advanced, in 1980.
[2]Quantity in thousands of stones.

Table 6.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by country

(Thousand carats and thousand dollars)

Country	1979				1980			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	40	12,042	685	325,055	33	19,494	687	466,235
Central African Empire	75	5,267	--	--	66	7,082	--	--
India	1	83	776	175,016	(1)	22	860	201,703
Israel	59	18,406	754	308,177	24	12,471	877	440,559
Liberia	32	7,726	--	--	5	10,491	--	--
Netherlands	15	11,158	7	4,163	12	6,879	5	6,029
Sierra Leone	123	51,628	5	2,165	85	49,165	4	2,627
South Africa, Republic of	1,134	671,526	30	33,591	908	662,142	63	68,726
Switzerland	6	6,871	18	17,666	19	11,582	13	21,145
United Kingdom	266	145,389	19	13,797	201	193,541	18	21,276
Venezuela	308	20,324	(1)	61	205	16,810	(1)	144
Other Africa, n.e.c	27	r1,432	(1)	234	15	1,052	1	478
Other	32	4,488	53	22,830	21	4,481	38	27,061
Total	r2,118	956,340	2,347	902,755	1,594	995,212	[2]2,567	1,255,983

r Revised.
[1] Less than 1/2 unit.
[2] Data do not add to total shown because of independent rounding.

Table 7.—Diamond (natural): World production, by type and country[1]

(Thousand carats)

Country	1976			1977			1978			1979[p]			1980[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:															
Angola	255	85	340	265	88	353	525	175	700	562	188	750	750	250	1,000
Botswana	358	2,026	2,384	404	2,287	2,691	418	2,367	2,785	659	3,735	4,394	765	4,336	[2]5,101
Central African Republic	172	114	286	178	119	297	199	85	284	205	110	315	180	99	279
Ghana	228	2,055	2,283	230	1,717	1,947	142	1,281	1,423	125	1,128	1,253	100	1,100	1,200
Guinea[e]	25	55	80	25	55	80	25	55	80	27	58	85	27	57	84
Ivory Coast	22	38	60	7	11	18	--	10	10	5	32	37	6	34	40
Lesotho	[r]4	[r]1	5	[r]39	[r]3	42	[r]62	[r]5	67	48	4	52	50	4	[2]54
Liberia[3]	163	162	325	163	163	326	128	180	308	170	132	302	170	130	300
Namibia	1,609	85	1,694	1,901	100	2,001	1,803	95	1,898	1,570	83	1,653	1,482	78	[2]1,560
Sierra Leone	433	650	1,083	423	538	961	[r]353	[r]426	779	419	436	855	400	450	850
South Africa, Republic of:															
Finsch Mine	441	1,762	2,203	485	1,941	2,426	526	2,104	2,630	517	2,068	2,585	581	2,326	[2]2,907
Premier Mine	458	1,375	1,833	502	1,508	2,010	496	1,487	1,983	[r]520	[r]1,561	2,081	510	1,529	[2]2,039
Other De Beers properties[4]	[r]1,460	[r]972	[r]2,432	[r]1,617	[r]1,040	[r]2,657	[r]1,638	[r]1,011	2,649	[r]2,054	[r]1,166	3,220	1,829	1,210	[2]3,039
Other	[r]499	[r]56	555	[r]495	[r]55	550	[r]418	[r]47	465	[r]448	[r]50	498	483	54	[2]537
Total	[r]2,858	[r]4,165	7,023	[r]3,099	[r]4,544	7,643	[r]3,078	[r]4,649	7,727	[r]3,539	[r]4,845	8,384	3,403	5,119	[2]8,522
Tanzania	219	219	[3]438	204	204	[3]408	146	147	[3]293	145	145	[e]290	120	120	240
Zaire[5]	[r]498	[r]11,323	11,821	[r]533	[r]10,681	[r]11,214	[r]640	[r]10,603	11,243	294	8,440	8,734	400	8,300	8,700
Other areas:															
Australia	--	--	--	--	--	--	--	--	--	--	--	--	--	48	48
Brazil[6]	[r]214	[r]47	[r] [e]261	[r]274	[r]46	[r] [e]320	[r]291	[r]49	[r] [e]340	[r]305	[r]55	[r] [e]360	305	55	360
Guyana	6	8	14	7	10	17	7	10	17	6	10	16	6	10	16
India	17	3	20	15	3	18	14	2	16	13	2	15	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	3	12	15	3	12	15

See footnotes at end of table.

Table 7.—Diamond (natural): World production, by type and country[1] —Continued

(Thousand carats)

Country	1976			1977			1978			1979[p]			1980[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Other areas: —Continued															
U.S.S.R.[e]	2,000	7,900	9,900	2,100	8,200	10,300	2,150	8,400	10,550	2,200	8,500	10,700	2,250	8,600	10,850
Venezuela	195	654	849	204	483	687	[r]269	[r]487	756	247	556	803	250	575	825
World total	[r]9,279	[r]29,602	[r]38,881	[r]10,074	[r]29,264	[r]39,338	[r]10,253	[r]29,038	39,291	[r]10,542	[r]28,471	39,013	10,679	29,379	40,058

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through May 12, 1981. Total diamond output (gem plus industrial) for each country is actually reported except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are Bureau of Mines estimates in the case of every country except the Central African Republic (1976-78), Liberia (1976-78), Sierra Leone (1977 and 1978), and Venezuela (1978), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries is based on the best available data at time of publication. Mainland China also produces some natural diamond, but output is not reported.

[2]Reported figure.

[3]Total exports.

[4]All company output from the Republic of South Africa, except for that credited to the Finsch and Premier Mines for the years indicated; excludes De Beers Group output from Botswana, Lesotho, and Namibia.

[5]Excludes very substantial quantities produced and exported illicitly; estimates of these quantities are quite variable, but for recent years, the principal Zairian producer indicates 5 to 6 million carats annually (gem plus industrial) and may have exceeded this level in 1979 and 1980.

[6]Series revised to reflect the substantial output by small miners (garimpos), which is estimated as follows in thousand carats: 1976—185; 1977—254; 1978—269; 1979—280; 1980—280 (1976 and 1977 estimates from the Brazilian Ministry of Mines and Energy; 1978-80 estimates by U.S. Bureau of Mines).

Gold

By J. M. Lucas[1]

The price of gold rose to the unprecedented level of $850 per ounce in 1980. After increasing steadily in 1978 and part of 1979, the price, impelled by political and economic unrest, began to rise steeply near the end of 1979, peaked on January 21, 1980, and closed the final month at an average of about $595, or nearly double the 1979 average.

World mine production increased somewhat over that of the previous year, but production declines were registered in many countries as miners, aided by higher gold prices, mined lower grade ores. Gold exploration increased substantially in many countries. The year was highlighted by events in Brazil where new discoveries spurred increased development.

The demand for gold in jewelry, dental, and some industrial applications was severely impacted by the high gold price which prevailed in 1980. Conversely, the demand for gold-filled industrial items and items for investment registered significant gains.

Table 1.—Salient gold statistics

	1976	1977	1978	1979	1980
United States:					
Mine production ----- thousand troy ounces--	1,048	1,100	999	r970	951
Value ---------------- thousands--	$131,340	$163,192	$193,324	r$298,250	$582,758
Ore (dry and siliceous) produced:					
Gold ore -------- thousand short tons--	3,063	5,806	4,292	r7,046	9,512
Gold-silver ore ---------------do----	1,027	481	738	756	872
Silver ore -----------------do----	651	800	992	962	961
Percentage derived from:					
Dry and siliceous ores---------------	61	60	58	r57	67
Base-metal ores -------------------	36	38	40	r42	32
Placers-------------------------	3	2	2	1	1
Refinery production:					
Domestic ores---- thousand troy ounces--	954	956	962	795	773
Secondary (old scrap) -----------do----	1,068	1,040	1,384	r1,675	2,184
Exports:					
Commercial-----------------do----	2,879	7,011	5,509	16,499	6,119
Monetary -------------------do----	652	1,660	NA	NA	NA
Imports for consumption------------do----	2,656	4,454	4,690	4,630	4,542
Gold contained in imported coins-------do----	1,333	1,614	3,736	2,790	3,081
Net sales from foreign stocks in Federal Reserve Bank ----------------------do----	2,125	6,406	1,569	40	1,785
Stocks, Dec. 31:					
Monetary --------million troy ounces--	274.7	277.6	276.4	264.6	264.3
Industrial[1] ----- thousand troy ounces--	928	1,976	1,672	r868	872
Consumption in industry and the arts---do----	4,648	4,863	4,738	r4,785	3,215
Price:[2] Average per troy ounce ------------	$125.32	$148.31	$193.55	$307.50	$612.56
World:					
Production -------- thousand troy ounces--	r39,024	r38,921	r38,985	r38,802	38,882
Official reserves[3] ------million troy ounces--	r1,166.7	r1,157.8	r1,149.9	r1,130.7	1,133.5

rRevised. NA Not available.
[1]Unfabricated refined gold held by refiners, fabricators, and dealers.
[2]Engelhard Industries quotations.
[3]Held by market-economy-country central banks and Governments. Source: International Monetary Fund.

Table 2.—Volume of U.S. gold futures trading

(Million troy ounces)

Exchange	Location	1976	1977	1978	1979	1980
Commodity Exchange, Inc	New York	47.94	98.17	373.40	654.15	788.72
New York Mercantile Exchange	do	.08	.03	.85	.21	(1)
International Monetary Market	Chicago	34.09	90.82	281.30	355.87	254.35
Chicago Board of Trade	do	1.06	1.33	5.49	10.30	7.15
Mid-America Commodity Exchange	do	.08	.09	1.50	6.65	14.86
Total		83.25	190.44	662.54	1,027.18	1,065.08

[1]Less than 5,000 troy ounces.

In May, the International Monetary Fund (IMF) completed its monthly bullion auctions, begun in 1976. There were no monthly bullion auctions by the U.S. Department of the Treasury during 1980. Much of the IMF bullion auctioned in the 5-year program was delivered in the United States, but then most of it was promptly exported. U.S. bullion exports declined toward normal levels in 1980.

Legislation and Government Programs.—On May 7, 1980, the IMF conducted its final public gold bullion auction. During the 4-year series of auctions, which were begun in 1976 to provide capital for low-interest loans to developing countries, a total of 25 million ounces[2] of gold, or one-sixth of the total IMF stocks, was sold.

In mid-1980, the Department of the Treasury began public sales of gold medallions bearing the images of celebrated American artists; a total of 338,000 ounces of gold in medallions was sold during the second half of the year.

Alaska enacted legislation during 1980 enabling the State Department of Revenue to invest up to 10% of the State's total public employees and teachers' pension funds in gold bullion; the principal objective of the investment plan is to maintain the long-term purchasing power of State revenues destined for payment of State retirement obligations. The Alaska State legislature established a new miner's loan fund providing loans of up to $5 million at no more than 10% interest.

DOMESTIC PRODUCTION

Domestic mine production declined for the third consecutive year (tables 3-4). The decline was attributed primarily to the mining of leaner ores which, in years past, could not be mined economically at existing gold prices, and to a reduction in gold from copper-producing States due to a 20-week strike in the copper industry, in which gold is an important byproduct.

Reminiscent of the early gold rush days, 1980 witnessed a surge in prospecting and interest in gold mining by both the novice and the experienced miner. The sudden popularity of gold panning, especially in the Western States, led to serious overcrowding and occasional conflict along some waterways open to casual or weekend prospectors.

Table 3.—Mine production of gold in the United States, by State

(Troy ounces)

State	1976	1977	1978	1979	1980
Alaska	22,887	18,962	18,652	6,675	9,826
Arizona	102,062	90,167	92,989	101,840	72,773
California	10,392	5,704	7,480	3,195	3,651
Colorado	50,764	72,668	32,094	13,850	39,447
Idaho	2,755	12,894	20,492	24,140	W
Montana	24,075	22,348	19,967	24,050	48,366
Nevada	287,962	324,003	260,895	r250,097	274,382
New Mexico	15,198	13,560	9,879	22,976	15,787
Oregon	28	675	340	W	187
South Dakota	318,511	304,846	285,512	245,912	267,392
Tennessee	W	13	W	--	--
Utah	187,318	210,501	235,929	260,916	179,538
Washington	W	24,006	W	W	W
Other	26,085	--	14,603	16,269	39,999
Total	1,048,037	1,100,347	998,832	r969,920	951,348

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other."

Table 4.—Mine production of gold in the United States, by month

(Troy ounces)

Month	1976	1977	1978	1979	1980
January	91,121	90,768	82,304	72,239	76,441
February	82,215	81,705	89,695	69,245	76,813
March	88,096	93,498	87,198	76,000	85,386
April	91,488	87,294	89,196	75,653	87,776
May	93,317	94,166	81,305	76,590	91,285
June	87,760	86,924	84,701	76,939	81,696
July	83,776	82,238	69,119	80,013	58,462
August	84,971	93,690	83,502	r93,507	56,044
September	88,727	85,855	85,600	r89,162	72,484
October	93,195	99,402	94,090	r92,860	82,561
November	81,377	101,034	80,506	r85,860	81,781
December	81,994	103,773	71,616	r81,852	100,619
Total	1,048,037	1,100,347	998,832	r969,920	951,348

rRevised.

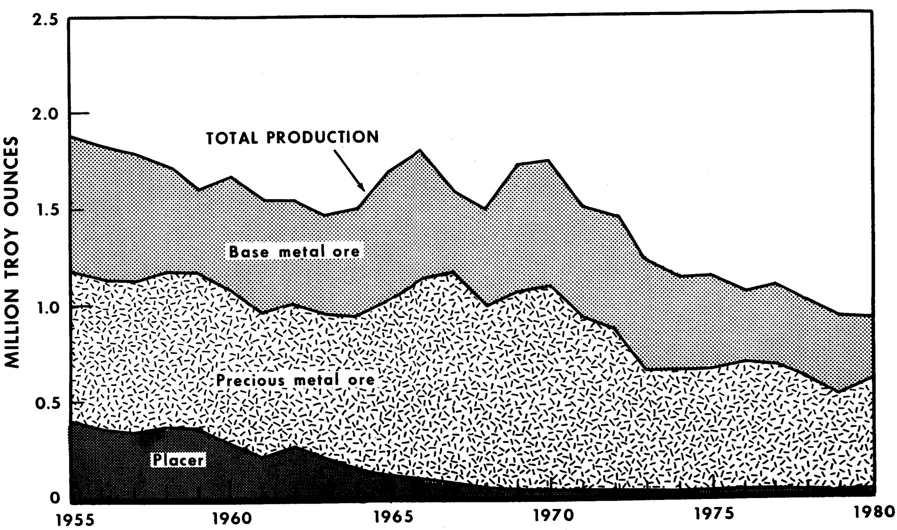

Figure 1.—Gold mined in the United States.

Approximately 60% of domestic gold mine output was accounted for by three mines—Homestake, Utah Copper (Bingham Canyon), and Carlin. The 25 largest mines (table 6) accounted for 95% of domestic production in 1980.

Gold production in 1980 was reported by 157 mines, of which 26 were placer mines, 75 were lode mines producing from precious-metal ores or tailings, and 56 were lode byproduct producers. About 67% of the gold came from precious-metal ores, 32% came from base metal ores, and 1% came from placers (figure 1, table 8.). The methods by which gold was extracted from its ores reflected the nature of the ores; thus, most of the gold was recovered by cyanidation of precious-metal ores and by smelting of base-metal ores, while minor quantities were recovered by amalgamation and by gravity methods (tables 9-11). The average recovery grade of gold ores mined in lode mines was 0.6 ounce per ton, while placer mines averaged 0.014 ounce per cubic yard of gravel washed.

Table 5.—Twenty-five leading gold-producing mines in the United States in 1979,[r] in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore.
2	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Do.
4	Battle Mountain	Lander, Nev	Duval Corp	Do.
5	Round Mountain	Nye, Nev	Smokey Valley Mining Corp	Do.
6	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
7	Magma	do	do	Do.
8	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
9	Delamar	Owyhee, Idaho	Earth Resources Co	Gold-silver ore.
10	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper ore.
11	Morenci	Greenlee, Ariz	do	Do.
12	Knob Hill	Ferry, Wash	Day Mines, Inc	Gold ore.
13	Gooseberry	Storey, Nev	West Coast Oil & Gas Corp	Do.
14	Leadville Unit	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
15	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
16	Atlanta	Lincoln, Nev	Standard Slag Co	Gold ore.
17	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore.
18	Bootstrap	Elko, Nev	Carlin Gold Mining Co	Gold ore.
19	Continental	Grant, N. Mex	UV Industries, Inc	Copper ore.
20	Tyrone	do	Phelps Dodge Corp	Do.
21	Pinto Valley	Gila, Ariz	Cities Service Co	Do.
22	Sacaton Unit	Pinal, Ariz	ASARCO Incorporated	Do.
23	Windfall	Eureka, Nev	Idaho Mining Co	Gold ore.
24	Nome Unit	Seward Peninsula, Alaska	Alaska Gold Co	Placer.
25	Summit Mountain	Grant, N. Mex	Summit Minerals, Inc	Gold-silver ore.

[r]Revised.

Table 6.—Twenty-five leading gold-producing mines in the United States in 1980, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
4	Battle Mountain	Lander, Nev	Duval Corp	Do.
5	Round Mountain	Nye, Nev	Smokey Valley Mining Corp	Do.
6	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
7	Delamar	Owyhee, Idaho	Earth Resources Co	Gold-silver ore.
8	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
9	Pegasus	Phillips, Mont	Zortman & Landusky Mining Co. Inc	Gold ore.
10	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
11	Knob Hill	Ferry, Wash	Day Mines, Inc	Gold ore.
12	Argo	Phillips, Mont	Zortman & Landusky Mining Co. Inc	Do.
13	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper ore.
14	Magma	Pinal, Ariz	Magma Copper Co	Do.
15	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
16	Leadville Unit	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
17	Gooseberry	Storey, Nev	West Coast Oil & Gas Corp	Gold ore.
18	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
19	Continental	Grant, N. Mex	UV Industries, Inc	Copper ore.
20	Atlanta	Lincoln, Nev	Standard Slag Co	Gold ore.
21	Cortez	Lander, Nev	Cortez Gold Mine	Do.
22	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore.
23	Carr Fork	Tooele, Utah	The Anaconda Company	Do.
24	Bootstrap	Elko, Nev	Carlin Gold Mining Co	Gold ore.
25	Nome Unit	Seward Peninsula, Alaska	Alaska Gold Co	Placer.

Table 7.—Gold produced in the United States in 1979, by State, type of mine, and class of ore

State	Placer (troy ounces of gold)	Lode: Gold ore		Gold-silver ore		Silver ore		Copper ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	6,675	--	--	--	--	--	--	--	--
Arizona	--	80,521	1,794	--	--	W	W	159,750,391	99,542
California	W	9,384	2,060	2,037	714	--	--	--	--
Colorado	W	--	--	6,410	574	108,642	1,206	--	--
Idaho	--	W	W	W	W	775,298	2,583	--	--
Montana	W	285	170	3,633	259	78,055	2,007	17,122,259	21,356
Nevada	12	r5,478,166	r250,003	W	W	W	W	W	W
New Mexico	12	1,730	567	13,486	3,112	--	--	27,122,254	19,284
South Dakota	--	1,429,886	245,912	--	--	--	--	--	--
Other[1]	348	45,742	16,241	730,654	30,525	294	20	r37,859,721	r251,176
Total	7,047	r7,045,714	r516,747	756,220	35,184	962,289	5,816	r241,854,625	r391,358
Percent of total gold	1	XX	r53	XX	4	XX	1	XX	r40

State	Lode: Lead and zinc ores		Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total[3]	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	--	--	--	--	--	6,675
Arizona	W	W	--	--	37,491	490	159,868,974	101,840
California	--	--	--	--	--	W	11,421	3,195
Colorado	W	W	180,236	11,899	W	W	295,302	13,850
Idaho	673	80	821,649	550	--	--	2,288,784	24,140
Montana	12,862	196	188	48	W	W	17,217,287	24,050
Nevada	--	--	--	--	--	--	r5,478,572	r250,097

Table 7.—Gold produced in the United States in 1979, by State, type of mine, and class of ore —Continued

	Lode						Total[3]	
	Lead and zinc ores		Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.			
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
New Mexico	192	1	--	--	--	--	27,137,662	22,976
South Dakota	--	--	--	--	--	--	1,429,886	245,912
Other[1]	3,365,294	157	--	--	5,002	[4]347	41,314,547	277,185
Total	3,379,021	434	1,002,073	12,497	42,493	837	[r]255,042,435	[r]969,920
Percent of total gold	XX	([2])	XX	1	XX	([2])	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Other." XX Not applicable.
[1]Includes Missouri, Oregon, Utah, Washington, and items indicated by symbol W.
[2]Less than 1/2 unit.
[3]Data may not add to State totals because of items withheld to avoid disclosing company proprietary data.
[4]Includes byproduct gold recovered from tungsten ore in California.

Table 8.—Gold produced in the United States in 1980, by State, type of mine, and class of ore

State	Placer (troy ounces of gold)	Lode: Gold ore — Short tons	Lode: Gold ore — Troy ounces of gold	Lode: Gold-silver ore — Short tons	Lode: Gold-silver ore — Troy ounces of gold	Lode: Silver ore — Short tons	Lode: Silver ore — Troy ounces of gold	Lode: Copper ore — Short tons	Lode: Copper ore — Troy ounces of gold
Alaska	8,331	1,912	1,441	23	41	--	--	--	--
Arizona	--	50,000	1,000	--	--	3,546	97	140,294,391	71,533
California	1,161	6,854	1,951	1,789	476	--	--	--	--
Colorado	W	1,615	219	20	2	W	W	--	--
Montana	W	W	W	W	W	55,130	219	9,056,938	11,541
Nevada	14	7,086,042	274,157	--	--	4,206	80	13,500	46
Oregon	--	941	187	--	--	--	--	--	--
South Dakota	--	1,786,521	267,392	--	--	--	--	--	--
Other[1]	59	578,514	50,107	870,187	32,909	898,357	4,015	51,234,942	182,627
Total	9,565	9,512,399	596,454	872,019	33,428	961,239	4,411	200,599,771	265,747
Percent of total gold	1	XX	63	XX	4	XX	([2])	XX	28

State	Lode: Lead and zinc ores — Short tons	Lode: Lead and zinc ores — Troy ounces of gold	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores — Short tons	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores — Troy ounces of gold	Lode: Old tailings, etc. — Short tons	Lode: Old tailings, etc. — Troy ounces of gold	Total[3] — Short tons	Total[3] — Troy ounces of gold
Alaska	187	13	--	--	--	--	2,122	9,826
Arizona	--	--	--	--	14,329	143	140,362,266	72,773
California	W	W	--	--	W	W	8,660	3,651
Colorado	43,878	1,377	W	W	5,414	368	504,738	39,447
Montana	10,039	240	--	--	--	--	9,646,851	48,366
Nevada	1,297	4	--	--	19,800	81	7,124,845	274,382
Oregon	--	--	--	--	--	--	941	187

Table 8.—Gold produced in the United States in 1980, by State, type of mine, and class of ore —Continued

	Lode						Total[3]	
	Lead and zinc ores		Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.			
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
South Dakota	--	--	--	--	--	--	1,786,521	267,392
Other[1]	3,355,555	253	1,145,259	37,092	28,080	[4]2,172	57,132,322	235,324
Total	3,410,956	1,887	1,145,259	37,092	67,623	2,764	216,569,266	951,348
Percent of total gold	XX	([2])	XX	4	XX	([2])	XX	100

W Withheld to avoid disclosing company proprietary data; included in "Other ." XX Not applicable.
[1]Includes Idaho, Missouri, New Mexico, Utah, Washington, and items indicated by symbol W.
[2]Less than 1/2 unit.
[3]Data may not add to State totals because of items withheld to avoid disclosing individual company proprietary data.
[4]Includes byproduct gold recovered from tungsten ore in California.

Table 9.—Gold produced in the United States from ore, old tailings, etc., by State and method of recovery

State	Total ore, old tailings, etc., treated[1] (thousand short tons)	Ore and old tailings to mills: Thousand short tons[1]	Recoverable in bullion: Amalgamation (troy ounces)	Recoverable in bullion: Cyanidation (troy ounces)	Concentrates smelted and recoverable metal: Concentrates (short tons)	Concentrates smelted and recoverable metal: Troy ounces	Crude ore, old tailings, etc., to smelters[1]: Thousand short tons	Crude ore, old tailings, etc., to smelters[1]: Troy ounces
1979:								
Arizona	[2]204,463	[2]203,902	48	1,746	3,481,562	99,089	561	957
California	[3]12	[3]11	812	--	2,900	1,694	1	368
Colorado	393	382	374	--	39,554	12,555	11	898
Idaho	2,339	2,335	--	20,855	149,062	2,840	4	445
Montana	17,230	17,135	4	47	306,115	21,562	95	2,433
Nevada	r[2,4]5,479	r[2,4]5,479	--	r249,994	r84	r22	([5])	69
New Mexico	27,161	27,062	--	--	920,305	19,284	99	3,680
South Dakota	1,430	1,430	--	245,912	--	--	--	--
Utah	37,905	37,859	--	--	83,826	250,965	46	9,951
Other	9,154	9,152	--	--	875,613	15,967	2	302
Total	r305,566	r304,747	1,238	r518,554	r5,859,021	r423,978	819	19,103
1980:								
Alaska	2	2	720	700	--	--	([5])	75
Arizona	[2]170,081	[2]169,618	--	1,000	2,759,846	71,447	463	326
California	9	9	693	--	2,153	1,681	([5])	116
Colorado	605	591	7,602	--	51,905	30,628	15	1,174
Montana	[2]9,657	[2]9,597	--	34,329	160,880	12,466	59	1,564
Nevada	[2,4]7,257	[2,4]7,257	--	274,174	8,980	130	([5])	64
New Mexico	24,512	24,445	--	--	860,806	14,140	67	1,638
Oregon	1	--	--	--	--	--	1	187
South Dakota	1,787	1,787	--	267,392	--	--	--	--
Utah	32,360	32,222	--	--	640,315	168,487	137	11,051
Other	12,508	12,506	--	21,547	1,040,320	18,235	2	217
Total[6]	258,778	258,033	9,015	599,142	5,525,205	317,214	745	16,412

rRevised.
[1]Includes some nongold-bearing ores not separable.
[2]Includes tonnages from which gold was recovered by heap leaching.
[3]Excludes tonnage of tungsten ore from which gold was recovered as a byproduct.
[4]Includes tonnages from which gold was recovered by vat leaching.
[5]Less than 1/2 unit.
[6]Data may not add to totals shown because of independent rounding.

Table 10.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recovered from all sources

Year	Bullion and precipitates recovered (troy ounces): Amalgamation	Bullion and precipitates recovered (troy ounces): Cyanidation	Gold recovered from all sources (percent): Amalgamation	Gold recovered from all sources (percent): Cyanidation	Gold recovered from all sources (percent): Smelting[1]	Gold recovered from all sources (percent): Placers
1976	18,207	587,540	1.7	56.1	39.6	2.6
1977	26,615	597,633	2.4	54.3	41.2	2.1
1978	2,254	532,670	.2	53.3	44.3	2.2
1979	1,238	r518,554	.1	r53.5	r45.7	r.7
1980	9,015	599,142	.9	63.0	35.1	1.0

rRevised.
[1]Crude ores and concentrates.

Table 11.—Gold produced at placer mines in the United States, by method of recovery

Method and year	Mines producing	Washing plants	Material washed (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1976	3	4	[1]2,816	17	$2,124	$0.754
1977	3	4	1,377	12	1,742	1.265
1978	2	3	1,010	11	2,187	2.164
1979	2	3	475	3	977	2.056
1980	2	3	170	3	1,719	5.776
Dragline dredging:						
1976	3	3	245	5	606	2.474
1977	7	7	[2]10	[3]2	311	[4]5.932
1978	9	9	[2]60	[3]3	519	[4]4.339
1979	3	3	86	1	347	4.019
1980	3	8	[2]55	[3]1	869	5.780
Hydraulicking:						
1976	14	14	129	1	157	1.212
1977	12	13	273	5	754	2.762
1978	10	10	233	4	784	3.367
1979	8	8	176	2	613	3.480
1980	14	14	453	4	2,657	5.869
Nonfloating washing plants:						
1976	25	26	[2]136	[3]4	560	[4]2.097
1977	7	7	[2]106	[3]3	477	[4]2.319
1978	11	11	[2]152	[3]4	812	[4]2.448
1979	7	8	[2]42	[3]1	225	[4]2.988
1980	5	7	[2]54	[3]1	581	[4]7.927
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1976	4	4	2	([5])	15	8.881
1977	7	7	41	1	159	3.901
1978	5	5	1	([5])	13	13.431
1979	3	3	4	([5])	5	1.281
1980	2	2	3	([5])	33	12.473
Total placers:[6]						
1976	49	51	[1] [2]3,328	[3]28	3,462	[4].958
1977	36	38	[2]1,807	[3]23	3,443	[4]1.638
1978	37	38	[2]1,456	[3]22	4,314	[4]2.483
1979	23	25	[2]784	[3]7	2,167	[4]2.639
1980	26	34	[2]734	[3]10	5,859	[4]7.020

[1]Does not include platinum-bearing material from which byproduct gold was recovered.
[2]Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[3]Includes gold recovered at commercial sand and gravel operations.
[4]Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[5]Less than 1/2 unit.
[6]Data may not add to totals shown because of independent rounding.

The high level of exploration activity set in motion during the preceeding years of rising prices was further stimulated in 1980 by the spectacular January increase in the price of both gold and silver. Exploration for high-grade vein and placer deposits, as well as for large low-grade disseminated gold deposits that are amenable to improved heap leaching and bulk haulage techniques, continued both inside and outside of established gold mining districts. Domestic exploration during 1980 was highlighted by the discovery of a large low-grade gold deposit in Napa County, Calif., by the Exploration Div. of the Homestake Mining Co. The California discovery, which was made in a new geological setting and in an area in which previous exploration for gold had been unproductive, should stimulate renewed exploration elsewhere in geologically similar areas which heretofore were not considered favorable targets. Homestake estimated that the deposit, designated "the McLaughlin project," contains in excess of 6 million tons of ore, with an average grade of about 0.17 ounce per ton. Placer Service Corp. (PSC), a wholly-owned subsidiary of St. Joe Minerals Corp., in a joint venture with Yuba Goldfield, Inc., was developing a placer dredging operation in the Yuba River Valley east of Marysville. Production was expected to commence in 1981. PSC also evaluated another placer deposit at San Juan Ridge in Nevada County. Noranda Mining Inc. announced plans to develop their Gray Eagle gold and silver deposit in Siskiyou County. The proposed open pit mine is scheduled for production in 1983. Other developments in California included the opening or reopening of a number of smaller mines and the exploration and development of several recent discoveries. Small-scale placer mining was an increasingly popular pursuit in many areas of the State.

The Nation's largest gold producer, the Homestake Mine at Lead, S. Dak., again accounted for essentially all of the gold production from that State. The average cost per ounce of gold produced there during 1980 rose to $308, compared with $251 in 1979. The increase in cost per ounce resulted partly from milling lower grade ores, which yielded less gold per ton of ore, and from increased State severance taxes. Ore reserves at the Homestake Mine in 1980 were 17.8 million tons grading 0.207 ounce per ton.

Kennecott Copper Corp.'s Utah Copper (Bingham Canyon) Mine, South of Salt Lake City, the largest copper mine in the Nation, was the second largest gold producer in 1980. Kennecott Minerals Co., a division of Kennecott Copper, began exploration for gold and silver on lands leased in the East Tintic Mining District, Juab County, Utah. Included in these lands is the Trixie Mine which ranked 18th on the 1980 list of 25 leading domestic gold producers (table 6). Other areas targeted by the company for exploration included the Eureka Standard, Sioux-Ajax, and Homansville fault structures. Gold developments elsewhere in Utah included an agreement made between Noranda Mining, Inc., and New Park Resources, Inc., to form a joint venture to reopen the old Mayflower gold and silver mine near Park City. Energy Development, Inc., started up a placer mining operation in the Henry Mountain Mining District in Wayne County. The Anaconda Company's New Carr Fork copper mine near Tooele completed its first year of production.

Gold mining activity in Nevada continued to grow as new mines were brought into production and recent discoveries underwent further development. Production rose to 274,382 ounces or 10% over production reported during 1979. Seven mines in Nevada were among the top 25 gold producers in the Nation in 1980. Output by the Carlin Mining Co., west of Elko, from three open pits and an ore dump leaching operation, decreased to 110,000 ounces. Production was lower mainly because of low-grade ore mined. In July, Carlin Mining Co. began mining at their new Maggie Creek Mine, which is located 14 miles southeast of Nye. The company also announced the discovery of a new gold ore body on their Gold Quarry property adjacent to the Maggie Creek Mine. Preliminary tests indicated at least 12.5 million tons of ore grading 0.05 to 0.17 ounce per ton. Carlin's total reserves at the end of the year, excluding the Gold Quarry property, were 7,291,000 tons containing 0.171 ounce per ton. Near the end of the year, Amselco Minerals Inc. began production at the Alligator Ridge Mine in White Pine County. Amselco, a wholly owned subsidiary of Selection Trust Ltd. and Occidental Minerals Corp., expected to mine from three adjacent open pits at an annual rate of 750,000 tons. Reserves were estimated at over 4.8 million tons grading 0.12 ounce per ton. Completion of a permanent ore-crushing facility was expected during 1981. In June, ground-breaking ceremonies were held for the Jerritt Canyon Mine, north of Elko. The mine, which is a joint venture of Freeport Gold Co. and FMC Gold, was expected to be the largest gold producer in the United States when fully operational in 1982. Louisiana Land and Exploration Co. announced the discovery of a new gold and silver ore body, estimated to contain 600,000 ounces of gold and 300,000 ounces of silver, adjacent to its Smokey Valley Mining Div.'s Round Mountain Mine in northern Nye County. Commercial production was expected by mid-1983. In May, Houston Oil and Minerals Corp. opened its new 1,500-ton-per-day cyanide mill at Gold Hill.

Of the gold recovered in Alaska during the year, 85% came from placer deposits. Claim-staking activity, much of which was done by small miners securing precious-metals properties, especially placer deposits, more than doubled during the year to a possible record of 19,000 claims. Seasonal gold lode and placer mining operations were continued by Jan-Drew Holdings Ltd., of Edmonton, Alberta, on properties of the Little Squaw Gold Mining Co. in the Chandalar District north of Fairbanks. Tri-con Mining, Inc., produced lode gold from their newly equipped Grant Mine west of Fairbanks. In the upper Chistochina area, northeast of Anchorage, Ranchers Exploration and Development Corp. began full-scale mining of their placer claims which have been under development since 1975. Other companies actively developing Alaskan placers during the 1980 field season included the following: Cusac Industries of Vancouver, British Columbia, drilled for placer gold in beach sands along the Gulf of Alaska at Cape Yakataga; Noranda Mining, Inc., and the Tuluksak Co. formed Northland Gold Dredging Joint Venture, Inc., to run a gold-dredging operation at Nyac on the Tuluksak River, east of Bethel; Asamera Oil (United States) Inc. completed testing and evaluation at their Livengood placer claims near the Tolovana River northwest of Fairbanks. Exploration of lode deposits was conducted by Placid Oil Co. in the Sherman Creek area north of Juneau; Apollo Alaska Gold Mines Inc. of Canada explored the old Apollo gold mine on Unga Island on the Alaska Peninsula; and Lion Mines Ltd. (N.P.L.) of Vancouver, British Columbia continued diamond drilling at their Beaver Creek property near the Canadian border.

In Colorado, Standard Metals Corp. reopened the Sunnyside Mine near Silverton in mid-January. The mine, which produced byproduct gold, had been closed since June 1978 when the bed of an overlying lake collapsed into an old stope. Among the companies that were engaged in gold exploration and development during the year were Texasgulf Metals Co., Golden Cycle Gold Corp., Homestake Mining Co., Union Mines Inc., ASARCO Incorporated, AZL Resources, Inc., The Anaconda Company, and Ranchers Exploration and Development Corp.

Nearly all of Arizona's gold production came as a byproduct of copper mines in that State. Production from this source, however, was impacted during 1980 by a labor strike. Ranchers Exploration and Development Corp. announced the discovery of a gold deposit in the Hieroglyphic Mountains, northwest of Phoenix.

Production of byproduct gold from the Butte, Mont., copper mine of the Anaconda Copper Company was impacted by the copper strike and the permanent closure of the company's smelter at Anaconda, Mont. The Zortman and Landusky Mining Co. Inc. began heap leaching gold and silver ore mined from their open pit mines, the Pegasus and Argo, located in the Little Rocky Mountains, northeast of Great Falls. The Pegasus and Argo ranked 9th and 12th, respectively, on the 1980 list of 25 leading domestic gold producers. Ranchers Exploration and Development Corp. announced plans to develop their Golden Grizzly deposit near Cooke City. Mining of the deposit, which contains an estimated 500,000 tons of ore grading about 0.2 ounce of gold per ton, will be by open pit methods and was expected to begin in 1982. Among the other companies producing or planning to produce gold in Montana in the near future are Placer Amex Corp. and Gold Reserve Corp. Gold Cup Mining Co. filed an operating plan with officials at the Gallatin National Forest for a new open pit gold and platinum mine in the Crazy Mountains. In July, a fire gutted the Goldsil Ranches' 1,000-ton-per-day gold and silver mill on the site of the Old Drummlumon Mine near Marysville.

Texasgulf Metals Co. reported that the company's share of concentrate produced at the Iron Dyke Mine in eastern Oregon included 4,564 ounces of gold in addition to copper and silver. Baretta Mining Inc. of Calgary, Alberta, continued drilling and evaluation of its Turner Albright gold-silver-copper-cobalt claims in southern Oregon near the California border. In Washington State, the Republic Unit (formerly the Knob Hill Mine) of Day Mines, Inc., in Ferry County, milled 62,718 tons of ore, averaging 0.27 ounce of gold per ton. Ore reserves estimated at yearend were 179,430 tons containing 0.32 ounce of gold per ton and 1.48 ounces of silver per ton. Mining continued for the third year at the New Lite property of Lion Mines Ltd. (N.P.L.), Vancouver, British Columbia. During the seasonal operations at the mine, which is located 40 miles from Winthrop at an elevation of 6,000 feet, high-grade gold and silver concentrates were produced and shipped to refineries located in Washington State and British Columbia.

Elsewhere in the Nation, gold-bearing properties and prospects were under investigation in Georgia, South Carolina, Michigan, Minnesota, Maine, Texas, New Mexico, and Idaho.

Refinery production of gold from new (manufacturer's) scrap increased substantially over 1979 production, but was still 4% below production achieved during 1978. Gold refined from old scrap, however, increased 30% over 1979 levels. New and old scrap accounted for about 83% of 1980 refinery production, and gold refined from foreign and domestic ores and concentrates accounted for the remainder.

Table 12.—U.S. refinery production of gold

(Thousand troy ounces)

Source	1976	1977	1978	1979	1980
Concentrates and ores:					
Domestic	954	956	962	795	773
Foreign	123	62	71	83	14
Old scrap[1]	1,068	1,040	1,384	[r]1,675	2,184
New scrap	1,436	1,414	1,701	[r]1,208	1,640
Total	3,581	3,472	4,118	[r]3,761	[2]4,612

[r]Revised.
[1]Excludes upgrading of U.S. Government-owned gold (mostly coin gold) by the U.S. Assay Office, amounting to 316,137 ounces in 1977, 2,386,874 ounces in 1978, 3,000,068 ounces in 1979, and 2,921,587 ounces in 1980.
[2]Data do not add to total shown because of independent rounding.

CONSUMPTION

Domestic consumption of refined gold, as measured by its conversion into fabricated and semifabricated forms, declined significantly in 1980 (figure 2; table 13). Jewelry accounted for nearly 47% of consumed gold, industrial uses for about 40%, and dental uses for about 11%. Declines were registered in nearly all demand categories, with the exceptions of industrial gold-filled applications and small items for investment, which rose 21% and 82%, respectively, over 1979 levels. The rapid rising gold price in late 1979 and early 1980 had a severe effect on consumption, as users, to conserve their inventories of refined gold, turned to less expensive substitutes and used fewer units of gold per product. Thus, electronics manufacturers were substituting palladium, tin, and other suitable metal for gold where possible, and jewelry makers were reportedly beginning to shift away from karat golds to gold-filled, rolled gold, gold-plated, and gold-silver combinations.

Although data are not reported on the purchase, or "consumption" of gold bullion by the private sector, the quantities purchased annually are believed to be represented approximately by the sizable

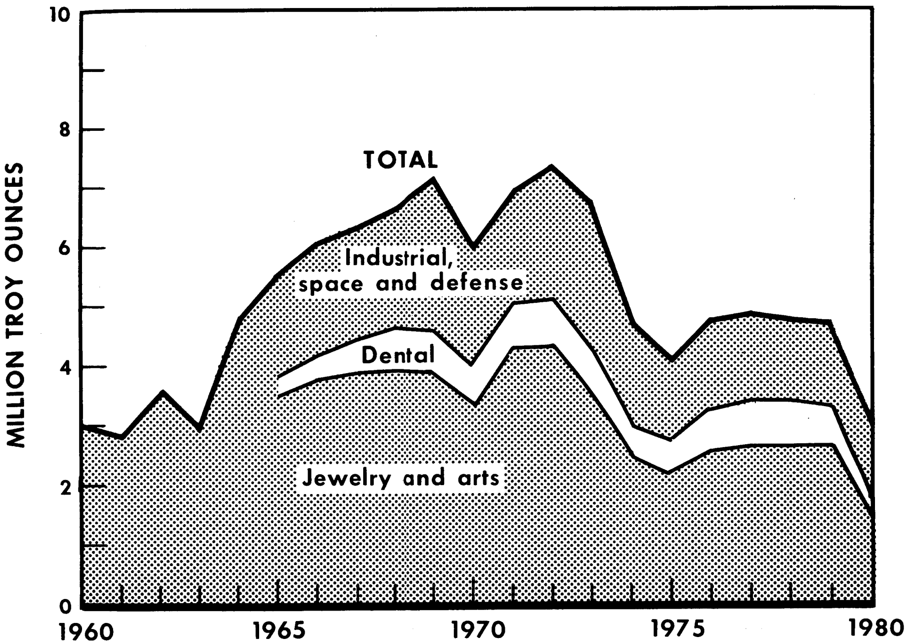

Figure 2.—Fabrication of gold in the United States.

Table 13.—U.S. fabrication of gold, by end use

(Thousand troy ounces)

End use	1976	1977	1978	1979	1980
Jewelry and arts:					
Karat gold	2,153	2,236	2,224	r2,276	1,249
Fine gold for electroplating	29	37	42	32	30
Gold-filled and other	380	385	385	r380	226
Total	2,562	2,658	2,651	r2,688	1,505
Dental	694	728	706	r646	341
Industrial:					
Karat gold	56	60	64	64	38
Fine gold for electroplating	686	656	687	797	592
Gold-filled and other	491	494	562	r545	657
Total	1,233	[2]1,209	1,313	r1,406	1,287
Small items for investment[1]	159	268	68	45	82
Total consumption	4,648	[2]4,863	4,738	r4,785	3,215

rRevised.

[1]Fabricated bars, medallions, coins, etc.

[2]Data do not add to total shown because of independent rounding.

supply surpluses that have occurred each year since 1975, when the right of U.S. citizens to own gold bullion was reinstated. In 1975, the supply surplus was 520,000 ounces and grew to 2.4 million ounces in 1976, 2.7 million ounces in 1977, and 4.1 million ounces in 1978, and again in 1979. In 1980, however, this trend was reversed, and a deficit of about 0.7 million ounces of bullion was registered, largely because IMF auctions were completed in May and there were no Department of Treasury sales, as there had been in recent years. Also, the flow of gold coins, mostly "bullion coins," into the United States has been substantial since the purchase of nonnumismatic coins in quantity was authorized in 1974. Estimated imports of gold coins, in millions of ounces, were: 1975, 1.7; 1976, 1.3; 1977, 1.6; 1978, 3.7; 1979, 2.8; and 1980, 3.1.

STOCKS

Official.—There were no public bullion auctions by the Department of the Treasury during 1980. Stocks of bullion held by the Department at yearend were 284,000 ounces less than stocks on hand at yearend 1979. The decline was attributed in part to the use of bullion stocks to satisfy the minting requirements of the Department's gold medallion sales program.

Bullion distributed under the restitution provision of the IMF Gold Accord between 1977 and 1980 resulted in the restitution of 5.7 million ounces to the United States. The fourth and final restitution took place during December 1979 and January 1980, when 1.4 million ounces were restituted to the United States.

Official gold reserves of the market-economy countries, including stocks held by the IMF and the Bank of International Settlements, totaled 1.134 billion ounces at yearend. Fulfillment of the IMF's public auction and restitution programs in early 1980 were reflected in a 3.4-million-ounce decline of yearend 1979 IMF stocks to 103.43 million ounces by yearend 1980.

Commercial.—Industrial stocks of refined gold held by U.S. refiners, fabricators, and dealers increased slightly from 0.868 million ounces at yearend 1979 to 0.872 million ounces at the close of 1980. Stocks held at the ends of the first three quarters were significantly higher than those on hand at the beginning of the year, apparently reflecting the negative impact on demand by extraordinarily high gold prices during the period. Futures exchange stocks increased 102% over those reported at the end of 1979 (table 14).

Table 14.—Stocks of gold in the United States, end of period

(Thousand troy ounces)

	1976	1977	1978	1979	1980
Treasury Department[1]	274,704	277,570	276,433	264,614	264,330
Industry	928	1,976	1,672	[r]868	872
Futures exchange	320	1,835	2,752	2,473	4,998
Earmarked gold[2]	388,773	378,683	366,248	359,285	354,453

[r]Revised.
[1]Includes gold in Exchange Stabilization Fund.
[2]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

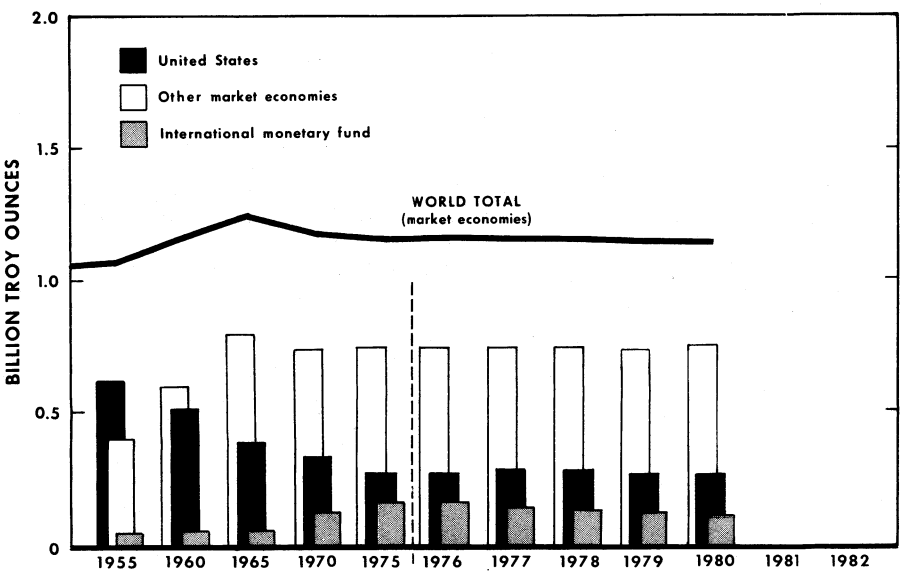

Figure 3.—World monetary gold stocks.

PRICES

The price of refined gold (table 15, figure 4) which continued the upward trend established in late 1979, surged upward at a rapid pace during the second half of January 1980, reaching an historic high of $850 per troy ounce on January 21. The average Engelhard Industries price of gold in 1980 was $612.56 per troy ounce. Since 1979, many of the industrialized nations have adopted market-related prices for valuation of their bullion reserves; again, the United States was the only holder of large gold stocks still valuing its bullion at a fixed price ($42.22 per ounce).

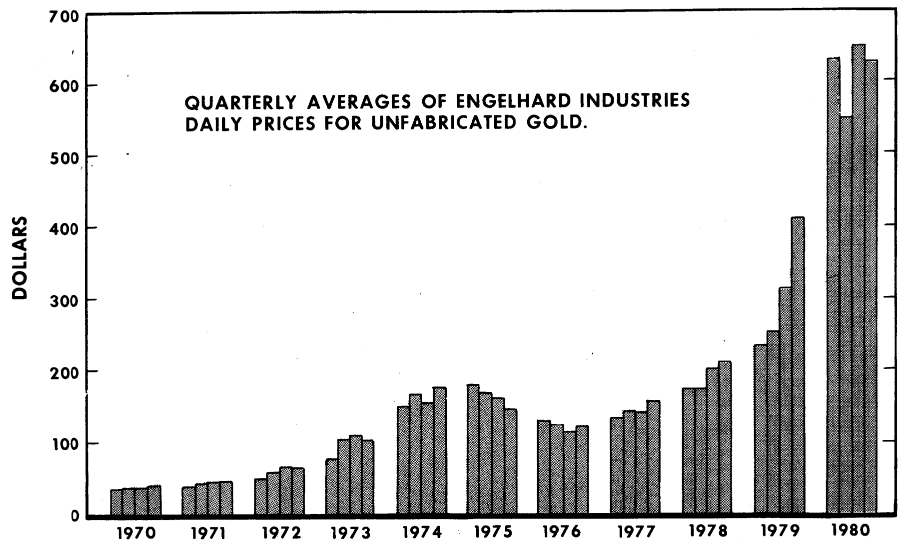

Figure 4.—U.S. gold prices.

Table 15.—U.S. monthly gold prices[1]

(Dollars per troy ounce)

Month	1979			1980		
	Low	High	Average	Low	High	Average
January	217.15	236.40	227.57	559.80	850.00	675.36
February	229.65	252.65	245.84	606.00	710.50	665.32
March	238.45	249.10	242.35	481.50	643.50	553.58
April	232.20	245.60	239.12	485.75	554.00	516.77
May	246.60	274.90	257.64	490.00	535.50	513.97
June	273.20	284.15	279.37	552.50	653.50	600.72
July	281.65	306.10	295.57	606.00	687.50	643.27
August	283.00	319.45	301.67	605.00	645.25	627.45
September	325.40	397.60	357.17	636.75	711.00	675.76
October	372.35	426.40	391.99	629.00	690.00	661.15
November	373.10	415.95	392.64	596.00	652.00	622.44
December	426.75	517.00	459.04	558.00	635.00	594.92
Year	217.15	517.00	307.50	481.50	850.00	612.56

[1]Engelhard Industries daily quotation.

FOREIGN TRADE

With completion of bullion auctions by the IMF in May and the absence of bullion sales by the Department of the Treasury during the year, exports of refined gold declined by 10.9 million ounces from the level of 15.6 million ounces achieved during 1979. The United Kingdom received 37% of the refined total, followed by Canada, Switzerland, and Mexico with 32%, 16%, and 8%, respectively. Of the gold imported into the United States in 1980, 45% came from Canada, followed by Switzerland, the United Kingdom, and the Netherlands, with 17%, 8%, and 5%, respectively. An estimated 3.1 million ounces of gold in coins was imported during the year, of which over one-half came from the Republic of South Africa, and important amounts came from Canada, Mexico, and Switzerland.

Table 16.—U.S. exports of gold in 1980, by country

Destination	Ore, base bullion, and scrap: Troy ounces	Ore, base bullion, and scrap: Value (thousands)	Refined bullion: Troy ounces	Refined bullion: Value (thousands)	Total: Troy ounces	Total: Value[1] (thousands)
Argentina	9	$3	3,864	$2,309	3,873	$2,312
Belgium-Luxembourg	207,834	126,967	--	--	207,834	126,967
Brazil	707	144	3,459	2,104	4,166	2,248
Canada	817,036	497,761	1,495,490	903,691	2,312,526	1,401,452
France	3,175	1,771	66,504	39,507	69,679	41,278
Germany, Federal Republic of	71,111	44,063	152,235	88,664	223,346	132,726
Italy	6,141	3,432	5,308	3,154	11,449	6,586
Japan	7,691	2,713	6,647	4,226	14,338	6,939
Mexico	20	6	399,113	228,883	399,133	228,889
Netherlands	6	3	107,283	66,101	107,289	66,105
South Africa, Republic of	79,588	50,521	--	--	79,588	50,521
Sweden	6,639	3,903	--	--	6,639	3,903
Switzerland	40,294	22,498	731,427	422,854	771,721	445,351
United Kingdom	173,058	104,798	1,728,689	1,024,603	1,901,747	1,129,401
Other	3,325	1,918	2,178	1,335	5,503	3,253
Total[1]	1,416,634	860,501	4,702,197	2,787,431	6,118,831	3,647,932

[1]Data may not add to totals shown because of independent rounding.

Table 17.—U.S. imports for consumption of gold in 1980, by country

Country	Ore, base bullion, and scrap: Troy ounces	Ore, base bullion, and scrap: Value (thousands)	Refined bullion: Troy ounces	Refined bullion: Value (thousands)	Total: Troy ounces	Total: Value[1] (thousands)
Argentina	3,643	$2,068	71,241	$45,182	74,884	$47,250
Australia	4,769	3,162	349	216	5,118	3,378
Brazil	3,540	2,171	52,533	30,112	56,073	32,283
Canada	157,001	92,572	1,872,439	1,141,645	2,029,440	1,234,217
Chile	34,178	18,874	64,525	38,575	98,703	57,449
Costa Rica	8,387	3,206	1,309	651	9,696	3,857
Dominican Republic	70,178	35,474	36,950	22,783	107,128	58,257
Ecuador	455	255	16,678	10,569	17,133	10,824
France	59	30	10,639	2,406	10,698	2,436
Germany, Federal Republic of	1,271	864	5,457	3,232	6,728	4,096
Guyana	6,045	3,017	2,624	1,437	8,669	4,454
Hong Kong	9,096	4,914	2,263	1,220	11,359	6,134
Italy	192	70	3,129	1,789	3,321	1,859
Japan	2,088	1,079	168,254	102,350	170,342	103,429
Korea, Republic of	913	514	6,413	4,052	7,326	4,566
Liberia	1,156	594	1,502	880	2,658	1,474
Malaysia	7,607	4,701	--	--	7,607	4,701
Mexico	5,354	2,759	408	272	5,762	3,031
Netherlands	3	1	225,478	112,861	225,481	112,861
Nicaragua	2,993	1,870	7,140	4,431	10,133	6,301
Panama	86,858	39,025	113,731	53,485	200,589	92,510
Paraguay	--	--	36,580	21,697	36,580	21,697
Peru	11,761	7,246	27,882	17,537	39,643	24,782
Philippines	5,299	3,069	12	8	5,311	3,078
Singapore	4,407	2,485	--	--	4,407	2,485
South Africa, Republic of	582	229	55,794	33,021	56,376	33,250
Switzerland	5,408	3,369	757,153	488,776	762,561	492,146
U.S.S.R	3,566	2,083	126,192	85,695	129,758	87,777
United Kingdom	8,542	4,940	354,259	239,230	362,801	244,170
Uruguay	622	240	19,776	12,365	20,398	12,605
Yugoslavia	--	--	45,414	27,937	45,414	27,937
Other	5,536	2,350	4,364	2,476	9,900	4,826
Total[1]	451,509	243,230	4,090,488	2,506,889	4,541,997	2,750,120

[1]Data may not add to totals shown because of independent rounding.

Table 18.—Value of U.S. gold trade

(Thousand dollars)

Year	Exports	Imports[1]
1976	375,048	331,018
1977	1,112,711	674,026
1978	1,113,794	903,024
1979	4,907,864	1,480,203
1980	3,647,932	2,750,120

[1]Value of general imports for 1976-77. Value of imports for consumption for 1978-80; values of general imports were $921,504,188 (1978), $1,506,716,888 (1979), and $2,795,549,207 (1980).

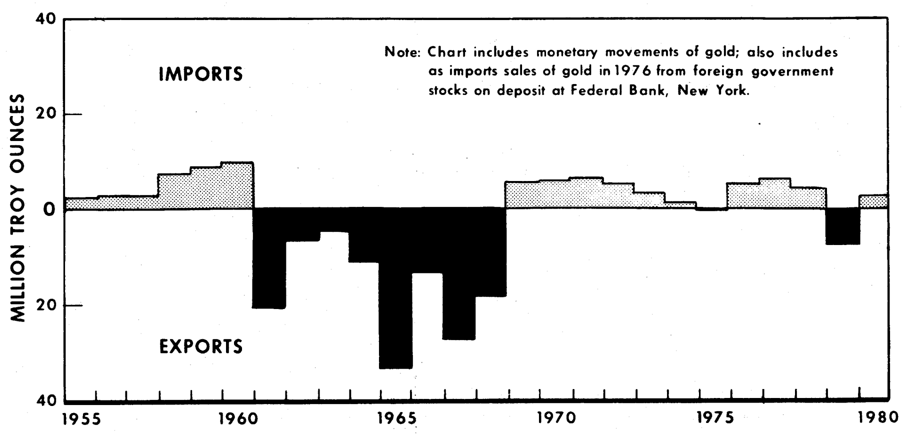

Figure 5.—Net U.S. trade in gold.

WORLD REVIEW

World gold mine production increased slightly to about 38.9 million troy ounces in 1980. Production in the United States and a few other countries decreased somewhat because mines could develop their leaner ores as the price of gold increased. With the exception of developments in Brazil, the pattern of production established in recent years remained essentially unchanged, with the Republic of South Africa accounting for 56% of the world mine output, followed by the U.S.S.R., Canada, Brazil, the United States, and 59 other countries for the remainder (figure 6, table 19).

The supply of gold (excluding most secondary gold), available to official and commercial purchasers in the market-economy countries in 1980 was about 33.2 million ounces, of which 30.3 million ounces was mined in the market-economy countries and 2.9 million ounces originated as net trade with the central-economy countries. When net purchases of gold for official or governmental financial purposes, 7.4 million ounces, were excluded, the supply available to the commercial sectors of the market-economy countries was about 25.8 million ounces. Most of the gold entering the market from the Republic of South Africa, the U.S.S.R., and several other producing countries was funneled through Switzerland, England, and other Western European countries. In 1980, however, because of domestic economic policies, less gold was released into international trade by both the Republic of South Africa and the U.S.S.R. than had been released in recent years. Much of the gold flowing from the United States to Europe was bullion auctioned from IMF stocks. There were no bullion sales by the Department of Treasury during 1980.

Table 19.—Gold: World mine production, by country[1]

(Troy ounces)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	1,691,806	1,733,609	1,735,077	1,644,265	[3]1,552,366
Costa Rica[e]	9,600	12,200	15,900	16,718	16,000
Dominican Republic	[r]412,937	[r]342,755	342,830	352,982	[3]369,603
El Salvador	3,007	2,156	3,619	2,720	2,800
Honduras	2,280	2,481	[e]2,500	1,501	2,000
Mexico	162,811	212,709	202,003	190,043	[3]195,990
Nicaragua	75,841	65,764	[e]65,800	[r] [e]61,086	66,000
United States	1,048,037	1,100,347	998,832	969,920	[3]951,348
South America:					
Argentina	5,804	5,509	5,594	10,140	[3]11,108
Bolivia	41,540	[r]24,293	24,660	30,319	[3]52,075
Brazil[4]	239,520	279,520	300,898	353,600	1,300,000
Chile	129,172	116,376	102,416	111,405	114,800
Colombia	300,307	263,437	257,632	269,369	280,000
Ecuador	11,014	[r]8,124	2,734	3,215	3,500
French Guiana	[r]2,437	4,823	2,894	1,993	3,500
Guyana	15,656	11,899	15,396	10,600	[3]11,003
Peru	79,412	104,393	103,069	122,333	150,000
Suriname	39	376	--	--	--
Venezuela	16,506	17,403	13,384	14,989	[3]16,519
Europe:					
Finland	26,299	27,392	29,096	28,325	28,000
France	61,022	50,444	59,640	40,606	40,000
Germany, Federal Republic of	2,456	2,392	2,119	2,370	2,400
Hungary[e]	155,000	115,000	60,000	60,000	60,000
Portugal	10,031	8,830	7,765	10,706	11,000
Romania[e]	60,000	65,000	65,000	65,000	65,000
Spain	148,601	117,800	102,882	91,404	100,000
Sweden	62,179	67,934	76,294	70,000	70,000
U.S.S.R.[e]	7,700,000	7,850,000	8,000,000	8,160,000	8,300,000
Yugoslavia[5]	157,088	164,226	142,556	138,987	135,000
Africa:					
Burundi	426	[e]450	[e]450	133	130
Cameroon	251	182	200	147	150
Central African Republic	[e]400	[e]100	965	2,181	2,000
Congo[e]	6,900	7,000	7,000	7,000	7,000
Ethiopia	11,253	7,725	[e]8,000	[6]7,970	9,000
Gabon	3,086	2,572	965	964	900
Ghana	532,473	480,884	402,034	362,000	410,000
Kenya	37	[r]135	205	[e]200	200
Liberia	[e]4,500	[r] [e]3,000	[r] [e]3,000	1,086	7,243
Madagascar	[e]160	76	125	[e]125	100
Mali[e]	900	932	965	1,000	1,500
Mauritania	22,120	28,000	8,000	--	--
Rwanda	936	1,814	1,125	473	500
Senegal	--	--	250	--	--
South Africa, Republic of	[r]22,936,018	22,501,886	22,648,558	22,617,179	[3]21,669,468
Sudan[e]	300	300	300	300	300
Tanzania	10	23	[e]12	[e]10	13
Zaire	91,093	80,418	76,077	69,992	[3]39,963
Zambia	10,955	[e]11,250	8,457	7,941	[3]10,576
Zimbabwe	387,094	401,884	398,990	386,130	367,000
Asia:					
China, mainland[7]	80,000	100,000	150,000	200,000	225,000
India[5]	100,696	96,902	89,186	84,749	[3]78,834
Indonesia[8]	114,000	82,300	66,166	57,452	50,000
Japan	[r]137,643	[r]149,004	145,240	127,626	130,000
Kampuchea[e]	1,000	1,000	--	--	--
Korea, North[e]	160,000	160,000	160,000	160,000	160,000
Korea, Republic of[5]	18,744	21,380	27,392	24,081	[3]38,291
Malaysia:					
Peninsular Malaysia	3,574	4,172	5,805	5,273	[3]4,621
Sarawak	964	742	971	1,062	[3]379
Philippines	501,210	[r]558,554	586,531	561,040	701,000
Taiwan	26,952	14,995	13,407	14,243	[3]13,278
Oceania:					
Australia	502,741	630,155	647,579	596,910	[3]556,850
Fiji	65,757	49,067	28,065	30,768	27,900
New Zealand	3,276	7,168	7,011	7,500	7,300
Papua New Guinea	668,014	739,730	751,265	630,496	[3]451,717

See footnotes at end of table.

Table 19.—Gold: World mine production, by country[1] —Continued

(Troy ounces)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Oceania —Continued					
Solomon Islands	[e]600	372	[e]400	1,076	[3]1,093
Total	[r]39,024,485	[r]38,921,364	38,985,286	38,801,703	38,882,318

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 8, 1981.

[2]Gold is also produced in Bulgaria, Burma, Czechoslovakia, the German Democratic Republic, Guinea, Norway, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates. The 1977 and previous editions of this table listed Angola and Nigeria as gold producers, but output of these countries for 1976 and later years has been revised to zero.

[3]Reported figure.

[4]All figures except that for 1978 differ substantially from those appearing in latest available official Brazilian sources owing to the inclusion of estimates for unreported production by small mines (garimpos). Offically reported figures are as follows, in troy ounces; major mines: 1976—119,536; 1977—121,047; 1978—128,860; 1979—107,158; 1980—not available; small mines (garimpos); 1976—38,709; 1977—51,120; 1978—172,038; 1979—36,234; 1980—not available.

[5]Refinery output.

[6]Data are for year ending July 6 of that stated.

[7]Very conservative estimate of output, based on reports covering a limited number of operating properties; total national production probably is much greater than these estimates, but no basis for quantification of the balance of output is available.

[8]Excludes production from so-called people's mines.

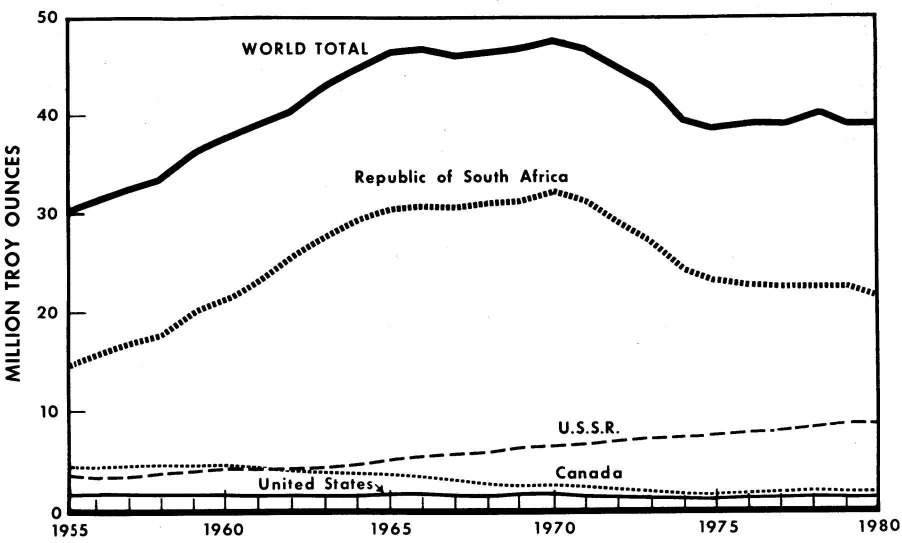

Figure 6.—Gold: World mine production.

Private investors continued to turn to gold for its traditional functions as a store of value and a hedge against currency inflation, but the tendency of gold to move from the official sector to the private sector, as occurred between 1973 and 1979, was reversed in 1980 when official purchases of gold exceeded official sales by an estimated 7.4 million ounces. Demand for gold in the commercial sector declined substantially in 1980. In the market-economy countries, the distribution of commercial gold in 1980, compared with the previous year (1979 figures are in parentheses) was reported[3] as follows: 65% (77%) was held in the form of fabricated gold and 35% (23%) was held as bullion. Lower demand for fabricated gold in the developed countries, plus widespread conversion of gold from fabricated products into bullion in the developing countries, resulted in a 40% overall decline in fabricated gold demand in the market-economy countries. In the developed countries, about 41% (52%) was held as, or went into, jewelry; 12% (9%) went into electronics; 9% (8%) into dental uses; 9% (7%) into other industrial and/or decorative uses; 25% (23%) into coins; and 3% (2%) into medallions and unofficial coins. The distribution of gold in the developing countries changed significantly between 1979 and 1980; in 1980, the flow of gold into dental and other industrial and/or decorative uses declined by about 50% from 1979 levels. Electronic usage was unchanged, but usage in coins declined nearly 70%. Despite continued fabrication of gold in the two categories which include jewelry and medallions and unofficial coins, the net quantity of gold held in these combined categories in the developing countries declined 175% during 1980, as holdings of fabricated items were melted down and converted into bullion.

In May of 1980, the IMF completed its 4-year program of monthly gold auctions. During the 4-year period which began in June 1976, 44 auctions were conducted, and 25 million ounces of gold were sold.

Argentina.—New mining legislation passed by the Government of Argentina allows, for the first time since 1887, tenders from international interests for prospecting and mining contracts, taxation and marketing concessions, etc. The new mining code is expected to encourage expanded exploration and development activities for gold and other mineral products.

Australia.—Gold production decreased 7% in 1980 to 556,850 ounces in spite of the reopening of several old mines and increased development work by several long-established producers. In Western Australia, production at the Telfer Mine (70% owned by Newmont Pty. Ltd.), Mt. Charlotte, and Central Norseman Mines declined to 132,000, 103,000, and 77,000 ounces, respectively, as greater tonnages of lower grade ores were mined. Elsewhere in Western Australia, the Marvel Loch, Comet, and Haveluck Mines were reopened, and a number of other properties were being developed. Whim Creek Consolidated Mining Co. completed test work and design studies on their gold deposit at Cork Tree Well near Laverton. Western Mining Corp. Holdings Ltd. began preparations to resume gold production at the Fimiston, Mt. Magnet, and Lancefield Mines, and a gold ore body was under development in the Hunt Mine at Kambalda. Consolidated Resources N.L. began mining at their Pinnacles leases, which include the Comet Mine. In the Northern Territory, Peko-Wallsend Ltd. continued to produce byproduct gold from its copper mines at Tennant Creek. The company also continued to explore a gold discovery adjacent to the abandoned Juno Mine at Tennant Creek. In December, Wattle Gully Gold Mines N.L. reopened the old Wattle Gully Mine near Castlemaine, Victoria.

Numerous exploration companies and individual prospectors actively pursued gold throughout Australia in 1980. Exploration programs included the search for new ore bodies, reevaluation of past producers and prospects, and investigation of gold recovery potentials from tailings dumps of existing and abandoned mines. The discovery of several large nuggets in Western Australia and Victoria sparked a prospecting and claim-staking rush in both States; one nugget, found with a metal detector in Victoria, weighed nearly 870 ounces and was valued in excess of $1 million. In Western Australia, exploration projects underway during 1980 included investigation of the Bamboo Creek leases near Marble Bar by C.R.A. Exploration Pty. Ltd. and Kitchener Mining N.L., and exploration of claims within the southern extension of the Norseman goldfield by Central Norseman Gold Corp. N.L. and by a joint venture between C.R.A. Exploration and Australis Mining N.L. In northeastern Queensland, Placer Development Ltd. had nearly completed diamond drilling at their Kidston gold prospect by yearend. A high-grade portion of the proven reserve which is targeted for open pit development is calculated to contain over 9.4 million tons of ore grading 0.07 ounce of gold per ton.

Brazil.—Throughout 1980, considerable attention was focused on the gold rush which followed the February discovery of a large deposit of placer gold in the Carajas region of the eastern Amazon Basin in the Province of Para. During the rush, which was reminiscent of earlier rushes to California and the Klondike, an estimated 20,000 alluvial gold prospectors or garimpeiros converged on the discovery site, later known as Serra Pelada, and by the end of the year an estimated 386,000 ounces of gold had been recovered. Mining of the deposit, which later came to be overseen by the Brazilian Government, is limited to hand methods on a myriad of individual claims, measuring 2 by 3 meters. The discovery sparked intense prospecting activity throughout the region and elsewhere within the country. Of the gold produced in Brazil during the year, an estimated 1.15 million ounces or 88% of the estimated production was won from the country's numerous alluvial deposits, most of which are operated by garimpeiros. The Anglo American Co., Manager of Brazil's largest gold mining company, Mineracao Morro Velho, plans to initiate a major expansion program which is expected to increase production from the mine nearly fourfold. Morro Velho production during 1980 was estimated at about 150,000 ounces. Anglo American was also expanding gold exploration and developing new mines in the States of Bahia and Minas Gerais, and increasing production capacity at their six other mines in Brazil. Gold exploration by the Companhia de Pesquisas de Recursos Minerais, the Brazilian Government Mineral Exploration Co., was directed toward the following four prospects during 1980:[4] Itapetim, on the Alto Pajeu River, between Brejinho and Santa Teresinha, in the State of Pernambuco; Reriutaba on Ibiapaba Hill in the State of Ceará; the Eldorado project, in the Riberia Valley, in the municipality of Iporanga, State of São Paulo; and Uriapuru, in the municipality of Almeirim, State of Para.

Canada.—The number of mines producing gold in Canada increased from 21 to 29, between 1979 and 1980; however, reported gold production declined during the same period to 1,552,366 ounces as miners, enabled by higher metal prices, processed greater tonnages of their leaner ores. Ontario was again the leading producer, with 38% of the total, followed by Quebec, British Columbia, and the Northwest Territories, with 34%, 15%, and 6%, respectively. Gold exploration activity throughout Canada was particularly intense during 1980, especially in the vicinity of established gold camps and other areas with a history of past production. Several new Canadian gold mines started production during the year, and several others were in the final stages of preproduction development. Placer mining increased considerably during 1980, especially in the western part of the country. Details of the operations of individual mines and highlights of exploration and development were published in the Canadian Minerals Yearbook.

Chile.—Development of the El Indio gold-silver-copper mine and mill complex (80% owned by St. Joe International Corp.) in the Coquimbo area proceeded toward its scheduled startup in the third quarter of 1981. The company began limited mining in 1979, and since that time has been shipping gold-bearing ore which requires no processing at the mine. In December, St. Joe reached an agreement with Preussag A.G. of the Federal Republic of Germany, Empresa Pesquera Eperva S.A., and Pesquera Indo S.A. to proceed with drilling and underground exploration to further evaluate the Sacarron prospect located about 12 miles north of El Indio.

China, Mainland.—As indicated by the footnote accompanying China in table 19, actual gold production in mainland China is unknown, but may be much greater than the conservative estimates shown. A more realistic appraisal of China's gold production will not be possible until more precise data become available. To meet the immediate expenses required to implement new economic policies and to provide a means for readily accumulating foreign currency, China has placed the highest priority on the development of its gold resources. China's current policy is to expand geological exploration and the development of both new and established gold mines; accordingly, various reports originating from China during the year included announcements of new discoveries in nearly all provinces and the establishment of contracts with several North American engineering companies to modernize or expand operations at established mining facilities in Shandong Province.

Colombia.—Ecominas, Colombia's State-owned mining company, will spend $5.6 million to investigate the further development of the Marmato gold deposits in the Western Caldas department. In late 1980, Ecominas took over administration of the Marmato Mine and announced a 2-phase development plan to modernize equipment and to introduce new mining systems. More than one-half of the gold production reported by Colombia came from placer deposits in the Antioquia department.

Dominican Republic.—The output of the Pueblo Viejo gold and silver mine, the sole gold producer in the country, was reported at 369,603 ounces in 1980. The mine, which has been State-owned since 1979, is managed under a contract with the Dominican Government by Rosario Dominicana, S.A. (a subsidiary of AMAX Inc.). At present, only doré, a mixture of gold and silver, is produced; however, the Government has commissioned a study to determine the feasibility of building a domestic refinery to handle the output of the mine.

Ghana.—Ghanian gold mine production, based on preliminary estimates, rose for the first time in several years to about 410,000 ounces or 48,000 ounces over production of 1979. During the year, the Government of Ghana began actively seeking foreign participation in the country's gold mining industry. In the Ashanti region of the country where the country's largest gold producer is located, the Obenemase gold mine may be reopened following the discovery of new gold reserves.

Mexico.—Reported gold production was 195,990 ounces in 1980; nearly all recovered as a byproduct or coproduct with silver or other metals. In early 1980, the Government of Mexico adopted a variable tax system for gold and silver. The tax on gold is levied against producers and begins when the price reaches $403.54 per ounce and graduates to 40% when the price reaches $504.44 per ounce.

Papua New Guinea.—For the first time since 1972 when production began at Bougainville Copper Ltd.'s copper deposit, the value of byproduct gold production exceeded that of copper. Gold production from the mine in 1980 amounted to 451,717 ounces or all of the gold produced in Papua during the year. The contribution of gold to the total export earnings of the Nation has grown from 11% in 1972 to an estimated 26% in 1980, surpassing traditional exports such as copra, coffee, and cocoa. Construction of the $1.6 billion Ok Tedi Copper and Gold Mine in the Star Mountains, near the Indonesian border, is expected to begin in 1981, with gold production commencing in 1984. The mine will be operated by a consortium of U.S., Australian, and West German companies plus the Government of Papua New Guinea. Exploration was continued by another international consortium at the Porgera Gold prospect in the Central Highlands; preliminary work completed in 1980 indicated two promising gold-silver zones. At the Frieda River Copper prospect in the West Sepik Province, an international joint venture team continued exploration; two of the zones explored during the year were estimated to contain over 250 and 500 million tons of copper-gold ore, respectively. Drilling at a third prospect nearby produced encouraging copper-gold assays.

Philippines.—The production of gold from mines in the Philippine Islands increased 25% over production reported during the previous year. This substantial increase is attributed to increased placering activity and to the first full year of production from two new mines by Benguet Consolidated Inc. and Atlas Consolidated Mining and Development Corp. Benguet, on the Island of Luzon, started production from their new 18,700-ton-per-day Dizon copper-gold deposit in Zambales Province. The company began an expansion program at their Balatoc gold mill located near Bagio. Benguet, together with the Symcon Corp., explored placer deposits along the Iponan River. Preliminary results indicated large reserves or reserves of gold-bearing gravels. In late January, Atlas Consolidated produced their first doré bullion from their recently reopened Masbate open pit mine on Masbate Island. The mine, which the company was forced to close when the Japanese invaded the Philippines in December 1941, is expected to yield an estimated 90,000 ounces of gold per year. At Marinduque Mining and Industrial Corp.'s Sipalay Mine, on the Island of Negros Occidental, the concentrator capacity was increased to handle nearly 20,000 tons of copper-gold-silver ore per day. In Surigao del Norte Province, Surigao Consolidated Mining completed construction on their new 1,100-ton-per-day gold mill which was expected to begin producing gold during the first quarter of 1981. Philippine Eagle Mines, Inc. (formerly Metals Exploration Asia, Inc.), continued development of the Longos gold project in Camarines Norte Province, Luzon. Production was expected to begin in early 1981. In Quezon Province, Golden Arrow Mining Co. planned to spend $25 million to explore and develop a new mine. The Philippine Ministry of Natural Resources, Bureau of Mines, and Geo-Sciences continued their project aimed at accelerating the assessment, exploration, and evaluation of gold deposits in selected areas of the country; technical assistance which may be granted to qualified gold claimholders includes geological mapping, exploration drilling and metallurgical testing, chemical analyses, engineering and planning services, and technical and economic feasibility studies.

South Africa, Republic of.—Gold production in South Africa during 1980 amounted to 21.7 million ounces or 56% of world gold mine production. For the third consecutive year, the South African gold mining industry flourished as unprecedented metal prices spurred activity and expansion in all sectors of the industry from exploration to refining. Many mines which had recently closed or were threatened with closure were being actively developed in response to the increased value of their product. The 36 mines and 2 metallurgical recovery operations that were members of the Chamber of Mines accounted for 98.4% of all South African production. The total ore milled, including ore milled by producers of byproduct and coproduct uranium, amounted to 99.1 million tons, averaging 0.23 ounce of gold per ton. In 1979, 92.0 million tons, averaging 0.26 million ounces per ton were milled, for a total yield of 22.6 million ounces. Working costs for South African gold mines in 1980 averaged, in South African rands (R) R142.67 (US$183.39) per ounce and ranged from R70.42 (US$90.51) per ounce at East Driefontein to R379.93 (US$488.36) per ounce at Loraine. Production by the seven major mining groups was as follows, in million ounces: Anglo American Corp. of South Africa, Ltd., 8.2; Gold Fields of South Africa, Ltd., 4.7; Rand Mines Ltd., 2.2.; General Mining Union Corp., Ltd, 2.0; General Mining and Finance Corp., 1.6; Johannesburg Consolidated Investment Corp., Ltd., 1.3; and Anglo Transvaal Consolidated Investment Co. Ltd., 1.2. The largest producing mines, in terms of millions of ounces of gold output, were Vaal Reefs, 2.2; Western Deep Levels, 1.5; and West Driefontein, 1.4. Nine gold mines and two metallurgical recovery units also produced uranium during 1980. Vaal Reefs was the largest uranium producer, with a yield of 1,938 tons of uranium oxide. Estimates of fully developed or blocked-out gold ore reserves reported by the Chamber of Mines at the close of 1980 totaled 530 million tons, containing an average of about 0.30 ounce of gold per ton.

The Deelkraal Mine began production in January, following 5 years of development by Gold Fields of South Africa, Ltd. During the first year of production, 915,000 tons of ore were milled for a production yield of 101,725 ounces of gold. In July, an agreement was reached by members of the Anglo American Group to establish a new mine in the Erfdeel-Dankbaarheid area of the Orange Free State. The mine will be a part of the Western Holdings Ltd. complex, which resulted from a merger of the Free State Saaiplaas Gold Mining Co. Ltd., Welkom Gold Mining Co. Ltd., and Western Holdings. The mineral rights holders will form a new company, Eastern Gold Holdings Ltd. In March, the General Mining Union Corp. Ltd. announced plans to proceed with the development of the Beatrix gold mine in the Orange Free State. The property was expected to be in full production in about 5 years, milling ore at a rate of about 2.2 million tons per year. Rand Mines Ltd. began recovering gold from old tailings dumps around Johannesburg in 1980. The company expects to recover about 72,000 ounces of gold annually for about 12 years. At Bank Gold, near the East Driefontein Mine in the Far West Rand, Texasgulf Inc. completed an exploratory drill hole which intersected the Ventersdorp Contact Reef at a depth of over 3,100 feet. Assays of the reef cores from the main hole and three deflection holes indicated high values for both gold and silver.

U.S.S.R.—Soviet gold production was estimated to have risen about 1.7% over estimated 1979 production. The export of gold by centrally planned economy countries to market-economy countries was estimated to have amounted to 2.9 million ounces in 1980 compared with exports of 13.2 million ounces in 1978 and 7.4 million ounces in 1979. Because nearly all that gold, which was exported to gain essential foreign exchange, came from the U.S.S.R., the decline in Soviet gold exports between 1978 and 1980 may indicate that the Soviet Union was able to satisfy a growing percentage of its exchange requirements from other exports such as oil and gas. No direct imports of Soviet gold were received by the United States during 1980, though in 1979, 35% of U.S. gold imports were from the U.S.S.R.

Venezuela.—Gold production in Venezuela rose 10% during the year to 16,500 ounces. In February, the State-owned gold mine of Minerven began processing low-grade ore and developing its operations to meet a full-capacity production target of about 170,000 ounces of gold by 1986. Preliminary data indicate that Minerven produced about 4,300 ounces during 1980. The only other State-owned gold operation, Venorca, near the Minerven, relies entirely upon ore delivered by independent miners operating in the district.

TECHNOLOGY

The Bureau of Mines conducted further research aimed at improving the recovery of precious metals from low-grade resources and industrial waste and scrap. In 1980, the Bureau investigated a cyanidation-carbon adsorption technique for extracting gold from arsenopyrite concentrates. Results reported in leaching the concentrates showed that 96.9% of the contained gold and 90.7% of the silver could be extracted in 96 hours of agitation leach experiments.[5] Gold and silver were recovered from the resulting pregnant solution by exposure to granular activated carbon in a counter current system.

The Gold Bulletin, a quarterly journal of the Chamber of Mines of South Africa, contained a variety of articles on new gold uses and technology.[6]

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[1]Physical scientist, Section of Nonferrous Metals.
[2]Ounce means troy ounce.
[3]Potts, D. Gold 1981. Published by Consolidated Gold Fields, Ltd., London. May 1981.
[4]Comércio & Mercados. Explosão do Ouro Arrebenta as Cotacoes. V. 14, No. 150, February 1980, pp. 2-7.
[5]Heinen, H. J., G. E. McClelland, and R. E. Lindstrom. Recovery of Gold From Arsenopyrite Concentrates by Cyanidation-Carbon Adsorption. BuMines RI 8458, 1980, 10 pp.
[6]Chamber of Mines of South Africa Research Organization (Johannesburg). Gold Bulletin. V. 13, Nos. 1-4, 1980.

Graphite

By Harold A. Taylor, Jr.[1]

Natural crystalline flake graphite continued in short supply in 1980. Prices of imported flake graphite increased significantly during the year. Supplies of Mexican amorphous graphite remained sufficient and substitution of it for scarcer crystalline flake appears to have continued.

Production of manufactured graphite in 1980 decreased 6% in quantity from that of 1979.

Imports of natural crystalline and amorphous graphite in 1980 were down 30% in quantity from the 1979 level.

Table 1.—Salient natural graphite statistics

	1976	1977	1978	1979	1980
United States:					
Apparent consumption[1] ....short tons..	[2]66,862	[2]73,773	90,396	77,562	52,438
Exports ....do....	12,236	13,783	9,595	8,623	8,880
Value ....thousands..	$2,388	$2,662	$2,304	$3,741	$3,695
Imports for consumption[3] ....short tons..	79,098	87,556	99,991	86,185	61,318
Value ....thousands..	$6,753	$8,058	$11,700	$13,035	$15,765
World: Production ....short tons..	[r]495,481	[r]546,022	[r]583,030	[r]590,774	597,429

[r]Revised.
[1]Excludes domestic production.
[2]Revised to include some manufactured graphite imported for consumption.
[3]Includes some manufactured graphite; see table 6.

Legislation and Government Programs.—National stockpile goals for strategic graphite were changed to reflect specification revisions. Stockpile goals and inventories for each type of graphite are shown in table 2. There were no acquisitions or disposals of strategic graphite in 1980.

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Type of graphite	Goal	National stockpile inventory (Dec. 31, 1980)
Madagascar crystalline flake	20,000	17,906
Sri Lanka amorphous lump	6,300	5,442
Crystalline, other than Madagascar and Sri Lanka	2,800	1,934
Non-stockpile-grade, all types	--	935

Source: General Services Administration. Inventory of Stockpile Materials as of Dec. 31, 1980.

DOMESTIC PRODUCTION

The Southwestern Graphite Co., a division of Joseph Dixon Crucible Co., no longer produced from its mine near Burnet, Tex., although some shipments were made in 1980 as stocks were liquidated. Other graphite deposits in Alabama, Montana, and the Province of Saskatchewan, Canada, continued to receive some attention from investigators contemplating the development or redevelopment of additional mines. However, no mine openings seem likely in the near future.

Reported production of manufactured graphite decreased 6% to 367,154 tons in 1980. Electrode production decreased 10% in 1980. Production of high-modulus fibers grew rapidly, rising 91% in quantity in 1980 from that of 1979. The value per pound of high-modulus fiber decreased about 22% from around $35 in 1979 to about $27 in 1980.

Manufactured graphite was produced at 28 plants in 1980, with some additional production for in-house use likely. Union Carbide Corp. broke ground for a proposed carbon fiber facility at Greenville, S.C., that would use polyacrylonitrile (PAN) as a raw material.[2] This would be in addition to its new pitch-based carbon fiber capacity that operated for the first time on a commercial basis in 1980. Superior Graphite Co. doubled the capacity of its synthetic graphite additive plant at Hopkinsville, Ky.[3] The Carborundum Co. sold its graphite electrode plant at Hickman, Ky., to Sigri Carbon Corp., a subsidiary of Sigri Elektrographit G.m.b.H. of the Federal Republic of Germany, effective June 1, 1980.[4] The Great Lakes Carbon Corp. was building a graphite electrode plant at Ozark, Ark., at a cost of $40 million, to be fully operational in 1981.[5] The following is a list of principal producers of manufactured graphite:

Company	Plant location	Product[1]
Airco Carbon, Div. of Airco, Inc	Niagara Falls, N.Y	Anodes, electrodes, crucibles, motor brushes, refractories, unmachined shapes, powder.
Do	Punxsutawney, Pa	
Do	St. Marys, Pa	
Avco Corp., Avco Specialty Materials Div	Lowell, Mass	High-modulus fibers.
The Carborundum Co., Graphite Products Div.	Hickman, Ky.[2]	Electrodes, motor brushes, unmachined shapes, cloth.
Do	Niagara Falls, N.Y	
Do	Sanborn, N.Y	
Celanese Corp., Celanese Research Lab	Summit, N.J	High-modulus fibers.
Fiber Materials, Inc	Biddeford, Maine	Do.
BF Goodrich Co., Engineered Systems Div., Super Temp Operation.	Santa Fe Springs, Calif	Other.
Great Lakes Carbon Corp	Morganton, N.C	Anodes, electrodes, powder.
Do	Niagara Falls, N.Y	
Do	Rosamond, Calif	
Hercules Inc	Salt Lake City, Utah	High-modulus fibers.
HITCO Materials Group ARMCO Co	Gardena, Calif	Cloth and high-modulus fibers.
Pfizer Minerals, Pigments & Metals Div	Easton, Pa	Other.
Poco Graphite, Inc	Decatur, Tex	Unspecified.
Polycarbon, Inc	North Hollywood, Calif	Cloth.
Sigri Carbon Corp	Hickman, Ky	Electrodes, other.
The Stackpole Corp., Carbon Div	Lowell, Mass	High-modulus fibers, anodes, motor brushes, unmachined shapes, powder.
Do	St. Marys, Pa	
Superior Graphite Co	Chicago, Ill	Powder and other.
Do	Hopkinsville, Ky	
Union Carbide Corp., Carbon Products Div	Clarksburg, W. Va	
Do	Columbia, Tenn	Anodes, electrodes, unmachined shapes, motor brushes, powder, cloth, high-modulus fibers.
Do	Fostoria, Ohio	
Do	Greenville, S.C	
Do	Niagara Falls, N.Y	
Do	Yabucoa, P.R	

[1]Cloth includes low-modulus fibers; electric motor brushes includes machined shapes; crucibles includes vessels.
[2]Plant sold to Sigri Carbon Corp., May 31, 1980.

Table 3.—Production of manufactured graphite in the United States, by use

Use	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Synthetic graphite products:				
Anodes	14,973	$21,338	17,848	$42,364
Cloth and fibers (low-modulus)	r169	r9,569	173	10,590
Crucibles, vessels, refractories	W	W	W	W
Electric motor brushes and machined shapes	W	W	W	W
Electrodes	285,950	430,361	258,453	527,949
High-modulus fibers	145	10,066	277	14,997
Unmachined graphite shapes	r16,269	r26,845	12,625	27,533
Other	r37,018	r66,983	51,838	98,274
Total	r354,524	r565,162	341,214	721,707
Synthetic graphite powder and scrap	36,913	20,724	25,940	11,226
Grand total	r391,437	r585,886	367,154	732,933

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."

CONSUMPTION AND USES

Reported consumption of natural graphite in 1980 (table 4) decreased 17% to 49,876 tons from 60,191 tons (revised) in 1979. The three major uses of natural graphite, refractories, foundries, and steelmaking, accounted for 67% of reported consumption in 1979 and 61% in 1980.

The actual amount of natural graphite consumed was greater than that shown in table 4, which reports only the results of a canvass of major known consumers. While this canvass probably gives some indication of consumption patterns, caution is advised in using these data owing to incomplete coverage and inconsistencies in company reporting. Some 1978 data have been revised, as follows: Consumption of amorphous graphite in the foundries end use was 11,054 tons valued at $1,794,973, and consumption of amorphous graphite in the steelmaking end use was 6,771 tons valued at $891,351. Apparent graphite consumption in 1979 was 77,562 tons, and was 52,438 tons in 1980, excluding domestic production in 1979.

Sales of graphite fiber composites were projected to grow rapidly in current markets such as aerospace and sporting goods and the composites have a good chance of becoming important in automobiles.[6] Graphite fiber composites are actively competing for the automotive market, along with many other lightweight materials.[7]

Table 4.—Consumption[1] of natural graphite in the United States, by use

Use	Crystalline		Amorphous[2]		Total	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1979						
Batteries	W	W	W	W	W	W
Brake linings	r1,008	r$810,969	r1,886	r$1,178,046	r2,894	r$1,989,015
Carbon products[3]	287	361,767	591	438,294	878	800,061
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries	3,352	1,464,368	r8,791	r2,347,805	r12,143	r3,812,173
Lubricants[4]	768	867,686	2,281	1,354,413	3,049	2,222,099
Pencils	1,484	1,407,522	579	274,786	2,063	1,682,308
Powdered metals	425	456,635	415	356,145	840	812,780
Refractories	912	180,909	13,460	3,592,064	14,372	3,772,973
Rubber	104	86,499	245	79,292	349	165,791
Steelmaking	615	267,972	r13,122	r4,327,004	r13,737	r4,594,976
Other[5]	r8,275	r5,286,230	r1,591	r1,384,992	r9,866	r6,671,222
Total	r17,230	r11,190,557	42,961	15,332,841	r60,191	r26,523,398
1980						
Batteries	W	W	W	W	1,737	2,178,963
Brake linings	933	959,438	2,013	1,534,062	2,946	2,493,500
Carbon products[3]	182	243,258	408	360,378	590	603,636
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	2,340	2,063,869
Foundries	1,366	1,092,086	6,466	2,411,549	7,832	3,503,635
Lubricants[4]	867	1,176,091	5,521	1,983,113	6,388	3,159,204
Pencils	977	1,502,433	340	337,236	1,317	1,839,669
Powdered metals	288	360,528	112	182,287	400	542,815
Refractories	1,062	224,887	11,577	2,161,400	12,639	2,386,287
Rubber	31	24,894	241	167,931	272	192,825
Steelmaking	386	164,875	9,373	4,732,611	9,759	4,897,486
Other[5]	6,928	5,471,546	805	693,470	3,656	1,922,184
Total	13,020	11,220,036	36,856	14,564,037	49,876	25,784,073

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Consumption data incomplete. Small consumers excluded.
[2]Includes mixtures of natural and manufactured graphite.
[3]Includes bearings and carbon brushes.
[4]Includes ammunition, packings, and seed coating.
[5]Includes paints and polishes, antiknock and other compounds, drilling mud, electrical and electronic products, insulation, magnetic tape, small packages, and miscellaneous and proprietary uses.

PRICES

Actual graphite prices are often negotiated between the buyer and seller, so price quotations represent the average of a range of prices. The source of information for imported graphite is the average customs value per ton of the different classes of imports, which can be derived from table 6. However, it should be noted that these mainly represent shipments of unprocessed graphite.

Average prices of graphite imports increased in 1980. Prices for crystalline flake rose from $391 per short ton in 1979 to $585 per short ton in 1980, or by 50%. Prices for other natural crude (mostly amorphous) graphite rose from $100 per short ton in 1979 to $134 per short ton in 1980, or by 34%. These prices reflect the tightness of the market, increases in producers' costs generated by worldwide economic conditions, and/or the strong position of some graphite producers.

Representative yearend prices of several types of imported graphite, as published in the Engineering and Mining Journal, are shown in the following tabulation.[8] All prices are f.o.b. the foreign port or border station and have been converted from metric tons.

	Per short ton	
	1979	1980
Flake and crystalline graphite, bags:		
China, mainland	$181- $907	$272-$1,361
Germany, Federal Republic of	327-1,633	381- 2,177
Madagascar	181- 508	272- 816
Norway	236- 363	318- 726
Sri Lanka	227- 816	816- 2,268
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	59- 68	71- 82
Mexico (bulk)	36- 64	54- 77

FOREIGN TRADE

Exports of natural graphite in 1980 were little changed from 1979.

Imports of natural graphite decreased 30% to 57,630 tons in 1980. Brazil gained significantly in importance in 1980, rising from 2,820 tons in 1979 to 4,305 tons in 1980, the result of a sizable amount of artificial graphite being exported for the first time.

Exports of graphite electrodes totaled 77,443 short tons ($123.1 million) in 1980, of which 10,556 tons ($15.1 million) went to Canada, 10,132 tons ($17.5 million) to Venezuela, 6,741 tons ($12.4 million) to Brazil, 6,064 tons ($12.4 million) to Argentina, 6,048 tons ($11.6 million) to the Federal Republic of Germany, and the balance to other destinations. Imports of graphite electrodes totaled 30,786 short tons ($38.1 million) in 1980, of which 18,112 tons ($26.8 million) came from Japan, 4,888 tons ($4.6 million), from France, 2,096 tons ($2.4 million), from Italy, and the balance, from other sources.

Table 5.—U.S. exports of natural graphite, by country

Destination	Natural[1]		Artificial		Total	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1979	8,623	$3,740,735	7,972	$4,802,454	16,595	$8,543,189
1980:						
Australia	83	67,235	1,006	721,376	1,089	788,611
Canada	3,351	1,263,514	1,618	556,500	4,969	1,820,014
Germany, Federal Republic of	1,313	476,132	257	143,202	1,570	619,334
Japan	504	233,685	1,403	977,639	1,907	1,211,324
Mexico	1,085	457,927	1,270	243,187	2,355	701,114
Netherlands	--	--	925	427,241	925	427,241
South Africa, Republic of	--	--	184	511,576	184	511,576
United Kingdom	694	273,708	505	415,939	1,199	689,647
Venezuela	703	355,881	39	97,405	742	453,286
Other	1,147	567,233	2,074	1,543,745	3,221	2,110,978
Total	8,880	3,695,315	9,281	5,637,810	18,161	9,333,125

[1]Amorphous, crystalline flake, lump or chip, and natural, n.e.s.

Table 6.—U.S. imports for consumption of natural and artificial graphite, by country

Year and country	Natural: Crystalline flake: Quantity (short tons)	Natural: Crystalline flake: Value (thousands)	Natural: Crystalline lump, chip or dust: Quantity (short tons)	Natural: Crystalline lump, chip or dust: Value (thousands)	Natural: Other natural crude and refined: Quantity (short tons)	Natural: Other natural crude and refined: Value (thousands)	Artificial[1]: Quantity (short tons)	Artificial[1]: Value (thousands)	Total: Quantity (short tons)	Total: Value (thousands)
1978	7,867	$2,572	279	$105	88,538	$7,300	3,307	$1,723	99,991	$11,700
1979:										
Australia	--	--	--	--	17	6	(2)	2	17	8
Austria	--	--	--	--	17	3	--	--	17	3
Brazil	1,458	505	112	39	1,250	394	--	--	2,820	938
Canada	--	--	--	--	27	7	751	189	778	196
China:										
Mainland	188	79	--	--	2,695	769	--	--	2,883	848
Taiwan	--	--	--	--	15	13	--	--	15	13
Finland	--	--	--	--	6	9	--	--	6	9
France	--	--	--	--	61	13	--	--	61	13
Germany, Federal Republic of	178	119	--	--	930	680	914	327	2,022	1,126
India	60	20	--	--	--	--	76	17	136	37
Japan	1	1	--	--	239	250	63	321	303	572
Korea, Republic of	--	--	--	--	11,574	788	--	--	11,574	788
Madagascar	3,379	1,351	--	--	1,782	573	--	--	5,161	1,924
Malaysia	--	--	--	--	218	75	--	--	218	75
Mexico	--	--	--	--	51,026	1,957	--	--	51,026	1,957
Netherlands	--	--	--	--	(2)	1	20	25	20	26
Norway	521	172	--	--	1,180	381	--	--	1,701	553
Sri Lanka	131	70	323	113	1,644	958	--	--	2,098	1,141
Sweden	--	--	--	--	33	61	--	--	33	61
Switzerland	--	--	--	--	2	4	1,594	2,011	1,596	2,015
U.S.S.R	--	--	--	--	3,644	710	--	--	3,644	710
United Kingdom	54	17	--	--	2	6	--	--	56	23
Total[3]	5,970	2,334	435	151	76,363	7,657	3,419	2,893	86,185	13,035
1980:										
Austria	--	--	--	--	18	5	--	--	18	5
Belgium-Luxembourg	--	--	--	--	17	19	--	--	17	19
Brazil	2,921	1,634	--	--	345	168	1,039	582	4,305	2,385
Canada	530	152	22	5	451	130	518	127	1,521	414
China:										
Mainland	228	152	--	--	2,222	943	--	--	2,450	1,095
Taiwan	--	--	--	--	55	27	--	--	55	27
France	199	116	--	--	3	12	--	--	202	129
Germany, Federal Republic of	160	166	--	--	800	697	32	428	992	1,291
Hong Kong	88	104	--	--	165	95	--	--	253	198
India	55	37	--	--	--	--	--	--	55	37
Japan	--	--	--	--	346	307	191	1,050	537	1,357
Madagascar	2,011	1,063	--	--	462	144	--	--	2,473	1,207
Mexico	137	106	--	--	40,277	1,677	--	--	40,414	1,784
Netherlands	18	6	--	--	--	--	3	1	21	7
Norway	71	28	--	--	173	95	--	--	244	122
South Africa, Republic of	137	83	--	--	279	144	--	--	416	227
Sri Lanka	597	541	77	43	1,036	1,076	--	--	1,710	1,661
Sweden	--	--	--	--	18	53	--	--	18	53
Switzerland	(2)	3	--	--	--	--	1,905	2,585	1,905	2,588
U.S.S.R	--	--	--	--	3,594	1,089	--	--	3,594	1,089
United Kingdom	36	12	--	--	82	45	(2)	12	118	69
Venezuela	--	--	--	--	(2)	1	--	--	(2)	1
Total[3]	7,188	4,203	99	48	50,343	6,728	3,688	4,787	61,318	15,765

[1]Includes only that received in raw material form; excludes products made of graphite.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World production of natural graphite increased 1% from 1979 to 1980. Supplies of amorphous graphite continued to be adequate domestically and in the world. Supplies of crystalline graphite were tight, as was true in 1979; supplies of coarse crystalline flake graphite were not only as tight as they were in 1979 but even grew somewhat tighter.

Australia.—A crystalline flake graphite mine is under consideration by Consolidated Resources. The deposit is about 75 miles west of Esperance near the Munglinup River in Western Australia. The ore has been successfully treated to a 98.5% concentrate at a pilot plant. The company will develop the deposit if long-term sales contracts can be obtained.[9] A lump graphite deposit has also attracted the attention of some developers.

Canada.—Asbury Grafite de Quebec, a subsidiary of Asbury Graphite Mills, Inc., opened a crystalline flake graphite mine in July at Notre Dame de Laus, 150 miles north of Montreal. There will probably be enough ore to last 10 to 20 years.[10] Graphite production from this mine will raise Canadian production almost to the level of such medium-sized crystalline flake producers as Brazil and Norway and is also reflected in the increase in U.S. crystalline flake graphite imports from Canada in 1980.

Germany, Federal Republic of.—Government geologists have conducted an airborne geophysical survey and subsequent core drilling that revealed some graphite deposits in a previously unexplored area near Kropfmuehl, in Bavaria.[11] Graphitwerk Kropfmuehl extended its mining at Kropfmuehl by nearly a mile of new tunnels at the Erhard shaft, thus improving its productive capability.[12] In addition to producing a wide variety of flake, powder, and micron-size graphite at its domestic mine, Graphitwerk Kropfmuehl also has graphite-producing affiliates in the Republic of South Africa, Namibia, and Zimbabwe.

India.—The Rajasthan State Mineral Development Corp. has approved the construction of a small graphite beneficiation plant near Talmatia in the Banwara District that would use local ores at the rate of almost 900 tons per day.[13] Sri Lanka has sought Indian participation, up to a 49% holding, in graphite-based industries in Sri Lanka that would produce items such as foundry facing material, lubricants, paints, and carbon brushes.[14] Crystalline lump graphite from Indian sources, probably mined near Madras, was offered on the world market for the first time.

Madagascar.—The main producers of crystalline flake graphite continued to have problems with equipment failures in 1980. Production was also held down by very bad weather in the early part of the year.[15]

Mexico.—Grafitos Mexicanos S.A., which has usually accounted for about 60% of Mexican amorphous graphite production, is conducting an exploration program to develop some new deposits.[16]

Grafito de Mexico S.A. de C.V., a Government-owned company, has started up a crystalline flake mining operation at Telixtlahuanco in Oaxaca State, the first crystalline flake operation in Mexico. The mine will initially produce almost 3,900 short tons per year of graphite with a carbon content of 95.5% from reserves totaling over 5.5. million tons. Capacity can be easily doubled if there is enough demand. Problems associated with obtaining adequate supplies of graphite from Madagascar and high import tariffs spurred the creation of this new enterprise.[17]

Sri Lanka.—Production at the Bogala Mine, which usually accounts for about 55% of Sri Lankan output, was severely disrupted in 1980 by a decrease in availability of hydroelectric power caused by a drought. In addition, all mines had trouble with equipment failures.[18]

U.S.S.R.—The increasing demand from a wide range of domestic industries in the last few years has resulted in increased production. The Government is planning to increase demand for amorphous graphite by shifting the demand in a number of industrial uses from crystalline graphite types, mostly flake, to amorphous graphite.[19] It also stopped selling crystalline flake graphite to North American destinations in mid-1980. The Soviet Union attempted to purchase crystalline flake graphite from Madagascan producers in the middle of the year but was refused by the producers because of the nonavailability of product.

Zimbabwe.—The coowners of this nation's major mine, the Lynx Mine near Koroi, are planning to double the capacity to over 13,000 short tons per year. The mine would have enough reserves for over 25 years at the expanded rate. The owners are the Zimbabwe Industrial Development Corp. and Graphitwerk Kropfmuehl, a West German firm.[20]

Table 7.—Graphite: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Argentina	160	94	28	11	[3]13
Austria	36,439	38,898	44,645	44,664	44,000
Brazil (marketable)	6,634	10,127	11,417	11,979	13,200
Burma[4]	177	106	309	295	300
China, mainland[e]	55,000	66,000	88,000	110,000	110,000
Czechoslovakia[e]	49,600	49,600	49,600	49,600	49,600
Germany, Federal Republic of[e] [5]	[r]10,528	[r]9,178	7,034	4,047	4,000
India	42,189	53,412	70,310	56,141	[3]53,787
Italy	4,242	4,210	4,528	4,522	4,500
Korea, North[e]	[r]22,000	[r]22,000	[r]22,000	28,000	28,000
Korea, Republic of:					
Amorphous	42,193	68,904	59,288	59,789	[3]65,209
Crystalline flake	3,762	3,799	2,793	2,704	[3]1,575
Madagascar	19,193	17,336	18,326	15,699	16,000
Mexico:					
Amorphous	66,510	64,410	57,611	56,086	61,000
Crystalline flake	--	--	--	--	200
Norway	9,999	10,028	12,292	13,226	12,200
Romania[e]	6,600	6,600	6,600	6,600	6,600
Sri Lanka	[r]9,138	9,783	11,581	10,397	10,600
South Africa, Republic of	584	1,004	643	434	--
Thailand	33	33	25	25	25
Turkey	NA	NA	NA	231	220
U.S.S.R.[e]	105,000	105,000	110,000	110,000	110,000
United States	W	W	W	W	--
Zimbabwe	[e]5,500	[e]5,500	[e]6,000	6,324	6,400
Total	[r]495,481	[r]546,022	583,030	590,774	597,429

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 18, 1981.

[2]In addition to the countries listed, Namibia may have produced graphite during the period covered by this table, but output is unreported and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Reported figure.

[4]Data are for fiscal year beginning Apr. 1 of that stated.

[5]Series revised; data now presented represents estimated marketable product derived from raw graphite mined indigenously, assuming that marketable output equals one-half of officially reported raw graphite production.

TECHNOLOGY

Advances in technology in 1980 were almost all concentrated on various synthetic graphite products, and mostly on graphite fiber.

Several new products were introduced in 1980. A composite made from aluminum or magnesium and reinforced with graphite fibers is reportedly 33% lighter, stronger, and four times more rigid than aluminum, and in addition does not expand or contract significantly.[21] A new graphite fiber (30-million-modulus) reinforced nylon has been developed for use in injection molding, where it substitutes for aluminum on the basis of its equal strength at only half the weight.[22] A new resin-bonded carbon-magnesite brick containing up to 20% natural graphite has gone into production and is expected to replace conventional carbon-magnesite products that go through an energy-intensive firing process. The new resin-bonded brick is said to have better oxidation resistance and thermal conductivity in certain uses as well.[23] The technical and economic feasibility of making solar-cell-quality sheet silicon by coating a ceramic substrate with graphite on one side and then dipping the graphite-coated surface into molten silicon to obtain a uniform thin layer of large-grain polycrystalline silicon continued to be investigated.[24]

Basic research into the nature of carbynes, a much rarer elemental form of carbon than graphite or even diamond, led to the discovery of carbynes in two primitive meteorites. However, traces of carbynes have also been found in terrestrial graphites. A team from Argonne National Laboratory has made a breakthrough in easily synthesizing carbynes by heating a mixture of carbon monoxide and hydrogen at 600° F in the presence of a chromite catalyst to yield metastable carbynes.[25]

Investigation into intercalated graphite compounds, which are called "synthetic metals" because of their ability to conduct electricity better than copper and which are actually graphite with certain chemicals inserted between the sheets of the sheetlike crystal structure, disclosed possible uses in powerful lightweight batteries and lightweight transmission lines.[26]

Research into high-temperature structural ceramics made from silicon carbide formed by reacting graphite powder or cloth with silicon has been accelerating. Reaction-sintered silicon carbide is made by forming a green body from silicon carbide powder, graphite, and a plasticizer by extruding or injection-molding, pyrolyzing the green body, and then reacting it with liquid silicon or silicon vapor and thus reaction-sintering the components. Reaction-sintered silicon carbide has been used in a variety of gas turbine components. Reaction-formed silicon carbide fiber-silicon composites, made by taking a preform made from graphite cloth, felt, or chopped fiber and infiltrating it with liquid silicon to form a silicon carbide fiber-silicon-matrix composite, has been used in an experimental combustion liner and gives promise of being useful in a wide range of ceramic items.[27]

Another newly developed process allows the production of high-modulus graphite fiber from commercial-grade acrylic fiber.[28]

The increased demand for strong, lightweight materials has resulted in a large number of new fibers and grades that can be used in a variety of end uses. The high cost of these fibers is the only barrier preventing mass marketing. The recent development and forthcoming production of pitch-based, high-modulus graphite fiber is likely to halve the price of high-modulus graphite fiber, now mostly produced from PAN. Graphite fiber has advantages of cost, strength, or stiffness over other reinforcing fibers.[29]

The automobile industry is trying to adapt graphite fiber composites to its requirements for lightweight, high-strength materials resulting from its need to reduce the weight of automobiles. Since any composite must be low-cost and easily fabricated, the cost will be kept down by using a blend of graphite fiber and low-cost glass fiber, and easy fabricability and high-volume production will be attained by using quick-curing polyesters and injection-moldable thermoplastics such as nylon. Automobile parts made of graphite fiber-containing composites that are in or near production include an air-conditioner mounting bracket, a driveshaft, and a leaf spring.[30]

A comprehensive article appeared on the properties and functions of the fiber and matrix components of fiber-reinforced composites and their manufacturing and fabrication. It emphasized the commercially available fibers, or glass, graphite, and Kevlar, and important matrix materials, such as the polyesters and epoxys, and how they might be adapted to various end uses. One possible new use, an experimental automobile designed for maximum use of graphite fiber composites, required 400 pounds of graphite fiber per vehicle and resulted in a vehicle that weighed only two-thirds of the weight of the standard vehicle.[31]

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Gypsum

By J. W. Pressler[1]

The gypsum industry suffered a severe decrease in demand starting in March 1980, and, as reflected by only 1.3 million housing unit starts for 1980 (public and private), ended the year with the lowest shipments of gypsum wallboard since 1976, a decrease of 15% compared with 1979 shipments. In 1980, output of crude gypsum decreased 16% to 12.3 million tons. Production of calcined gypsum decreased 19% to 11.8 million tons. Sales of gypsum products in 1980 decreased 11% to 19.5 million tons, and total value of gypsum products sold decreased 11% to $1.2 billion. Imports of crude gypsum decreased 5% in 1980 to 7.4 million tons.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Active mines and plants[1]	117	115	116	113	122
Crude:					
Mined	11,980	13,390	14,891	14,630	12,376
Value	$59,888	$74,341	$92,726	$99,868	$103,059
Imports for consumption	6,231	7,074	8,308	7,773	7,365
Byproduct gypsum sales	573	797	669	828	663
Calcined:					
Produced	11,036	12,590	14,041	14,543	11,848
Value	$236,775	$277,835	$387,010	$442,157	$270,324
Products sold (value)	$654,860	$910,526	$1,248,013	$1,391,993	$1,241,949
Exports (value)	$32,594	$15,703	$19,804	$22,388	$27,222
Imports for consumption (value)	$21,756	$31,398	$63,882	$65,079	$51,880
World: Production	r72,888	r78,718	r83,839	r83,455	78,290

rRevised.
[1]Each mine, calcining plant, or combination mine and plant is counted as one establishment; includes plants that sold byproduct gypsum.

DOMESTIC PRODUCTION

The United States was the world's leading producer of gypsum, accounting for 16% of the total world output.

In 1980, 45 companies mined crude gypsum at 73 mines in 22 States. Output decreased 15% compared with that of 1979. Leading producing States were Texas, California, Iowa, Michigan, and Oklahoma. These five States produced more than 1 million tons each and together accounted for 61% of the total domestic production. Stocks of crude ore at mines and plants at yearend 1980 were 3.2 million tons.

Leading companies in 1980 were United States Gypsum Co. (12 mines), National Gypsum Co. and Georgia-Pacific Corp. (6 mines each), Celotex Div. of Jim Walter Corp. and The Flintkote Co. (3 mines each), and H. M. Holloway, Inc. (1 mine). These 6 companies, operating 31 mines, produced 77% of the total crude gypsum in 1980.

Leading individual mines in 1980 were United States Gypsum's Plaster City Mine, Imperial County, Calif.; National Gypsum's Tawas Mine, Iosco County, Mich.; United States Gypsum's Shoals Mine, Martin County, Ind.; United States Gypsum's Sweetwater Mine, Nolan County, Tex.; United States Gypsum's Southard Mine, Blaine County, Okla.; National Gypsum's Shoals Mine, Martin County, Ind.; and H. M. Holloway's Lost Hills Mine, Kern County, Calif. These seven mines accounted for 34% of the national total. Average output per mine in 1980 for the 73 U.S. mines was 169,500 tons, compared with 225,000 tons per mine in 1979.

In 1980, 15 companies calcined gypsum at 72 plants in 30 States. Output decreased from 14.5 million tons of calcine valued at $442 million in 1979 to 11.8 million tons valued at $270 million in 1980, a tonnage decrease of 19% and a value decrease of 39% compared with that of 1979. Output in 1980 was the lowest since 1976. Leading States were California, Texas, Iowa, and New York. These 4 States, with 23 plants, accounted for 37% of the national output.

Leading companies were United States Gypsum (22 plants), National Gypsum (19 plants), Georgia-Pacific (9 plants), Flintkote (6 plants), and Celotex Div. of Jim Walter Corp. (4 plants). These 5 companies, operating 60 plants, accounted for 85% of the national output in 1980.

Leading individual plants were United States Gypsum's Plaster City plant, Imperial County, Calif.; United States Gypsum's Stony Point plant, Rockland County, N.Y.; Weyerhaeuser's Briar plant, Howard County, Ark.; United States Gypsum's Shoals plant, Martin County, Ind.; United States Gypsum's Sweetwater plant, Nolan County, Tex.; Georgia-Pacific's Acme plant, Hardeman County, Tex.; United States Gypsum's Jacksonville plant, Duval County, Fla.; National Gypsum's Shoals plant, Martin County, Ind.; United States Gypsum's Southard plant, Blaine County, Okla.; and United States Gypsum's Fort Dodge plant, Webster County, Iowa. These 10 plants accounted for 27% of the national output. Average output per plant in 1980 for the 72 U.S. plants was 164,600 tons, compared with 202,000 tons per plant in 1979.

In 1980, the following companies sold a total of 663,000 tons of byproduct gypsum, valued at $5.7 million, for agricultural purposes: Occidental Petroleum Corp., Allied Chemical Corp., and SimCal Chemical Co. (all in California); Occidental Petroleum Corp. (Florida); Texasgulf Inc. (North Carolina); and American Cyanamid Co. (Georgia).

Several gypsumboard plant expansions and improvements increased the national production capacity an additional 0.44 billion square feet per year. The available capacity of operating gypsumboard plants in the United States at yearend 1980 was 18.67 billion square feet per year, a 2% increase compared with that of yearend 1979. Total 1980 gypsumboard production in the United States was 14.1 billion square feet. This indicated a 76% national utilization of capacity for the year. Domtar Gypsum America Inc. started construction of a major $17 million gypsum wallboard plant on the Blair Waterway at the Port of Tacoma, Wash., and will have an annual rated capacity of 300 million square feet of gypsum wallboard products. Project completion is scheduled for the spring of 1981.[2]

United States Gypsum Co. designated $25 million for a major wallboard plant expansion in Florida. The company's Jacksonville, Fla., gypsumboard plant capacity will be increased to 600 million board feet. The plant is slated for completion in 1981, and will make it one of the largest gypsum production centers in the world. The plant was built in 1939, and in addition to gypsum wallboard, it also produces textured and predecorated panels and plaster products.[3]

United States Gypsum is also expanding its Sperry, Iowa, gypsumboard plant and mine. The plant, built in 1961, primarily serves markets in the Midwestern States. The expansion is expected to be completed by mid-1982 and will increase the plant's capacity by 27%.[4]

During 1980, 140 million square feet of board capacity was added at United States Gypsum's Oakfield, N.Y., plant, and an expansion project was underway at the Sweetwater, Tex., plant.[5]

In late 1980, Valley Nitrogen Producers, Inc., was taken over by the agricultural conglomerate, Simplot (Boise, Idaho), a private company owned by founder J. R. Simplot and his family. Simplot expects Valley, rechristened SimCal Chemical Co., to help make it a major force in the California fertilizer market. SimCal is a major producer of byproduct gypsum for agricultural use.[6]

United States Gypsum purchased 37 acres of land fronting the deepwater channel near the Port of Sacramento, Calif. The company reported that it intends to construct a gypsum wallboard plant on the site with a capacity of up to 500 million square feet of wallboard annually.[7]

Table 2.—Crude gypsum mined in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Active mines	1979 Quantity	1979 Value	1980 Active mines	1980 Quantity	1980 Value
Arizona	4	231	1,245	4	209	2,017
Arkansas, Kansas, Louisiana	5	1,171	5,584	5	1,040	6,047
California	3	1,624	10,355	8	1,644	12,763
Colorado	4	275	1,727	6	227	3,409
Idaho, Montana, South Dakota, Washington	6	161	1,393	6	128	1,431
Indiana, New York, Virginia	4	1,430	13,021	4	1,501	13,646
Iowa	6	1,695	13,777	6	1,468	13,136
Michigan	5	2,526	14,633	5	1,382	8,605
Nevada	3	1,075	6,771	4	852	8,276
New Mexico	3	251	3,244	3	182	1,688
Ohio	1	151	1,359	1	136	1,346
Oklahoma	6	[r]1,480	[r]9,770	6	1,326	11,230
Texas	7	1,903	11,438	7	1,681	14,124
Utah	5	[r]292	[r]2,450	5	287	2,612
Wyoming	3	366	3,100	3	312	2,731
Total[1]	65	14,630	99,868	73	12,376	103,059

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 3.—Calcined gypsum produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Active plants	1979 Quantity	1979 Value	1980 Active plants	1980 Quantity	1980 Value
Arizona, Colorado, New Mexico, Utah	6	591	17,401	6	461	12,048
Arkansas, Illinois, Indiana, Kansas, Louisiana, Oklahoma	12	2,772	77,277	12	2,293	48,313
California	7	1,818	45,651	7	1,457	24,776
Delaware, Maryland, Virginia, North Carolina	6	1,074	41,569	6	1,154	29,702
Florida	3	659	18,359	3	637	15,998
Georgia	3	678	22,098	3	621	18,455
Iowa	5	1,077	32,121	5	912	17,505
Massachusetts, New Hampshire, New Jersey, Pennsylvania	5	822	23,063	5	674	15,425
Michigan	4	752	27,260	4	386	10,764
Montana, Washington, Wyoming	4	505	16,597	4	373	10,261
Nevada	3	802	15,010	3	576	10,653
New York	5	1,187	48,074	5	768	21,626
Ohio	3	408	11,667	3	302	7,191
Texas	6	1,398	46,010	6	1,235	27,608
Total[1]	72	14,543	442,157	72	11,848	270,324

[1]Data may not add to totals shown because of independent rounding.

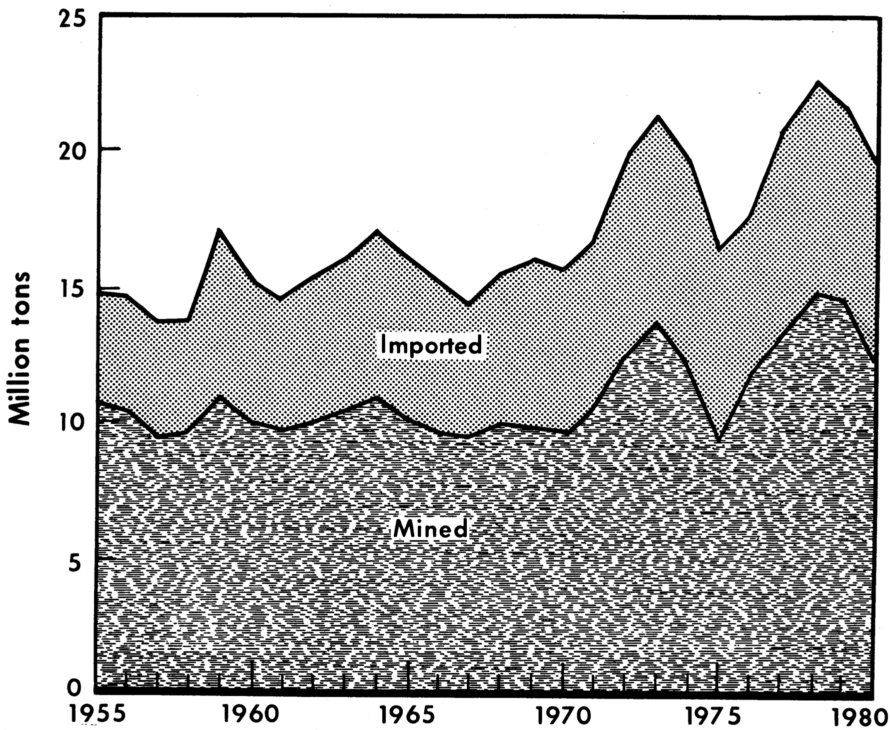

Figure 1.—Supply of crude gypsum in the United States.

CONSUMPTION AND USES

Apparent consumption of crude gypsum in 1980 (production plus imports, minus exports) decreased 12% to 20.0 million tons. Imports provided 37% of the crude gypsum consumed. Apparent consumption of calcined gypsum in 1980 decreased 19% to 11.8 million tons.

Stocks of crude gypsum at mines and calcining plants at yearend 1980 were 3.2 million tons. Of this, 1.3 million tons (40%) was at calcining plants in coastal States.

Of the total gypsum products sold or used in 1980, 5.7 million tons (29%) was uncalcined. Of the total uncalcined gypsum, 3.9 million tons (68%) was used for portland cement and 1.7 million tons (29%) was used in agriculture. The leading sales regions in 1980 for gypsum used in cement were the West South Central, Pacific, and Middle Atlantic; these three regions accounted for 45% of the total. For agricultural gypsum, the Pacific sales region accounted for 73% of the total.

Of the total calcined gypsum in 1980, 94% was used for prefabricated products and 6% for industrial and building plasters. Of the prefabricated products, 75% was regular wallboard, 21% was fire-resistant Type X wallboard, 2% was veneer base, and sheathing and predecorated wallboard were 1% each. Of the regular wallboard, 84% was 1/2 inch and 8% was 3/8 inch. The leading sales regions for prefabricated products were the South Atlantic, Pacific, and West South Central, accounting for 52% of the total. For industrial and building plasters, the East North Central, Middle Atlantic, and Pacific regions accounted for 55% of the total.

Table 4.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Uncalcined:				
Portland cement	4,024	38,223	3,885	41,440
Agriculture[1]	1,700	14,064	1,658	19,121
Fillers and miscellaneous	124	3,846	135	4,353
Total	[2]5,849	56,133	5,678	64,914
Calcined:				
Industrial plaster	365	23,663	393	28,296
Building plaster:				
Regular base coat	134	6,733	143	7,657
Mill-mixed base coat	98	6,725	89	6,985
Veneer plaster	98	8,591	79	7,942
Gaging, molding, Keene's cement	30	2,493	30	2,733
Other[3]	56	2,892	57	3,694
Total	416	27,434	398	29,011
Prefabricated products[4]	15,203	1,284,763	13,025	1,119,728
Total calcined	15,984	1,335,860	13,816	1,177,035
Grand total	21,833	1,391,993	19,494	1,241,949

[1]Includes 828,254 tons of byproduct gypsum in 1979 and 662,987 tons in 1980.
[2]Data do not add to total shown because of independent rounding.
[3]Includes roof deck concrete and other uses.
[4]Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated products sold or used in the United States, by product

Product	1979 Thousand square feet	1979 Thousand short tons[1]	1979 Value (thousands)	1980 Thousand square feet	1980 Thousand short tons[1]	1980 Value (thousands)
Lath:						
3/8 inch	117,729	92	$9,827	75,319	58	$6,323
1/2 inch	7,330	7	665	3,730	3	308
Total	125,059	99	10,492	79,049	61	6,631
Veneer base	444,154	396	33,498	338,362	353	26,051
Sheathing	220,006	204	20,278	199,416	176	17,487
Regular gypsumboard:						
3/8 inch	732,575	596	54,728	710,998	548	51,058
1/2 inch	11,247,016	9,796	805,538	8,910,714	7,763	644,931
5/8 inch	833,493	777	74,332	822,033	755	73,437
1 inch	20,816	43	3,263	32,034	49	5,960
Other[2]	[r]235,681	[r]145	[r]18,304	74,881	54	9,606
Total	[r]13,069,581	[r]11,357	[r]956,165	10,550,660	9,169	784,992
Type X gypsumboard	2,617,147	2,923	226,689	2,637,933	2,998	231,539
Predecorated wallboard	252,883	224	37,641	118,838	105	35,224
5/16-inch mobile home board	NA	NA	NA	219,975	164	17,802
Grand total[3]	16,728,830	15,203	1,284,763	14,144,233	13,025	1,119,728

[r]Revised. NA Not available.
[1]Includes weight of paper, metal, or other material.
[2]Includes 1/4-, 5/16-, 7/16-, and 3/4-inch gypsumboard in 1979, but excludes 5/16-inch mobile home board in 1980.
[3]Data may not add to totals shown because of independent rounding.

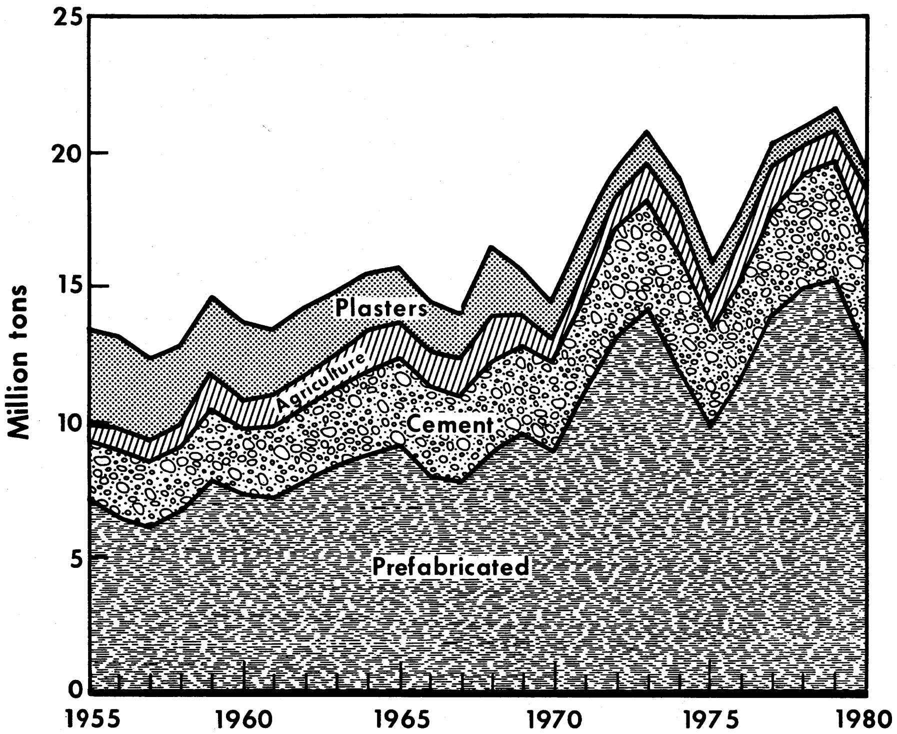

Figure 2.—Sales of gypsum products, by use.

ENERGY

Although the gypsum industry's national operational capacity was only 76% for 1980, efficient production scheduling, improved insulation, and energy-saving processing equipment such as one-step drying and calcining, combined to approximate the same utilization of energy as in 1979. The Gypsum Association reaffirmed its improvement target of 22% by 1985, compared with the base year of 1972. In 1980, British thermal unit consumption per thousand square feet of gypsum wallboard sales was 2.65 million.

As reported by the Gypsum Association, fuel sources for the gypsum industry at yearend 1980 were natural gas, 80.0%; propane, 3.0%; electricity, 5.5%; fuel oil, No. 2 and No. 6, 8.5%; and coal, 3.0%.

PRICES

The average value of crude gypsum increased from $6.83 per ton in 1979 to $8.33 in 1980. The average value of calcined gypsum decreased from $30.40 per ton in 1979 to $22.82 in 1980 as a result of reappraisal by the major producers of the in-process value of stucco in the manufacture of wallboard and plaster products. The average value of byproduct gypsum sold increased from $6.05 per ton in 1979 to $8.56 in 1980.

The average value of gypsum products sold or used remained almost the same, at $63.53 per ton in 1980, compared with $63.70 in 1979. In 1980, prefabricated products were valued at $85.84 per ton, industrial plasters at $72.00 per ton, building plaster at $72.89 per ton, and uncalcined products at $11.43 per ton.

Quoted prices for gypsum products are published monthly in Engineering News-Record. Prices at yearend 1980 showed a wide range, based on truck lots delivered to the job. Regular 1/2-inch wallboard prices ranged from $79 per thousand square feet in Dallas to $145 in Minneapolis. Average price at yearend for 19 cities was $122 per thousand square feet, with some minor discounts for prompt settlement. Prices for building plaster in 1980 ranged from $75 per ton at St. Louis to $146 at New York.

FOREIGN TRADE

In 1980, the gypsum industry continued to rely on imports for 35% of apparent consumption. Imports of crude gypsum were from Canada (74%), Mexico (21%), Spain (3%), and the Dominican Republic, Jamaica, the Bahamas, and Italy, (the remaining 2%). Imports decreased 5% compared with those of 1979 to 7.4 million tons. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico. For 1980, total value of gypsum and gypsum products imported was $51.9 million, a 20% decrease compared with 1979 value. In 1980, 149 million square feet of wallboard was imported from Canada, a 56% decrease compared with that of 1979. Total value of gypsum product exports to all countries was $27.2 million in 1980, a 22% increase compared with 1979 value.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Other manufactures n.e.c. (value)[1]	Total value
	Quantity	Value		
1978	132	8,752	11,052	19,804
1979	91	10,891	11,497	22,388
1980	88	11,774	15,448	27,222

[1]Includes gypsum or plaster building boards and lath (TSUSA 245.7000), and articles, not specifically provided for, of plaster of Paris (TSUSA 512.4500).

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude		Ground or calcined		Alabaster manufactures[1] (value)	Plasterboard[2] (value)	Other manufactures n.s.p.f.[3] (value)	Total value
	Quantity	Value	Quantity	Value				
1978	8,308	33,085	3	306	2,976	24,710	2,805	63,882
1979	7,773	34,095	2	194	2,319	25,379	3,092	65,079
1980	7,365	35,664	2	231	1,959	10,958	3,068	51,880

[1]Includes imports of jet manufactures, which are believed to be negligible.
[2]Includes gypsum or plaster building boards and lath (TSUSA 245.7000).
[3]Comprised of "articles, not specifically provided for, of plaster of Paris, with or without reinforcement" (TSUSA 512.3100, 512.3500, 512.4100, and 512.4400).

Table 8.—U.S. imports for consumption of crude gypsum, by country

(Thousand short tons and thousand dollars)

Country	1979		1980	
	Quantity	Value	Quantity	Value
Austria	--	--	1	2
Bahamas	--	--	7	39
Canada[1]	5,700	24,324	5,463	25,607
Dominican Republic	80	686	69	623
Italy	(2)	28	(2)	21
Jamaica	5	34	11	71
Mexico	1,851	8,370	1,565	8,030
Norway	12	49	--	--
Poland	(2)	1	--	--
Spain	125	604	250	1,271
United Kingdom	(2)	(2)	(2)	1
Total	7,773	[3]34,095	7,366	35,665

[1]Includes anhydrite.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

WORLD REVIEW

Domestic and foreign resources of gypsum are adequate for any foreseeable time. World reserves are conservatively estimated at 2.4 billion tons. Total world production figures may be somewhat low since in some countries only sales of gypsum are recorded, and much of the mine production is consumed by the company in what is frequently an integrated industrial plant producing plaster, wallboard, and other gypsum products.

Austria.—Austrian gypsum and anhydrite mines are found in the Northern Calcareous Alps, although there are occurrences in the south of the country. Total production in 1980 was 919,000 tons, a 4% increase over the previous year; however, the production of anhydrite dropped off appreciably. There are eight producing companies, and almost 80% of the production comes from four of them. Two mines, the Mooseg-Abtenau Mine of Erste Salzburger Gipswerke-Gesellschaft Christian Moldan AG, and the Grundlsee Mine of Rigips Austria AG, produce both gypsum and anhydrite. The Grundlsee Mine is unique in that it produces gypsum from its open pit mine and anhydrite from its underground mine. The drop in demand for anhydrite was mainly due to a fall in sales to Chemie Linz, which has a plant producing cement and sulfuric acid from anhydrite, coke or coal, silica, and clay. Chemie Linz has substituted phosphogypsum from its own phosphoric acid units.[8]

Canada.—Canada continued to be the second leading producer of crude gypsum and anhydrite in 1980, accounting for 10% of the world total with shipments of 7.9 million tons, even though it was an 11% decrease from the 1979 level. As an exception, shipments were greater from British Columbia and Manitoba, due to good activity in housing and cement shipments, and Manitoba shipments were greater than in 1979 because of the new quarry operations at Amaranth.

Of the crude gypsum produced on the Canadian Atlantic seaboard, 70% is shipped to company wallboard plants in the Eastern United States from their subsidiary operations. Manitoba production from Windermere in British Columbia supplies the Prairie and British Columbia markets. Some imports from San Marcos Island in Mexico are used by both wallboard and cement producers in British Columbia.

Domtar Inc.'s new wallboard plant at Caledonia, Ontario, began production on schedule in 1980. The new plant incorporates an energy- and labor-saving, one-step grinding and calcining technique to produce stucco. Domtar's long-term plans include development of a new underground mine there. Westroc Industries Ltd. began producing wallboard from its new Calgary plant during 1980. Canadian Gypsum Co., Ltd., closed its 70-year-old Hillsborough, New Brunswick, plant on December 31, 1980, claiming the plant had been inefficient for many years, and the regional market would not support a new optimum-sized plant.[9]

Egypt.—Egyptian Gypsum, Marble and Quarries Co. of Cairo has awarded a contract for the construction of a gypsum plant in Alexandria to Claudius Peters of Hamburg. The $20 million plant and quarry is scheduled to produce 300,000 tons per year of gypsum, of which 50,000 tons per year will be used to manufacture gypsum blocks for housing construction.[10]

France.—France is the third leading producer of gypsum in the world, at a production level of about 6.6 million tons per year. Around 80% of the gypsum and anhydrite produced is derived from the Paris Basin (4 million tons per year) and the Rhône Basin (1.8 million tons per year). Approximately 75% of the production is used to make plaster products, and 25% is used in the manufacture of cement, with small quantities used in glassmaking and for fertilizer applications. The French construction industry does not use plasterboard as much as other Western nations, but prefer to use plaster blocks for more solid construction. The total market for all thicknesses of plaster blocks in France is of the order of 150 million square feet per year.[11]

National Gypsum Co. of Dallas, Tex., announced that it is investing $25 million on expanding its gypsum joint venture in France. It was contributing capital to Pregypan S.A., a French company owned jointly by Lafarge (60%) and National Gypsum (40%). To maintain its working relationship, Lafarge will contribute its 95% ownership of Platrieres de France, which owns 17 facilities engaged in the mining and quarrying of gypsum rock and the production of gypsum plaster and gypsum block products.[12]

India.—India produced 943,000 tons of gypsum and anhydrite in 1980. India is one of the most important consumers for gypsum as a fertilizer, both in direct application and as a raw material in the manufacture of ammonium sulfate fertilizer. About 35% of the total consumption was used in agriculture, and all but 2% of the balance was used as a cement set-retarder.[13]

Iraq.—The Government of Iraq awarded a contract in 1980 for $81.3 million to Salzgitter AG and Knauff Engineering GmbH of the Federal Republic of Germany, to build four gypsum plants in Nineveh, Wasit, Salaheddin, and Arbil Governorates. The plants will form the nucleus of a gypsum products industry in Iraq. Two of the plants are scheduled to be completed within 16 months and the other two within 2 years.[14]

Mexico.—Mexico has large resources of gypsum, many deposits of which are mined in over nine states. In addition, large deposits occur in the three states of the Yucatan Peninsula. Production in 1979 was 2.2 million tons, over 80% of which was exported principally to the United States, with smaller tonnages to Canada. Domestic consumption is concentrated in those areas of greater construction activity such as Mexico City, Monterrey, and Guadalajara. The largest mining operation is on San Marcos Island in Baja California Sur, operated by Compania Occidental Mexicana S.A. de CV, owned 49% by Domtar Inc. of Canada, and the remaining 51% by 10 individual Mexican investors. Occidental Mexicana exported 1.3 million tons of gypsum to the west coast of the United States and Hawaii in 1980. The balance of Mexican crude gypsum exports to the United States came from the open pit operations of Yeso Mexicano S.A. (YM) at San Luis Potosi, shipped to the ports of New Orleans and Houston. Yeso El Tigre has an 80,000-ton-per-year calcined gypsum capacity at plants near Mexico City and Puebla. The company plans to double its capacity over the next 2 years.[15]

Oman.—A gypsum deposit has been found near Salalah in southern Oman, according to the Petroleum and Mineral Resources Ministry. It was stated that the surface deposit could support a 2,000-ton-per-year mining operation.[16]

Pakistan.—Gypsum occurs in abundance in Pakistan, and the Peshawar Laboratories of the Pakistan Council of Scientific & Industrial Research are developing a process for gypsum plaster production to meet some of the current shortages of portland cement. The council estimated that around 6 million tons per year of gypsum is available for exploitation as a construction material.[17]

Thailand.—The Fläkt Industrial Div. in Sweden received a $7 million contract for a complete gypsum wallboard production line for a plant to be built 26 miles north of Bangkok. Siam Fibre-Cement Co., Ltd., owner of several other building materials manufacturing plants, announced that the plant capacity would be 200 million square feet per year of wallboard.[18]

Tunisia.—The Governments of Tunisia, Algeria, and Morocco were forming a consortium to build a sulfuric acid recovery plant, using gypsum as the raw material. A 100-ton-per-day H_2SO_4 plant was scheduled to be built at Gafsa, and will use gypsum from mines at Meknassi. Initial cost of the project was put at $30 million.[19]

Table 9.—Gypsum: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada[3,4]	6,616	7,974	8,901	8,927	[5]7,947
Cuba[e]	94	100	105	100	100
Dominican Republic	243	249	190	193	190
El Salvador	[e]7	8	8	8	10
Guatemala	15	35	42	28	[5]37
Honduras	[e]11	20	[e]25	[e]25	25
Jamaica	279	237	148	64	66
Mexico	1,559	1,649	1,938	2,228	[5]1,884
Nicaragua[e]	33	40	40	40	44
United States[6]	11,980	13,390	14,891	14,630	[5]12,296
South America:					
Argentina	559	603	674	648	[5]656
Bolivia	[e]1	--	1	1	[5]1
Brazil[7]	[r]568	[r]608	512	515	550
Chile	134	[r]224	246	240	242
Colombia	226	231	281	283	285
Ecuador	48	[r]46	38	39	39
Paraguay	18	15	10	12	11
Peru	189	237	263	239	242
Venezuela	122	172	404	464	485
Europe:					
Austria[3]	849	[r]892	844	880	[5]919
Belgium[3]	242	185	202	212	210
Bulgaria	[r]256	[r]325	375	341	[5]343
Czechoslovakia	728	752	768	809	834
France[3]	7,308	6,649	6,654	6,503	6,600
German Democratic Republic	[r]375	[r]375	385	400	410
Germany, Federal Republic of (marketable)[3]	2,315	2,445	2,467	2,481	2,480
Greece	490	452	474	496	510
Ireland	391	377	432	460	463
Italy	1,652	[r]1,674	1,624	1,630	1,810
Luxembourg	2	3	1	1	1
Poland[e,7]	1,380	[r]1,480	1,490	1,500	1,430
Portugal	176	194	222	[r] [e]220	220
Spain	[e]4,600	[r]6,042	5,918	5,815	6,060
Switzerland[e]	80	80	80	80	80
U.S.S.R.[e,8]	5,500	5,700	5,800	6,000	6,500
United Kingdom[3]	3,693	3,648	3,662	[e]3,600	3,600
Yugoslavia	[r]465	[r]532	554	626	635
Africa:					
Algeria[e]	190	190	190	210	220
Angola[e]	22	[r]22	[r]28	[r]28	28
Egypt	[r]819	[r]923	875	877	[5]761
Ethiopia	--	7	1	1	1
Kenya[3]	86	29	[e]33	[e]33	33
Libya	66	320	198	200	200
Mauritania	12	11	15	18	19
Niger	3	[e]3	3	[e]3	2
South Africa, Republic of	532	485	429	416	[5]478
Sudan[3]	20	17	22	33	33
Tanzania	[r]9	9	24	12	12
Tunisia	43	[e]44	[e]44	[e]44	44
Zambia	5	5	2	([9])	[5]([9])
Asia:					
Afghanistan	NA	NA	7	NA	NA
Burma[10]	50	37	39	42	[5]40
China:					
Mainland[e]	1,100	1,100	[r]1,700	[r]2,200	2,200
Taiwan[8]	3	8	4	3	9
Cyprus	71	92	76	68	61
India	801	858	974	949	[5]943
Iran	7,165	7,600	8,800	[e]7,000	3,900

See footnotes at end of table.

Table 9.—Gypsum: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Asia —Continued					
Iraq[e]	180	180	180	180	180
Israel	220	[e]220	[e]220	72	65
Japan[8]	5,581	[r]6,118	6,387	6,915	7,165
Jordan	23	24	40	40	[5]77
Korea, Republic of[e 8]	550	660	680	680	700
Lebanon	[e]14	17	12	11	11
Mongolia[e]	28	[r]31	[r]31	[r]31	33
Pakistan	493	312	279	378	375
Philippines[11]	130	123	123	121	121
Saudi Arabia	19	22	231	331	331
Syrian Arab Republic	69	94	[e]95	[e]70	72
Thailand	295	419	310	388	[5]454
Turkey	36	72	67	[e]70	70
Vietnam[e]	11	13	15	15	17
Oceania: Australia	1,038	1,010	1,036	1,278	[5]1,420
Total	[r]72,888	[r]78,718	83,839	83,455	78,290

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 10, 1981.
[2]Gypsum is also produced by Romania, but production data are not available.
[3]Includes anhydrite.
[4]Shipments.
[5]Reported figure.
[6]Excludes byproduct gypsum.
[7]Series revised to represent sum of (1) mine product sold without beneficiation and (2) output of concentrates.
[8]Includes byproduct gypsum. (In the case of Japan, byproduct gypsum was virtually all gypsum consumed during 1976-80.)
[9]Less than 1/2 unit.
[10]Data are for years beginning Apr. 1 of that stated.
[11]Series revised to include byproduct gypsum, which constitutes total output in 1979-80 and virtually all output in 1976-78.

TECHNOLOGY

The use of gypsum in the set-retarding of cement is governed by chemical reactions that occur in the first few minutes after mixing with water, and in which primarily small, soluble components of the tricalcium aluminate (C_3A) from the clinker and the soluble calcium sulfate from the gypsum interreact. To obtain setting behavior in conformity with standard requirements, the availability of sulfate should be controlled so that the hydrating portion of the C_3A is combined exclusively as ettringite ($2CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$). After the initial setting time, scanning microscopic research indicated that the initially small ettringite crystals have grown in size and then have bridged the interstices between the cement particles, and impart a certain strength to the paste. Adjustment of the sulfate-bearing admixture to the reactivity of the C_3A is therefore of considerable importance in retarding the setting. The addition of a mixture of gypsum and natural anhydrite has proven particularly reliable for the purpose. The gypsum ($CaSO_4 \cdot 2H_2O$), in an amount duly suited to the C_3A reactivity, should be dehydrated as completely as possible to hemihydrate in the grinding process.[20]

Anhydrite has a growing potential for use in the markets throughout the world. It has been used for some time in the construction of gate side packs in coal mines to give better gateway support with reduced maintenance. About 400,000 tons was used for this purpose in Federal Republic of Germany coal mines in 1979. The finely ground anhydrite is mixed with accelerating agents for the setting and hardening process (potassium and ferrous sulfate) and water, and blown into position by compressed air. The safety aspects of this process and the reduction in maintenance required are the main reasons for the popularity of this material.

Anhydrite can also be used in pack and floor consolidation in mines, cavity and back fillings, and air crossing and junction construction. British Gypsum, Ltd., in the United Kingdom, has recently started selling anhydrite specifically for these mining purposes.[21]

Research Cottrell, Inc., received a $24 million order from the Board of Water and Light Trustees of Muscatine, Iowa, for an air pollution control system that will be the first in the United States to generate commercial-grade gypsum as a byproduct. The system will consist of an electrostatic precipitator and a flue gas desulfurization (FGD) unit, to be installed on the coal-fired 150-megawatt Unit 9 of Muscatine Power & Water. The Double-Loop limestone FGD system will treat emissions from the coal-fired system with a sulfur content of 2.5% to 3.2%. This system, through an oxidation process, will produce a commercial-quality gypsum byproduct suitable for use in building materials such as wallboard, or for use in the cement industry. Construction was scheduled to begin January 1981.[22]

Gypsum wallboard systems and assemblies continued to be more widely used in such nonhousing construction as lightweight elevator shaft walls, stairwells, and ducts in high-rise buildings. Demountable wallboard partitions are also appearing more widely in offices and other commercial buildings. To conform with fire safety codes, fire-resistant gypsum wallboard is finding greater applications in interior walls and ceilings and other areas that require greater fire resistance, such as furnaces, water heaters, ranges, etc. Fire-resistant, 5/16-inch wallboard is more widely used in mobile home construction, and some manufacturers are now producing or planning to produce mobile homes with 100% gypsum drywall interiors. Such diversified uses also carry over into remodeling and renovating of homes, apartments, and commercial buildings.[23]

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[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Industrial Minerals (London). Company News and Mineral Notes. No. 160, January 1981, p. 47.
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Helium

By Philip C. Tully[1] and Charles L. Davis[2]

Grade A helium (99.995% or better) sales volume in the United States by private industry and the Bureau of Mines was 863 million cubic feet (MMcf) in 1980.[3] Grade A helium exports by private producers were 298 MMcf for total sales of 1,161 MMcf of U.S. helium. The Bureau's price, f.o.b. plant, for Grade A helium was $35 per thousand cubic feet (Mcf), unchanged since 1961. The price of Grade A helium gas sold by private producers averaged $23 per Mcf, and the price of liquid helium averaged $27 per Mcf gaseous equivalent.

Legislation and Government Programs.—Several bills to amend the Helium Act of 1960 were introduced during the 96th Congress. None of them were reported out of committee prior to adjournment.

DOMESTIC PRODUCTION

In 1980, there were nine privately owned domestic helium plants, which were operated by six companies (table 1). Seven privately owned plants and two Bureau plants extracted helium from natural gas. Private and Bureau plants use a cryogenic extraction process. The Bureau and four of the five private plants that produce Grade A helium—Cities Service Cryogenics, Inc., Ulysses, Kans.; Kansas Refined Helium Co., Otis, Kans.; Phillips Petroleum Co., Elkhart, Kans.; and Union Carbide Corp., Linde Div., Bushton, Kans.—have helium liquefaction facilities. Air Products and Chemicals, Inc., announced plans to build a 250-MMcf-per-year helium plant in Hansford County, Tex.

The volume of crude (a gas mixture containing about 50% to 80% helium) and Grade A helium extracted from natural gas for 1976-80 is summarized in table 2, and the total volume is plotted in figure 1. All of the natural gas processed for helium extraction came from the gasfields shown in figure 2.

Table 1.—Ownership and location of helium extraction plants in the United States, 1980

Category and owner or operator	Location	Product purity
Government owned:		
Bureau of Mines	Masterson, Tex	Crude and Grade A helium.[1]
Do.	Keyes, Okla	Do.
Private industry:		
Cities Service Cryogenics	Scott City, Kans	Crude helium.[2]
Do.	Ulysses, Kans	Grade A helium.[1]
Cities Service Helex, Inc	do	Crude helium.
Kansas Refined Helium Co	Otis, Kans	Grade A helium.[1]
Do[3]	Shiprock, N. Mex	Do.
Northern Helex Co	Bushton, Kans	Crude helium.
Phillips Petroleum Co	Elkhart, Kans	Grade A helium.[1]
Do[4]	Hansford County, Tex	Crude helium.
Union Carbide Corp., Linde Div	Bushton, Kans	Grade A helium.[1]

[1]Including liquefaction.
[2]Output is piped to Cities Service Cryogenics, Inc., plant at Ulysses, Kans., for purification.
[3]Plant started again in September 1980.
[4]A portion of the output is piped to Elkhart, Kans., for purification.

Supply and disposal of helium for 1978-80 at Bureau helium plants are summarized in table 3.

The Bureau awarded a contract for a pressure swing adsorption helium purification unit in 1979. The unit was installed at the Masterson, Tex., (Exell) plant during 1980, and acceptance tests were scheduled for early 1981. A new cryogenic helium purification unit and helium liquefier, also purchased under contract, were installed at the Bureau's Exell plant, and performance tests were in progress at the end of 1980.

Table 2.—Helium extracted from natural gas in the United States

(Thousand cubic feet)

	1976	1977	1978[r]	1979	1980[p]
Crude helium:[1]					
Extracted at Bureau of Mines plants	195,758	118,760	42,483	[r]34,868	22,887
Extracted at private industry plants	391,553	419,228	432,626	501,647	275,798
Total	587,311	537,988	475,109	[r]536,515	298,685
Grade A helium:[2]					
Extracted at Bureau of Mines plants[3]	[r]308,033	[r]424,443	445,128	[r]433,168	383,975
Extracted at private industry plants[3]	[r]500,449	[r]522,610	549,922	[r]646,657	775,236
Total	808,482	947,053	995,050	[r]1,079,825	1,159,211
Grand total	1,395,793	1,485,041	1,470,159	[r]1,616,340	1,457,896

[p]Preliminary. [r]Revised.
[1]Excludes crude helium purified after interplant transfer.
[2]Includes only those quantities produced for sale.
[3]Includes helium purified at the Bureau of Mines Keyes plant from crude helium previously stored for the accounts of others, as follows, in thousand cubic feet: 1976—130,356; 1977—204,948; 1978—229,512; 1979—222,320; 1980—200,600.

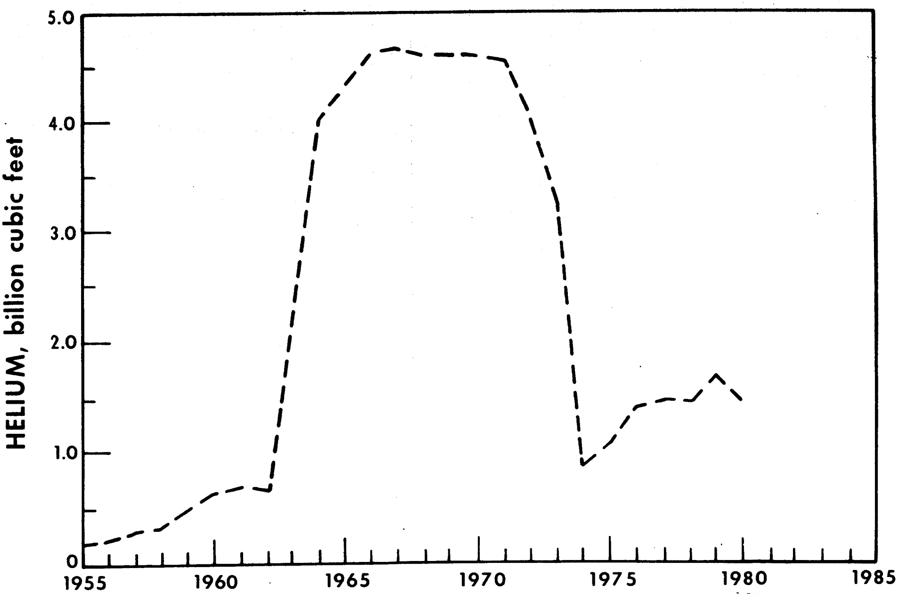

Figure 1.—Helium production in the United States, 1955-80.

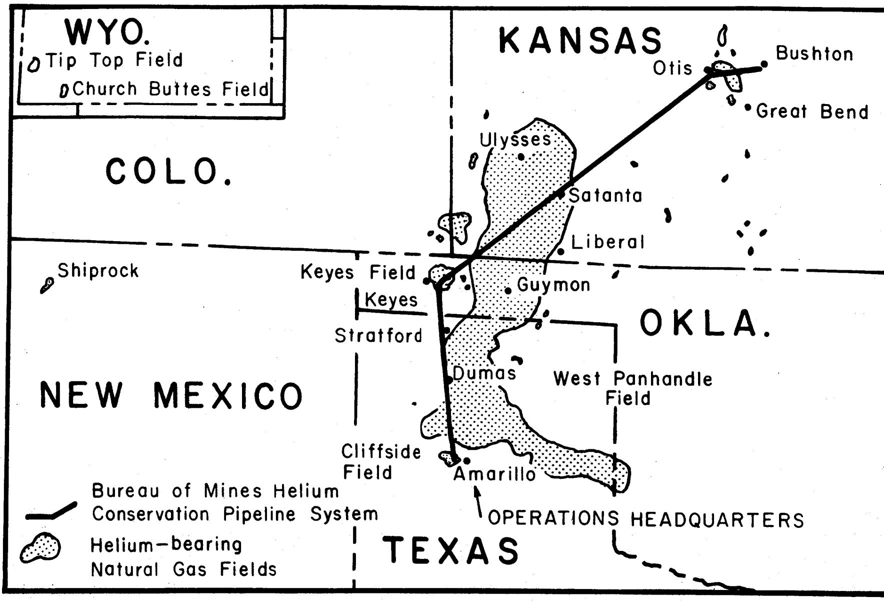

Figure 2.—Major U.S. helium-bearing natural gas fields.

Table 3.—Summary of Bureau of Mines helium plant operations

(Thousand cubic feet)

	1978	1979	1980
Supply:			
Inventory at beginning of period[1]	5,721	18,066	16,326
Helium extracted:			
Exell plant:			
Crude[2]	[r]-17,226	[r]-60,103	-70,275
Grade A	[r]14,317	[r]38,222	35,063
Total Exell plant[2]	[r]-2,909	[r]-21,881	-35,212
Keyes plant:			
Crude	[r]59,709	[r]94,971	93,162
Grade A[3]	[r]430,811	[r]394,946	348,912
Total Keyes plant	[r]490,520	[r]489,917	442,074
Total extracted	[r]487,611	[r]468,036	406,862
Helium returned in containers (net)[2]	4,981	-2,894	2,544
Total supply	[r]498,313	[r]483,208	425,732
Disposal:			
Sales of Grade A helium	[r]208,252	[r]209,680	187,735
Redelivered to private producers	229,512	222,334	200,600
Net deliveries to helium conservation system	[r]42,483	[r]34,868	22,887
Inventory at end of period[1]	18,066	16,326	14,510
Total disposal	[r]498,313	[r]483,208	425,732

[r]Revised.
[1]At Amarillo, Exell, and Keyes helium plants.
[2]Negative numbers denote net withdrawal from storage.
[3]Includes 229,512 thousand cubic feet purified for others in 1978, 222,320 thousand cubic feet in 1979, and 200,600 thousand cubic feet in 1980.

CONSUMPTION AND USES

The major domestic end uses of helium in 1980 were cryogenics, welding, and pressurizing and purging, as shown in figure 3. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. Annual helium sales volumes for 1976-80 are shown in table 4. The Pacific and Gulf Coast States were the principal areas of demand.

Federal agencies purchase their major helium requirements from the Bureau of Mines. Direct helium purchases by the Department of Energy, the Department of Defense, the National Aeronautics and Space Administration, and the National Weather Service constituted most of the Bureau's Grade A helium sales (table 5). All of the remaining sales to Federal agencies were through private helium distributors which purchased equivalent volumes of Bureau helium under the provisions of the Code of Federal Regulations (30 CFR 602). Some of the private distributors also have General Services Administration helium supply contracts. These contracts make relatively small volumes of helium readily available to Federal installations at reduced freight charges.

The Bureau of Mines price, f.o.b. plant, of Grade A helium in 1980 was $35 per Mcf, unchanged since the Government established that price in 1961. Private producers' average price for Grade A helium gas was $23 per Mcf. The price of liquid helium averaged $27 per Mcf gaseous equivalent.

All Grade A gaseous helium sold by the Bureau was shipped in cylinders, special railway tank cars, or highway tube semitrailers. Liquid helium was shipped in dewars from the Amarillo helium plant. Private industrial gas distributors shipped helium as gas and liquid. Much of the private helium was transported in liquid form by semitrailers to distribution centers, where a portion was gasified and compressed into trailers and small cylinders for delivery to the end user.

Table 4.—Total sales of Grade A helium in the United States

(Million cubic feet)

Year	Volume
1976	634
1977	779
1978	811
1979	817
1980	863

Table 5.—Bureau of Mines sales of Grade A helium, by purchaser[1]

(Thousand cubic feet)

	1978	1979	1980
Federal agencies:			
Department of Energy	23,382	23,634	24,894
Department of Defense	119,627	114,050	103,267
National Aeronautics and Space Administration	15,464	27,555	24,059
National Weather Service	1,850	1,483	1,301
Other	r1,529	r1,916	2,464
Total Federal agencies	r161,852	r168,638	155,985
Private helium distributor sales[2]	44,169	38,478	29,478
Commercial sales	2,231	2,564	2,272
Grand total	r208,252	r209,680	187,735

rRevised.
[1]Table identifies purchaser, which is not necessarily a Federal helium user.
[2]Purchased by commercial firms and redistributed to Federal installations under 30 CFR 602.

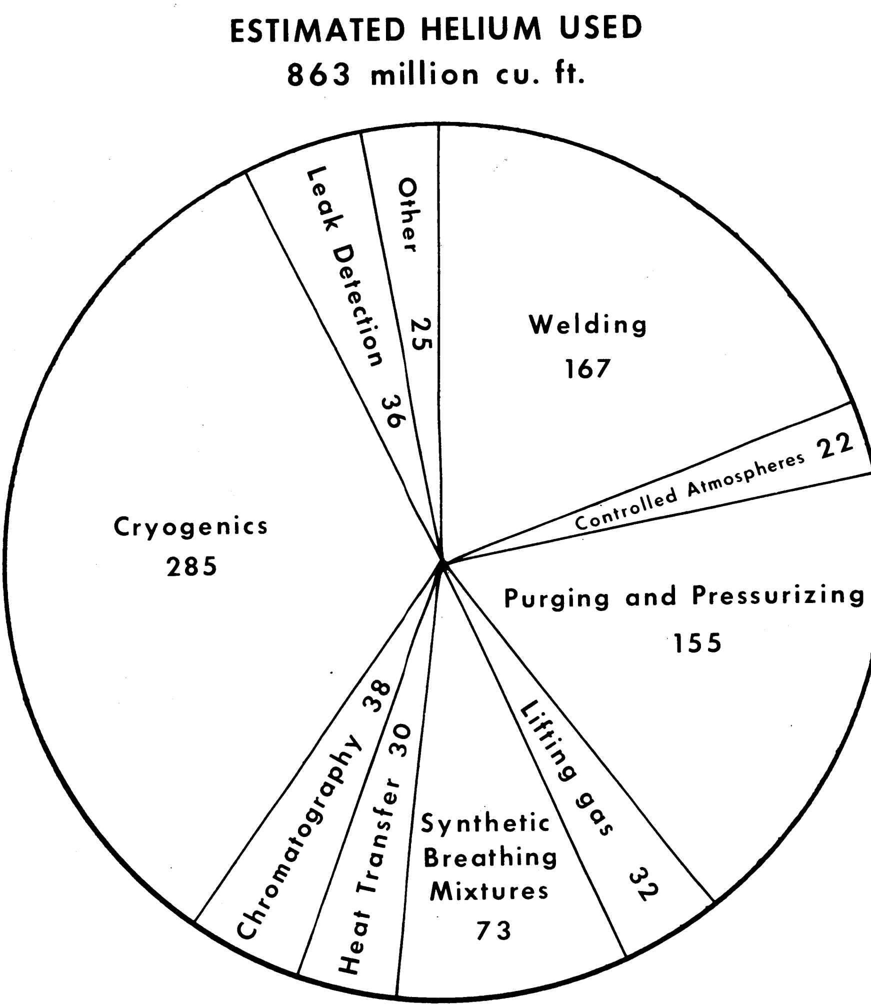

Figure 3.—Helium consumption by end use in the United States, 1980, (million cubic feet).

CONSERVATION

The volume of helium stored for future use in the Bureau of Mines helium conservation storage system, which includes the conservation pipeline network and the Cliffside Gasfield near Amarillo, Tex., totaled over 40 billion cubic feet (Bcf) at the end of 1980 (table 6). The conservation storage system contains crude helium purchased by the Bureau of Mines under contract; crude helium accepted under court order between April 4 and November 12, 1973; Bureau helium extracted in excess of sales; and privately owned helium stored under contract. During 1980, 634 MMcf of private helium was delivered to the Bureau's helium conservation storage system and 467 MMcf was withdrawn, for a net increase of 167 MMcf of private helium in storage.

Table 6.—Summary of Bureau of Mines helium conservation storage system[1] operations

(Thousand cubic feet)

	1978	1979	1980
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program[2]	r37,783,076	r37,825,559	37,860,427
Stored for private producers under contract	r1,695,007	r2,031,567	r2,415,532
Total	r39,478,083	r39,857,126	40,275,959
Input to system:			
Net deliveries from Bureau of Mines plants[3]	r42,483	r34,868	22,887
Stored for private producers under contract	723,788	787,125	634,309
Total	r766,271	r821,993	657,196
Redelivery of helium stored for private producers under contract	-387,228	-403,160	-467,415
Net addition to system	r379,043	r418,833	189,781
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program[2]	r37,825,559	r37,860,427	37,883,314
Stored for private producers under contract	r2,031,567	r2,415,532	2,582,426
Total	r39,857,126	r40,275,959	40,465,740

rRevised.
[1]Includes conservation pipeline system and Cliffside Field.
[2]Includes helium accepted after Apr. 4, 1973, under court order.
[3]Includes 1,518,000 thousand cubic feet of helium accepted under court order.

RESOURCES

Domestic measured and indicated helium resources as of January 1, 1981, are estimated to be 346 Bcf. The resources included measured and indicated reserves estimated to be 163 Bcf and 37 Bcf, respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included 40 Bcf stored in the Bureau's helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 55 Bcf. Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 91 Bcf. Approximately 95% of the domestic helium resources under Federal ownership or control are in the Tip Top and Church Buttes Fields in Wyoming, the Keyes Field in Oklahoma, and the Cliffside Field in Texas.

The majority of U.S. helium resources are located in the Midcontinent and Rocky Mountain regions. The measured and indicated helium reserves are located in approximately 76 gasfields in 10 States. About 89% of these reserves are contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Tip Top Field in Wyoming. The Bureau analyzed a total of 288 natural gas samples from 21 States and 2 foreign countries during 1980 in conjunction with a program to survey and identify possible new sources of helium.

FOREIGN TRADE

Exports of Grade A helium, all by private industry, increased by 22% in 1980 to 298 MMcf (table 7). Nearly 64% of the exported helium was shipped to Europe. The United Kingdom, Belgium-Luxembourg, and France, collectively, received more than three-fourths of the European helium imports. Fifteen percent of the U.S. helium exports went to Asia, 7% to North America, 5% to South America, 4% to Australia and New Zealand, 3% to the Middle East, 1% to Africa, and less than 1% to the Caribbean. The shipments of large volumes of helium to Western Europe in 1980 were attributed to helium's use in for oil and gas, especially in the North Sea.

Table 7.—Exports of Grade A helium from the United States

(Million cubic feet)

Year	Volume
1976	174
1977	168
1978	190
1979	245
1980	298

Source: U.S. Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated to be 120 MMcf. This production was attributed to the central-economy countries, particularly Poland. The Polish helium plant was damaged by an explosion in December 1979, but was scheduled to resume operations in late 1980.

TECHNOLOGY

The Bureau of Mines has perfected two techniques for helium analysis. The first determines the helium content of ground waters. This method is used to analyze samples collected in geochemical searches for helium anomalies associated with natural gas, oil, and uranium deposits. The second is a mass spectrometer method for determining helium-3 in air in the parts-per-trillion range.

The 4,000-liter-per-hour helium liquefier, the world's largest, at Fermi National Accelerator Laboratory produced liquid helium. Startup problems encountered earlier in Union Carbide Corp., Linde Div.'s Bushton, Kans., plant, which combines a noncryogenic pressure swing adsorption helium purifier and a 1,400-liter-per-hour wet expansion engine helium liquefier, have apparently been solved.

Large-scale applications of superconductivity, such as the construction of 1,100 7-meter-long superconducting magnets for the main ring at Fermi National Accelerator Laboratory and Isabelle magnet construction at Brookhaven National Laboratory, require liquid helium for testing. Superconducting magnet development for fusion and magnetohydrodynamic systems is proceeding, although the technology is not as fully advanced as for the other systems mentioned.

The Electric Power Research Institute has entered into a $19 million, cost-sharing contract with Westinghouse Electric Corp. for the design and construction of a 270-megawatt superconducting electric generator. This generator will be the largest of its kind and will be partially cooled by liquid helium to maintain the near-absolute-zero temperature (-452° F) necessary to achieve the superconducting state. Superconducting generators are smaller, lighter, and more efficient than conventional generators of the same capacity.

Use of helium for pressurizing and purging in the aerospace industry should resume normal rates since the problem of space shuttle rocket engine failure (not helium related) was identified and corrected during 1980.

[1]Chemical engineer, Division of Helium Operations, Amarillo, Tex.
[2]Physical scientist, Section of Nonmetallic Minerals, Washington, D.C.
[3]All helium volumes herein are reported at 14.7 pounds per square inch absolute at 70° F.

Iron Ore

By F. L. Klinger[1]

World iron ore production and trade in 1980 declined by about 3% compared with the levels of 1979. Production was estimated at 874 million long tons,[2] and trade was estimated at 379 million tons of which 83% was oceanborne. The declines were due mainly to lower demand for iron and steel in the United States and Western Europe.

The leading producing countries in 1980 were the U.S.S.R., Brazil, Australia, and the United States, while the leading exporting countries were Australia, Brazil, the U.S.S.R., and Canada. The principal importing countries were Japan, the Federal Republic of Germany, and the United States.

Reduced imports by the United States and the United Kingdom in 1980 were largely responsible for declines of 15% to 20% in exports by Canada, Sweden, Liberia, and Venezuela. However, falling demand for steel, combined with increasing stocks of ore at consuming plants and rising costs of production, led to declines in production and exports in several other countries including France, Mauritania, and Norway. On the other hand, increased shipments to Japan and other consumers in Asia allowed Australian exports to remain high and were an important factor in Brazilian exports, which rose to a record level in 1980. New markets for iron ore continued to grow in developing countries of Asia, Africa, the Middle East, and Latin America.

Prices for iron ores marketed in Japan and Western Europe increased by as much as 30% in 1980 but most increases ranged between 15% and 20%. In the United States, published prices for Lake Superior iron ores rose by 9% to 16%. Freight rates also increased, as the cost of fuel oil continued to rise and many vessels that could have carried iron ore were engaged in the grain and coal trades.

World production of iron ore pellets in 1980 was estimated at 185 million tons, about 30% less than the capacity of existing plants. The relatively low output was partially due to rising costs of production, particularly in oil-fired plants. Some pelletizing plants were closed due to the high cost of oil, and others were temporarily closed due to lack of demand. With increased freight rates pressuring producers to reduce f.o.b. prices, there was a trend toward increasing production of sinter feed.

Direct reduction of iron ore continued to grow, and reduction plants were completed or under construction in at least 12 countries in 1980. Most of these countries had access to low-cost natural gas, but coal-based processes were also receiving attention. World output of direct-reduced iron (DRI), exclusive of the U.S.S.R., East Europe, and mainland China, was estimated at 7 million tons of which nearly half was produced in Latin America.

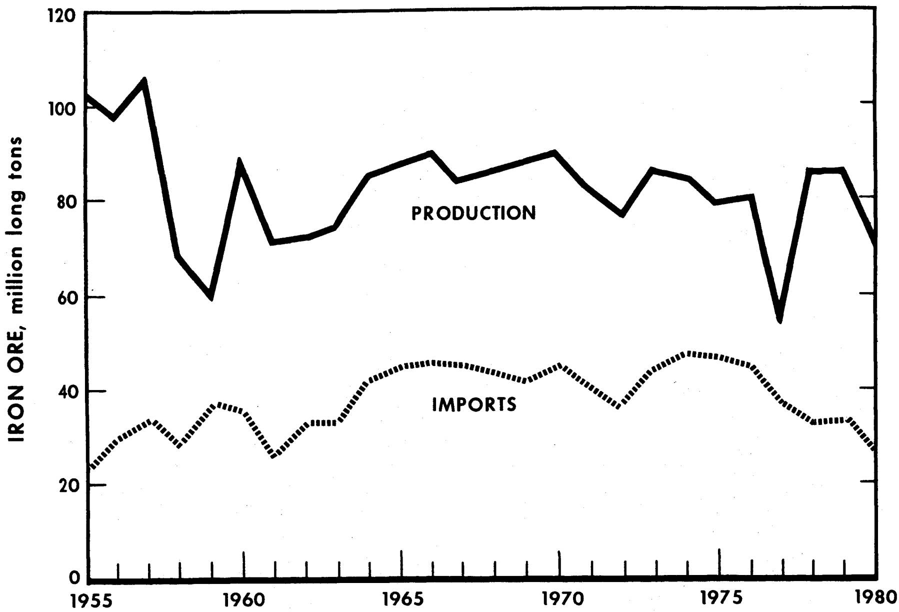

Figure 1.—United States iron ore production and imports for consumption.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production[2]	79,993	55,750	81,583	85,716	69,613
Shipments	[2]77,076	[2]54,053	[2]83,207	[2]86,218	[2]69,594
Value	[2]$1,871,114	[2]$1,422,696	[2]$2,401,387	[2]$2,814,440	[2]$2,544,121
Average value at mines, dollars per ton	$24.28	$26.32	$28.86	$32.64	$36.56
Exports	2,913	2,143	4,213	5,148	5,689
Value	$82,192	$62,760	$136,721	$178,749	$230,568
Imports for consumption	44,390	37,905	33,616	33,776	25,058
Value	$980,348	$956,584	$845,039	$923,426	$772,844
Consumption (iron ore and agglomerates)	125,424	116,034	124,797	125,431	98,879
Stocks, Dec. 31:					
At mines[3]	13,993	14,811	12,359	11,266	10,636
At consuming plants	56,246	42,271	39,301	38,969	35,706
At U.S. docks	4,763	2,979	3,569	5,416	6,095
Manganiferous iron ore (5% to 35% manganese): Shipments	229	193	279	215	155
World: Production	[r]885,098	[r]828,334	[r]835,359	[r]897,099	873,633

[r]Revised.
[1]Direct shipping ore, concentrates, agglomerates, and byproduct ore.
[2]Includes byproduct ore.
[3]Excludes byproduct ore.

EMPLOYMENT

Statistics on employment and productivity in the U.S. iron ore industry in 1980 are shown in table 3. Employment data were supplied by the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor, from reports received from producers. The statistics in table 3 include persons employed at mines and mills but do not include approximately 2,400 persons engaged in management, research, or office work.

In 1980, the average number of employees and total hours worked declined by about 13% and 15%, respectively, compared with the levels of 1979. This was due mainly to layoffs resulting from reduced production schedules at many operating mines in 1980.

DOMESTIC PRODUCTION

U.S. mine production and shipments of iron ore in 1980 fell by 19% compared with those of 1979. The declines resulted from sharply reduced demand for ore from the domestic iron and steel industry, and would have been steeper if imports of ore had remained at the 1979 level and if exports had not been increased. The drop in demand led to the permanent closing of one underground mine, suspension of production at another, and suspension of production at several open pit mines. Most pelletizing plants in the Lake Superior district were on reduced production schedules, and 6 of the 13 plants were closed for periods of 2 to 5 months.

Crude ore production in 1980 totaled 212 million tons, 17% less than in 1979. Three of the 37 producing mines were underground and the rest were open pits. Open pit mines accounted for about 99% of total output, and virtually all ore was extensively beneficiated before shipment. The average total iron content of crude ore produced was estimated at about 32%, although the content of recoverable iron at most mining operations probably ranged between 21% and 28%. Nationwide, an average of 3.05 tons of crude ore was mined for each ton of usable ore produced, compared with 2.93 tons in 1979 and 2.87 tons in 1978. The continuing increase of this ratio follows a long-term trend that reflects the depletion of higher-grade direct-shipping ores in the United States and the increasing production of low-grade ores of the taconite type.

Iron ore pellets and other agglomerates made up 93% of the total mine output of usable ore in 1980; concentrates made up about 5%, and direct-shipping ores made up less than 2%. The average iron content of usable ore (including byproduct ore) produced was 63.0%, compared with 62.6% in 1979 and 62.2% in 1978. The Lake Superior district produced 89% of the national output. Minnesota produced 65%, Michigan 23%, and the remainder was produced in 11 other States. U.S. production capacity for pellets was increased in 1980 by completion of a 2.7-million-ton-per-year expansion of the Empire plant in Michigan; however, this gain was partially offset by reduction of capacity in Minnesota and Missouri. Annual production capacity for pellets totaled about 90.7 million tons in January 1980, and 92.3 million tons at yearend.

In Minnesota, Reserve Mining Co. completed its $370 million project to shift tailings disposal from Lake Superior to a land site, and to modify its concentrator. Lake disposal ended in March, and pumping of tailings to the Milepost 7 site began in June. Modifications to the concentrator, including installation of dry-cobbing and flotation circuits, resulted in significant improvement of product quality. Temporary suspensions of production at the Butler, National, Minorca, and Erie taconite operations affected about 3,000 employees during the year, while others were affected by cutbacks in production at Minntac, Eveleth, and other mining and concentrating facilities including several producing hematite ore. The Canisteo hematite mine near Coleraine was scheduled to close in 1981.

In Michigan, expansion of the Empire facility was completed by Cleveland-Cliffs Iron Co. in the first quarter of 1980. Production capacity for pellets was raised to 8 million tons annually at a cost of about $250 million. In June, the Empire and Republic Mines were temporarily shut down, affecting about 2,000 employees. The Humboldt pelletizing plant, which produced pellets from Republic Mine concentrates, remained closed throughout the year. Hanna Mining Co. announced plans to suspend production at the Groveland Mine in January 1981, for an indefinite period.

In Missouri, the Pilot Knob underground mine, concentrator, and pellet plant were permanently closed in November 1980 by Hanna Mining Co. About 400 employees were affected. The company stated that the mine was near the end of its economic life and that the low level of demand from the steel industry accelerated the mine's closing by about 2 years. The Pilot Knob plant had a production capacity of 1.1 million tons of pellets per year. Pea Ridge Mining Co. continued production of pellets near Sullivan, and was considering construction of a direct-reduction plant.

In Utah, production of ore at Iron Springs was suspended for an indefinite period by Utah International, Inc., in 1980. The suspension included the McCahill-Thompson alluvial ore mining operation.

In Wyoming, CF&I Steel Corp. closed the Sunrise underground mine in July for an indefinite period.

As scheduled in 1979, Oregon Steel Mills division of Gilmore Steel Corp. closed its direct-reduction plant at Portland in 1980. The plant was the first commercial direct-reduction facility built in the United States and had been in operation since 1969. The main reason for the closure was stated to be the rising cost of imported (Canadian) natural gas.

CONSUMPTION

Total consumption of iron ore and agglomerates (in blast furnaces, steel furnaces, and for miscellaneous purposes) in 1980 was approximately 21% less than 1979. Consumption in blast furnaces declined by 21%, while that in steel furnaces dropped by 39%. In blast furnaces, the weight ratio of iron ore and agglomerates consumed to pig iron produced was approximately 1.566:1, compared with 1.569:1 in 1979 and 1.551:1 in 1978.

Iron ore pellets made up 67% of all iron ore and agglomerates consumed in 1980, and 73% of all agglomerates consumed. Sinter made up 25% of all iron ore and agglomerates consumed, and natural ores accounted for the remaining 8%.

Consumption data are shown in tables 11 and 12. In these tables, iron ore concentrate used to produce agglomerates such as pellets or sinter at mine sites is not reported as iron ore consumed; its consumption was reported when such agglomerate was used at the furnace site (table 11). Iron ore concentrate and fines used to produce sinter at ironmaking and steelmaking plants are reported in table 12 as iron ore consumed, while consumption of agglomerates from this source is included in table 11. In table 12, the difference in weight between iron ore consumed and agglomerate produced results from the elimination of moisture as well as the addition of materials such as flue dust, mill scale, lime, and coke.

Consumption of iron ore and agglomerates, as reported by the American Iron Ore Association (AIOA), was 89.4 million tons in 1980, compared with 115.0 million tons in 1979. The difference between these figures and those reported by the Bureau of Mines in table 11 is due mainly to different reporting procedures for sinter. The AIOA reports iron ore consumed in sintering plants at iron and steel works, while the Bureau reports the gross weight of sinter consumed in ironmaking and steelmaking furnaces. The AIOA figure thus does not include the weight of additives such as flue dust, mill scale, slag, etc., that are used for production of sinter and constitute part of the furnace charge. The AIOA figure also does not include iron ore used for miscellaneous purposes, as listed in table 11.

STOCKS

Stocks of iron ore and agglomerates reported at U.S. mines, docks, and consuming plants at yearend 1980 totaled about 52 million tons, approximately 3 million tons less than 1 year earlier. Most of the reduction took place at consuming plants. Of the 41.8 million tons of iron ore on hand at receiving docks and consuming plants at yearend, 66% consisted of domestic ores, 20% consisted of Canadian ores, and 14% consisted of other foreign ores. According to the AIOA, U.S. iron ores made up nearly 50% of the 6.5 million tons of ore stocked at Canadian consuming plants at yearend 1980.

PRICES

Published prices for Lake Superior iron ores, delivered rail-of-vessel at lower lake ports, continued to increase in 1980. In February, the price of iron ore pellets increased by 9% to 73.66 cents per long ton unit (ltu) of iron, natural, and remained at that level for the rest of the year. By midyear the price of Mesabi non-Bessemer ore (basis 51.5% Fe, natural) was $28.50 per long ton, a rise of 16% compared with the price at yearend 1979. By August the price of Old Range non-Bessemer increased about 16% to $28.75 per ton. Prices for manganiferous ore ($24.85) and semi-taconite fines ($21.54) were unchanged during 1980. Any increases in the cost of transportation and handling, subsequent to the effective date of a price increase, were to be borne by the buyer.

The average value (f.o.b. mine or concentrating plant) of usable iron ore shipped from domestic mines in 1980 was estimated at $36.56 per long ton, compared with $32.64 in 1979 and $28.86 in 1978. These average values are mainly based on statements by major producers, and are believed to approximate the average commercial selling price less the cost of mine-to-market transportation; however, due to the concentration of U.S. production in the Lake Superior district and the relatively high value of the principal product (pellets), the average value of natural ores and concentrates shipped by smaller producers in the Western States may be considerably less.

Prices for Canadian and most other foreign ores increased substantially in 1980. Compared with prices in 1979, most of the increases were on the order of 15% to 25%. The price of Wabush pellets, f.o.b. Pointe Noire, Quebec, was 58.25 cents per ltu of contained iron during 1980, compared with 52.2 cents in 1979. Under a long-term contract, the price of Carol concentrates shipped to Japan during the year begun April 1, 1980, was 25.1 cents per ltu of contained iron, f.o.b. Sept-Iles, Quebec, an increase of 15.6% compared with that of the previous year. The average f.o.b. value of Venezuelan ore shipped to the United States in 1980, as determined from data released by the Bureau of the Census, was $22.48 per long ton, compared with $19.20 in 1979. Reported f.o.b. prices for iron ores marketed in Western Europe and Japan during 1980 (per ltu of contained iron) ranged from about 25 to 28 cents for fines, 29 to 32 cents for lump ore, and 46 to 53 cents for pellets.

In March 1980, the U.S. Department of Justice announced that it was dropping its investigation of price-setting procedures for Lake Superior iron ores, and that no antitrust action would be brought. The Department's investigation was begun in 1977.

The average export price of Swedish iron ores increased by 21% in 1980, compared with that of the previous year; however, according to the Swedish Mineowners' Association, the 1980 average export price of 91 kronor per metric ton was no higher than that of 1976. This reflected a contention by many iron ore producers, that the real price of iron ore has increased very little in recent years despite higher costs of production. Consumers, however, were faced with the problem of keeping raw material costs down to meet competition. The situation of both producers and consumers was complicated by rising oil prices, which in 1980 helped to drive up freight rates, forced some pelletizing plants to close, and led to increased production and purchases of cheaper grades of ore.

The published price of DRI, f.o.b. Georgetown, S.C. and Contrecoeur, Quebec, was $115 per metric ton in January 1980. By midyear, the price at Contrecoeur rose to $130 and by October, the price at Georgetown ranged from $125 to $135. C.i.f. prices of DRI reported during 1980 in Taiwan, the Netherlands, and Spain ranged from about $140 to $150 per metric ton.

TRANSPORTATION

Shipments of iron ore from U.S. upper lake ports to receiving ports on the Great Lakes in 1980 totaled 59.4 million tons, about 20% less than in 1979. The decline in lake shipments was similar to the declines in domestic mine shipments and in consumption of ore at domestic iron- and steelmaking plants. Shipments of iron ore from Canadian producers to U.S. receiving ports on the lakes declined to about 8 million tons, 34% less than in 1979.

Ore shipments declined in 1980 at all U.S.

upper lake ports except Marquette, Mich. Declines at individual ports ranged from 10% at Two Harbors, Minn., to 47% at Silver Bay, Minn. Shipments from Marquette increased by about 7%. The tonnage shipped from each port during the 1980 ore-shipping season is shown in the accompanying tabulation:

Port	Date of first shipment	Date of last shipment	Total tonnage (thousand long tons)
Duluth, Minn	Mar. 30	Dec. 22	13,263
Two Harbors, Minn	Apr. 2	Dec. 30	10,010
Taconite Harbor, Minn.	Apr. 15	Dec. 28	6,097
Silver Bay, Minn	Apr. 3	Dec. 16	4,399
Superior, Wis	Apr. 2	Dec. 25	10,146
Escanaba, Mich	Mar. 28	Jan. 20 (1981).	9,725
Marquette, Mich	Mar. 22	Jan. 4 (1981).	5,721
Total	---	-------	59,361

Source: American Iron Ore Association, and Skillings' Mining Review (various issues).

Lake freight rates for iron ore in August 1980 were 17% to nearly 20% higher than in July 1979. Rates in August 1980 were as follows (per gross ton): From the head of the lakes to lower lake ports, $6.15; from Marquette, Mich., to lower lake ports, $4.96 to $5.07; from Escanaba, Mich., to Detroit and Lake Erie, $4.67; and from Escanaba to lower Lake Michigan ports, $3.69. These rates were in effect for the remainder of the year. Dock, storage, and handling charges also increased by as much as 25% in 1980.

Railroad freight rates for iron ore on most major haulage routes increased substantially in 1980. Compared with rates in July 1979, rates in effect in August 1980 were 8% to 21% higher for mine-to-port hauls, and 13% to 15% higher for most mine-to-consuming plant or port-to-consuming plant hauls. Examples of rates (per gross ton) in August 1980 were as follows: From the Mesabi Range to Duluth-Superior, $4.57; from the western Mesabi Range to Allouez (Superior) (pellets delivered direct into vessel), $3.46; from the Marquette Range to Escanaba (pellets delivered direct into vessel), $1.91; from Lake Erie ports to Pittsburgh and Wheeling districts, $7.74; from Baltimore or Philadelphia to the Pittsburgh district, $11.37; Mesabi Range to Granite City, Ill., $12.06; Marquette Range to Chicago, $12.87; Black River Falls (Wis.) to Chicago, $6.23; Pilot Knob (Mo.) to Granite City, $5.52; Sunrise (Wyo.) to Minnequa (Colo.), $13.40; and from Winton Junction (Wyo.) to Geneva (Utah), $5.24. The rate from Pea Ridge (Mo.) to the Chicago district dropped from $14.43 to $10.57 in 1980.

Ocean freight rates from eastern Canada to the United States east coast (north of Hatteras) more than doubled in 1980, to $3.50 to $3.75 per ton, while those to the U.S. gulf coast increased from $1.50 to $1.75 per ton in 1979 to as much as $10 by year-end 1980.

Ocean freight rates to other countries also increased in 1980. Spot rates published by *Metal Bulletin* for cargoes of 75,000 to 130,000 tons to Western Europe indicated the following ranges (per ton): From eastern Canada, $6.35 to $7.65; from Brazil, $7.15 to $11.75; from West Africa, $5.28 to $7.10; and from Australia, $8.00 to $12.40. Rates for shipments to Japan ranged from $9.22 for 80,000 tons from Saldanha Bay, to $10.75 for 140,000 tons from Brazil, to $16.00 for 100,000 tons from Sept-Iles. The spot rates appeared to be about 15% to 60% higher than those quoted in 1979.

Two more 1,000-foot self-unloading ore carriers were placed in service on the Great Lakes in 1980. The vessel *Burns Harbor*, owned by Bethlehem Steel Corp., received its first cargo of iron ore pellets (60,599 tons) on October 1, 1980, at the Burlington Northern docks in Superior, Wis. Later in the same month, the *Edgar B. Speer*, owned by United States Steel Corp., loaded its first cargo of pellets at Two Harbors, Minn. This brought the number of 1,000-foot ore carriers operating on the lakes to 10, and 2 more were scheduled to begin service in 1981.

Republic Steel Corp. began operating its new $20 million pellet terminal at Lorain, Ohio, in May 1980. The facility is equipped to unload 1,000-foot carriers, and to reload pellets from stockpile into railway cars for delivery to the company's steelworks in the Mahoning Valley or into vessels of 20,000-ton carrying capacity for delivery to the company's Cleveland steelworks on the Cuyahoga River. The rail car loading system requires only one locomotive operator and can deliver 5,000 tons of pellets per hour.

Pickands Mather & Co., a subsidiary of Moore McCormack Resources, Inc., received a 25-year contract to transport iron ore on the Great Lakes for Republic Steel Corp.

beginning in 1981. Ore transport requirements under this contract may be as much as 7 million tons per year.

A 238-mile slurry pipeline, designed to transport up to 4.5 million tons of iron ore concentrate per year, was under construction in northern Mexico in 1980. The pipeline will carry concentrate from the La Perla and Hercules Mines to Monclova. Completion was expected in 1982.

FOREIGN TRADE

U.S. imports of iron ore for consumption in 1980 totaled approximately 25 million tons valued (f.o.b. country of origin) at $773 million. The tonnage was 26% less than in 1979 and was the lowest since 1958. The decline from 1979 was mainly due to the sharp drop in demand for pig iron from the domestic iron and steel industry. The average value of imports in 1980 was $30.84 per ton, compared with $27.32 in 1979 and $25.14 in 1978. Canada remained the principal source of imports, accounting for 69% of the total quantity, followed by Venezuela (14%), Brazil (8%), and Liberia (6%).

U.S. exports of iron ore continued to increase, largely due to shipments of pellets to Canadian participants in recently expanded U.S. taconite projects. Exports in 1980 totaled approximately 5.7 million tons valued at $230 million; the average value was about $40.51 per ton, compared with $34.72 in 1979. The 1980 tonnage was the largest in 12 years. As in 1979, more than 99% was destined for Canada.

World imports of iron ore in 1980 were estimated at 379 million tons, about 3% less than in 1979. The principal importing countries continued to be Japan, the Federal Republic of Germany, and the United States, in that order. Japan accounted for an estimated 35% of world imports; the European Economic Community, 33%; and Eastern Europe, 15%. The United States imported about 7% of the total.

WORLD REVIEW

Argentina.—Production at the Sierra Grande project in Patagonia in 1980 included 1.04 million tons of crude ore and 336,000 tons of concentrates, from which 306,000 tons of pellets were produced. Shipments of pellets to Soc. Mixta Siderurgia Argentina totaled 132,000 tons. Argentine consumption of iron ore in 1980 was estimated at 2.5 million tons.

Australia.—Shipments of iron ore products in 1980 totaled 93.8 million tons, of which about 81 million tons was exported and the remainder was shipped for domestic consumption. Shipments by individual producers were as follows (in million tons): Hamersley Iron Pty. Ltd., 38.3; Mt. Newman Mining Co. Pty. Ltd., 26.9; Cliffs Robe River Iron Associates, 14.6 including 1.1 of pellets; Broken Hill Pty. Co. Ltd., 6.4; Goldsworthy Mining Ltd., 5.3; and Savage River Mines, 2.3. Shipments by the Hamersley and Robe River operations were at record levels.

Iron ore concentrators completed in 1979 at the Hamersley and Mt. Newman projects, with annual production capacities of 6 million tons and 5 million tons, respectively, did not produce at design capacity in 1980 but were expected to do so in 1981. Concentrate produced by Hamersley totaled 4.5 million tons in 1980.

Pellet production in 1980 was estimated at 5.1 million tons, about 4 million tons less than in 1979. High costs of fuel oil led to closure of Hamersley's plant at Dampier at the end of February, and of Robe River's plant at Cape Lambert at the end of April. The parent company of Hamersley reported that fuel prices rose 70% in the 12 months ended June 30, 1980.

The Mt. Newman company began production of Marra Mamba ore in mid-1980, from a deposit near Mt. Whaleback. Production was at the rate of about 1.4 million tons annually. The ore was blended with fines from Mt. Whaleback, to prepare sinter feed containing about 15% of Marra Mamba ore. Goldsworthy Mining Ltd. continued to seek sales contracts with Japanese buyers, to enable development of Marra Mamba orebodies 212 miles south of Port Hedland. Ore reserves at mines now operated by the company were expected to be depleted in 1984 at current rates of production.

Cliffs Western Australia Mining Co. (CWAM) began development work in 1980 on the eastern Deepdale deposits where the company has 150 million tons of ore reserves under lease. Mining was expected to begin in 1982. The company also continued to evaluate the economic feasibility of mining ore at West Angelas, 200 miles south east of Cape Lambert. In October 1980, Cliffs International Investments purchased a 35% interest in CWAM from Texasgulf, Inc.

Austria.—All iron ore produced in 1980 came from the Erzberg Mine of Voest-Alpine AG. Imports of iron ore totaled 3.25 million tons, 17% less than in 1979.

Brazil.—Shipments of iron ore for export and for domestic consumption appeared to reach record levels in 1980. Exports totaled approximately 78.9 million tons and probably included more than 15 million tons of pellets. Shipments for domestic consumption were estimated at about 20 million tons.

Companhia Vale do Rio Doce (CVRD) reported exports of 52.6 million tons, including 43.8 million tons for the company's own account and 8.8 million tons of pellets for the Nibrasco, Itabrasco, and Hispanobras joint ventures. Domestic shipments by CVRD were reported at 17.6 million tons; this figure, however, was several times larger than those reported for previous years and possibly includes up to 10 million tons of ore fines destined for pelletizing at Tubarao.

Shipments reported by other Brazilian producers in 1980 are summarized in the accompanying tabulation:

Company	Shipments in 1980 (million long tons)	
	For export	For domestic consumption
Mineracoes Brasileiras Reunidas (MBR)	11.7	2.8
S.A. Mineracao da Trindade (SAMITRI)	4.5	2.2
Ferteco Mineracao S.A	6.1	1.7
Samarco Mineracao S.A.	3.9	.2
Wm. H. Muller S.A. (sales)	.13	1.0
Total	26.33	7.9

In addition, Companhia Siderurgica Nacional was estimated to have shipped about 3 million tons from the Casa de Pedra Mine for its own consumption at Volta Redonda. Empresa de Mineracao Esperanca S.A. reported shipment of 133,000 tons in 1980.

In a major decision, the Government decided to proceed with development of iron ore deposits at Serra dos Carajas. CVRD was to undertake development of mining and shipping facilities. Production was scheduled to begin in 1984, with the goal of 35 million tons annually by 1986. Of the $2.8 billion reportedly needed for fixed investments by 1987, nearly 50% was reported to have been secured from outside sources and an additional 40% was to be provided by CVRD. Proven ore reserves were stated to be 1.6 billion tons with an average iron content of 66%.

Canada.—Production and exports of iron ore products in 1980 declined by 18% and 20%, respectively, compared with those of 1979. These declines were principally due to reduced demand for iron ore in the steel industries of the United States and the European Communities. Shipments totaled about 49 million tons, including 38 million tons for export and 11 million tons for domestic consumption. Stocks of ore products at mines and shipping ports totaled 13.5 million tons at yearend, compared with 12 million tons at the end of 1979. The average natural iron content of ores shipped in 1980 was 62.9%. Total shipments of ore products in 1980 included about 24 million tons of pellets, 20 million tons of concentrates, 3.5 million tons of direct-shipping ore, and 1.5 million tons of sinter.

The low level of demand in 1980 led to temporary suspensions of production by the Iron Ore Co. of Canada (IOC) at Carol Lake and Sept-Iles, and by Wabush Mines. IOC suspended mining at Schefferville in mid-September, about 1 month earlier than usual. Production by Quebec Cartier Mining Co. and by Sidbec-Normines Inc. was also reduced late in the year. Caland Ore Co. Ltd. permanently closed its pellet plant in April 1980, after closing its mine in late 1979. International Nickel Co. Ltd. (Inco) suspended production of pellets at Sudbury in June.

Shipments of ore products by individual producers in 1980 were as follows (in million tons): IOC, 21.2 including 11.0 of pellets; Quebec Cartier, 11.8 from Mt. Wright; Wabush Mines, 4.8 of pellets; Sidbec-Normines Inc., 4.23 of pellets including 1.33 of low-silica pellets; Algoma Steel Corp. Ltd., 1.5 of sinter; the Griffith Mine, 1.5 of pellets; Caland, 1.1 including 0.5 of pellets; Adams Mine, 1.2 of pellets; Sherman Mine, 1.1.; Wesfrob Mines Ltd., 0.6; and Inco, 0.06.

Chile.—Shipments of iron ore products in 1980 by Compania de Acero del Pacifico (CAP) totaled 8.46 million tons. Exports totaled 7.46 million tons and 1 million tons was shipped for domestic consumption at Huachipato.

CAP's production by mine was as follows, in million tons: El Romeral, 4.04; El Algorrobo (pellets), 3.1; and Santa Fe, 1.05 including 0.87 at Los Colorados and 0.18 at Cerro Iman. An additional 296,000 tons was purchased from local mines. The Cerro Iman Mine was closed in April 1980. At El Algorrobo, production of preconcentrate for further concentration and processing into pellets at Huasco was 3.8 million tons in 1980.

China, *Mainland.*—Several large projects for construction of new iron ore mines and beneficiating facilities in north China, announced during 1978 and 1979, appeared to have been postponed in 1980 but there was no indication that the projects had been canceled. China continued to supplement domestic production by imports, and an estimated 7 million tons of iron ore was imported in 1980, mostly from Australia.

Taiwan.—China Steel Corp. was reportedly negotiating with Australian producers of iron ore in 1980 for the supply of about 5.5 million tons of ore per year beginning in 1983. Imports of ore in 1980 totaled nearly 2.8 million tons.

European Communities (EC).—EC production, trade, and consumption of iron ore declined in 1980, compared with 1979. The principal cause was a severe curtailment of iron and steel production in the United Kingdom, but reduced output of pig iron was evident in all major producing countries except Italy. Production of iron ore declined in all countries except the Federal Republic of Germany, and imports of iron ore from other countries declined to an estimated 115 million tons, about 8% less than in 1979. Imports of ore by France, however, rose to a record 18.3 million tons in 1980; imports by the Netherlands rose to 7.8 million tons; while imports by the Federal Republic of Germany (48.6 million tons), Italy (estimated at 17 million tons), and Belgium-Luxembourg (estimated, 24 million tons) were close to the levels of 1979. Exports of iron ore from France to Belgium, Luxembourg, and the Federal Republic of Germany declined to a total of 8.6 million tons, about 1 million tons less than in 1979.

Based on total output of pig iron in 1980, EC consumption of iron ore was estimated to have declined by about 9% compared with 1979. Consumption of ore by the Federal Republic of Germany in 1980 totaled 48.9 million tons with an average iron content of 59.4%.

In the United Kingdom, a labor strike and massive cutbacks in operations by the British Steel Corp. in 1980 resulted in record declines in iron ore production (down 79%), imports of ore (down 52%), and consumption (down 56%), compared with 1979. There was virtually no blast furnace production of iron in the first 3 months of the year.

At Emden, the Federal Republic of Germany, Norddeutsche Ferrowerke GmbH was expected to begin production of DRI in 1981. The company's plant was designed to produce 880,000 metric tons of DRI per year. A/S Sydvaranger, the principal Norwegian producer of iron ore pellets, owned a controlling interest in the facility.

Finland.—Production of iron ore concentrates in 1980 by Rautaruukki Oy. included 518,000 tons from the Rautavaara Mine and 238,000 tons from the Otanmaki Mine. Crude ore hoisted from these underground mines totaled 1.18 million tons and 1.38 million tons, respectively. Output of byproduct ore (averaging 60.8% iron content) from processing of sulfide ores at Kokkola and Siilinjarvi totaled 356,000 tons. All ore was shipped to blast furnaces at Raahe. Imports of iron ore in 1980 were estimated at 1.7 million tons.

India.—Production and exports of iron ore in 1980 appeared to be slightly higher than the levels of 1979. Exports in 1980 were estimated at 23 million tons. Exports from Goa, originating from about 12 producers, rose to a record 13.9 million tons including about 1 million tons of pellets. Shipments for export by the National Mineral Development Corp. (NMDC) totaled 6.5 million tons of which 84% came from the Bailadila mines in Madhya Pradesh and 16% from the Donimalai Mine in Karnataka.

Iron ore shipments from the principal Indian ports during the fiscal years 1978-79 and 1979-80 (April 1 to March 31) are shown in the accompanying tabulation:

Port	Shipments (thousand long tons) 1978-79	1979-80
Mormugao (Goa)	9,214	12,614
Visaghapatnam	5,874	5,344
Madras	2,905	2,819
Paradip	1,699	1,625
Total	19,692	22,402

Source: Skillings' Mining Review. V. 70, No. 19, May 9, 1981, p. 8.

The port of Mangalore on the west coast was expected to become a major shipping port for iron ore in 1981 or 1982, owing to completion of the $700 million Kudremukh project in 1980. This project was completed on schedule, but developments in Iran made it unlikely that Iran would be able to take the full tonnage of output (7.5 million tons annually) as originally agreed. Kudremukh Iron Ore Co. was therefore faced with the problem of finding other markets for several million tons per year of pellet feed. In 1980, the company issued tenders for construction of a 3- to 6-million-ton-per-year pelletizing plant at Mangalore. Bidders for the project included Met-Chem Consultants Ltd., Allis Chalmers Corp., Lurgi Chemie und Huttentechnik GmbH, and a Rumanian firm. Prospective buyers for pellets from Kudremukh included Indonesia and Qatar, where direct-reduction plants have been completed.

Construction of a pelletizing plant at Mangalore was likely to further postpone plans by NMDC to build pelletizing plants at Bailadila and Donimalai, where large tonnages of iron ore fines were stockpiled.

A semicommercial, coal-based (SL-RN) direct-reduction plant, with output capacity of 30,000 tons per year, was completed in 1980 at Kothagudem, Andhra Pradesh. The operating company was Sponge Iron India Ltd. In Orissa, a direct-reduction plant using the ACCAR process developed by Allis Chalmers Inc. was scheduled for completion in 1981. The $25 million plant, designed to produce 150,000 metric tons of product per year, will be operated by Orissa Sponge Iron Ltd.

In other developments, NMDC was expected to complete development of the Meghahatuburu Mine for production in 1981. The mine was designed to produce up to 4 million tons of ore per year.

Domestic consumption of iron ore in India in 1980 was estimated at 14 million tons.

Japan.—Imports of iron ore by Japan in 1980 rose to 131.6 million tons, of which 45% was supplied by Australia, 21% by Brazil, and 12% by India. Imports included about 13 million tons of pellets and 4 million tons of sinter.

Production of sinter in Japan was 104 million tons, about 6% more than in 1979, while output of pellets declined about 14% to 4.1 million tons. Consumption of iron ore totaled 121 million tons including 10.8 million tons of pellets. Pellet consumption was about 3 million tons less than in 1979, as a greater proportion of sinter was charged in blast furnaces.

About 1 billion tons of iron ore was covered by Japanese contracts with foreign suppliers for the period 1980 through 1989. The shares of Australian and Brazilian producers were about 49% and 30%, respectively.

Korea, Republic of.—Imports of iron ore in 1980 rose to an estimated 8.2 million tons, nearly half of which was supplied by Australia. Annual consumption of iron ore in Korea has doubled since 1978.

Liberia.—Exports of iron ore in 1980 totaled 17.2 million tons, 12% less than in 1979. Shipments by individual producers were as follows, in million tons: Lamco Joint Venture, 9.15; Bong Mining Co., 6.4 including 4.13 of pellets; and National Iron Ore Co. (NIOC), 1.64. Shipments by NIOC were 30% less than in 1979, and the company was seeking financial assistance to upgrade its production facilities.

Mauritania.—Exports of iron ore in 1980 totaled 8.6 million tons, about 6% less than in 1979. The sole producer, Société Nationale Industrielle et Minière (SNIM), continued to develop the Guelbs magnetite deposits for initial production in 1983. These deposits were scheduled to replace depleting reserves at Zouerate. At the port of Nouadhibou, construction of a 2-million-ton-per-year pelletizing plant was delayed and completion was not expected before late 1982.

Mexico.—Reported production of iron ore in 1980 increased by 26% compared with that of 1979 and was approximately equal to estimated domestic consumption.

Output of pig iron and sponge iron, estimated to total 5.15 million tons in 1980, was expected to increase substantially in the next 3 years. Several new direct-reduction plants were scheduled to be completed by Hylsa S.A. by early 1984, including a 2-million-ton-per-year plant at Lazaro Cardenas and a 750,000-ton-per-year plant at Monterrey. Altos Hornos de Mexico S.A. (AHMSA) was increasing production capacity for iron and steel at Monclova. Most of the iron ore required by these plants was expected to come from new production facilities being built at the Las Truchas, La Perla, and Hercules Mines. Premexsa S.A., a consortium of 10 Mexican steel companies, planned to build a 1 million-ton-per-year direct-reduction plant on the east coast but these plans were contingent upon construction of port facilities at Altamira. If built, the Premexsa plant would be supplied mainly with imported ore.

Las Encinas S.A., a subsidiary of Hylsa, reported production of 1.6 million tons of pellets in 1980 at Alzada, Colima. Shipments to Hylsa direct-reduction plants totaled 1.46 million tons, of which 59% was destined for Puebla and the remainder for Monterrey.

AHMSA was reported in 1980 to have awarded a contract to Dravo de Mexico S.A. for design and construction of an iron ore concentrator and pelletizing plant at Monclova. AHMSA was also a participant in construction of an iron ore slurry pipeline connecting mines in Chihuahua and Coahuila with the company's steelworks in Monclova (see Transportation section).

New Zealand.—Exports of titaniferous magnetite concentrates, obtained from beach sand deposits on North Island, totaled about 3.1 million tons in 1980. Almost all shipments were destined for Japan, but import of 45,000 tons was reported by the Republic of Korea.

New Zealand Steel Ltd. produced about 2 million dry tons of concentrates, including about 1.8 million tons for export and 193,000 tons for domestic consumption. Waipipi Iron Sands Ltd. exported about 1.3 million tons.

Nigeria.—Imports of iron ore for the Delta Steel project near Warri were expected to be about 1.5 million tons annually. A pelletizing plant, direct-reduction plant, and an electric steelmaking furnace were under construction. Completion of the facilities was scheduled by 1982.

At Ajaokuta, northeast of Warri, a blast furnace and steelmaking plant were being built with Soviet assistance. When completed, possibly by 1984, iron ore requirements were expected to be about 2 million tons annually. The ore may be supplied from deposits near Itakpe.

Norway.—Declining demand for exports of pellets in the latter half of 1980 resulted in large accumulations of stocks by A/S Sydvaranger and temporary suspension of production in November. The company's output in the first half of the year was equivalent to about 2.9 million tons annually, but production for the year was estimated at 2.1 million tons. Norwegian exports of iron ore in 1980 were estimated at 2.9 million tons, about 11% less than in 1979.

A/S Norsk Jernverk produced 968,000 tons of hematite and magnetite concentrates at Storforshei and processed part of the output into 342,000 tons of pellets. Increased recovery of hematite was expected in 1981 following installation of a Jones high-intensity magnetic separator. Other Norwegian production in 1980 included 448,000 tons of concentrates at Malm; 137,000 tons of vanadium-bearing magnetite concentrates at Raudsand; and 42,000 tons of byproduct ore at Tellnes.

Pakistan.—Pakistan Steel Mills Corp. (Pasmic) began imports of iron ore in 1980 to build up supplies for production of iron at the new Pipri steelworks east of Karachi, where the first of two 1,700-ton-per-day blast furnaces was scheduled to be lit in 1981. Pasmic negotiated long-term contracts for supplies of about 1.6 million tons of ore per year, distributed among five foreign producers as follows: MBR (Brazil), 27%; Mt. Newman (Australia), 18.8%; (unspecified) (India), 18.8%; Lamco (Liberia), 17.7%; and Quebec Cartier (Canada), 17.7%. Ore shipments were to be received at the new port of Muhammad bin Qasim, about 2.5 miles from the steelworks. The port can accommodate vessels of 25,000 deadweight tons, but improvements were planned to accommodate 50,000-ton vessels.

Peru.—Shipments of iron ore products from San Nicolas by Hierro Peru in 1980 totaled 6.2 million tons, including 5.8 million tons for export and 430,000 tons for domestic consumption at Chimbote. Shipments included 3 million tons of sinter feed, 1.6 million tons of pellet feed, and 1.6 million tons of pellets. About 25% of pellet feed shipped was in the form of slurry. Owing to rising prices for fuel oil, production of pellets was reduced to less than 50% of plant capacity.

Two rotary kilns for production of DRI were scheduled to be built for Siderperu at Chimbote by 1983. A coal-based reduction process (CODIR) will be used. Combined production capacity of the kilns was to be 200,000 tons of DRI per year.

Poland.—Under an agreement signed with Brazil in 1980, Poland will import 3.6 million tons of iron ore annually for 10 years. Imports of iron ore by Poland totaled a record 19.8 million tons in 1980.

Sierra Leone.—Production of iron at Marampa was expected to resume in 1982, under a contract between the Government and Austromineral, a subsidiary of Voest-Alpine AG. The mine was expected to produce up to 1 million tons of fines annually for export. There has been no production of iron ore at Marampa since 1975.

Spain.—The Marquesado Mine, operated by Cia. Andaluza de Minas, S.A., shipped a record 3.4 million tons of iron ore in 1980, including 2 million tons for domestic consumption and the remainder for export. Shipments of 2.2 million tons were reported by Cia. Minera de Sierra Menera S.A. from Ojos Negros. Altos Hornos de Vizcaya S.A. (AHV) produced 1.6 million tons of siderite concentrates from the Gallarta-Bodovalle Mines, and an additonal 423,000 tons of oxide concentrates from mines in Santander and Murcia. AHV installed a high-intensity magnetic separator at the Bodovalle concentrator, and planned to increase underground production of ore to 2.1 million tons annually by 1985.

South Africa, Republic of.—South African Iron & Steel Industrial Corp. Ltd. reported exports of 12.1 million tons of iron ore from the Sishen Mine in 1980. Ores consumed at the company's steelworks included about 6.9 million tons from Sishen and 2.1 million tons from the Thabazimbi Mine. At the Sishen Mine, the company was developing an in-pit crushing and conveying system, and an overhead trolley system to drive rear-dump trucks.

Highveld Steel and Vanadium Corp. Ltd. produced 2.1 million tons of vanadium-bearing magnetite ore from the Mapochs Mine, all for consumption at the company's works. The company also planned to increase iron production by 33% in early 1983.

Shipments of iron ore by Associated Manganese Mines of South Africa Ltd. totaled 1.25 million tons, all from the Beeshoek area of Cape Province.

Palabora Mining Co. Ltd., which recovers large quantities of magnetite from copper ore milling operations, expanded its magnetite regrinding facilities to produce a superfine product for use in coal cleaning.

Swaziland.—Swaziland Iron Ore Development Co. Ltd. completed shipments of stockpiled ore from the Ngwenya Mine in July 1980. A total of 545,000 tons was shipped to Japan in 1980, all from the port of Maputo in Mozambique. The Ngwenya Mine was closed in late 1977.

Sweden.—Shipments of iron ore products from Swedish mines in 1980 totaled 24.1 million tons, 6.3 million tons less than in 1979. Of the total quantity shipped, 20.8 million tons was exported and the rest was destined for domestic consumption. Stocks of ore totaled 7.5 million tons at yearend.

At Kiruna and Malmberget, Luossavaara-Kiirunavaara AB (LKAB) produced 23.7 million tons of ore products, including (in million tons) 10.1 of high-phosphorus ores, 7.1 of low-phosphorus ores, 6.2 of pellets, and 300,000 tons of special high-grade concentrates for consumers in the iron powder and chemical industries. About 75% of total output was produced at Kiruna and the remainder was produced at Malmberget. Ore shipments by LKAB totaled 20.8 million tons, of which 94% was exported, mostly through the port of Narvik, Norway. Declining demand for pellets during 1980 led to closing of the shaft-furnace plant in April, and production from other plants was reduced in October. All ore production and shipments at Kiruna were suspended for 2 weeks in November owing to accumulations of stocks at Narvik. Construction of a new pellet plant at Kiruna was continued. LKAB ores were increasingly beneficiated to reduce phosphorus content, and production of byproduct apatite began at Kiruna.

In central Sweden, Svenskt Stal AB produced 1.7 million tons of ore products at Grangesberg, including 1 million tons of low-phosphorus concentrates. Shipments of pellets from Strassa totaled 342,000 tons. At the Dannemora Mine, which will be 500 years old in 1981, 530,000 tons of concentrates were produced.

Trinidad and Tobago.—The first of two 400,000-ton-per-year direct-reduction plants being built at Point Lisas, 35 miles south of Port-of-Spain, began production in 1980. Iron ore import requirements for these plants may be as much as 1 million tons annually by 1983. The Iron and Steel Co. of Trinidad and Tobago was reported in 1980 to have contracted with CVRD of Brazil for supply of 3 million tons of pellets over a period of 10 years.

U.S.S.R.—Exports of iron ore in 1980 were estimated at 39.4 million tons, approximately the same as in 1978 and 1979. New production facilities reportedly completed in the Ukraine in 1980 included the Yubileynaya Mine (production capacity 4 million tons per year); expansion of ore concentration capacity in Krivoi Rog and Dnepropetrovsk Oblast by a total of 3.5 million tons of concentrate per year; and two pelletizing plants. Construction of the Kostamus project was also continued in Soviet Karelia. Soviet production capacity for pellets in 1980 appeared to approach 50 million tons annually, with another 5 million tons scheduled for completion by 1983; however, there was no official confirmation available from Soviet sources.

Venezuela.—C.V.G. Ferrominera Orinoco C.A. produced 15.7 million tons of iron ore in 1980. Shipments totaled 13.8 million tons including 11 million tons for export and 2.8 million tons for domestic consumption. Exports included 3.4 million tons to the United States and 7.4 million tons to Europe. Shipments for domestic consumption in 1980 were more than three times the quantity shipped in 1979, as Venezuelan output of DRI rose by an estimated 40% to 1.1 million tons and output of pig iron rose by 9% to 552,000 tons. Consumption was expected to increase substantially in 1981 and 1982, as a large direct-reduction plant was completed in 1980 and another was nearing completion at Matanzas.

Yugoslavia.—In Bosnia, an iron ore mine was to be developed at Omarska by the Zenica and Smederovo metallurgical combines. Production was planned to begin in 1983 at the rate of 2 million tons annually, rising to 4 million tons in 1984.

[1]Physical scientist, Section of Ferrous Metals.
[2]Unless otherwise stated, the unit of weight used in this chapter is the long ton of 2,240 pounds.

Table 2.—Crude iron ore mined in the United States in 1980, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Open pit	Underground	Total quantity
Lake Superior:			
Michigan	47,479	--	47,479
Minnesota	145,479	--	145,479
Wisconsin	1,996	--	1,996
Total	194,954	--	194,954
Other States:			
Utah	1,326	--	1,326
Other[1]	13,339	2,442	15,781
Total	14,665	2,442	17,107
Grand total	209,619	2,442	212,061

[1]Includes California, Colorado, Missouri, Nevada, New York, Texas, and Wyoming.

Table 3.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per worker in 1980, by district and State

District and State	Average number of employees	Worker hours (thousands)	Production (thousand long tons)			Iron content (natural, percent)	Average per worker-hour (long tons)		
			Crude ore	Usable ore	Iron contained (in usable ore)		Crude ore	Usable ore	Iron contained
Lake Superior:									
Minnesota	11,716	22,133	145,479	45,162	28,631	63.4	6.57	2.04	1.29
Michigan and Wisconsin	3,886	7,304	49,475	17,120	10,935	63.9	6.77	2.34	1.50
Total or average	15,602	29,437	194,954	62,282	39,566	63.5	6.62	2.12	1.34
Other States[1]	2,630	4,653	17,107	[2]7,331	[2]4,322	59.0	3.68	1.58	0.93
Grand total or average	18,232	34,090	212,061	[2]69,613	[2]43,888	63.0	6.22	2.04	1.29

[1]Includes California, Colorado, Missouri, Nevada, New York, South Dakota, Texas, Utah, and Wyoming.
[2]Includes byproduct ore.

Table 4.—Crude iron ore mined in the United States in 1980, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Number of mines	Hematite	Limonite[1]	Magnetite	Total quantity
Lake Superior:					
Michigan	4	W	--	W	47,479
Minnesota	14	4,635	--	140,844	145,479
Wisconsin	1	--	--	1,996	1,996
Total reportable	19	4,635	--	142,840	194,954
Other States:					
Utah	4	--	--	1,326	1,326
Other[2]	14	W	[3]W	W	15,781
Total reportable	18	--	--	1,326	17,107
Total withheld	--	26,832	[3]W	36,428	--
Grand total	37	31,467	[3]W	180,594	212,061

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes siderite ore.
[2]Includes California, Colorado, Missouri, Nevada, New York, Texas, and Wyoming.
[3]Included with hematite ore.

Table 5.—Crude iron ore shipped from mines in the United States in 1980, by district, State, and disposition

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Direct to consumers	To beneficiating plants	Total quantity
Lake Superior:			
Michigan	W	W	47,523
Minnesota	W	W	145,555
Wisconsin	--	1,980	1,980
Total reportable	--	1,980	195,058
Other States:			
Utah	W	W	1,355
Other[1]	268	15,644	15,912
Total reportable	268	15,644	17,267
Total withheld	1,021	193,412	--
Grand total	1,289	211,036	212,325

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes California, Colorado, Missouri, Nevada, New York, South Dakota, Texas, and Wyoming.

Table 6.—Usable iron ore produced in the United States in 1980, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Hematite	Limonite[1]	Magnetite	Total quantity[2]
Lake Superior:				
Michigan	W	--	W	16,421
Minnesota	2,035	--	43,127	45,162
Wisconsin	--	--	699	699
Total reportable	2,035	--	43,826	62,282
Other States:				
Utah	--	--	976	976
Other[3]	W	[4]W	W	[5]6,356
Total reportable	--	--	976	[5]7,332
Total withheld	9,792	[4]W	12,985	--
Grand total[2]	11,827	[4]W	57,787	[5]69,613

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Total quantity."
[1]Includes siderite ore.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes California, Colorado, Missouri, Nevada, New Mexico, New York, Texas, and Wyoming.
[4]Included with hematite ore.
[5]Includes byproduct ore.

Table 7.—Usable iron ore produced in the United States in 1980, by district, State, and type of product

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Direct-shipping ore	Agglomerates	Concentrates	Average iron content (natural), percent
Lake Superior:				
Michigan	W	W	--	63.8
Minnesota	--	43,112	2,050	63.4
Wisconsin	--	699	--	64.8
Total reportable	--	43,811	2,050	63.5
Other States:				
Utah	W	--	W	53.9
Other[1 2]	W	W	W	59.7
Total reportable	--	--	--	59.0
Total withheld	1,189	20,940	1,623	--
Grand total	1,189	64,751	3,673	63.0

W Withheld to avoid disclosing company proprietary data; included with "Total withheld."
[1]Includes California, Colorado, Missouri, Nevada, New Mexico, New York, Texas, and Wyoming.
[2]Includes byproduct ore.

Table 8.—Shipments of usable iron ore from mines in the United States in 1980

(Thousand long tons and thousand dollars exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				Total value[1]
	Direct-shipping ore	Agglomerates	Concentrates	Total quantity[1]	Direct-shipping ore	Agglomerates	Concentrates	Total quantity[1]	
Lake Superior:									
Michigan	W	W	--	15,896	W	W	--	10,051	634,355
Minnesota	W	43,101	W	45,472	W	27,485	W	28,769	1,686,839
Wisconsin	--	679	--	679	--	440	--	440	W
Total reportable	--	43,780	--	62,046	--	27,925	--	39,260	2,321,194
Other States:									
Utah	W	--	W	1,307	W	--	W	718	W
Other[2]	W	W	[3]1,370	[3]6,239	W	W	772	3,710	177,030
Total reportable	--	--	1,370	7,546	--	--	772	4,428	177,030
Total withheld	1,289	20,340	2,814	--	665	12,784	1,542	--	45,896
Grand total[1]	1,289	64,120	4,184	[3]69,594	665	40,709	2,314	43,688	2,544,121

W Withheld to avoid disclosing company proprietary data; included with "Total withheld."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes California, Colorado, Missouri, Nevada, New Mexico, New York, Texas, Virginia, and Wyoming.
[3]Includes byproduct ore.

Table 9.—Usable iron ore produced in Lake Superior district, by range

(Thousand long tons and exclusive after 1905 of ore containing 5% or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total[1]
1854-1974	426,680	315,818	320,334	103,528	2,995,312	70,336	8,149	4,419	4,244,574
1975	12,443	2,331	--	--	51,177	--	--	784	66,735
1976	14,663	2,318	--	--	49,764	--	--	668	67,413
1977	W	W	--	--	30,943	--	--	690	43,952
1978	W	W	--	--	55,316	--	--	660	72,727
1979	W	W	--	--	59,320	--	--	698	77,151
1980	W	W	--	--	45,162	--	--	699	62,282
Total[1]	507,608	329,269	320,334	103,528	3,286,994	70,336	8,149	8,618	4,634,834

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.

Table 10.—Average analyses of total tonnage[1] of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Quantity (thousand long tons)	Content (percent)[2]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1974	72,194	60.26	0.030	6.68	0.35	0.40	3.94
1975	64,174	60.91	.030	6.72	.28	.39	3.53
1976	64,928	61.38	.029	6.72	.26	.43	3.20
1977	43,239	61.66	.028	6.60	.28	.44	2.99
1978	74,307	62.26	.025	6.44	.27	.40	2.61
1979	77,837	62.55	.031	6.24	.22	.35	2.61
1980	61,536	62.98	.023	5.88	.18	.32	2.57

[1]Railroad weight—gross tons.
[2]Iron and moisture on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association. Iron Ore, 1980, p. 92.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1980

(Thousand long tons and exclusive of ore containing 5% or more manganese)

State	Iron ore and concentrates[1]		Agglomerates[2]		Miscellaneous[3]	Total reportable
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Texas	636	W	7,428	W	W	8,064
California, Colorado, Utah	1,422	W	4,997	--	W	6,419
Ohio and West Virginia	332	25	17,187	52	W	17,596
Illinois, Indiana, Michigan	1,643	W	34,817	W	W	36,460
Maryland, New York, Pennsylvania	2,000	183	26,597	61	W	28,841
Undistributed	--	50	--	314	1,133	1,497
Total[4]	6,034	258	91,026	428	1,133	98,879

W Withheld to avoid disclosing company proprietary data; included in "Undistributed."
[1]Not including pellets or other agglomerated products.
[2]Includes 56,779,057 tons of pellets produced at U.S. mines and 9,937,205 tons of foreign pellets.
[3]Includes iron ore consumed in production of cement, and iron ore shipped for use in manufacture of paint, ferrites, heavy media, cattle feed, refractory and weighting materials, and in lead blast furnaces.
[4]Data may not add to totals shown because of independent rounding.

Table 12.—Iron ore consumed in production of agglomerates at iron and steel plants in 1980, by State

(Thousand long tons)

State	Iron ore consumed[1]	Agglomerates produced
Alabama, Kentucky, Texas	1,934	2,843
California, Colorado, Utah	1,725	2,001
Ohio and West Virginia	1,011	1,882
Illinois, Indiana, Michigan	3,417	7,556
Maryland, New York, Pennsylvania	6,325	10,069
Total	14,412	24,351

[1]Includes domestic and foreign ores.

Table 13.—Beneficiated iron ore shipped from mines in the United States[1]

(Thousand long tons and exclusive of ore containing 5% or more manganese)

Year	Beneficiated ore	Total iron ore	Proportion of beneficiated ore to total (percent)
1975	73,951	75,695	97.7
1976	74,848	76,697	97.6
1977	52,061	53,880	96.6
1978	80,875	82,826	97.6
1979	84,489	86,130	98.1
1980	68,272	69,562	98.1

[1]Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore.

Table 14.—Production of iron ore agglomerates[1] in the United States, by type

(Thousand long tons)

Type	Agglomerates produced	
	1979	1980
Sinter	[2]32,407	[3]24,351
Pellets	77,799	64,218
Total	[4]110,207	88,569

[1]Production at mines and consuming plants.
[2]Includes 15,558,665 tons of self-fluxing sinter.
[3]Includes 10,840,615 tons of self-fluxing sinter.
[4]Data do not add to total shown because of independent rounding.

Table 15.—Stocks of usable iron ore at mines,[1] December 31, by district

(Thousand long tons)

District	1979	1980
Lake Superior	6,481	6,305
Other States	4,785	4,331
Total	11,266	10,636

[1]Excluding byproduct ore.

Table 16.—Average value of usable iron ore[1] shipped from mines or beneficiating plants in the United States in 1980

(Dollars per long ton)

Type of ore	Lake Superior District	Other States[2]
Direct-shipping	W	[e]14.12
Concentrates	17.83	20.61
Pellets	38.72	32.04

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]F.o.b. mine or plant. Excludes byproduct ore.
[2]Includes California, Colorado, Missouri, Nevada, New York, Utah, and Wyoming.

Table 17.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	4,206	136,277	5,108	177,069	5,652	228,868
France	(1)	5	(1)	7	(1)	48
Germany, Federal Republic of	1	46	2	162	1	42
Japan	--	--	(1)	4	(1)	6
Mexico	2	42	24	914	25	1,212
Norway	--	--	--	--	--	--
Taiwan	(1)	2	(1)	9	(1)	3
United Kingdom	(1)	31	3	197	(1)	10
Other	3	317	11	386	11	379
Total[2]	4,213	136,721	5,148	178,749	5,689	230,568

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 18.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	264	3,935	183	2,936	(1)	1
Brazil	3,979	96,773	3,095	81,446	1,995	62,889
Canada	19,236	555,657	22,602	683,286	17,311	581,759
Chile	390	4,828	245	4,458	322	10,293
India	--	--	54	1,332	--	--
Liberia	2,170	38,737	2,190	38,112	1,590	27,612
Norway	302	6,567	44	561	--	--
Peru	818	21,629	456	14,126	193	6,678
South Africa, Republic of	94	2,949	106	2,551	6	82
Sweden	256	6,055	171	4,568	33	917
Tunisia	--	--	--	--	--	--
U.S.S.R.	(1)	2	--	--	--	--
Venezuela	6,083	107,392	4,563	87,613	3,602	80,981
Other	23	515	65	2,437	6	1,632
Total[2]	33,616	845,039	33,776	923,426	25,058	772,844

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 19.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	6,417	184,312	6,763	207,840	5,230	185,445
Buffalo	1,486	37,690	1,482	41,322	592	10,756
Charleston	17	921	--	--	--	--
Chicago	4,200	107,143	5,013	141,691	2,811	102,566
Cleveland	7,156	206,507	5,367	135,439	4,333	124,893
Detroit	540	10,233	668	16,255	547	8,751
Galveston	--	--	--	--	212	5,979
Houston	797	21,728	1,075	35,053	944	34,633
Los Angeles	406	6,526	695	15,388	107	2,745
Mobile	3,340	69,021	4,933	130,231	3,675	113,050
New Orleans	1,559	32,525	856	14,641	180	3,465
Philadelphia	7,062	153,708	6,087	164,775	6,005	166,943
Portland, Oreg	151	2,723	199	3,536	--	--
Wilmington, N.C	481	11,627	638	17,227	406	13,140
Other	4	376	(1)	27	16	478
Total[2]	33,616	845,039	33,776	923,426	25,058	772,844

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production, by country[1]

(Thousand long tons)

Country[2]	Gross weight[3]					Metal content[4]				
	1976	1977	1978	1979[p]	1980	1976	1977	1978	1979[p]	1980[e]
North and Central America:										
Canada[5]	r54,677	r56,727	41,091	58,942	[6]47,984	r36,030	r35,596	25,814	37,086	[6]30,316
Mexico[7]	r5,693	r5,604	5,555	6,313	[6]7,948	r3,587	r3,531	3,500	3,977	[6]5,007
United States[8]	79,993	55,750	81,583	85,716	[6]69,613	49,362	34,489	50,764	53,639	[6]43,888
South America:										
Argentina	498	1,014	895	601	[6]699	268	535	480	322	[6]375
Bolivia	([9])	[9]7	55	25	[6]6	--	4	35	16	[6]4
Brazil	92,601	80,706	83,643	102,439	104,320	60,191	52,459	54,368	66,585	67,800
Chile	9,896	r7,766	6,931	7,407	[6]8,451	6,088	r4,778	4,267	4,561	[6]5,203
Colombia	490	453	446	372	394	r226	208	205	171	181
Peru	r7,017	r6,150	4,844	5,358	5,640	r4,647	4,000	3,148	3,565	[6]3,663
Venezuela	18,390	13,467	13,302	16,091	[6]15,848	r11,402	8,349	8,247	9,976	[6]9,826
Europe:										
Albania[10] [e]	r471	r502	r502	r521	541	r165	r176	r176	r183	189
Austria	3,724	3,394	2,744	3,149	[6]3,149	1,147	1,052	853	984	[6]970
Belgium	62	46	42	--	--	19	14	13	--	--
Bulgaria	2,279	2,234	2,413	2,070	2,067	736	696	749	641	640
Czechoslovakia	1,874	1,963	1,991	1,980	[6]1,897	564	589	597	539	[6]517
Denmark	8	5	5	9	9	3	2	2	4	4
Finland[11]	1,149	1,123	1,071	1,126	[6]1,154	756	741	700	726	[6]743
France	44,467	36,051	32,925	31,127	[6]28,522	13,574	10,875	10,147	9,645	[6]8,920
German Democratic Republic[12]	r58	r65	79	69	69	23	r26	31	27	27
Germany, Federal Republic of (salable)	2,220	2,453	1,575	1,631	[6]1,913	738	r808	503	518	[6]608
Greece	2,170	2,017	1,659	1,803	1,476	933	r867	713	775	635
Hungary	592	517	526	524	[6]420	141	123	123	126	[6]101
Italy[13]	506	471	347	215	[6]182	253	198	140	86	[6]72
Luxembourg	2,046	1,523	822	620	[6]555	605	458	267	210	[6]188
Norway	3,909	3,577	3,713	4,182	[6]3,747	2,524	r2,302	2,402	2,705	[6]2,423
Poland	663	649	521	245	197	199	195	156	74	59

See footnotes at end of table.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production, by country[1] —Continued

(Thousand long tons)

Country[2]	Gross weight[3]					Metal content[4]				
	1976	1977	1978	1979[p]	1980	1976	1977	1978	1979[p]	1980[e]
Europe —Continued										
Portugal[14]	[r]49	52	54	59	[6]56	28	[r]26	26	28	[6]25
Romania	2,790	2,428	2,472	2,483	2,264	[r]714	[r]622	633	636	580
Spain[8]	8,097	8,196	8,444	8,687	8,850	[r]4,008	4,057	3,845	3,931	4,300
Sweden	29,390	24,446	21,147	26,199	[6]26,755	18,807	15,861	13,724	16,374	16,722
U.S.S.R	[r]237,300	[r]238,031	242,362	237,920	[6]241,130	[r]128,141	[r]128,507	130,876	128,477	130,210
United Kingdom	4,510	3,686	4,172	4,202	[6]898	1,083	885	1,085	1,092	233
Yugoslavia	4,202	4,381	4,492	4,543	[6]4,458	1,475	1,490	1,595	1,593	1,564
Africa:										
Algeria	2,756	3,132	2,988	3,149	3,740	[r]1,488	1,691	1,613	1,701	2,020
Egypt	1,223	1,387	1,433	1,413	[6]1,748	[r]612	693	717	706	874
Kenya[15]	20	16	20	[e]20	20	[e]12	[e]9	[e]12	[e]12	12
Liberia	[r]20,208	[r]17,381	17,705	18,055	17,105	[r] [e]12,529	[r] [e]10,776	[r] [e]10,978	[r] [e]11,194	10,605
Mauritania	[r]9,492	9,639	6,824	9,225	8,465	6,135	6,217	4,231	5,720	5,248
Morocco	337	434	58	61	79	[r]212	[r]278	37	39	50
South Africa, Republic of[16]	15,416	[r]26,062	23,824	29,098	[6]25,897	[r]9,635	[r]16,680	15,247	18,623	[6]16,574
Swaziland	[r]1,716	1,418	1,246	--	--	1,030	851	748	--	--
Tunisia	487	338	334	387	[6]383	251	172	170	198	[6]195
Zimbabwe	1,330	1,157	1,105	1,182	[6]1,596	[r] [e]599	[r] [e]521	[r] [e]497	[r] [e]532	718
Asia:										
China:										
Mainland[e]	[r]59,100	49,200	68,900	73,800	73,800	[r]29,500	24,600	[r]34,400	[r]36,900	36,900
Taiwan	--	32	--	--	--	--	[r]16	--	--	--
Hong Kong	36	--	--	--	--	18	--	--	--	--
India	[r]43,175	[r]41,925	38,224	38,910	[6]40,028	[r]27,028	[r]26,245	23,929	24,357	[6]25,057
Indonesia	[r]288	307	230	79	[6]74	161	172	133	44	[6]41
Iran[17]	1,053	1,083	1,535	[e]600	590	643	660	937	[e]365	360
Japan[18]	746	673	587	450	470	443	435	382	183	291
Korea, North[e]	[r]6,500	[r]6,800	[r]7,000	[r]7,300	7,900	[r]2,700	[r]2,800	2,900	3,000	3,100
Korea, Republic of	743	778	682	629	[6]609	416	436	382	352	[6]341
Malaysia	303	325	315	345	[6]365	185	198	192	210	[6]223
Philippines	562	--	2	3	--	315	--	1	2	--
Thailand	25	62	87	101	[6]84	15	37	52	61	[6]50

Turkey	r3,574	3,415	4,132	1,924	2,165	r1,858	1,776	2,149	1,001	1,126
Oceania:										
Australia	91,782	94,408	81,821	90,268	694,033	57,642	r59,508	51,990	57,097	659,318
New Zealand[19]	2,435	r2,908	3,884	3,472	3,270	1,388	r1,658	2,214	1,979	1,865
Total	r885,098	r828,334	835,359	897,099	873,633	r503,252	r470,948	474,095	513,548	500,961

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 10, 1981.
[2]In addition to the countries listed, Cuba and Vietnam may produce iron ore, but definitive information on output levels, if any, is not available.
[3]Insofar as availability of sources permits, gross weight data in this table represent the nonduplicative sum of marketable direct-shipping iron ores, iron ore concentrates, and iron ore agglomerates produced by each of the listed countries. Concentrates and agglomerates produced from imported iron ores have been excluded, under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.
[4]Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron ore content reported, except for the following countries for which grades are U.S. Bureau of Mines estimates: Albania, Denmark, Hungary, Zimbabwe, mainland China, and North Korea.
[5]Series revised to represent gross weight and metal content of usable iron ore (including byproduct ore) actually produced dry tons. (Data in previous edition represented shipments.)
[6]Reported figure.
[7]Gross weight calculated from reported iron content based on grade of 63% Fe.
[8]Includes byproduct ore.
[9]Exports.
[10]Nickeliferous iron ore.
[11]Includes magnetite concentrate, pelletized iron oxide (from pyrite sinter) and roasted pyrite (purple ore).
[12]Includes "roasted ore," presumably pyrite sinter, not separable from available sources.
[13]Excludes iron oxide pellets produced from pyrite sinter.
[14]Includes manganiferous iron ore.
[15]For cement manufacture.
[16]Includes byproduct magnetite as follows in thousand long tons: 1976—r3,412; 1977—r4,971; 1978—3,821; 1979-80—not available.
[17]Year beginning March 21 of that stated.
[18]Concentrate including concentrate derived from iron sand as follows in thousand long tons: 1976—191; 1977—124; 1978—66; 1979-80—not available.
[19]Largely concentrates from magnetite-titanium sands.

Iron Oxide Pigments

By William I. Spinrad, Jr.[1]

Production and trade in finished iron oxide pigments were down in 1980. Automotive and construction slowdowns decreased the demand for pigments in coatings and construction materials. The coatings industry was down 50 million gallons from 1979 levels, a 4.7% decrease. Shipments of synthetic iron oxide pigments continued to dominate over those of natural iron oxides in both unit price per pound and volume. Natural iron oxides have continued to compete with synthetic oxides, however, owing to their low cost and special applications by some industries.

In 1980, Mobay Chemical Corp. completed its 45,000-ton-per-year synthetic iron oxide plant in New Martinsville, W. Va. Pfizer Inc. completed expansion to its synthetic iron oxide plant in East St. Louis, Ill., and opened a new synthetic iron oxide plant in Valparaiso, Ind. Virginia Earth Pigments Co., a new crude producer located in Wythe County, Va., maintained a pilot operation for the production of crude brown iron oxide.

Prices increased for many iron oxides in 1980, with increases occurring in January, April, and November. Italian burnt sienna showed an annual increase of 23.0 cents per pound, Turkish burnt umber increased 7.0 cents per pound, and other annual increases ranged from 2.0 cents per pound for metallic brown to 6.0 cents per pound for synthetic red.

Table 1.—Salient iron oxide pigments statistics in the United States

	1976	1977	1978	1979	1980
Mine production short tons	66,848	59,233	84,796	87,869	49,078
Crude pigments sold or used do	59,636	55,953	75,967	74,548	62,642
Value thousands	$1,626	$2,143	$2,799	$2,578	$4,043
Iron oxides from steel plant wastes short tons	21,403	21,024	20,924	25,186	20,717
Value thousands	$1,258	$1,644	$1,396	$1,703	$1,394
Finished pigments sold short tons	135,915	140,707	152,510	156,036	136,336
Value thousands	$64,506	$73,851	$81,830	$94,175	$97,270
Exports short tons	5,805	6,493	7,064	4,852	5,046
Value thousands	$3,353	$4,065	$6,649	$7,359	$9,132
Imports for consumption short tons	50,102	58,694	70,549	55,377	39,446
Value thousands	$16,554	$20,596	$24,706	$24,341	$20,035

DOMESTIC PRODUCTION

Sales data for finished iron oxide pigments (table 2) were compiled from information received from the Bureau of Mines annual canvass. In 1980, 19 companies responded to this canvass, representing 95% coverage of all companies that produce finished natural and/or synthetic iron oxide pigments. These companies are listed in table 3.

Domestic production of finished iron oxide pigments decreased 13% in 1980. Natural pigments sustained a 20% decrease, synthetics and other specialty oxides had a 6% decrease, and mixtures of natural and synthetic iron oxides experienced a 10% decline from 1979. Mobay Chemical Corp.'s new 45,000-ton-per-year synthetic iron oxide pigment plant, located in New Martinsville,

W. Va., reached final completion by the last quarter of 1980. Pfizer Inc., opened a new synthetic iron oxide plant in Valparaiso, Ind., and completed expansion of its synthetic iron oxide plant in East St. Louis, Ill.

Steel plant byproducts, reported by five steel companies, totaled 20,717 short tons of regenerator oxides and steel plant dust, a decline of 18% from 1979. These byproducts are mainly used in the manufacture of ferrites, industrial coatings, and foundry sands. Other uses for these byproducts are categorized in table 4.

Mine production of crude pigments decreased 44% in 1980. A portion of this decrease was effected by the July 1979 closure of Cleveland-Cliffs Iron Co.'s Mather Mine, located in Negaunee, Mich. Cleveland-Cliffs continued to ship from stockpiles, however. Virginia Earth Pigments Co., a newcomer in crude production, has been producing brown iron oxides as a pilot project. Their mine is located in Wythe County, Va.

The downturn in iron oxide pigment production, both crude and finished, was caused by recessionary trends in the U.S. economy. Slowdowns in automotive, coating, construction, and other industries in turn affected the pigment producers. According to the F. W. Dodge Division of McGraw Hill Information Systems Co., 1980 saw a 25% slump in new housing starts and a 13% dip in contracting for new construction. Inflationary trends also took their toll. As the cost of borrowing increased, companies began reducing inventories, which also affected pigment producers.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Pigment	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Black: Magnetite	8,075	$906	5,402	$635
Brown:				
Iron oxide[1]	10,075	3,481	8,123	2,026
Umbers:				
Burnt	4,495	2,665	3,954	2,583
Raw	1,782	970	1,383	873
Red:				
Iron oxide[2]	40,618	3,953	33,136	3,379
Sienna, burnt	647	464	544	401
Yellow:				
Ocher[3]	6,865	945	5,214	850
Sienna, raw	683	399	630	395
Total natural[4]	73,240	13,782	58,386	11,143
Synthetic:				
Brown: Iron oxide[5]	11,404	11,319	10,328	10,820
Red: Iron oxides	33,344	32,540	31,998	34,791
Yellow: Iron oxide	24,550	22,651	21,703	21,424
Other: Specialty oxides	10,291	12,053	11,044	17,367
Total synthetic[4]	79,590	78,563	75,073	84,402
Mixtures of natural and synthetic iron oxides	3,205	1,830	2,877	1,726
Grand total[4]	156,036	94,175	136,336	97,270

[1]Includes Vandyke brown.
[2]Includes pyrite cinder.
[3]Includes yellow iron oxide.
[4]Data may not add to totals shown because of independent rounding.
[5]Includes synthetic black iron oxide.

Table 3.—Producers of iron oxide pigments in the United States in 1980

Producer	Mailing address	Plant location
Finished pigments:		
BASF Wyandotte Corp., Pigments Div.	491 Columbia Ave. Holland, MI 49423	Wyandotte, Mich.
Blue Ridge Talc Co., Inc	Box 39 Henry, VA 24102	Henry, Va.
Chemalloy Co., Inc	Box 350 Bryn Mawr, PA 19010	Bryn Mawr, Pa.
Columbian Chemicals Co	Box 300 Tulsa, OK 74102	St. Louis, Mo.; Monmouth Junction, N.J.; Trenton, N.J.
Combustion Engineering, Inc., CE Minerals Div.	901 East 8th Ave. King of Prussia, PA 19406	Camden, N.J.
DCS Color & Supply Co., Inc	1050 East Bay St. Milwaukee, WI 53207	Milwaukee, Wis.
E. I. du Pont de Nemours & Co.	Pigments Dept. Wilmington, DE 19898	Newark, N.J.
Ferro Corp., Ottawa Chemical Div.	700 North Wheeling St. Toledo, OH 43605	Toledo, Ohio.
Foote Mineral Co	Route 100 Exton, PA 19341	Exton, Pa.
Hoover Color Corp	Box 218 Hiwassee, VA 24347	Hiwassee, Va.
Mobay Chemical Corp	Penn Lincoln Parkway West Pittsburgh, PA 15205	New Martinsville, W. Va.
New Riverside Ochre Co	Box 387 Cartersville, GA 30120	Cartersville, Ga.
Pfizer Inc., Minerals, Pigments & Metals Div.	235 East 42d St. New York, NY 10017	Emeryville, Calif.; East St. Louis, Ill.; Easton, Pa.; Valparaiso, Ind.
Prince Manufacturing Co	700 Lehigh St. Bowmanstown, PA 18030	Quincy, Ill. and Bowmanstown, Pa.
Reichard-Coulston Inc	15 East 26th St. New York, NY 10010	Bethlehem, Pa.
George B. Smith Chemical Works, Inc.	1 Center St. Maple Park, IL 60151	Maple Park, Ill.
St. Joe Lead Co., Pea Ridge Iron Ore Co.	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, Mo.
Solomon Grinding Service	Box 1766 Springfield, IL 62705	Springfield, Ill.
Sterling Drug, Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, OH 45237	Cincinnati, Ohio.
Crude pigments:		
Cleveland-Cliffs Iron Co., Mather Mine & Pioneer Plant (closed July 31, 1979; shipping from stockpile).	1460 Union Commerce Bldg. Cleveland, OH 44115	Negaunee, Mich.
Hoover Color Corp	Box 218 Hiwassee, VA 24347	Hiwassee, Va.
St. Joe Lead Co. Pea Ridge Iron Ore Co.	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, Mo.
New Riverside Ochre Co	Box 387 Cartersville, GA 30120	Cartersville, Ga.
Virginia Earth Pigments Co	Box 1403 Pulaski, VA 24301	Patterson, Va.

CONSUMPTION AND USES

Demand for iron oxide pigments in coatings and building materials was down in 1980. Consumption by the coating industry, which accounted for 37% of all iron oxide consumption, dwindled to a total of 50 million gallons from that of 1979, a decrease of 4.7%. Architectural coatings were off 7.3% or 41,881,000 gallons, product coatings were down 10.3% or 34,101,000 gallons, these being partially offset by special-purpose coatings, up 15.6% or 25,854,000 gallons.[2] The use of micaceous iron oxide as an anticorrosion pigment is slowly making an appearance in the United States. Because of its opaque metallic luster and lamellar structure, adhesiveness, chemical inertness, and durability, the pigment shows excellent resistance to chemicals and solvents, moisture, sunlight, and ultraviolet radiation. Micaceous iron oxide is also nontoxic and exhibits excellent heat resistance. It has been used in Europe for over 80 years on bridges and other structures with continued success. The State of Virginia presently uses it in an alkyd topcoat of a two-coat system, and other States are becoming cognizant of its attributes.

Construction industries and some consumer product industries also showed a downturn in 1980, adversely affecting construction materials, which accounted for 22% of all iron oxide use; colorants, which accounted for 11% of all iron oxide use; and other consumptive uses of iron oxides. Iron oxides have continued to find burgeoning uses, however, as high-quality cement additives, as weighting agents for drilling, in concrete for nuclear shielding, and in high-density pipeline coatings.

Table 4.—Percent of iron oxide consumption, by end use

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1979	1980	1979	1980	1979	1980
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	38.0	37.0	26.0	28.0	48.0	44.0
Construction materials (cement, mortar, preformed concrete, roofing granules)	21.0	22.0	23.0	25.0	18.0	21.0
Ferrites and other magnetic and electronic applications	11.0	9.0	10.0	7.0	11.0	10.0
Colorants for plastics, rubber, paper, textiles, glass, ceramics	10.0	11.0	7.0	7.0	12.0	13.0
Industrial chemicals (such as catalysts)	7.0	7.0	6.0	5.0	9.0	8.0
Animal feed and fertilizers	8.0	7.0	17.0	15.0	1.0	3.0
Foundry sands	4.0	5.0	9.0	11.0	--	--
Other (including cosmetics and jeweler's rouge)	1.0	2.0	2.0	2.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

PRICES

Prices increased for well over one-half of the finished iron oxide pigments in 1980, with increases occurring in January, April, and November. January's increases were reported to have been initiated by Mobay Chemical Corp., soon followed by Pfizer Inc., and other primary producers. Both synthetic red and synthetic yellow iron oxides increased 1.5 cents per pound, these increases being attributed to higher energy, labor, and raw materials costs.

In April, Italian burnt sienna increased a notable 11 cents per pound. Other increases ranged from 0.5 cent per pound for metallic brown to 5.75 cents per pound for Vandyke brown, red domestic primers, and Spanish red iron oxides. Synthetic yellow dropped 0.5 cent per pound.

November's round of price increases again showed a strong 12-cent-per-pound increase in Italian burnt siennas. Because of its price and scarcity, some major users have purportedly started to formulate away from this colorant. Burnt Turkish umbers showed a 7-cent-per-pound increase. This natural oxide is also becoming scarce in some shades because of ore depletion in some mines. Other increases ranged from 1.5 cents per pound for metallic brown to 4.5 cents per pound for synthetic yellow. Increases in synthetics were again attributed to higher energy costs in their production.

It was reported that Reichard-Coulston Inc. announced price increases for its various iron oxide products, effective December 10, 1980. These increases were to range from 5% to 7.5%.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments, December 31, 1980

Pigment	Low	High
Black:		
Synthetic	$0.4300	$0.4900
Micaceous	.5500	--
Brown:		
Ground iron ore	.1000	.1300
Metallic	.1825	.2050
Pure, synthetic	.4700	.5500
Sienna, Italian, burnt	--	.7000
Umber, Turkish, burnt	.3100	.3600
Vandyke brown	--	.3600
Red:		
Domestic primers	0.2200	0.2900
Pure, synthetic	--	.5250
Spanish	.2800	.3200
Yellow:		
Synthetic	--	.5175
Ocher, domestic	.1275	--

Source: American Paint Journal.

FOREIGN TRADE

Exports of pigment-grade iron oxides and hydroxides increased 4% in quantity and 24% in value in 1980, Canada accounting for 38% of these exports. Exports of other grade iron oxides and hydroxides, however, decreased in quantity and value, 37% and 22%, respectively. Canada, Japan, and the Netherlands were our primary export markets in this category.

Imports for consumption of selected iron oxide pigments decreased 29% in quantity and 18% in value in 1980. The Federal Republic of Germany, which accounts for 51% of U.S. imported synthetic iron oxides, experienced a 24% decrease from 1979. This was largely attributed to the completion of a 45,000-ton-per-year synthetic iron oxide plant in New Martinsville, W. Va., owned by Mobay Chemical Corp., a subsidiary of Bayer AG of the Federal Republic of Germany. Cyprus, which sustained a 43% decrease from 1979, still accounts for 67% of all imported natural iron oxides and hydroxides to the United States. Synthetic iron oxides accounted for 84% of U.S. total imports, up 3% from 1979, showing continued interest in synthetics over natural iron oxides. The average price per pound for these synthetics also increased in 1980.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Destination	1979				1980			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	13	$25	7	$8	1	$16	6	$11
Australia	272	337	329	799	216	445	131	432
Belgium-Luxembourg	19	103	39	43	142	190	37	42
Brazil	238	388	64	137	398	459	124	227
Canada	1,756	1,696	4,050	2,214	1,929	1,986	1,622	1,559
Colombia	41	48	12	11	13	28	--	--
Costa Rica	6	5	14	9	8	14	1	1
Denmark	46	189	3	2	14	65	23	53
Dominican Republic	9	11	7	7	5	6	7	10
Ecuador	24	36	15	36	14	20	8	9
Egypt	21	17	--	--	--	--	--	--
El Salvador	1	5	1	2	2	1	--	--
Finland	62	51	2	6	172	155	--	--
France	74	144	342	887	94	173	105	148
Germany, Federal Republic of	41	63	364	889	60	147	264	756
Guatemala	14	15	--	--	4	6	2	1
Hong Kong	72	78	29	45	98	119	--	--
India	1	5	12	28	2	7	2	5
Indonesia	39	118	--	--	15	46	--	--
Iran	--	--	23	13	--	--	--	--
Israel	(1)	1	--	--	2	5	--	--
Italy	289	681	218	411	277	735	25	32
Jamaica	8	22	--	--	1	1	--	--
Japan	206	646	1,431	3,136	267	1,264	1,523	4,024
Korea, Republic of	402	624	183	461	289	454	57	208
Liberia	15	14	--	--	7	7	9	8
Mexico	69	89	379	551	25	46	206	344
Netherlands	73	159	4,028	2,857	95	279	3,198	2,250
New Zealand	9	12	2	3	7	20	1	3
Pakistan	--	--	75	116	--	--	--	--
Philippines	38	36	--	--	21	20	1	2
Poland	--	--	3	14	--	--	3	15
Portugal	4	7	5	22	--	--	22	83
Seychelles	--	--	12	26	--	--	--	--
Singapore	26	45	17	56	30	57	66	96
South Africa, Republic of	16	31	1	3	25	86	--	--
Spain	36	45	(1)	1	32	41	5	20
Sweden	39	139	7	9	22	54	12	19
Switzerland	1	2	4	27	(1)	1	6	23
Taiwan	105	185	302	233	39	142	15	61
Thailand	7	6	18	21	9	8	40	64
United Kingdom	505	994	585	1,337	391	1,631	188	244
U.S.S.R	--	--	--	--	--	--	--	--
Venezuela	206	227	89	68	254	319	117	195
Yugoslavia	--	--	--	--	--	--	--	--
Other	48	60	19	21	66	80	218	376
Total[2]	4,852	7,359	12,691	14,508	5,046	9,132	8,042	11,318

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 7.—U.S. imports for consumption of selected iron oxide pigments

Pigment	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Crude:				
Siennas	287	$133	151	$73
Umbers	6,831	615	3,800	444
Other	74	168	10	74
Total[1]	7,191	916	3,962	591
Finished:				
Ochers	3	2	1	1
Siennas	178	77	93	43
Umbers	736	242	634	242
Vandyke brown	798	259	687	260
Other	1,350	302	807	224
Total[1]	3,064	882	2,222	770
Synthetic:				
Black	9,439	1,975	3,694	1,832
Red	8,148	4,469	5,667	3,103
Yellow	12,143	8,513	11,648	8,484
Other[2]	15,390	7,587	12,253	5,255
Total[1]	45,121	22,543	33,262	18,674
Grand total[1]	55,377	24,341	39,446	20,035

[1]Data may not add to totals shown because of independent rounding.
[2]Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Bureau of the Census.

Table 8.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, by country

Country	Natural				Synthetic			
	1979		1980		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	118	$70	79	$57	--	--	--	--
Belgium-Luxembourg	21	7	--	--	252	$120	163	$68
Brazil	--	--	--	--	20	4	--	--
Canada	24	10	2	6	16,614	3,383	9,750	2,805
Cyprus	7,268	731	4,136	551	--	--	--	--
France	(1)	2	1	6	15	25	(1)	(1)
Germany, Federal Republic of	794	277	689	271	22,122	14,882	16,836	11,595
India	20	1	--	--	--	--	--	--
Italy	405	190	163	88	(1)	2	--	--
Japan	47	141	13	74	3,059	2,792	5,057	3,481
Mexico	--	--	--	--	1,261	524	998	485
Netherlands	(1)	1	--	--	830	224	208	89
South Africa, Republic of	2	1	1	1	--	--	--	--
Spain	1,176	217	719	142	56	26	40	8
United Kingdom	380	152	360	159	891	560	155	107
Other	--	--	14	6	1	1	56	37
Total[2]	10,256	1,798	6,183	1,361	45,121	22,543	33,262	18,674

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

WORLD REVIEW

World mine production of natural iron oxide pigments, for reporting countries surveyed, decreased in 1980. In addition to the countries listed in table 9, other countries undoubtedly produced iron oxide pigments, but do not quantitatively report this data, including but not limited to the centrally planned economy countries.

The major world suppliers of natural red iron oxides are India and Spain, Spain's "Spanish red" oxide being well established in world markets. Major suppliers of yellow ocher include the Republic of South Africa, France, Cyprus, Spain, and the United States, while Italy dominates in the supply of sienna, and Cyprus dominates in the world supply of umber.

Australia.—Universal Milling Co. Pty. Ltd. has been granted rights to mine a red iron oxide deposit northeast of Geraldton. Universal is establishing a $250,000 mining and processing plant and is presently conducting mapping studies of the deposit. It is estimated that this project will be ongoing in mid-1982.

Austria.—Karntner Montanindustrie GmbH, a micaceous iron oxide producer located in Waldenstein, has experienced a rise in demand from 2,000 to 10,000 tons per year over the last 10 years. The producer has continued to upgrade and further delineate its reserves to handle increased demands in the future.[3]

Germany, Federal Republic of.—Synthetic iron oxide pigment production in the world continues to be led by Bayer AG. At present, Bayer is expanding its plant in Verdingen to 300,000 tons per year. Its subsidiary, Mobay Chemical Corp. of New Martinsville, W. Va., completed its 45,000-ton-per-year synthetic iron oxide plant in 1980.

Spain.—At the request of the country's pigment producers, on November 25, 1980, the Spanish commercial authorities invalidated the minimum price quotations for Spanish natural iron oxide pigments, allowing the producers to set their own prices.

Table 9.—Natural iron oxide pigments: World mine production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Argentina	192	230	534	679	550
Australia	1,130	68	[e]55	[e]55	80
Austria	11,714	10,808	11,750	13,553	13,200
Brazil	6,566	7,308	6,833	7,200	7,200
Burma	679	254	508	407	440
Canada	--	--	--	3,000	3,100
Chile	7,651	8,979	5,801	2,900	6,300
Cyprus[e 3]	[r]22,400	[r]30,200	32,700	28,700	28,000
Egypt	3,590	35	270	149	150
France	12,152	17,529	[r e]17,600	[r e]18,200	17,600
Germany, Federal Republic of[4]	25,177	29,124	23,672	31,439	31,000
India	101,471	83,704	85,725	93,556	[5]95,017
Iran[6]	5,057	[r e]3,900	[e]2,200	[e]1,100	550
Italy[e]	[r]2,000	1,900	1,500	1,100	1,000
Morocco	15	39	24	23	22
Pakistan	17,411	15,774	5,150	1,133	4,400
Paraguay	132	132	165	220	190
Portugal	44	68	90	[e]65	70
South Africa, Republic of	2,658	2,392	2,411	2,382	1,500
Spain:					
Ocher	9,902	13,630	13,478	16,621	16,500
Red iron oxide	29,929	39,971	[r e]26,100	[e]27,500	27,500
United States	66,848	59,233	84,796	87,869	[5]49,078

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 4, 1981.
[2]In addition to the countries listed, a considerable number of others undoubtedly produce iron oxide pigments, but output is not reported quantitatively, and no basis is available for formulating estimates of output levels. Such countries include (but are not limited to) mainland China and the U.S.S.R. Because unreported output is probably substantial, this table is not added to provide a world total.
[3]Series revised; data presented in previous editions represented only exports; revised series incorporates a substantial estimate for domestic consumption.
[4]Includes Vandyke brown.
[5]Reported figure.
[6]Iranian calendar year (Mar. 21 to Mar. 20), beginning in the year stated.

TECHNOLOGY

The Bureau of Mines published Information Circular 8813 in 1980 entitled, "Iron Oxide Pigments (in Two Parts). 2. Natural Iron Oxide Pigments–Location,Production, and Geological Description." This comprehensive circular, comprising 79 pages, reviews the location, principal producers, and geologic occurrence of natural iron oxides worldwide. It is supplied with political and geologic maps pertinent to text discussion.[4]

Iron oxides have expanded in the industrial mineral market because of their high specific gravity and low costs. As a weighting agent for drilling fluids, iron oxides are competing with barytes. Densimix Ltd. of Houston, Tex., is introducing a Brazilian soft micaceous hematite with a specific gravity of 5.0 plus. Sactleben Chemie GmbH, a subsidiary of Metallgesellschaft AG, Federal Republic of Germany, is marketing "Fer-O-Bar," a composite of 85% iron oxide and 15% silicates of aluminum, calcium, and zinc. This composite is prepared from iron oxide cinders resulting from the roasting of the company's pyrites. "Fer-O-Bar" has a specific gravity of 4.7, a maximum of 0.1% of water-soluble solids, and a maximum of 100 parts per million of water-soluble metals.[5]

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[1]Physical scientist, Section of Ferrous Metals.

[2]American Paint & Coatings Journal. Coatings Volume Continuing Downslide. V. 65, No. 43, Apr. 6, 1981, p. 29.

[3]Industrial Minerals. The Industrial Minerals of Austria. No. 161, February 1981, pp. 21-41.

[4]Jolly, J. L. W., and C. T. Collins. Iron Oxide Pigments (In Two Parts). 2. Natural Iron Oxide Pigments—Location, Production, and Geological Description. BuMines IC 8813, 1980, 79 pp.

[5]Industrial Minerals. Iron Oxides—The Other Uses. No. 161, February 1981, pp. 53-63.

Iron and Steel

By D. H. Desy[1]

World raw steel production declined for the first time since 1975, with the largest declines shown in Western Europe and North America. Raw steel production in the United States fell to 111.8 million tons,[2] the lowest since 1963.

Japan surpassed the United States in raw steel production in 1980, becoming the second largest world steel producer, following the U.S.S.R., which remained in first place.

The trigger price mechanism (TPM) was suspended by the U.S. Government when a major steel company filed antidumping complaints against seven European countries. The TPM was later reinstated as part of an overall plan for the steel industry, and the dumping petitions were then withdrawn.

The European Communities (EC) declared a condition of "manifest crisis" in their steel industry and established mandatory steel production quotas for member countries.

Table 1.—Salient iron and steel statistics

(Thousand short tons unless otherwise stated)

	1976	1977	1978	1979	1980
United States:					
Pig iron:					
Production	86,848	81,494	87,690	86,975	68,699
Shipments	86,693	82,392	88,543	87,781	69,445
Annual average composite price, per ton	$187.67	$189.57	$198.31	$203.00	$203.00
Exports	58	51	51	105	73
Imports for consumption	415	373	655	476	400
Steel:[1]					
Production of raw steel:					
Carbon	112,008	108,130	116,916	116,226	94,689
Stainless	1,684	1,862	1,954	2,107	1,701
All other alloy	14,308	15,341	18,161	18,008	15,445
Total	128,000	125,333	137,031	136,341	111,835
Capability utilization (percent)[2]	80.9	78.4	86.8	r87.2	72.8
Net shipments of steel mill products	89,447	91,147	97,935	100,262	83,853
Finished steel annual average composite price, cents per pound	14.213	15.577	17.957	r20.006	21.677
Exports of major iron and steel products[3]	3,671	3,098	r3,271	r3,400	4,729
Imports of major iron and steel products[3]	15,038	19,930	22,027	18,428	16,355
World production:					
Pig iron	r548,550	r539,933	557,717	p583,357	e559,685
Raw steel (ingots and castings)	r742,439	r738,608	782,554	p816,283	e779,973

eEstimated. pPreliminary. rRevised.

[1]American Iron and Steel Institute (AISI).

[2]Raw steel production capability is defined by AISI as the tonnage capability to produce raw steel for a sustained full order book.

[3]U.S. Bureau of the Census. Figures for 1978-80 not strictly comparable to those of previous years.

Legislation and Government Programs.—Import quotas on specialty steel (stainless steel and alloy tool steels), which were instituted on June 14, 1976, were eliminated on February 13, 1980.

On March 19, 1980, the U.S. Department of Commerce, which had assumed responsibility for the TPM on January 2, announced that trigger prices for the second quarter of 1980 would remain at first-quarter levels.

On March 21, United States Steel Corp. filed antidumping petitions pertaining to five basic steel mill products exported variously by Belgium, France, the Federal Republic of Germany, Italy, Luxembourg, the Netherlands, and the United Kingdom. As required by law, the antidumping petitions were filed with the Department of Commerce and the International Trade Commission (ITC). On March 24, the Department of Commerce announced that, in light of the filing of major antidumping petitions, the TPM would be suspended, effective immediately. The announcement noted that the TPM was established to determine whether the Government should initiate expedited antidumping investigations and was intended as a substitute for individual antidumping complaints by domestic steel firms. The possibility was left open for reinstatement of the TPM if the antidumping petitions were withdrawn or otherwise satisfactorily resolved.

On September 30, the administration announced its new program for the domestic steel industry. A major part of that program was the reinstatement of the TPM, effective October 21. Trigger prices were raised 12% over those of the first quarter of 1980. An antisurge provision was added to the TPM to assure that the TPM would be administered effectively and to help identify instances in which dumped or subsidized imports might be causing injury. Under this provision, when the domestic industry was operating below 87% of capability utilization, and if there was a surge in imports when imports exceeded 13.7% of domestic sales, the Department of Commerce would review the situation. If a surge occurred at a 15.2% import share and the industry was operating below 87% capability utilization, the Department of Commerce could initiate antidumping proceedings. The TPM was extended for a 5-year period; however, it was to be reviewed after 3 years and could be terminated if the Department of Commerce found that the domestic steel industry was not making sufficient progress toward modernization. When the TPM was reinstated, the dumping petitions were withdrawn by United States Steel.

Other provisions of the administration's steel plan, which would require legislative approval, included an accelerated depreciation rate for equipment, an additional 10% tax credit for steel firms located in distressed regions, a partially refundable tax credit, extension of deadlines for pollution control installations for up to 3 years, expansion of worker assistance programs, and additional support for research and development.

During the year, a number of steel companies signed air and water pollution control agreements with the Environmental Protection Agency (EPA). The companies included United States Steel at Lorain, Ohio, Allegheny County, Pa., and Provo, Utah; Jones & Laughlin Steel Corp. at Pittsburgh and Aliquippa, Pa., Cleveland and Youngstown, Ohio, and East Chicago, Ind.; Republic Steel Corp. at South Chicago, Ill.; and National Steel Corp. at Weirton, W. Va., Granite City, Ill., and Ecorse, Mich.

ITC determined that a U.S. industry was being materially injured by imports of subsidized pig iron from Brazil. In 1979, the U.S. Treasury Department had found that 16 Brazilian firms exporting pig iron to the United States were subsidized. Following the ITC determination, the Department of Commerce assessed countervailing duties on pig iron from Brazil imported after November 26, 1979.

DOMESTIC PRODUCTION

Production of pig iron and raw steel and shipments of steel mill products declined in 1980 because of lower demand from most major markets. Pig iron production fell 21% to 68.7 million tons, and raw steel production fell 18% to 111.8 million tons, the lowest since 1963. Shipments of steel mill products declined 16% because of diminished demand in the automotive, construction, machinery, and containers industries, as well as most other markets. The only exception was the oil and gas industry, which received 44% more steel shipments in 1980 than in 1979.

Raw steel production capability utilization began the year at 78% and rose to 89% by the end of March. It then dropped steadily to a minimum of 52% in the first week of July and rose again to 81% in December, giving an average value for the year of 72.8%.

The United Steelworkers of America and nine major steel companies signed a 3-year labor contract, effective August 1, 1980.

Inland Steel Co.'s No. 7 blast furnace was dedicated on September 19 and produced its first iron on October 10, completing a 6-year expansion program at the company's Indiana Harbor Works, in East Chicago, Ind. The furnace, one of the two largest in North America, is similar in size to Bethlehem Steel Corp.'s "L" furnace at Sparrows Point, Md., which began operation in 1978.

Inland's No. 7 furnace has a hearth diameter of 45 feet, a working volume of 123,897 cubic feet, and an initial capacity of 7,000 tons of hot metal per day, which will eventually be increased to 10,000 tons per day. Advanced technology incorporated in the furnace includes a bell-less top, conveyer belt feed, three external-combustion blast stoves, computer controls, and complete environmental controls. The furnace is also equipped with an expansion turbine generator operated by the high-pressure top gas to produce up to 15 megawatts of electrical power.

North Star Steel Co. began operation of its new minimill at Monroe, Mich., in March. The mill has an initial capacity of 400,000 tons of raw steel and includes a 120-ton, 55-megawatt electric-arc furnace; a four-strand, 6- by 6-inch billet caster; and a 17-stand mill for producing reinforcing bars, special bars, and structural shapes.

Two minimills that had closed reopened for limited operation in 1980. New Jersey Steel Corp. (formerly New Jersey Steel and Structural Corp.), Sayreville, N.J., which had been closed since September 1979, resumed rolling operations in December 1980. Witteman Steel Mills Inc., Fontana, Calif., resumed partial operation under new ownership after filing in 1977 under chapter 11 of the Bankruptcy Act. The mill is now owned by a subsidiary of K-Star International of the Republic of Korea. The company has filed for a loan guarantee from the Economic Development Administration.

Berg Steel Pipe Corp., Panama City, Fla., began operating in May. This is the only mill in the United States capable of producing American Petroleum Institute specification steel pipe over 48 inches in diameter, and it can produce pipe up to 64 inches in diameter. Berg Steel Pipe Corp. is 60% owned by Bergrohr GmbH of the Federal Republic of Germany, and the remaining 40% is held by Intercontinental Metals Corp., Charlotte, N.C., and Western Steel International Metals Corp., New York, N.Y. The plant will produce pipe for oil, gas, and coal slurry pipelines.

Because of increased demand for oil-country tubular products, several steel producers announced plans for expansion or construction of new plants to produce these products. Armco, Inc., reported that it would build a new plant for oil-country seamless tubing, with a capacity of 300,000 tons of tubes per year. Armco plans to break ground in 1981 and to complete the plant within 3 years.

CF & I Steel Corp., Pueblo, Colo., reported that it would expand its capacity for oil-country goods by adding a continuous caster and piercing mill, with completion expected in 1983. United States Steel announced plans for adding continuous casters at Braddock, Pa., and Lorain, Ohio, to produce material for oil-country tubular goods. Lone Star Steel Co., Dallas, Tex., a leading producer of oil-country goods, announced plans for modernization and expansion of its plant, including installation of a basic oxygen furnace (BOF) and a continuous caster.

Other planned expansions and modernizations announced during the year included installation of two 185-ton electric-arc furnaces at the Johnstown facility of Bethlehem Steel, replacing the existing coke ovens, blast furnaces, and open-hearth furnaces. Bethlehem Steel also was replacing six older soaking pits with six new ones at the Bethlehem, Pa., plant, and adding a continuous caster and other equipment at the rail plant at Steelton, Pa. Bethlehem Steel also announced modernization plans for its plant at Los Angeles, Calif.

Ford Motor Co. Steel Div. announced a modernization program including improvements to the hot-strip mill and the addition of desulfurization to the BOF shop.

United States Steel was planning to install a slab caster at the Gary (Ind.) works and a heat recycling system at its Pittsburg, Calif., plant. United States Steel also agreed with EPA to bring its Pennsylvania plants into compliance with air and water pollution standards. This would entail construction of a new blast furnace and coke oven battery in that area, as well as upgrading existing coke ovens and blast furnaces.

Northwestern Steel and Wire Corp., Sterling, Ill., planned to construct a continuous caster for cross sections, 18 by 22 inches, over the next 2 years.

Armco was planning to expand and modernize its grain-oriented silicon steel plants at Butler, Pa., and Zanesville, Ohio.

Minimills undergoing expansion included Chaparral Steel Co., Midlothian, Tex., with expansion to more than double its present capacity and completion scheduled for 1982; Florida Steel Corp., with a fifth minimill planned at Jackson, Tenn., starting in 1981; and Nucor Corp., currently constructing a minimill at Plymouth, Utah, with a planned capacity of 350,000 tons per year, scheduled for completion in the second half of 1981. Davis-Walker Corp. proposed to build a minimill in California near Stockton or Sacramento.

Ohio River Steel Corp. was planning the construction of a rolling mill at Calvert City, Ky., to be in operation by mid-1982. The second phase of construction would include a melt shop and was planned for completion in 3 to 5 years.

Allegheny Ludlum Industries, Inc., sold its specialty steel subsidiary, Allegheny Ludlum Steel Corp., to a group of private investors and former executives of the company. The firm will retain the name of Allegheny Ludlum Steel Corp.

The Portsmouth, Ohio, plant of the Empire-Detroit Steel Div. of Cyclops Corp. ceased operations during the year. The coke ovens were sold to McLouth Steel Corp., and the remainder of the plant was sold to American Buckeye Development Corp. of Chesapeake, Ohio.

Wisconsin Steel, a division of Envirodyne Industries Inc., closed on March 28 and filed under chapter 11 of the Bankruptcy Act on March 31. Later in the year, the Bankruptcy Court ordered the plant and equipment to be sold at public auction on January 20, 1981.

Minimills that closed during the year included Yale Steel Corp., Wallingford, Conn.; the mills of Interlake, Inc., at Newport and Wilder, Ky.; California Steel Co., Chicago, Ill.; and Penn-Dixie Steel Corp., Kokomo, Ind.

The board of directors of Kaiser Steel Corp., Fontana, Calif., after considering liquidation of the company, decided to remain in operation. The company had operated at a loss for the past 4 years.

Materials Used in Ironmaking.—Materials used in ironmaking are shown in tables 3 and 5. Domestic pellets charged to blast furnaces in 1980 totaled 63.5 million tons, and sinter charged amounted to 27.2 million tons. Pellets and other agglomerates from foreign sources amounted to 11.3 million tons. A total of 16.1 million tons of iron ore was consumed by agglomerating plants at or near blast furnaces in producing 27.9 million tons of agglomerates. Other materials consumed by agglomerating plants were 3.5 million tons of mill scale, 1.8 million tons of flue dust, 2.2 million tons of slag, 1.4 million tons of coke breeze, 171,000 tons of anthracite, and 6.6 million tons of fluxes.

Blast furnace oxygen consumption totaled 23.0 billion cubic feet according to the American Iron and Steel Institute (AISI). Blast furnaces, through tuyere injection, consumed 26.8 billion cubic feet of natural gas; 35.0 billion cubic feet of coke oven gas; 327 million gallons of oil; 81 million gallons of tar, pitch, and miscellaneous fuels; 527,000 tons of bituminous coal; and 27,000 tons of anthracite.

Materials Used in Steelmaking.—In addition to the materials shown in tables 8 and 9, steelmaking furnaces, according to AISI, consumed 0.5 million tons of fluorspar, 1.0 million tons of limestone, 6.4 million tons of lime, 0.8 million tons of other fluxes, and 163.0 billion cubic feet of oxygen. Metalliferous materials consumed in domestic steel furnaces, per ton of raw steel produced, averaged 1,171 pounds of pig iron, 1,107 pounds of scrap, 26 pounds of ferroalloys, and 14 pounds of ore and agglomerates. The revised figures for 1979 were 1,202 pounds of pig iron, 1,052 pounds of scrap, 25 pounds of ferroalloys, and 18 pounds of ore and agglomerates.

PRICES

The annual average composite price for finished steel for 1980, as reported by Iron Age, was 21.677 cents per pound, an increase of 8.4% over the average price of 20.006 cents per pound for 1979. The composite price increased 6.4% to 22.286 cents per pound, from January 1 to December 31, 1980.

Hot-rolled sheets and strip rose 5.4% from 17.50 to 18.45 cents per pound, and cold-rolled sheets rose 5.5% to 21.90 cents per pound on April 1. Tin plate and galvanized sheets also increased in price by 6.3% and 4.2%, respectively, on April 1. On October 1, structural shapes increased in price by 5.3% to 19.90 cents per pound, and plates increased 3.9% to 21.5 cents per pound. Special-quality bars increased 8.6% to 22.80 cents per pound on November 1. Major steelmakers announced a 5.5% price increase for sheet and strip, effective January 1, 1981. The composite price for pig iron, according to Iron Age, remained at $203.00 per ton during the year.

FOREIGN TRADE

Imports of steel mill products in 1980 decreased to 15.5 million tons, or 11.5% less than imports in 1979. Compared with 1979 data, net imports (imports less exports) decreased from 14.7 to 11.4 million tons, or 22.5%. Imports from Japan decreased 5.7% to 6.0 million tons, and imports from EC decreased 28.1% to 3.9 million tons. Imports from Japan represented 38.8% of total imported steel mill products for 1980, compared with 36.2% in 1979, and imports from EC were 25.1% of the total, compared with 30.9% in 1979.

In 1980, the value of imports of steel mill products was $6.89 billion, compared with exports valued at $2.56 billion, resulting in an unfavorable balance of trade of $4.33 billion, compared with an unfavorable balance of $5.09 billion in 1979.

WORLD REVIEW

World raw steel production declined by 4% to about 780 million tons, with the largest declines in Western Europe and North America. Developing countries continued to add capacity, although not so rapidly as in previous years.

Argentina.—The privately owned seamless tube producer, Dalmine Siderca SAIC, operated close to its capacity of about 330,000 tons of finished tubular products in 1980. The company, located in Compana, 50 miles northwest of Buenos Aires, is reported to be the world's only integrated seamless tube plant based on direct-reduced iron (DRI). The Midrex Series 400 direct-reduction (DR) module began operation in 1976. Melting is done in four electric-arc furnaces, consisting of two 50-ton furnaces with regular power, one high-power 50-ton furnace, and a 75-ton ultra-high-power furnace with a transformer rating of 33 megavolt amperes. After tapping, the steel is transferred either to one of the two continuous casting machines or to ingot casting. The curved-mold continuous casters produce tube rounds for the continuous tube mill, and the ingots are processed on Pilger mills. About 75% of the product goes to oil-country tubular goods, and the remainder goes to tubes for pressure vessels, heat exchangers, boilers, agricultural machinery, and automotive uses. About 25% of the output is exported.

The Government-owned Altos Hornos Zapla awarded a contract for the conversion of two of its Bessemer converters to 25-ton bottom-blown basic oxygen process (Q-BOP) vessels. During conversion, production will continue in the third Bessemer converter and in the electric melting shop. The converted equipment is scheduled to begin operation in 1983. Capacity had been limited by lack of hot metal supplied by the five small charcoal blast furnaces. Modification to these furnaces will be made to raise capacity from 239,000 tons per year to 303,000 tons per year. The new Q-BOP vessels are to have a combined capacity of 259,000 tons per year, capable of expansion to 330,000 tons per year.

HYL, the iron and steel technology company of Grupo Industrial Alfa of Mexico, and a consortium of rerollers known as Siderúrgica de Sur (Sidersur) have signed a contract for the construction of a 550,000-ton-per-year DR plant using the newly developed HYL III process, in San Antonio Este, Rio Negro. Steelmaking facilities will also be located at the site.

Brazil.—Construction work on the first phase of the Companhia Siderúrgica de Tubarão at Vitória, Espirito Santo, scheduled to have started in 1978, reportedly began in June 1980. Some equipment for the plant was shipped from Japan during the year. The company is a joint venture of Siderúrgica Brasileira, S.A. (Siderbrás), with 51% ownership, and Società Finanziaria Siderurgica (Finsider) of Italy and the Kawasaki Steel Corp. of Japan, with 24.5% each. The plant is expected to produce 3.3 million tons per year of slabs when operations begin at the end of 1982.

Canada.—The Lake Erie works of Stelco Inc. at Nanticoke, Ontario, was formally dedicated by Prime Minister Pierre Trudeau on September 16, 1980. Equipment that became operational during the year included a 3,900-foot-long receiving dock, a blast furnace, two basic oxygen vessels, and a twin-strand slab caster. The blast furnace is 300 feet high with a hearth diameter of 32.8 feet, and it will have an ultimate capacity of 5,250 tons per day. The two basic oxygen vessels each have a capacity of 254 tons, and the continuous caster can produce slabs 6 feet wide by 9.5 inches thick. The slabs are currently sent to Stelco's Hilton works in Hamilton, Ontario, for finishing. A 45-oven coke battery, scheduled for completion in 1981, and an 80-inch hot-strip mill, scheduled for 1983, will complete the first phase of the plant.

The Algoma Steel Corp., Ltd., authorized the engineering of a 75-oven, 500,000-ton-per-day coke oven battery as part of its expansion at Sault Ste. Marie, Ontario. The battery, which is to replace No. 6 battery, is scheduled for completion in 1983. Algoma also announced construction of a new seamless tube mill beginning in 1981, with completion scheduled for 1984. The mill will produce drill pipe, casing, and other seamless tubing products. Initial capacity is expected to be 200,000 tons per year, and ultimate capacity is expected to be 300,000 tons per year.

Dofasco Inc. announced the construction of a 66-inch hot-strip mill at its plant in Hamilton, Ontario. The initial capacity is intended to be 1.2 million tons per year, and the ultimate capacity will be 4 million tons per year.

Interprovincial Steel and Pipe Corp., Ltd. (IPSCO), placed a contract for a 125-ton electric-arc furnace at Regina, Saskatchewan. The furnace will have a modular double-split shell, a 20-foot inside diameter, and water-cooled panels. IPSCO also commissioned a reversing hot-strip mill, reportedly the world's largest, at Regina. The 80-inch mill was designed to roll and coil high-impact-strength, arctic-grade steels up to 72 inches wide and 0.75 inch thick.

In November, the Provincial Government of Nova Scotia released a Federal-Provincial plan for Sydney Steel Corp. (SYSCO), Sydney, Nova Scotia, including $290 million in aid. The plant is largely obsolete and has been operating at a loss for the past few years. Since the Government of Nova Scotia took over the company in 1968, it has given SYSCO over $120 million in grants. During the year, the plan for SYSCO to supply billets to Tree Island Steel Co., Ltd., in British Columbia was dropped, and SYSCO's 10-inch bar mill was closed down.

China.—*Mainland.*—Contracts were awarded to Japanese and West German firms for the installation of the first phase of the Baoshan General Iron and Steel Works near Shanghai, and construction was initiated during the year. The first phase of the works will consist of a blast furnace with a capacity of 10,000 tons per day, a coke oven battery, basic oxygen converters, hot- and cold-strip mills, a seamless tube mill, and auxiliary equipment. Completion of phase 1 is expected in 1982. The Government announced that the second phase of the Baoshan project, originally scheduled for completion in 1984, would be postponed for an unspecified period of time.

As a result of the change in emphasis from heavy to light industry, China accumulated excessive inventories of heavy steel products, while shortages of lighter products, including wire, sheet, and pipe, occurred. The Government announced that the steel industry would be restructured to place more emphasis on light products.

Construction of a new 1.3-million-ton basic oxygen steel shop, consisting of three 50-ton converters, was completed at the Maanshan complex in Anhui Province, East China. The new construction, begun in 1970, was suspended during the mid-1970's and resumed in 1978. It was announced that a new blast furnace and rolling mills will also be built at Maanshan.

Taiwan.—China Steel Corp., the major steel producer in Taiwan, continued with its second-phase expansion from 1.65 to 3.58 million tons of raw steel per year, with completion scheduled for 1982. The ultimate planned capacity is 8.8 million tons, with completion expected in the late 1980's. The fully integrated plant, which began operation late in 1977, is located in the industrial city of Kaohsiung on the southwest coast of Taiwan. Equipment at the plant includes docking facilities for raw material vessels, a sinter plant, two coke oven batteries, a blast furnace with a hearth diameter of 10.3 meters and a capacity of 4,400 tons per day, two 160-ton basic oxygen converters, two four-strand bloom casters, one two-strand slab caster, a plate mill, a semicontinuous billet mill, a bar mill, and a rod mill. Iron ore and coking coal are imported mainly from Australia, Africa, and Brazil.

European Communities (EC).—Raw steel production in the EC was about 141 million tons, or 9% less than in 1979, representing an average capacity utilization of about 61%. A sharp drop in demand for steel beginning in the second quarter of 1980 was followed by a decline in production and prices of steel. The anticrisis measures adopted in 1977 and continued through 1979 did not improve these conditions, leading the EC Commission to request the application of "manifest crisis" measures under article 58 of the European Coal and Steel

Community Treaty of Paris of 1951. The declaration, which was approved by the EC Council of Ministers at the end of October, was retroactive to October 1, 1980, and extended to June 30, 1981. The measures under article 58 established mandatory steel production quotas for the fourth quarter of 1980, averaging 14.2% below the production levels of the fourth quarter of 1979. Initial opposition to the plan by the Federal Republic of Germany brought about a compromise in which certain steel products were exempted from the quota system. Later in the year, quotas for the first quarter of 1981 were announced which were 13% to 20% below production for the fourth quarter of 1979, depending on product.

Bilateral trade agreements for 1980, establishing quotas for exports of steel to the EC, were negotiated with 12 countries. Countries that did not have trade agreements with the EC were subject to import base prices on steel exported to the EC. Preliminary negotiations for bilateral trade agreements for 1981 were underway at the end of the year.

Germany, Federal Republic of.—Conversion of the Oberhausen works of Thyssen Niederrhein AG from blast furnace-open hearth to electric-furnace operation was completed with the opening of the electric furnace shop on February 27. Thyssen Niederrhein AG is a wholly owned subsidiary of Thyssen AG. The plant equipment comprises two 132-ton ultra-high-power electric-arc furnaces, ladle refining facilities, a six-strand continuous billet caster and rolling mills for wire rod, light and medium bars, and sections. The capacity of the plant is 660,000 tons per year of raw steel.

A plant to produce DRI solely for sale to consumers was nearing completion at the North Sea port of Emden. The plant, operated by Norddeutsche Ferrowerke GmbH, will utilize two Midrex Series 400 modules, and it is expected to have a capacity of 880,000 tons per year of DRI iron by 1982. Iron ore pellets for the plant will come from Sweden and Norway, and lump ore will come from Brazil, the Republic of South Africa, and Australia.

India.—In the 1979-80 fiscal year (April through March), steel production declined for the first time since 1973 because of a continued shortage of electrical power and coking coal. Demand for steel continued to rise, leading to increased imports. The Indian steel minister announced a major expansion of raw steel capacity from 12.6 million tons to 26.5 million tons by 1990. Expansion and modernization will be primarily at the integrated steel plants controlled by the Steel Authority of India Ltd. In addition to the Government-controlled plants at Bokaro, Bhilai, Rourkela, and Salem, the private sector Tata Iron and Steel Co., which is the oldest steel facility in India, will also undergo modernization and expansion.

Indonesia.—The DR plant of P. T. Krakatau Steel in Cilegon, West Java, which began operation in 1979, operated at about one-half its maximum capacity of 2.2 million tons per year in 1980. The DR plant consists of four HYL modules, each with four fixed-bed reactors, fueled by natural gas. The DRI supplies the associated electric-furnace melting shop and continuous billet-casting machines, which supply the rolling mills producing wire rod, bar, and sections. Some DRI is also exported to Japan, Taiwan, the Republic of Korea, Singapore, and India.

Iran.—Korf Engineering GmbH postponed resumption of work on three Midrex DR plants at Ahwaz, where work had been held up for over 18 months because of political unrest and delays in meeting outstanding payments.

Japan.—In 1980, Japan surpassed the United States in raw steel production, becoming the second largest world steel producer, following the U.S.S.R. Raw steel production declined slightly in 1980 to a total of 122.8 million tons, compared with 123.2 million tons in 1979. Production by the basic oxygen process fell by 1%, and electric-furnace production rose by 3% to a record high of 30.0 million tons. Exports declined by 4% to 33.4 million tons of finished steel in 1980.

Nippon Steel Corp. announced the completion of its program to close obsolete facilities at four of its plants, which was intended to reduce the company's raw steel capacity from 52 to 40 million tons per year, and to make production profitable at 70% capacity utilization. Nippon Steel also announced that new continuous casting and rolling facilities would be added, and wire rod rolling would be modernized at some of the same plants.

The steel industry continued with its program to reduce oil injection in its blast furnaces. It is estimated that approximately one-half of Japan's blast furnaces were operated without oil in 1980. Although this leads to increased coke consumption and lower production rates, overall costs are reported to be less than under the previous oil injection practice.

Several companies announced plans for the construction or modification of blast furnaces. Nippon Steel said it would build a new furnace with an inner volume of 3,300 cubic meters at Muroran works to replace two or three smaller furnaces. Kobe Steel Ltd. announced that its smallest furnace at the Kakogawa works would be enlarged, and Sumitomo Metal Industries, Ltd., announced that No. 2 blast furnace at the Kashima Steel Works would be enlarged from a volume of 4,080 cubic meters to about 5,000 cubic meters.

Mexico.—The steel industry of Mexico was undergoing an expansion program that was intended to raise raw steel capacity from 10.3 to 27.6 million tons per year in 1990. About 85% of the total will be produced in Government-owned mills.

HYL announced a new continuous DRI process termed HYL III. The phase-2 expansion of the Government-owned Siderúrgica Lázaro Cárdenas-Las Truchas S.A. (SICARTSA) will employ the HYL III process with electric-arc furnace melting. Four 550,000-ton-per-year modules, with a common charging and discharging system, will be installed, giving a total capacity of 2.2 million tons of DRI per year.

The first commercial HYL III process plant was constructed by Hylsa S.A. at Monterrey in 1978, and production began in September 1979. After a shutdown period to make changes and improvements, it was restarted in May 1980, and operated continuously throughout the remainder of the year. The 385,000-ton-capacity plant was converted from the fixed-bed HYL process.

Hylsa also planned to convert a second fixed-bed unit at Monterrey to a 550,000-ton HYL III plant. Construction has begun on this plant, and operation is scheduled for late 1981. Hylsa also planned to build a completely new HYL III plant at Monterrey, with a capacity of 827,000 tons per year.

Prereducidos Mexicanos S.A. (Premexsa), a group of scrap-based steel mills, planned to build an HYL III plant, with a capacity of 1.1 million tons of DRI, at Altamira, near Tampico on the Gulf of Mexico. The project is scheduled to begin operation in 1984.

Tubos de Acero de Mexico S.A. (Tamsa), Mexico's largest producer of seamless tubing, planned to convert a 275,000-ton-per-year fixed-bed HYL process plant to the HYL III process and to increase the capacity to 550,000 tons per year.

Two joint Japanese-Mexican projects to be established in the Las Truchas area on the Pacific Coast were also announced. The Kobe Steel Group of Japan planned to establish a steel casting and forging plant, and the Sumitomo Metal Industry Group of Japan planned to build a large-diameter steel pipe plant.

Another Japanese group, New Iron Resources Development Co., signed a contract with HYL for a feasibility study of a DRI plant in Mexico to supply iron to a group of Japanese concerns.

Other expansion plans at the Government-owned Siderúrgica Mexicana plants include, for Altos Hornos de Mexico S.A. (AHMSA), modifications to blast furnaces and finishing mills at its Monclova works and the addition of a second basic oxygen converter and a slabbing mill at the Piedras Negras plant. A continuous slab caster will be installed at Fundidora Monterrey S.A.

Peru.—The Government-owned steel company, Empresa Siderúrgica del Peru (Siderperu), has taken steps to expand the capacity of its Chimbote works and to reduce its dependence on imported raw materials. A new 100-ton ultra-high-power electric-arc furnace and a continuous slab caster have been ordered.

A solid-fuel-based, SL-RN, DRI plant was brought into commercial production at Chimbote in 1980. The plant consists of three former cement kilns converted to the SL-RN process, with a total capacity of 132,000 tons per year. A second DR plant was ordered from Krupp Industrie und Stahlbau of the Federal Republic of Germany. The plant will utilize the coal-based Krupp-Codir process, with Peruvian iron ore pellets and anthracite as raw materials. The installation is expected to take 33 months, and the plant will have a capacity of 220,000 tons per year.

Laminadora del Pacifico, a subsidiary of Aceros Arequipa S.A., has ordered equipment for a minimill, consisting of two 40-ton electric-arc furnaces, a three-to-four-strand continuous billet caster, and a bar mill. Scheduled completion is set for spring 1982, with an output capacity of 165,000 tons per year.

Qatar.—Qatar Steel Co. (QASCO) reportedly operated above its rated capacity of 440,000 tons per year in 1980. The plant utilized local natural gas to operate a Midrex DR unit. The DRI, together with scrap, is melted in two 77-ton electric-arc furnaces, continuously cast into billets, and rolled into reinforcing bars. About 85% of the finished steel is exported, mainly to Middle East countries.

Spain.—The Spanish steel industry shared the depressed conditions experienced by the steel industry in most of Western Europe, with declining domestic demand for steel and heavy financial losses by the major steel producers. Domestic consumption fell from a peak of 13.0 million tons in 1974 to 8.8 million tons per year in 1979, while production increased from 12.6 to 13.6 million tons in the same period. Excess production went to exports, which increased from 1.1 million tons in 1974 to about 6 million tons per year currently. The Government announced a 2-year restructuring program for the integrated steel industry, which would include financial aid, a gradual reduction in work force, and the closing of a few small obsolete installations.

A substantial proportion of the specialty steel industry combined to form a consortium (Sociedad de Aceros Especiales) to resolve the restructuring of the troubled industry. Specialty steelmakers not already members were to have an opportunity to join later. The consortium will receive Government aid.

Sweden.—SKF Stål announced that it was converting its Wiberg-Söderfors sponge-iron plant at Hofors to a new process called Plasmared, and expanding the capacity of the plant from 27,600 to 77,000 tons per year. The new process replaces the old gas reformer with a plasma arc for heating the reducing medium, which may be liquefied petroleum gas, heavy fuel oil, or pulverized coal.

Trinidad and Tobago.—The first Midrex Series 400 DR module began operation at the Point Lisas works of the Iron & Steel Co. of Trinidad and Tobago (Iscott) on August 31, 1980. Situated 35 miles south of Port of Spain, Trinidad, the plant has a capacity of 463,000 tons of DRI. A second Series 400 module is scheduled to begin operation in 1980; the plant uses offshore natural gas as the reducing agent. Oxide pellets from Brazil will be the principal source of raw material. Iscott plans to install two ultra-high-power electric-arc furnaces later. Until they are in operation, the DRI produced will be exported.

United Kingdom.—A strike that shut down British Steel Corp. (BSC) and parts of the private steelmaking sector from January 2 through the first quarter of 1980 reduced average weekly raw steel production for the first quarter to 66,000 tons, compared with 431,000 tons for the equivalent period in 1979. Production remained low during the last three quarters because of low demand and markets lost to imports during the strike. Average weekly production for the last 9 months of 1980 was 297,000 tons, compared with 463,000 tons for the equivalent period in 1979. BSC had planned to reduce its raw steel capacity from 23.7 million tons per year to 16.5 million tons per year, and to reduce steelmaking employment from 152,000 to 100,000 persons by August 1980, but the strike caused this deadline to be extended. BSC announced a record loss of £545 million (about $1.2 billion) for fiscal year 1979-80 (April 1 to March 31), compared with a loss of £309 million (about $603 million) for 1978-79. For the first half of fiscal year 1980-81, BSC lost £279 million.

In December, BSC revealed plans for further reduction in capacity to 13.2 million tons per year and reduction in employment to 60,000 to 70,000 persons.

BSC announced it was seeking a buyer for the DR plant at Hunterston. The plant, which consists of two Midrex Series 400 modules, completed in 1979, was never commissioned.

U.S.S.R.—The Soviet Union remained the world's largest steel-producing country, with raw steel production in 1980 of 163 million tons, slightly less than that in 1979.

A report by a leading Soviet steel expert stated that more effort would be made to improve the quality and optimize the range of rolled steel products. Problems calling for solutions included losses of metal during production, a limited range of products, an insufficiently high level of physical and mechanical properties of rolled products, high metal consumption in engineering and metalworking, and limitations of the technologies used at the various stages of producing and working of steel. Emphasis was to be placed on electric-arc furnace melting, the basic oxygen process, and continuous casting.

It was reported that the first stage of a continuous cold-strip mill began operation early in 1980 at the Novolipetsk iron and steel works at Lipetsk. The capacity is 1 million tons per year, with the capability of expansion to 3 million tons per year.

Construction of the steel complex at Stary Oskol, near Kursk, is continuing. The plant will use the Midrex process to produce DRI, followed by the electric-arc furnace melting.

Venezuela.—The Government-controlled Corporación Venezolana de Guyana-Siderúrgica del Orinoco CA (CVG-SIDOR) continued with the gradual startup of its Plan-IV expansion, although it was running behind schedule. The company sustained a loss of $233 million in 1980, compared with a loss of $100 million in 1978, and a profit of $0.7 million in 1978. Reasons advanced for lack of profitability were a low level of productivity, declining domestic orders, and tardy payment by its customers. Also contributing to the losses were expenses related to the Plan-IV expansion.

Construction of Siderzulia, the integrated steel plant portion of the Zulia coal and steel project, has been further delayed, and the opening of the first stage is now set for the second half of 1985, with commercial production to begin in 1986. Land has been set aside for the project on the shores of Lake Maracaibo. The first stage of the steel plant is expected to have a capacity of 1.5 million tons of raw steel, with bars and structural shapes as the principal products.

The high-iron briquet (HIB) DR plant of CVG Ferrominera Orinoco CA at Ciudad Guyana resumed operation in July 1979, after having been closed for 2 years, and operated two of its three reactor vessels during 1980. The plant's production was projected at 660,000 tons of DRI briquets in 1981.

TECHNOLOGY

Several new or improved processes were developed for production of DRI (sponge iron) or production of molten iron without the use of a blast furnace. HYL introduced a new continuous DR process (HYL III) in which a single moving-bed shaft furnace replaced the four fixed-bed reactors used in the HYL I and II processes. The principal advantages claimed for the new process were lower investment and operating costs, simple plant design and construction, low energy consumption, and a continuous flow of stable product.[3]

In December, Midrex Corp. introduced its electrothermal DR process, based on coal and electricity.[4] The process, which is continuous, utilizes a rectangular shaft furnace into which coal and lump iron ore or pellets are charged through the top, along with limestone and recycled char. The heat for the process is supplied by passing an electric current through the charge from conductive panels in the sides of the furnace. In the reduction zone of the shaft, the ore is reduced to 92% metallization; it then passes down through the lower part of the shaft where it is cooled and carburized, and is discharged through the bottom of the furnace at a temperature of 150° F. The sulfur from the coal is absorbed by the limestone. After discharging, the DRI is separated magnetically from the char and spent limestone. A 6-ton-per-day pilot plant was operated successfully at Charlotte, N.C., and Midrex Corp. was preparing a feasibility study for a 200,000-ton-per-year unit at Beaumont, Tex.

Two processes for producing molten pig iron that do not require a blast furnace were in the pilot plant stages during the year. In the SKF Plasmamelt process,[5] the iron ore is first prereduced in two fluidized-bed vessels, then melted by a stream of reducing gas superheated by a plasma generator in a vessel filled with coke. The Korf process,[6] also a two-stage process, utilizes a shaft furnace for prereduction of the ore and a vessel for melting the prereduced iron in a fluidized bed with coke and oxygen. Gases from the melting vessel are used in the prereduction stage.

Two experimental or pilot-plant processes for producing molten pig iron in a cupola from self-reducing, self-fluxing iron oxide-carbon pellets or briquets have been reported. In one process,[7] sufficient carbon, as anthracite fines or coke breeze, is incorporated in the mixture to provide heat for melting as well as acting as a reductant, and thus lump coke is unnecessary in the cupola charge. Flux and portland cement as a binder are added to the mixture which is formed into briquets. In the other process,[8] pellets are produced on a standard pelletizing disk from a mixture of iron oxide and carbon fines, with a binder consisting of 3% to 5% burnt lime and 1% to 2% silica flour. The pellets are then processed in an autoclave to harden them. Various ratios of pellets to scrap, up to 100% pellets, together with coke, were used in cupola tests.

Two industrial processes for the continuous annealing of steel sheet were described.[9] The processes were introduced by Nippon Steel and Nippon Kokan KK of Japan and are applicable to deep-drawing grades of steel. The major advantage of the processes is the time saved compared with the batch annealing process.

[1]Physical scientist, Section of Ferrous Metals.
[2]Tons in this chapter refer to short tons of 2,000 pounds.
[3]Engineering and Mining Journal. HYL Reveals Continuous DR Process. V. 181, No. 11, November 1980, p. 92.
[4]Iron and Steel Maker. Electrothermal Direct Reduction Process Introduced. V. 8, No. 4, April 1981, p. 27.
[5]33 Metal Producing. SKF Shares a New Idea for Producing Hot Metal Without a BF. V. 18, No. 5, May 1980, p. 67.
[6]Metal Bulletin. Korf's Coke-Less Iron Project. No. 6542, Nov. 21, 1980, p. 38.
[7]Rehder, J. E. Hot Metal From Ore and Coal Fines. Iron and Steel Eng., v. 57, No. 5, May 1980, pp. 31-33.
[8]Kaiser, F. T., and L. L. French. Iron Ore Concentrates and Waste Oxides in the Cupola. Mod. Cast., v. 70, No. 14, April 1980, pp. 80-82.
[9]Iron and Steel International. How the Japanese Have Put Continuous Annealing of Sheet Steel on the Industrial Map. V. 53, No. 3, June 1980, pp. 149-163.

Table 2.—Pig iron produced and shipped in the United States in 1980, by State

State	Production (thousand short tons)	Shipped from furnaces: Quantity (thousand short tons)	Shipped from furnaces: Value (thousands)	Average value per ton at furnace
Alabama	2,624	2,621	$547,784	$209.00
Illinois	4,376	4,405	849,308	192.81
Indiana	15,755	15,748	3,053,424	193.89
Michigan	5,476	5,474	1,105,181	201.90
New York	2,129	2,166	440,831	203.52
Ohio	10,692	10,736	2,199,720	204.89
Pennsylvania	14,557	15,245	2,980,965	195.54
California, Colorado, Utah	4,147	4,160	686,738	165.08
Kentucky, Maryland, Texas, West Virginia	8,944	8,889	1,792,295	201.63
Total[1] or average	68,699	69,445	13,656,247	196.65

[1]Data may not add to totals shown because of independent rounding.

Table 3.—Foreign iron ore and manganiferous iron ore (excluding agglomerates) consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1979[1]	1980[2]
Australia	450	263
Brazil	603	37
Canada	965	1,042
Chile	128	--
Liberia	1,026	--
Venezuela	2,345	1,871
Other countries	217	124
Total	[3]5,735	3,337

[1]Excludes 15,312,114 tons used in making agglomerates.
[2]Excludes 11,448,192 tons used in making agglomerates.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

Grade	1979: Quantity (thousand short tons)	1979: Value: Total (thousands)	1979: Value: Average per ton	1980: Quantity (thousand short tons)	1980: Value: Total (thousands)	1980: Value: Average per ton
Foundry	1,415	$282,693	$199.78	740	$153,635	$207.61
Basic	83,514	16,057,418	192.27	66,916	13,148,597	196.49
Bessemer	931	190,210	r204.31	402	82,594	205.46
Low phosphorus	88	17,884	r203.23	W	W	W
Malleable	1,173	226,753	r193.31	840	169,719	202.05
All other (not ferroalloys)	660	121,680	r184.36	547	101,702	185.93
Total or average	87,781	[2]16,896,639	192.49	69,445	13,656,247	196.65

rRevised. W Withheld to avoid disclosing company proprietary data; included with "All other."
[1]Includes pig iron transferred directly to steel furnaces at same site.
[2]Data do not add to total shown because of independent rounding.

Table 5.—Iron ore and other metalliferous materials, coke, and fluxes consumed in blast furnaces, and pig iron produced in the United States, by State

(Thousand short tons unless otherwise specified)

State	Metalliferous materials consumed in blast furnaces: Iron and manganiferous ores: Domestic	Foreign	Agglomerates	Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made (short tons): Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Coke and fluxes consumed per ton of pig iron (short tons): Net coke	Fluxes
1979:																
Alabama	W	789	5,209	5,910	--	4	5,914	2,192	302	3,675	1.608	--	0.001	1.607	0.596	0.082
Illinois	W	W	9,493	9,777	481	293	10,551	3,722	821	6,162	1.587	.078	.048	1.712	.604	.133
Indiana and Michigan	481	386	39,262	39,587	1,157	1,337	42,080	14,423	1,351	25,361	1.561	.046	.053	1.659	.569	.053
New York	W	W	5,046	5,148	178	2	5,327	1,906	457	3,387	1.520	.053	.001	1.573	.563	.135
Ohio	1,381	470	19,971	21,395	492	1,028	22,916	8,425	2,784	14,104	1.517	.035	.073	1.625	.597	.197
Pennsylvania	1,301	3,357	25,360	29,488	740	1,014	31,242	9,804	1,475	18,409	1.602	.040	.055	1.697	.533	.080
California, Colorado, Utah	1,420	W	6,679	8,411	192	95	8,699	2,921	784	5,142	1.636	.037	.018	1.692	.568	.152
Maryland, West Virginia, Kentucky, Texas	W	231	16,878	16,729	270	225	17,224	5,518	665	10,735	1.558	.025	.021	1.604	.514	.062
Total[4]	5,047	5,735	127,898	136,445	3,508	3,998	143,953	48,911	[5]8,639	86,975	1.569	.040	.046	1.665	.562	.099
1980:																
Alabama	W	W	3,408	4,080	20	19	4,120	1,657	257	2,624	1.555	.008	.007	1.570	.631	.098
Illinois	W	--	6,410	6,548	421	144	7,113	2,577	616	4,376	1.496	.096	.033	1.625	.589	.141
Indiana and Michigan	994	690	32,585	33,758	914	1,284	35,956	11,978	1,010	21,231	1.590	.043	.060	1.694	.564	.048
New York	W	W	3,291	3,350	132	4	3,486	1,238	236	2,129	1.574	.062	.002	1.637	.581	.111
Ohio	377	136	15,691	15,936	350	663	16,949	6,709	1,811	10,692	1.490	.033	.062	1.585	.627	.169
Pennsylvania	826	1,233	20,686	22,390	650	732	23,772	8,615	1,322	14,557	1.538	.045	.050	1.633	.592	.091
California, Colorado, Utah	1,556	W	5,596	7,338	307	81	7,727	2,307	638	4,147	1.769	.074	.020	1.863	.556	.154
Maryland, West Virginia, Kentucky, Texas	W	205	14,282	14,168	202	161	14,531	4,514	465	8,944	1.584	.023	.018	1.625	.505	.052
Total[4]	3,984	3,337	101,949	107,568	2,996	3,088	113,654	39,595	[6]6,355	68,699	1.566	.044	.045	1.654	.576	.093

W Withheld to avoid disclosing company proprietary data; included with "Total."
[1]Net ores and agglomerates equal ore plus agglomerates plus flue dust used minus flue dust recovered.
[2]Excludes home scrap produced at blast furnaces.
[3]Does not include recycled material.
[4]Data may not add to totals shown because of independent rounding.
[5]Fluxes consisted of the following: 3,706 limestone, 31 burnt lime, 4,380 dolomite, and 521 other fluxes, excluding 5,411 limestone, 17 burnt lime, 3,625 dolomite, and 47 other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6]Fluxes consisted of the following: 2,865 limestone; 1 burnt lime, 3,250 dolomite, and 239 other fluxes, excluding 3,520 limestone, 13 burnt lime, 3,036 dolomite, and 59 other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 6.—Number of blast furnaces in the United States, by State

State	1979			1980		
	In blast[1]	Out of blast	Total	In blast[1]	Out of blast	Total
Alabama	5	5	10	5	1	6
California	4	--	4	4	--	4
Colorado	3	1	4	3	1	4
Illinois	11	1	12	6	6	12
Indiana	22	3	25	16	6	22
Kentucky	2	--	2	2	--	2
Maryland	3	2	5	2	3	5
Michigan	9	--	9	7	2	9
New York	5	4	9	3	6	9
Ohio	23	7	30	16	12	28
Pennsylvania	27	17	44	22	20	42
Texas	2	--	2	2	--	2
Utah	3	--	3	3	--	3
West Virginia	4	--	4	3	1	4
Total	123	40	163	94	58	152

[1]In blast for 180 days or more during the year.

Table 7.—Steel production in the United States, by type of furnace

(Thousand short tons)

Year	Open hearth	Basic oxygen converter	Electric	Total
1976	23,470	79,918	24,612	128,000
1977	20,043	77,408	27,882	125,333
1978	21,310	83,484	32,237	137,031
1979	19,158	83,256	33,927	136,341
1980	13,054	67,615	31,166	111,835

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces[1] in the United States

(Thousand short tons)

Year	Iron ore[2]		Agglomerates[2]		Pig iron	Ferro-alloys[3]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1976	66	593	584	195	81,926	1,495	63,554
1977	112	372	123	102	77,086	1,519	64,231
1978	110	537	441	79	83,577	1,685	70,375
1979	73	409	704	74	81,948	1,725	71,715
1980	45	244	429	50	65,474	[e]1,450	61,907

[e]Estimated.
[1]Basic oxygen converter, open hearth, and electric furnace.
[2]Consumed in integrated steel plants only.
[3]Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium, and ferromolybdenum.

Table 9.—Consumption of pig iron in the United States, by type of furnace or other use

Type of furnace or other use	1978		1979		1980	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	69,028	78.1	68,526	78.4	56,414	81.7
Open hearth	13,444	15.2	12,865	14.7	8,606	12.5
Electric	1,440	1.6	905	1.0	855	1.2
Cupola	1,056	1.2	1,026	1.2	698	1.0
Air and other furnaces[1]	398	.4	397	.4	299	.4
Direct castings[2]	3,055	3.5	3,738	4.3	2,182	3.2
Total[3]	88,420	100.0	87,458	100.0	69,053	100.0

[1]Includes vacuum-melting furnaces and miscellaneous melting processes.
[2]Castings made directly from blast furnace hot metal. Includes ingot molds and stools.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—Consumption of pig iron[1] in the United States, by State

(Thousand short tons)

State	1979	1980
Alabama	3,517	2,559
Arkansas	3	2
California	2,512	1,703
Connecticut	13	10
Georgia	8	4
Illinois	6,191	4,386
Indiana	18,064	15,787
Iowa	27	21
Kansas	8	6
Kentucky	1,704	1,650
Maine	(2)	(2)
Maryland	4,733	3,537
Massachusetts	19	18
Michigan	7,506	5,601
Minnesota	44	30
Missouri	14	12
Nevada	(2)	(2)
New Jersey	7	5
New York	3,253	2,001
North Carolina	4	4
Ohio	14,227	10,847
Oklahoma	9	13
Pennsylvania	18,558	14,583
Rhode Island	3	3
Tennessee	23	12
Texas	1,211	1,378
Utah	1,681	1,622
Virginia	88	37
Washington	3	1
West Virginia	2,944	2,286
Wisconsin	94	65
Undistributed[3]	990	870
Total	87,458	69,053

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Less than 1/2 unit.
[3]Includes Colorado, Florida, New Hampshire, Oregon, and South Carolina in 1979 and 1980.

Table 11.—U.S. exports of major iron and steel products

Products	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	231,095	$47,110	357,965	$93,696	912,310	$249,092
Wire rods	40,772	13,103	28,403	14,180	212,823	70,291
Structural shapes, 3 inches and over	124,444	52,418	139,054	73,393	151,075	83,950
Structural shapes, under 3 inches	18,646	11,734	18,234	16,551	25,234	21,196
Sheet piling	2,840	999	6,823	4,614	2,677	1,664
Plates	172,064	79,321	207,866	100,986	207,840	119,042
Rails and track accessories	68,014	24,825	38,148	21,565	130,016	65,289
Wheels and axles	8,573	10,498	2,496	9,182	4,520	20,392
Concrete reinforcing bars	111,347	23,333	86,281	28,180	166,171	52,030
Bars, carbon, hot rolled	42,346	16,459	68,488	28,872	80,913	34,386
Bars, alloy, hot rolled	67,355	40,377	48,382	41,613	128,587	76,346
Bars, cold finished	32,170	24,245	29,486	30,561	28,442	34,261
Hollow drill steel	8,538	5,583	7,874	6,330	4,241	6,369
Pipe and tubing	561,990	530,326	728,430	791,131	470,168	718,647
Wire	38,503	41,723	34,827	45,243	42,648	55,054
Nails, brads, spikes, staples	23,910	23,607	10,320	26,014	11,600	31,681
Blackplate	79,199	15,872	125,548	35,377	179,459	52,046
Tinplate and terneplate	374,267	142,389	440,399	204,986	707,023	440,671
Sheets, hot rolled	98,679	42,864	100,527	53,582	211,291	104,937
Sheets, cold rolled	133,821	62,300	142,507	98,704	145,462	110,958
Strip, hot rolled	13,543	10,175	15,607	14,932	40,764	27,568
Strip, cold rolled	40,059	50,382	50,146	65,507	44,320	72,064
Plates, sheets, strip, galvanized, coated or clad	129,503	59,088	130,132	73,236	193,134	108,685
Total[1]	2,421,678	1,328,734	2,817,943	1,878,437	4,100,718	2,556,619
Other steel products:						
Plates and sheets, fabricated	31,208	39,395	22,362	38,417	28,763	52,913
Structural shapes, fabricated	119,557	163,021	121,296	195,258	175,035	313,644
Architectural and ornamental work	5,821	7,985	4,157	8,349	10,405	23,966
Sashes and frames	11,116	22,002	10,237	25,943	12,470	32,283
Pipe and tube fittings	58,711	182,387	42,058	214,369	50,104	259,805
Pipe and tubing, coated or lined	20,788	20,853	14,595	20,173	18,012	21,729
Bolts and nuts	101,814	107,274	95,094	113,687	56,131	123,230
Forgings	55,121	64,624	56,011	72,397	47,413	104,586
Cast-steel rolls	3,669	5,929	3,432	7,008	4,265	7,729
Railway track material	5,593	5,623	4,769	5,723	4,503	7,209
Total[1]	[r]413,398	[r]619,094	[r]374,011	[r]701,325	407,101	947,094
Iron products:						
Cast-iron pipes, tubes, fittings	115,427	124,361	66,367	121,517	86,245	140,661
Iron castings	320,240	212,323	141,194	102,740	134,714	83,755
Total	435,667	336,684	207,561	224,257	220,959	224,416
Grand total[1]	[r]3,270,743	[r]2,284,512	[r]3,399,515	[r]2,804,018	4,728,778	3,728,129

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. imports for consumption of pig iron, by country

Country	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	16,147	$2,352	7,880	$1,000	46,482	$6,258
Belgium-Luxembourg	6,752	788	--	--	--	--
Brazil	197,874	20,353	183,925	21,622	84,862	10,123
Canada	240,083	33,472	184,635	28,656	222,365	39,837
France	29,878	3,631	19,579	2,659	8,746	1,303
India	318	55	--	--	--	--
Mexico	--	--	--	--	15	22
Philippines	--	--	--	--	12	2
South Africa, Republic of	9,258	940	41,776	5,193	18,885	2,608
Spain	--	--	28,888	3,286	--	--
Sweden	144,161	9,396	9,658	834	18,658	2,884
United Kingdom	10,940	1,247	--	--	6	([1])
Total[2]	655,412	72,234	476,342	63,251	400,031	63,036

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 13.—U.S. imports for consumption of major iron and steel products

Products	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	413,898	$97,065	344,690	$91,863	155,345	$51,802
Wire rods	1,326,558	389,141	985,401	379,156	829,272	347,210
Structural shapes, 3 inches and over	1,798,998	458,756	1,881,959	596,769	1,739,543	589,762
Structural shapes, under 3 inches	239,742	57,054	231,608	76,162	136,939	49,960
Sheet piling	128,008	38,157	102,812	37,822	89,423	33,750
Plates	2,924,994	718,162	1,819,805	561,640	2,059,710	670,729
Rails and track accessories	189,161	51,369	213,677	74,336	271,164	106,264
Wheels and axles	96,724	47,257	99,550	58,877	142,906	101,150
Concrete reinforcing bars	109,958	20,807	116,958	33,164	78,641	23,770
Bars, carbon, hot rolled	597,826	156,798	452,433	147,958	366,659	129,253
Bars, alloy, hot rolled	182,479	94,077	153,894	90,499	129,147	90,054
Bars, cold finished	204,459	120,086	170,510	134,527	146,786	145,251
Hollow drill steel	2,202	1,970	2,023	2,212	1,814	1,742
Welded pipe and tubing	1,743,347	593,948	1,750,470	724,360	1,862,058	824,876
Other pipe and tubing	1,302,600	705,529	1,169,584	716,279	1,914,540	1,262,704
Wire	[r]627,238	[r]386,941	[r]479,162	[r]369,930	414,429	339,254
Wire nails	428,411	188,589	336,849	188,176	292,169	152,841
Wire fencing, galvanized	19,159	9,768	11,261	7,848	8,318	6,430
Blackplate	46,016	16,245	82,072	30,850	68,250	27,365
Tinplate and terneplate	380,552	165,193	262,781	137,252	309,292	179,232
Sheets, hot rolled	2,617,000	612,877	2,161,764	608,111	1,491,791	441,740
Sheets, cold rolled	3,236,855	1,022,261	2,412,994	894,821	1,477,122	589,037
Sheets, coated (including galvanized)	2,312,997	840,741	2,139,151	892,511	1,349,790	597,424
Strip, carbon, hot rolled	35,657	10,936	27,345	9,661	15,807	6,762
Strip, carbon, cold rolled	49,267	41,298	49,581	45,151	46,965	43,023
Strip, alloy, hot or cold rolled (including stainless)	25,043	34,757	21,267	36,682	15,341	34,362
Plates, sheets, strip, electrolytically coated (other than with tin, lead, or zinc)	95,121	36,507	38,588	20,124	81,854	41,716
Total[1]	[r]21,134,270	[r]6,916,288	[r]17,518,189	[r]6,966,738	15,495,075	6,887,462
Other steel products:						
Plates, sheets, strip, fabricated	10,026	7,468	6,749	7,582	6,010	5,879
Structural shapes, fabricated	126,196	70,685	154,365	113,101	175,292	170,719
Pipe fittings	79,267	85,222	81,753	107,851	88,329	131,293
Rigid conduit	3,324	5,116	3,095	5,035	2,058	3,705
Bale ties made from strip	28,207	10,720	8,046	3,677	2,050	1,339
Nails, brads, spikes, staples, tacks, not of wire	17,157	12,569	17,071	15,451	14,464	12,174
Bolts, nuts, rivets, washers, etc	509,954	471,161	477,092	496,999	430,011	473,632
Forgings	22,592	16,977	39,246	27,231	34,967	26,962
Total[1]	796,723	679,918	787,417	776,928	753,181	825,702
Iron products:						
Cast-iron pipes, tubes, fittings	25,976	21,220	26,852	25,387	23,859	25,278
Iron castings	69,899	40,473	95,841	53,460	82,712	53,577
Total[1]	95,875	61,692	122,693	78,847	106,571	78,855
Grand total[1]	[r]22,026,868	[r]7,657,899	[r]18,428,299	[r]7,822,513	16,354,827	7,792,019

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 14.—Pig iron: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	10,803	10,649	11,399	12,021	[3]12,007
Mexico[4]	3,889	[r]4,771	5,662	5,530	[3]5,806
United States	86,848	81,494	87,690	86,975	[3]68,699
South America:					
Argentina[4]	1,440	1,521	1,581	2,141	[3]1,991
Brazil[4]	9,295	10,735	11,388	13,159	[3]14,329
Chile	445	476	594	674	[3]710
Colombia	315	246	327	265	[3]307
Peru	[r]255	269	271	283	[3]288
Venezuela[4]	465	548	764	1,468	[3]1,868
Europe:					
Austria	3,658	3,268	3,392	4,081	[3]3,843
Belgium	[r]10,887	[r]9,837	10,310	11,878	[3]10,857
Bulgaria	1,717	1,779	1,645	1,598	[3]1,696
Czechoslovakia	10,444	10,709	10,961	10,504	[3]10,824
Finland	[r]1,465	1,944	2,112	2,247	[3]2,264
France	20,566	19,714	19,952	20,906	[3]20,470
German Democratic Republic[5]	2,787	2,896	2,822	2,630	2,650
Germany, Federal Republic of	[r]34,865	[r]31,728	33,002	38,508	37,260
Greece	441	485	660	362	380
Hungary	2,448	2,520	2,568	2,611	[3]2,441
Italy	12,821	12,578	12,500	12,486	12,700
Luxembourg[5]	4,140	3,933	4,102	4,190	[3]3,934
Netherlands	4,702	4,323	5,085	5,307	[3]4,773
Norway	723	565	613	717	[3]717
Poland	[r]9,015	10,490	12,246	12,087	11,000
Portugal	379	393	389	[e]400	410
Romania	8,174	8,580	8,989	9,787	10,100
Spain	7,301	7,280	6,893	7,174	7,470
Sweden[4]	3,504	[r]2,745	2,735	3,202	[3]2,670
Switzerland	25	30	38	33	32
U.S.S.R	115,086	117,278	121,025	120,052	[3]119,600
United Kingdom	15,115	13,380	12,604	14,220	7,050
Yugoslavia	2,115	[r]2,136	2,294	2,603	[3]2,673
Africa:					
Algeria	[r]502	[r]473	502	529	635
Egypt[e]	275	275	330	205	400
Morocco[e]	11	13	13	13	13
South Africa, Republic of	[r]6,307	[r]6,401	6,498	7,750	7,940
Tunisia	[r]114	146	148	165	155
Zimbabwe[e]	880	760	730	780	1,070
Asia:					
China:					
Mainland	[r]31,747	[r]30,920	38,349	40,488	[3]40,896
Taiwan	[r]210	[r]303	348	358	[3]306
India	[r]10,722	10,798	10,397	9,631	[3]9,324
Iran[e]	690	770	1,000	900	900
Israel[e]	44	44	44	45	45
Japan	95,434	94,673	86,629	92,402	[3]96,783
Korea, North[e]	[r]2,900	[r]3,000	3,100	3,200	3,300
Korea, Republic of	[r]2,135	[r]2,673	3,022	5,581	[3]6,148
Thailand	20	22	23	33	35
Turkey	2,195	1,905	1,852	2,538	2,200
Oceania:					
Australia	8,176	7,444	8,088	8,610	7,683
New Zealand[e] [4]	55	13	31	30	33
Total	[r]548,550	[r]539,933	557,717	583,357	559,685

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table excludes all ferroalloy production except where otherwise noted. Table includes data available through May 31, 1981.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1975-78, but output is not reported and available general information is inadequate to permit formulation of reliable estimates of output levels.

[3]Reported figure.

[4]Includes sponge iron output.

[5]May include blast furnace ferroalloys.

Table 15.—Raw steel:[1] World production, by country[2]

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada	[r]14,650	15,026	16,423	17,723	[3]17,528
Cuba	[r]276	[r]364	357	361	390
El Salvador	[e]12	15	[e]15	[e]15	15
Mexico	5,840	6,174	7,468	7,761	[3]7,788
United States	128,000	125,333	137,031	136,341	[3]111,835
South America:					
Argentina	2,670	2,950	3,064	3,577	[3]3,004
Brazil	10,107	12,306	13,346	15,230	[3]16,892
Chile	[r]529	604	659	724	[3]784
Colombia	393	364	431	398	[3]446
Ecuador	NA	NA	NA	9	[3]16
Peru	385	418	416	470	[3]519
Uruguay	17	19	10	18	[3]17
Venezuela	1,033	942	948	1,631	[3]2,289
Europe:					
Austria	4,935	4,511	4,779	5,420	[3]5,095
Belgium	13,388	12,408	13,890	14,817	[3]13,580
Bulgaria	2,712	2,854	2,723	2,736	[3]2,829
Czechoslovakia	16,196	16,605	16,859	16,333	[3]15,680
Denmark	796	756	952	886	[3]809
Finland	1,812	2,420	2,572	2,721	[3]2,743
France	25,597	[r]24,354	25,178	25,754	[3]25,535
German Democratic Republic	7,421	[r]7,551	7,690	7,742	[3]8,056
Germany, Federal Republic of	46,754	42,974	45,474	50,750	[3]48,325
Greece	788	837	1,032	1,102	1,200
Hungary	4,026	4,104	4,274	4,308	[3]4,154
Ireland	[r]97	52	76	79	70
Italy	[r]25,846	25,721	26,767	26,731	[3]29,221
Luxembourg	5,033	4,772	5,280	5,456	[3]5,090
Netherlands	[r]5,719	[r]5,431	6,162	6,400	[3]5,803
Norway	1,002	784	890	1,015	[3]956
Poland	17,240	19,666	21,221	21,184	21,477
Portugal	511	591	677	715	720
Romania	11,831	[r]12,629	12,984	14,230	[3]14,524
Spain	12,128	12,238	12,836	13,563	12,680
Sweden	5,666	4,374	4,767	5,217	[3]4,670
Switzerland	601	[r]721	864	977	990
U.S.S.R	159,642	161,685	166,929	164,353	[3]163,141
United Kingdom	24,553	22,499	22,389	23,673	12,460
Yugoslavia	[r]3,032	[r]3,510	3,806	3,899	[3]4,006
Africa:					
Algeria	392	441	435	459	550
Angola[e]	6	6	11	11	11
Egypt	504	290	[e]660	[e]700	840
Ghana[e]	17	17	11	6	6
Kenya[e]	11	11	11	11	11
Libya[e]	11	11	11	11	11
Morocco[e]	1	--	--	--	--
Mozambique[e]	22	13	19	22	22
Nigeria[e]	17	17	17	17	17
South Africa, Republic of	7,888	[r]8,131	8,710	9,783	9,900
Tunisia	113	172	175	194	190
Uganda	13	17	17	--	--
Zaire[e]	33	33	NA	NA	NA
Zimbabwe	1,100	990	990	990	990
Asia:					
Bangladesh[4]	91	128	137	139	145
Burma	44	44	44	NA	NA
China:					
Mainland	[r]22,600	[r]26,169	35,031	37,953	[3]39,793
Taiwan	699	[r]1,004	1,399	1,731	[3]1,556
Hong Kong[e]	79	83	83	100	100
India	10,202	10,933	11,009	11,019	11,320
Indonesia	153	160	165	[e]550	660
Iran[e]	600	600	860	[e]770	770
Iraq[e]	--	--	55	388	385
Israel[e]	88	110	110	110	110
Japan	118,387	112,882	112,551	123,181	[3]122,806
Jordan[e]	110	110	110	110	110
Korea, North[e]	3,300	[r]3,400	3,500	3,700	3,900
Korea, Republic of	2,974	3,017	3,460	5,732	[3]6,383
Lebanon[e]	9	8	7	--	--
Malaysia	209	214	224	257	240
Philippines	433	401	304	438	430
Saudi Arabia[e]	5	5	5	50	55

See footnotes at end of table.

Table 15.—Raw steel:[1] World production, by country[2] —Continued

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Asia —Continued					
Singapore	224	227	309	327	330
Syria[e]	88	127	132	[e]100	110
Thailand	[r]303	331	365	480	500
Turkey	1,606	1,540	1,664	3,329	3,300
Vietnam[e]	[r]80	[r]95	110	120	130
Oceania:					
Australia	8,569	8,061	8,365	8,956	[3]8,735
New Zealand	[r]220	[r]248	249	[e]220	220
Total	[r]742,439	[r]738,608	782,554	816,283	779,973

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Steel formed in first solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.
[2]Table includes data available through May 31, 1981.
[3]Reported figure.
[4]Data are for year ending June 30 of that stated.

Iron and Steel Scrap

By Franklin D. Cooper[1]

Scrap consumption in 1980 totaled 83.7 million tons,[2] 15% less than in 1979. The maximum monthly consumption of 9.0 million tons occurred in March, and the minimum of 5.0 million tons occurred in July.

Consumption of direct-reduced iron (DRI) fell to 552,887 tons from 693,000 tons in 1979. Imports of DRI in 1980 totaled 23,720 tons.

Oregon Steel Mills terminated its production of DRI on May 31 because of the high cost of natural gas for its process.

Table 1.—Salient iron and steel scrap and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1979	1980
Stocks Dec. 31:		
Scrap at consumer plants	8,724	8,018
Pig iron at consumer and supplier plants	881	889
Total	9,605	8,907
Consumption:		
Scrap	98,901	83,710
Pig iron	87,458	69,053
Exports:		
Scrap (excludes rerolling material and ships, boats, and other vessels for scrapping)	11,054	11,168
Value	$1,142,406	$1,225,941
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	760	582
Value	$70,804	$61,192

Legislation and Government Programs.—In mid-March, the House of Representatives added an amendment to the Solid Waste Disposal Act that could effectively prohibit the U.S. Department of Commerce from monitoring or curbing exports of ferrous scrap.

On March 26, 1980, the Ferrous Scrap Consumers Coalition (FSCC) petitioned the Department of Commerce to monitor exports of iron and steel scrap. On April 29, the Institute of Scrap Iron and Steel (ISIS), supported by the National Association of Recycling Industries and the Automotive Dismantlers and Recyclers of America, urged the Commerce Department to deny the FSCC petition seeking to monitor and eventually control scrap exports because the prices of ferrous scrap were considered noninflationary. Following a review of the situation, the Commerce Department on July 15, 1980, decided not to monitor ferrous scrap exports.

The Staggers Rail Act of 1980 was signed into law in October. The act gave railroads the flexibility to raise their freight rates without first getting Interstate Commerce Commission (ICC) approval if the rates do not exceed variable or out-of-pocket costs by more than 160%. However, while the act contained a freight rate maximum for nonferrous scrap, it excluded any similar provision for iron and steel scrap. In mid-November, the ICC set a 150% revenue-to-variable cost ratio that the railroads must use to haul all recyclables except iron and steel scrap.

On April 25, the U.S. Court of Appeals upheld the ISIS claim that scrap iron and iron ore compete. The court, in its review of the ICC's second Ex Parte 319 investigation of freight rates on recyclables, found that for those commodity categories where virgin and recyclable materials can be used to a significant extent to manufacture the same end product, it was reasonable for the ICC to conclude that they compete. As a result of the court's decision, the Ex Parte 319 investigation was returned to the ICC for defining permissible remedies for discrimination, and to define the rationale for its selection of a particular revenue-to-variable cost ratio as to its reasonableness standard for recyclables.

In response to a petition filed in 1979 by six members of the Merchant Pig Iron Producers Association, the U.S. Department of the Treasury found that Brazilian exporters of pig iron, by receiving Government financing and tax rebates, had been subsidized under terms of the countervailing duty law. Treasury passed its decision to the International Trade Commission (ITC), which issued a unanimous affirmative determination on March 11, 1980, finding that the domestic industry had been injured. The determination was sent to the U.S. Department of Commerce, which imposed countervailing duties averaging 6.2% on pig iron imported from Brazil.

AVAILABLE SUPPLY, CONSUMPTION, STOCKS

The foundry industry had a significant decrease of orders from the auto industry and from manufacturers of pipe, trucks, and heavy equipment. Castings demand remained strong for the aerospace, machine tool, and energy markets.

The consumption of iron and steel scrap, in million tons, decreased from 98.9 in 1979 to 83.7 in 1980. Monthly consumption in million tons averaged 7.0 in 1980, ranging from 9.0 in March to 5.0 in July.

Monthly stocks, in million tons, averaged 6.7 in 1980 compared with 8.5 in 1979. Stocks in January were 7.1, decreasing to 6.5 in July, and increasing to 8.0 in December 1980.

Domestic receipts of iron and steel scrap from brokers and dealers and other outside sources dropped to 39.3 million tons from 43.9 million tons in 1979.

The high cost of money threatened the ferrous scrap supply volume because of the rising costs of collection, preparation, and marketing.

Changing technology enabled basic oxygen furnaces to use more scrap during times of lower prices or when blast furnaces were shut down for relining.

At the time when the growing competition for high-quality scrap became more intense, scrap from junked automobiles was expected to become more scarce as the auto industry moved to using less steel, especially in smaller cars, and because of its increasing reliance on high-strength alloy steels, which generate lower quality scrap.

National Steel Corp. started a new tinplated-steel scrap credit arrangement for beer-and-beverage-can stock. National also began accepting used bimetallic (steel body, aluminum ends) cans from manufacturers for credits toward future can-stock tinplate purchases. National paid freight costs on the scrap.

United States Steel Corp. planned to create a scrap market for its new tinless cans that it began marketing late in 1980. The used cans would be received from civic recycling centers and from scrap dealers through the beverage industry recycling program. In 1980, of the 55 billion cans of all types produced, 15 billion were made only of steel.

The demand for ferrous scrap in the Southwestern United States surpassed the supply. Because electric-furnace capacity in the region increased 75% since 1973, scrap was being brought in from as far away as Chicago. Luria Brothers & Co. Inc. and Commercial Metals Co. announced intentions to obtain about 300,000 tons of DRI for the region from Canada and the Federal Republic of Germany. West coast demand for ferrous scrap at 15,000 tons per month was far below the 90,000-ton-per-month capacity of scrap processors, of which about 80% was exported.

Bethlehem Steel Co. devised a scrap management program using models to show scrap inventory data, transportation costs, purchased scrap options, scrap analyses, and scrap consumption. This program assured Bethlehem that scrap for its six eastern plants will be managed in a cost-effective manner.

Steel production cutbacks in 1980 did not hit scrap-melting electric furnaces as hard as they did the industry's open-hearth furnaces and oxygen converters. According to Union Carbide Corp., domestic steelmakers currently own about 330 electric furnaces, with an aggregate capacity of nearly 40 million tons annually, and by 1990, U.S. electric-furnace capacity will reach 50 million net tons annually, or nearly one-third of the industry's total steelmaking capacity.

Although there are no official figures on the scrap industry's current production potential, it certainly is much greater than in 1974 when 52.1 million tons of iron and steel scrap were processed. Since 1974, additional shredding machines, guillotine shears, and briquetting machines for short turnings have been installed. The industry's current investment in land, buildings, and equipment is calculated as far more than $2 billion.

Foreign-made equipment, available to U.S. scrap processors, included grapples and magnets from Liebherr-America, Newport News, Va.; shears, briquetters, and balers from Becker Machinery of America, Inc., Brookfield, Wis.; cable strippers from England, Denmark, and Japan; a Spanish hydraulic shear marketed under the Moros label; and the Class Bomatic shredder made in the Federal Republic of Germany and distributed by Manufacturing Marketing Corp., Jacksonsville, Fla. Tic Sales Corp., Canastota, N.Y., offered 10% financing, spare parts, and servicing on scrap balers imported from Italy. Two demonstration units made by the Lollini Co. of Bologna arrived in May 1980. A Tic spokesperson estimated that 10 to 15 Lollini balers, already operating in the United States, had been supplied by Z-Loda Corp., under a different label until about 4 years ago.

Some scrap shippers used truck haulage to steel mills because of the unavailability of railroad gondola cars. As of December 31, 1980, Class I railroads owned 150,245 units, down from 154,629 units 1 year earlier. Class I railroads scrapped 10,681 units and added 6,300 new units. The Clearing House Concept permitted 11 railroad members unrestricted use of each other's rolling stock, including general-purpose gondolas. The Railgon Co., a subsidiary of the Trailer Train Co., announced that it would lease 4,000 gondolas suitable for scrap handling to participating railroads on a "free-running" basis. By yearend, Railgon had leased 1,500 gondolas.

PRICES

Based on Iron Age composite ferrous scrap prices in the Pittsburgh, Chicago, and Philadelphia districts for 18 major classes of scrap, including No. 1 and No. 2 heavy melting and No. 1 dealers' bundles, maximum prices were attained in early February 1980 for 12 classes, while 16 classes, including No. 1 and No. 2 heavy melting and dealers' bundles, were at their minimum price in early June. The average price of No. 1 heavy melting scrap was $91.37 per long ton, ranging from $105.17 in early February to $69.83 in early June. No. 2 heavy melting averaged $81.45, ranging from $93.50 in early February to $62.50 in early June. No. 1 dealers' bundles averaged $102.04, ranging from $115.83 in early February to $72.83 in early June.

The 1980 Iron Age composite prices for 18-8 stainless steel scrap based on the Pittsburgh and Chicago districts showed bundles and solids averaging $659.48 per long ton, ranging from $717.50 in early February to $579.17 in late July. Turnings averaged $556.21 per long ton, ranging from $662.50 in early March to $466.70 in late July.

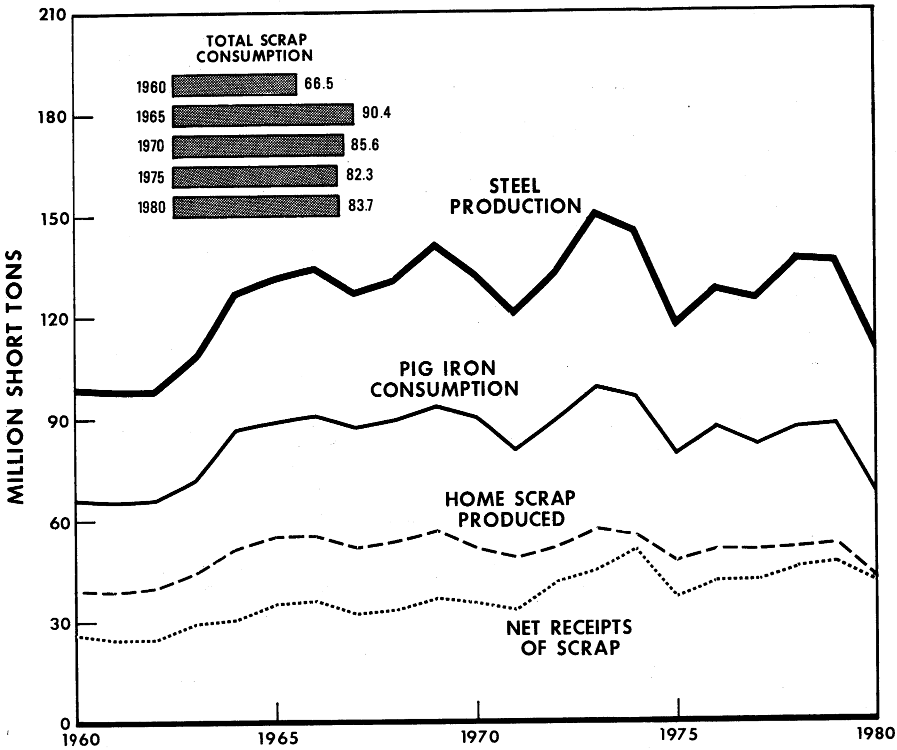

Figure 1.—Steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

FOREIGN TRADE

U.S. scrap exports to 59 countries in 1980 amounted to 11,168,000 tons valued at $1,225,941,000, or $109.77 average per ton. Prices on large tonnages of exports ranged from $126.99 per ton for 990,000 tons to Taiwan to $72.79 per ton for 790,000 tons to Canada. Collectively, Japan, the Republic of Korea, Mexico, and Spain received 6,871,000 tons, having an average value of $109.68 per ton. A detailed analysis of the other countries entry shown in table 11 shows that 16 countries, each importing more than 10,000 short tons, received 558,919 tons averaging $112.36 per ton, while 31 other countries, each receiving less than 10,000 tons, imported 46,526 total tons averaging $134.32 per ton.

Factors responsible for the large tonnages of exports to the specified countries were the expansion of steelmaking in the Republic of Korea, removal of restraints on Japanese electric-furnace production, and increased electric-furnace capacity in Spain and Taiwan.

The principal grades of scrap exported in 1980 were shredded steel, 3,323,058 tons at $104.10 customs value per ton; and No. 1 heavy melting, 2,906,702 tons at $102.41 per ton.

In 1980, Japan was the leading importer of U.S. scrap with 2,838,000 tons, compared with 1,736,000 tons sent to the Republic of Korea.

Imports of 581,512 tons of iron and steel scrap averaged $105.23 per ton, with Canada supplying 499,271 tons averaging $104.02 per ton. Imports of pig iron totaled 414,291 tons at $155.28 per ton, of which Canada supplied 236,580 tons at $173.67 per ton, while 84,862 tons came from Brazil at $119.28 per ton. Sponge iron imports totaled 23,720 tons at $151.86 per ton, with Canada supplying 23,570 tons at $141.29 per ton.

WORLD REVIEW

The General Accounting Office in May issued a new study on ferrous scrap which surveys world trade and pricing conditions for the commodity, but declines to state whether ferrous scrap supplies will be sufficient for the U.S. steel industry. Both domestic and foreign market conditions were essentially those of a spot market basis, with buyers and sellers preferring short-term contracts, responsive to supply-and-demand situations. The study noted that the United Kingdom, France, and the Federal Republic of Germany currently have no major barriers to scrap exports to the United States; Italy, Denmark, and Ireland have restrictive policies; and Belgium, Luxembourg, and the Netherlands have policies that are somewhere in between. Japan has no legal restrictions on the export of scrap, but actually exports very little.

Canada.—Intermetco Ltd., Hamilton, Ontario, operated 12 scrap-processing plants in Canada and 1 in Buffalo, N.Y. Intermetco doubled its shearing capacity in its Hamilton plant after installing a new hydraulic shear, the largest in Canada.

China, Taiwan.—In 1978, Taiwan's electric-furnace mills depended on scrapped ships for 80% of their requirements and 20% on scrap from the United States. The breaking of 224 ships in 1978 produced 5,824,000 long tons of scrap. By 1980, Taiwan withdrew from shipbreaking and increased its imports of scrap from the United States, Australia, and the United Kingdom. Stocks of scrap were falling at yearend. Prices for No. 1 heavy melting scrap were about $155 to $158 per ton c.i.f. As the U.S. price continued to rise, the Taiwanese looked for new sources including Saudi Arabia and Chile.

Egypt.—Egypt started negotiations with the Agency for International Development in April 1980 to obtain $10 million funding in each of 3 years for the purchase of high-quality scrap for a consortium of three ministeel mills in the public sector. At stake appeared to be about 160,000 tons of ferrous scrap annually, compared with present purchases of 50,000 tons per year. Eighty percent of the increased scrap acquisitions, primarily No. 1 heavy melting, will come from the United States.

Hungary.—In Hungary, KOKOV, a community enterprise, was responsible for the purchase of new production scrap amounting to about 725,000 tons annually. MEH, responsible for collecting old scrap from the mining and agriculture sectors, annually processes about 160,000 tons of steel scrap and 18,000 tons of cast iron scrap. Another organization, METALIMPLEX, has not imported scrap recently, nor was it exporting scrap in 1980.

India.—Private minimills in India paid about $200 per ton for scrap. The Government allowed liberal imports, but high freight rates and high U.S. prices held imports down. Sponge iron may be imported soon, and tool and alloy scrap and stainless steel scrap were beginning to arrive. Because of Government duties, shipbreaking was minimal, but it should increase.

Indonesia.—Indonesia's P.T. Karakatau Steel received a 5,000-ton order from Taiwan for Hylsa S.A. pellets, for about $140 per ton. Following Taiwan's first order of Indonesian sponge iron in late 1979 for testing, the receipt of a second order suggests that it is now being used commercially in Taiwan.

Italy.—Because of the large inventories of scrap held by Italian steel mills and dealers, very small tonnages of U.S. scrap were received after August 1980. Proler International, Houston, Tex., was the predominant supplier among six major U.S. exporters of scrap to Italy in 1980. U.S scrap traders were urged to use shallow draft vessels and to send them to small Italian ports to relieve congestion at the major depot at Genoa.

The Italian state railways stopped ferrous scrap shipments from France, the Federal Republic of Germany, Switzerland, and Austria for several weeks in late February because of a shortage of gondola cars. Scrap supplies from the EEC in 1980 cost the Italian users $142 to $144 per ton at Genoa, compared with $110 for French scrap and $100 for West German scrap. The Soviet Union exported about 480,000 tons to Italy in 1980 based on an accord between Finsider, the Genoa Port Authority, and Soviet steel and scrap agencies.

Italian electric-furnace steelmakers expected to import 75,000 metric tons of sponge iron in 1980 from Sidbec-Dosco Ltd. of Canada to offset the rising cost of scrap, according to Coimpre, a new consortium of eight minimills. Italimpianti, the engineering subsidiary of the State steel company Finsider, was constructing a 130,000-ton-per-year sponge iron plant to be run by a new company called Irfid in a Genoan steel complex. This direct-reduction plant will use coal as the reductant. Already in operation in Italy are a 10,000-ton-per-year Kinglor Metor coal-reductant process unit at Buttrio and a 40,000-ton-per-year Ferriere Arvedi process coal-reductant unit at Cremona.

Japan.—Japanese steelmakers were not unduly concerned about the level of home scrap supplies because electric-furnace operators agreed that imports from the United States were sufficient to cover their reduced requirements. The prices of imports from the United States were expected to fall following the withdrawal of some European, South Korean, and Taiwanese buyers from the U.S. market.

The Government-backed 3-year modernization program for Japan's ferrous scrap industry has encouraged the installation of new equipment, with major emphasis on guillotine shears and 6- to 7-ton trucks. A tentative list of new equipment needed for modernization, as prepared by the Japan Ferrous Scrap Association, called for spending $203 million, including pollution-control devices.

In June, the Japanese Ministry of International Trade and Industry formed a committee to discuss using DRI in electric furnaces and to conduct an economic study of building DRI plants overseas. Although it now produces 30 million tons of ferrous scrap annually, Japan will need U.S. scrap to maintain the 123-million-ton annual production of steel achieved in 1979 and in 1980.

Of the total imports of ferrous scrap received by Japan in 1980, about 88% came from the United States, 4% from the U.S.S.R., and 6% from Australia. Japanese firms purchase U.S. scrap on the basis of import price, the competing domestic price, and the yen-to-dollar exchange rate.

Korea, Republic of.—The Republic of Korea's Kumho Industries in late 1980 contracted for a 20,000-ton mixed cargo of U.S. scrap, agreeing to pay about $153 per ton c.i.f. for the No. 1 heavy melting material in the cargo. No further orders were expected until funding of Government purchases for electric-furnace operators become available in February 1981 at the earliest.

Netherlands.—The Dutch Scrap Federation announced that no scrap would be sent out of the Netherlands by 1985, thereby creating additional market opportunities for U.S. scrap brokers. In 1979, about 1.2 million tons of ferrous scrap was exported primarily to the Federal Republic of Germany, Belgium, France, Spain, and Italy. However, Holland's major steelmaker, Hoogovens IJmuiden B.V., a member of the Estel group, started a continuous caster May 1 and had several more casters on order. Consequently, this major steelmaker, which bought 400,000 tons of scrap in 1979, will purchase 1.2 million tons by 1985 at peak production level. The Ministry of Economic Affairs stated that no legislative bans on exports will be imposed because the marketplace will exert its own controls and keep the ferrous scrap at home.

The largest cargo so far of Midrex sponge iron pellets arrived at Rotterdam on February 2, 1980, from Matanzas, Venezuela. The purchase of the 18,174 tons of pellets was arranged by Eisenerz-Gesellschraft BmgH, a subsidiary of Metallgesellschraft AG. The shipment was used by a number of West European steel producers.

Sweden.—Three large companies, AB Gotthard Nilsson, Stena Metall and PLM Aatervining, dominated the Swedish scrap market because of the need for mechanized processing and transport, which placed equipment costs out of the reach of small operators. This is a reflection of the high cost of labor in Sweden. Exports of scrap from Sweden have been banned since 1927, and a majority of Swedish mills buy their scrap from a joint organization, the JBF, which almost creates a seller's monopoly. In 1979, Stena Metall held 35% to 40% of the Swedish scrap market.

United Kingdom.—The long lapse since the British Steel Corp. (BSC) bought a significant quantity of scrap, a 40% price slump on the 4.3 million tons used in the United Kingdom steelmaking, and a one-third decrease of consumption by independent steel producers and foundries indicated the depressed state of the ferrous scrap industry. Scrap processors faced higher costs for electricity, fuel, labor, cutting gases, and transportation. Competitiveness of continental merchants depressed the export market although sales totaling 2.79 million tons, averaged $137 per ton, including stainless steel scrap. Major customers were Spain, the Federal Republic of Germany, Italy, Denmark, and India.

Britain's Thomas W. Ward Co. in October 1980 loaded 15,000 metric tons of fragmentized and baled scrap destined for the Far East. This biggest single consignment was the largest ever exported from a United Kingdom port. In late 1980, more cargoes of from 15,000 to 20,000 metric tons were being gathered for shipment to India, Pakistan, and Japan. These composite shipments will comprise No. 1 heavy melting grade and cut material. The f.o.b. Midlands prices offered by the British scrap industry were close to $72 per gross ton. However, London trading company sources discounted prospects of the United Kingdom becoming a major factor in the Japanese market because there was no way it could compete with the U.S. tonnage available.

Employment level at 13,500 continued on a downtrend. The BSC, the British Independent Steel Producers Association, and the British Scrap Federation (BSF) agreed upon a 26-item list of ferrous scrap specifications and several techniques to reduce contamination of delivered scrap. Under its new strategy, BSC needs for ferrous scrap continued to fall as the bulk of its steel output was based on its five hot metal plants.

Ecobric Foundry Ltd., London, England, continuously processed cast iron borings into high-density ingots of guaranteed analysis as high-quality foundry feedstocks. Borings were heated in a rotating drum under a reducing atmosphere before compaction at 500 tons' pressure in a horizontal strain rod press. The product of 6 inches diameter up to 4 inches thick weighs 14 to 18 pounds and has an 80% theoretical density of gray iron. The BSC at its Teesside Laboratories developed a mechanized burning rig having outputs in tons per hour of 15 to 25 for blooms, slabs, and ingots; 10 to 12 for billets, plates and beams; and 5 for rods. The BSF spent $2.35 million in 1980 to modernize its United Kingdom facilities, including a large, new metals separator for its Longsmarten plant at Stratford-on-Avon.

[1]Physical scientist, Section of Ferrous Metals.
[2]All quantities are in short tons unless otherwise noted.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1980, by grade

(Thousand short tons)

Grade of scrap	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other own-company plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS[1]							
Carbon steel:							
Low-phosphorus plate and punchings	395	18	88	5	485	42	41
Cut structural and plate	381	199	775	--	1,199	156	87
No. 1 heavy melting steel	7,945	2,660	13,801	75	22,535	2,292	2,148
No. 2 heavy melting steel	2,441	179	1,350	9	3,560	142	511
No. 1 and electric-furnace bundles	5,226	348	2,326	2	7,968	162	901
No. 2 and all other bundles	1,990	81	50	--	2,261	36	296
Electric furnace 1 foot and under (not bundles)	48	1	3	([2])	50	([2])	10
Railroad rails	84	([2])	4	2	66	5	11
Turnings and borings	1,102	107	394	7	1,539	121	92
Slag scrap (Fe content 70%)	1,181	47	3,291	1	4,227	208	189
Shredded or fragmentized	2,771	572	65	--	3,188	--	339
No. 1 busheling	1,017	14	63	1	1,097	9	92
All other carbon steel scrap	2,254	278	9,186	99	10,744	734	796
Stainless steel scrap	361	37	594	([2])	930	54	96
Alloy steel (except stainless)	208	211	1,366	13	1,705	144	214
Ingot mold and stool scrap	376	729	858	1,522	2,797	867	533
Machinery and cupola cast iron	1	1	3	1	16	11	76
Cast iron borings	300	7	138	14	472	177	37
Motor blocks	4	--	--	--	4	--	([2])

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1980, by grade —Continued

(Thousand short tons)

Grade of scrap	Receipts of scrap		Production of home scrap				
	From brokers, dealers, and other outside sources	From other own-company plants	Recirculating scrap resulting from current operations	Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS[1] —Continued							
Other iron scrap	581	149	614	7	1,030	269	386
Other mixed scrap	315	121	241	--	684	30	55
Total scrap[3]	28,980	5,761	35,209	1,757	66,557	5,458	6,909
MANUFACTURERS OF STEEL CASTINGS[4]							
Carbon steel:							
Low-phosphorus plate and punchings	576	11	195	5	806	2	63
Cut structural and plate	229	17	20	--	270	1	24
No. 1 heavy melting steel	165	7	75	(2)	245	8	24
No. 2 heavy melting steel	65	(2)	19	(2)	92	(2)	7
No. 1 and electric-furnace bundles	26	--	2	--	30	--	2
No. 2 and all other bundles	7	(2)	(2)	--	6	--	2
Electric furnace 1 foot and under (not bundles)	68	--	19	--	83	1	6
Railroad rails	1	--	--	--	(2)	--	(2)
Turnings and borings	42	3	22	--	57	11	2
Slag scrap (Fe content 70%)	--	--	(2)	--	--	(2)	(2)
Shredded or fragmentized	46	6	1	--	52	--	3
No. 1 busheling	20	5	1	--	26	--	2
All other carbon steel scrap	437	17	313	(2)	786	4	28
Stainless steel scrap	21	1	32	(2)	51	4	5
Alloy steel (except stainless)	59	1	105	--	171	2	21
Ingot mold and stool scrap	2	(2)	1	--	2	1	1
Machinery and cupola cast iron	3	(2)	5	--	9	(2)	(2)
Cast iron borings	68	1	24	--	79	1	5
Motor blocks	(2)	--	--	--	(2)	--	(2)
Other iron scrap	27	3	64	(2)	90	6	9
Other mixed scrap	(2)	--	5	--	5	--	(2)
Total scrap[3]	1,861	72	903	6	2,862	40	205
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	678	72	64	(2)	817	18	39
Cut structural and plate	1,399	74	156	4	1,553	4	125
No. 1 heavy melting steel	148	40	62	--	217	75	12
No. 2 heavy melting steel	74	8	26	1	113	1	3
No. 1 and electric-furnace bundles	131	59	52	(2)	257	--	9
No. 2 and all other bundles	333	--	--	--	341	--	32
Electric furnace 1 foot and under (not bundles)	97	57	1	--	155	--	7
Railroad rails	126	(2)	(2)	--	121	(2)	13
Turnings and borings	454	91	19	(2)	558	53	65
Slag scrap (Fe content 70%)	32	--	(2)	--	34	1	8
Shredded or fragmentized	805	22	(2)	--	818	2	59
No. 1 busheling	202	20	14	--	240	18	7
All other carbon steel scrap	766	434	144	(2)	1,372	7	77
Stainless steel scrap	1	--	18	(2)	19	1	2
Alloy steel (except stainless)	17	(2)	5	2	19	5	10
Ingot mold and stool scrap	133	1	57	3	189	15	49
Machinery and cupola cast iron	904	72	584	1	1,541	7	117
Cast iron borings	633	342	315	4	1,279	53	56
Motor blocks	524	9	288	(2)	770	4	53

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1980, by grade —Continued

(Thousand short tons)

Grade of scrap	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other own-company plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks Dec. 31
IRON FOUNDRIES AND MISCELLANEOUS USERS —Continued							
Other iron scrap	691	85	2,157	8	2,875	113	117
Other mixed scrap	320	308	338	5	1,004	7	46
Total scrap[3]	8,470	1,694	4,303	29	14,291	385	905
TOTAL—ALL TYPES OF MANUFACTURERS[3]							
Carbon steel:							
Low-phosphorus plate and punchings	1,649	102	347	10	2,108	62	144
Cut structural and plate	2,009	290	952	4	3,022	161	237
No. 1 heavy melting steel	8,258	2,707	13,939	75	22,997	2,374	2,183
No. 2 heavy melting steel	2,580	187	1,395	9	3,765	143	522
No. 1 and electric-furnace bundles	5,383	407	2,380	3	8,255	162	912
No. 2 and all other bundles	2,329	81	50	--	2,608	36	329
Electric furnace 1 foot and under (not bundles)	213	57	23	(2)	288	1	22
Railroad rails	210	(2)	4	2	187	5	24
Turnings and borings	1,598	201	436	7	2,154	185	159
Slag scrap (Fe content 70%)	1,212	47	3,292	1	4,261	208	197
Shredded or fragmentized	3,622	600	66	--	4,058	2	400
No. 1 busheling	1,239	39	79	1	1,362	28	100
All other carbon steel scrap	3,457	730	9,642	100	12,903	745	901
Stainless steel scrap	383	38	643	(2)	1,000	58	102
Alloy steel (except stainless)	284	212	1,477	15	1,896	151	245
Ingot mold and stool scrap	511	730	916	1,526	2,988	883	582
Machinery and cupola cast iron	908	73	592	2	1,566	19	193
Cast iron borings	1,001	350	476	17	1,830	231	98
Motor blocks	529	9	288	(2)	775	4	53
Other iron scrap	1,299	238	2,835	15	3,995	387	513
Other mixed scrap	636	429	584	5	1,693	37	101
Total scrap[3]	39,310	7,527	40,415	1,792	83,710	5,883	8,018

[1]Includes only those castings made by companies producing raw steel.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Excludes companies that produce both raw steel and steel castings.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1980

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS					
Pig iron	2,952	68,699	67,114	5,467	792
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	40	--	41	(1)	5
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	1,862	--	1,898	16	93
TOTAL—ALL TYPES OF MANUFACTURERS[2]					
Pig iron	4,853	68,699	69,053	5,483	889
Direct-reduced or prereduced iron	592	W	715	W	58

W Withheld to avoid disclosing company proprietary data.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 4.—Consumption of iron and steel scrap and pig iron in the United States, in 1980, by type of consumer and type of furnace, or other use

(Thousand short tons)

Type of furnace or other use	Manufacturers of pig iron and raw steel and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Total all types[1]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace[2]	3,651	--	--	--	--	--	3,651	--
Basic oxygen process[3]	21,859	56,414	--	--	--	--	21,859	56,414
Open-hearth furnace	7,398	8,600	47	6	--	--	7,445	8,606
Electric furnace	32,673	529	2,706	34	4,775	292	40,154	855
Cupola furnace	114	117	98	1	9,228	581	9,440	698
Other (including air furnace)[4]	861	267	11	1	288	31	1,160	299
Direct castings[5]	--	1,188	--	--	--	994	--	2,182
Total[1]	66,557	67,114	2,862	41	14,291	1,898	83,710	69,053

[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption in all blast furnaces producing pig iron.
[3]Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[4]Includes vacuum melting furnaces and miscellaneous uses.
[5]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States in 1980

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	27.9	72.1
Open-hearth furnace	46.4	53.6
Electric furnace	97.9	2.1
Cupola furnace	93.1	6.9
Other (including air furnace)	79.5	20.5

Table 6.—Iron and steel scrap supply[1] available for consumption in 1980, by region and State

(Thousand short tons)

Region and State	Receipts of scrap		Production of home scrap		Total new supply[2]	Shipments of scrap[3]	New supply available for consumption[2]
	From brokers, dealers, and other outside sources	From other own-company plants	Recirculating scrap resulting from current operations	Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)			
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,368	133	1,128	21	2,650	229	2,421
Pennsylvania	5,552	2,459	9,151	562	17,724	2,108	15,616
Total[2]	6,920	2,592	10,279	584	20,374	2,337	18,036
North Central:							
Illinois	4,461	687	3,350	118	8,616	364	8,252
Indiana	2,140	149	7,680	372	10,341	904	9,436
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska,	5,656	1,530	3,091	67	10,345	158	10,186
Ohio	4,296	1,252	6,017	278	11,843	967	10,876
Wisconsin	653	11	529	([4])	1,194	25	1,168
Total[2]	17,206	3,630	20,667	835	42,338	2,418	39,919

See footnotes at end of table.

Table 6.—Iron and steel scrap supply[1] available for consumption in 1980, by region and State —Continued

(Thousand short tons)

Region and State	Receipts of scrap		Production of home scrap		Total new supply[2]	Shipments of scrap[3]	New supply available for consumption[2]
	From brokers, dealers, and other outside sources	From other own-company plants	Recirculating scrap resulting from current operations	Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)			
South Atlantic: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	4,674	255	2,888	169	7,987	225	7,761
South Central: Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	7,140	654	4,210	111	12,116	705	11,410
Mountain and Pacific: Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	3,371	396	2,371	92	6,230	196	6,034
U.S. total[2]	39,310	7,527	40,415	1,792	89,044	5,883	83,161

[1]New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The plus or minus difference in stock levels at the beginning and end of the year is not taken into consideration.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes scrap shipped, transferred, or otherwise disposed of during the year.
[4]Less than 1/2 unit.

Table 7.—Consumption of iron and steel scrap and pig iron[1] by region and State in 1980, by type of manufacturer

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings		Steel castings		Iron foundries and miscellaneous users		Total[2]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,460	1,954	139	5	951	81	2,549	2,040
Pennsylvania	14,291	14,053	361	13	876	517	15,528	14,583
Total[2]	15,750	16,008	500	18	1,827	598	18,078	16,623
North Central:								
Illinois	6,654	4,101	440	(3)	1,319	284	8,412	4,386
Indiana	8,988	15,721	198	1	591	64	9,777	15,787
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,925	5,366	362	1	3,916	304	10,203	5,671
Ohio	8,618	10,461	245	10	2,293	375	11,156	10,847
Wisconsin	--	--	267	1	922	64	1,189	65
Total[2]	30,185	35,650	1,512	14	9,041	1,092	40,738	36,756
South Atlantic: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	7,085	W	41	1	705	59	7,831	60
South Central: Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	8,545	[4]11,302	435	3	2,215	122	11,195	11,427

See footnotes at end of table.

Table 7.—Consumption of iron and steel scrap and pig iron[1] by region and State in 1980, by type of manufacturer —Continued

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings		Steel castings		Iron foundries and miscellaneous users		Total[2]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Mountain and Pacific:								
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	4,993	4,156	374	5	502	27	5,869	4,188
U.S. total[2]	66,557	67,114	2,862	41	14,291	1,898	83,710	69,053

W Withheld to avoid disclosing company proprietary data. Included in "South Central" region.
[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes South Atlantic region.

Table 8.—Consumer stocks of iron and steel scrap, by grade, and pig iron, December 31, 1980, by region and State

(Thousand short tons)

Region and State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks[1]	Pig iron stocks
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	221	17	18	54	3	313	78
Pennsylvania	1,358	41	136	386	40	1,960	330
Total[1]	1,579	58	154	440	43	2,273	409
North Central:							
Illinois	704	6	8	49	(2)	767	18
Indiana	595	5	10	339	1	950	36
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	501	5	(2)	100	18	624	18
Ohio	473	12	40	99	3	627	116
Wisconsin	15	1	(2)	10	(2)	27	7
Total[1]	2,288	29	58	597	22	2,995	196
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	715	W	9	109	1	834	42
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	1,024	[3]13	14	171	14	1,236	224
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	524	2	10	123	22	681	18
U.S. total[1]	6,130	102	245	1,439	101	8,018	889

W Withheld to avoid disclosing company proprietary data; included in "South Central" region.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes South Atlantic region.

Table 9.—Average monthly price and composite price for No. 1 heavy melting scrap in 1980

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$96.50	$102.00	$100.50	$99.67
February	100.50	106.50	108.00	105.00
March	96.50	105.50	101.50	101.17
April	86.00	98.00	92.75	92.25
May	70.50	79.50	82.50	77.50
June	63.50	69.50	76.10	69.70
July	67.50	77.75	83.00	76.08
August	77.50	87.50	88.25	84.42
September	88.50	102.90	91.90	94.43
October	93.75	102.50	91.50	95.91
November	98.75	105.25	91.50	98.50
December[e]	105.50	107.50	98.00	101.83
Average 1980[e]	87.08	95.37	92.13	91.37
Average 1979[r]	98.30	100.34	95.10	97.91

[e]Estimated. [r]Revised.
[1]Composite price, Chicago, Pittsburgh, and Philadelphia.

Source: Iron Age, Jan. 5, 1981.

Table 10.—U.S. exports and imports for consumption of iron and steel scrap, by class

(Thousand short tons and thousand dollars)

Class	1976		1977		1978[1]		1979[1]		1980[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,064	150,327	1,750	107,089	2,362	175,933	2,697	269,845	2,907	297,666
No. 2 heavy melting scrap	705	46,047	594	33,870	837	56,433	1,117	104,017	1,067	102,137
No. 1 bundles	95	7,726	103	2,442	148	11,231	145	14,455	119	11,542
No. 2 bundles	845	48,144	336	14,429	326	17,055	652	46,889	314	24,852
Stainless steel scrap	112	52,516	75	37,154	115	44,439	112	66,118	125	78,034
Shredded steel scrap	2,179	164,922	1,606	97,602	2,684	198,377	2,980	308,383	3,323	345,946
Borings, shovelings, turnings	644	32,339	476	17,916	750	33,163	889	59,467	769	50,381
Other steel scrap[2]	760	65,809	601	49,960	1,382	128,350	1,828	211,352	1,762	240,886
Iron scrap	474	33,996	314	20,579	434	33,258	632	61,879	783	74,497
Total[3]	7,877	601,826	5,854	381,041	9,039	698,237	11,054	1,142,406	11,168	1,225,941
Ships, boats, other vessels (for scrapping)	50	2,280	35	2,613	2	232	73	5,436	169	18,340
Rerolling material	241	32,652	321	31,691	50	5,528	70	10,222	86	12,768
Total[3]	8,168	636,758	6,211	415,345	9,090	703,996	11,197	1,158,064	11,423	1,257,049
Imports:										
Iron and steel scrap	507	35,120	614	40,501	794	50,220	760	70,804	582	61,192

[1]Starting in 1978, exports of rerolling material are not comparable with those of previous years because of a change of classification by the Bureau of Census.
[2]Includes terneplate and tinplate.
[3]Data may not add to totals shown because of independent rounding.

Table 11.—U.S. exports of iron and steel scrap, by country of destination

(Thousand short tons and thousand dollars)

Country	1976		1977		1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	889	48,140	522	23,847	795	41,698	861	60,275	790	57,507
Greece	222	17,475	300	17,192	340	25,079	500	52,395	545	57,484
Italy	634	57,489	208	18,441	657	54,522	1,186	124,361	892	101,865
Japan	1,256	93,115	1,036	61,927	3,190	238,979	2,922	305,509	2,838	308,784
Korea, Republic of	911	61,561	1,441	88,668	1,503	117,742	1,418	152,483	1,736	192,745
Mexico	571	44,541	322	22,555	450	35,808	814	85,098	1,134	137,273
Spain	1,862	136,093	784	46,909	744	53,038	1,400	127,592	1,163	114,837
Taiwan	249	22,063	435	35,647	394	41,126	634	70,004	990	125,716
Turkey	159	13,461	310	20,044	258	19,583	242	23,482	318	31,363
Other	1,124	107,888	496	45,811	708	70,662	1,077	141,207	762	98,367
Total	7,877	601,826	5,854	381,041	9,039	698,237	11,054	1,142,406	11,168	1,225,941

Table 12.—U.S. exports of rerolling material (scrap), by country of destination

(Thousand short tons and thousand dollars)

Country	1976		1977		1978[1]		1979[1]		1980[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Korea, Republic of	44	11,098	99	9,371	--	--	2	172	4	538
Mexico	24	2,464	21	2,061	38	4,176	57	8,614	65	10,848
Pakistan	3	278	18	742	7	470	--	--	2	185
Thailand	76	8,426	133	14,078	--	--	--	--	--	--
Turkey	4	541	16	1,709	--	--	--	--	--	--
Other	90	9,845	34	3,730	6	882	11	1,436	14	1,197
Total[2]	241	32,652	321	31,691	50	5,528	70	10,222	86	12,768

[1]Starting in 1978, exports of rerolling material are not comparable with those of previous years because of a change of classification by the Bureau of the Census.
[2]Data may not add to totals shown because of independent rounding.

Table 13.—U.S. imports for consumption of iron and steel scrap,[1] by country

Country	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	100	$830	18	$161
Belgium-Luxembourg	43,854	287	71	159
Canada	661,657	59,304	499,271	51,935
Germany, Federal Republic of	758	572	125	322
Japan	6,750	4,649	24,827	943
Mexico	20,360	1,440	25,792	2,548
Netherlands	8,737	855	7,900	516
Panama	2	1	8,422	600
Sweden	5,153	681	7,787	1,266
United Kingdom	8,233	969	457	1,424
Other	4,662	1,216	6,843	1,318
Total	760,266	70,804	[2]581,512	61,192

[1]Includes tinplate.
[2]Data do not add to total shown because of independent rounding.

Table 14.—Iron and steel scrap consumption in selected countries[1]

(Thousand short tons)

Country group and country	1975	1976	1977	1978	1979
European Economic Communities:					
Belgium[2,3]	4,091	4,032	3,728	4,182	4,467
Denmark[3,4]	634	[r]853	862	1,068	999
France[3,5,6]	8,307	8,964	8,282	9,018	8,941
Germany, Federal Republic of[6]	22,495	23,263	22,262	23,359	23,993
Ireland[2,3,5,6]	[7]100	[7]75	[7]60	[7]75	[8]93
Italy[3]	15,023	16,362	[r]16,629	17,897	[e]17,870
Luxembourg	[r]1,513	1,577	1,555	1,942	1,968
Netherlands[9]	1,748	1,957	1,857	2,030	2,166
United Kingdom[9]	17,526	18,534	[r]17,070	16,902	[e]16,810
Total[10]	[r]71,437	[r]75,617	[r]72,305	76,473	77,307
European Free Trade Association:					
Austria	1,881	[r]2,071	1,789	1,926	2,013
Finland[4]	767	[3]634	[r]898	[3]832	[3]819
Norway[2,5,6]	618	593	[3]485	[e]545	608
Portugal	284	219	[r]396	[e]490	[e]520
Sweden[2,3]	[r]3,780	[r]3,468	[r]2,679	[5,6]2,870	[e]3,150
Total[10,11]	[r]7,330	[r]6,985	[r]6,247	6,663	7,110
Other European market economy countries:					
Spain[3,5,6]	[r]7,247	[r]7,759	[r]8,111	8,726	[2,4]8,818
Yugoslavia[3,5,6]	1,883	1,747	1,921	2,249	2,272
Total[10,11]	[r]9,130	[r]9,506	[r]10,032	10,975	11,090
European centrally planned economy countries:					
Bulgaria[e,2,3,4,5,6]	550	680	750	720	800
Czechoslovakia[2,5,6]	7,886	8,088	8,216	8,173	8,438
German Democratic Republic[2,3,5,6]	4,852	5,117	4,730	4,665	[e]4,655
Hungary[2,5,6]	2,392	2,420	2,467	2,566	2,595
Poland[8]	[e]9,370	10,352	11,083	12,518	11,597
Romania[e,2,3,4,5,6]	3,530	3,600	3,890	4,080	4,200
U.S.S.R.[e,2,3,6,12]	51,806	[r]52,800	[r]52,800	54,500	53,000
Total[10,13]	[r]80,386	[r]83,057	[r]83,936	87,222	85,285
Latin America:[14]					
Argentina	1,620	1,657	1,892	1,523	[e]1,740
Brazil	4,040	4,644	5,044	5,800	[e]6,400
Chile	185	186	227	177	[e]190
Colombia	248	229	250	183	[e]170
Mexico	3,663	3,406	2,690	3,097	[e]3,240
Peru	192	185	184	150	[e]170
Venezuela	581	499	583	602	[e]650
Other[15]	83	101	112	118	[e]120
Total[10]	10,612	10,907	10,982	11,650	[e]12,680
Other countries:					
Australia[2,3,5,6,7]	2,674	2,697	2,105	2,448	[e]2,760
Canada[2,3,5,6]	[r]7,444	[r]7,142	[r]7,683	8,622	9,145
India[2,3,5,6]	[16]1,760	[e]2,100	[r,e]2,300	[e]2,350	[e]2,350
Japan[6,9]	37,714	42,138	38,147	43,445	[e]50,700
New Zealand[2,3,5,6]	[e]165	[e]165	[7]181	[e]182	[e]182
South Africa, Republic of[2,3,4,5,6,17]	2,835	3,098	3,147	3,656	[e]3,800

See footnotes at end of table.

Table 14.—Iron and steel scrap consumption in selected countries[1] —Continued

(Thousand short tons)

Country group and country	1975	1976	1977	1978	1979
Other countries —Continued					
Turkey[2 6]	r463	r726	[3 5 7]1,279	[3 5 7]1,017	e1,100
United States[18]	82,331	89,910	92,198	99,224	98,901
Total	r135,386	r147,976	r147,040	160,944	168,938
Grand total	r314,281	r334,048	r330,542	353,927	362,410

eEstimated. rRevised.

[1]Unless otherwise noted, figures represent reported actual consumption of iron and steel scrap utilized in the production of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel, as well as in other unspecified uses by the steel industry and by other unspecified industries as reported by the United Nations Economic Commission for Europe in its Annual Bulletin of Steel Statistics for Europe, v. 5, 1979, New York, 1980, 95 pp., which is the source of all data unless otherwise noted. (Estimates included are all by the U.S. Bureau of Mines.)

[2]Excludes scrap consumed in rerolling.

[3]Excludes scrap consumed in iron foundries.

[4]Excludes scrap consumed in blast furnaces (if any).

[5]Excludes scrap consumed within the steel industry for purposes other than the manufacture of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel.

[6]Excludes scrap consumed outside the steel industry.

[7]Sources: Organization for Economic Cooperation and Development. The Iron and Steel Industry in 1976, Paris 1978, 40 pp.; the Iron and Steel Industry in 1977, Paris 1979, 40 pp.; the Iron and Steel Industry in 1978, Paris 1980, 40 pp.

[8]Source: United Kingdom Iron and Steel Statistics Bureau. International Steel Statistics, Irish Republic, 1979, p. 4.

[9]Source reports scrap consumption outside the steel industry to be zero, but it is believed that this is actually not available rather than nil.

[10]Total of listed figures only; includes no estimates for omissions in individual countries as indicated by footnotes 2 through 6 and 8, nor for unlisted countries that are members of the group totaled.

[11]Series altered; Finland added to "European Free Trade Association" and deleted from "Other European market economy countries."

[12]Excludes scrap used in the production of steel by any method of production other than open-hearth furnace.

[13]Series revised to include estimates for Bulgaria, not included in previous editions.

[14]Sources: 1975-77: Instituto Latinoamericano del Fierro y el Acero. Statistical Yearbook of Steelmaking and Iron Ore Mining in Latin America, 1977. Santiago 1979, 178 pp.; 1978: Instituto Latinoamericano del Fierro y el Acero Siderurgia Latinoamericano, No. 243, July 1980, p. 56. Source does not provide details on what is included; presumably figures represent total steel industry consumption, excluding scrap used by nonsteel industry consumers.

[15]Includes Uruguay, unspecified countries in Central America, and Dominican Republic, as reported in source. (See footnote 14.)

[16]Source: United Kingdom Iron and Steel Statistics Bureau. International Steel Statistics, India 1977, p.4.

[17]Source: United Kingdom Iron and Steel Statistics Bureau. International Steel Statistics, South Africa, 1978, p. 4, 1979, p. 4.

[18]Data compiled by U.S. Bureau of Mines.

Table 15.—Iron and steel scrap imports by selected countries[1]

(Thousand short tons)

Country group and country	1975	1976	1977	1978	1979
European Economic Community:					
Belgium-Luxembourg	779	646	543	1,079	1,069
Denmark	3	8	14	290	313
France	305	302	316	434	465
Germany, Federal Republic of	1,896	1,703	1,569	1,705	1,769
Ireland	4	1	2	10	6
Italy	5,967	6,914	6,421	7,238	7,596
Netherlands	176	177	126	182	[2]136
United Kingdom	97	765	110	47	49
Total[3]	9,227	10,516	9,101	10,985	11,403
European Free Trade Association:					
Austria	37	50	88	127	149
Finland	105	60	69	24	98
Norway	60	78	20	11	8
Portugal	7	32	105	731	[2]161
Sweden	373	151	36	130	143
Switzerland	107	r49	63	96	197
Total[3 4]	r689	r420	r381	1,119	756
Other European market economy countries:					
Greece	108	88	103	218	254
Spain	r2,399	2,930	r2,197	2,811	[2 3]3,805
Yugoslavia	381	377	451	443	[2]292
Total[3 4]	r2,888	r3,395	r2,751	3,472	4,351

See footnotes at end of table.

Table 15.—Iron and steel scrap imports by selected countries[1] —Continued

(Thousand short tons)

Country group and country	1975	1976	1977	1978	1979
European centrally planned economy countries:					
Bulgaria	153	136	105	79	110
Czechoslovakia[5]	34	34	33	54	47
German Democratic Republic	384	596	547	602	780
Hungary	1	10	2	3	6
Poland	2	52	37	10	7
Romania	--	--	--	9	11
U.S.S.R.[5]	--	--	--	21	22
Total[3]	574	828	[r]724	778	983
Latin America:					
Argentina	[6]352	[6]79	[6]177	[6]18	[e]22
Brazil[6]	20	(7)	(7)	(7)	(7)
Chile	[e]10	[e]17	[6]11	[6]8	[e]10
Colombia	[e]10	[6]10	[6]13	[6]23	[e]25
Cuba	[5]61	[r]86	[5]80	[5]92	[5]80
Mexico	1,283	577	[r]392	516	[e]520
Peru	[6]69	[6]24	--	--	--
Venezuela	62	[e]66	[e]66	[e]55	50
Total[3]	[r]1,867	[r]859	[r]739	712	707
Other countries:					
Canada	1,024	907	644	1,052	1,156
China:					
Mainland[5]	219	52	--	19	6
Taiwan[6]	389	327	629	686	839
Egypt[6]	[e]40	41	127	46	18
Hong Kong[6]	62	120	45	139	116
India	22	31	50	128	[e]130
Indonesia[6]	18	32	52	89	33
Iran	[6]8	[e]11	[e]11	NA	NA
Japan	3,409	1,986	1,587	3,559	3,688
Korea, Republic of[6]	930	1,206	1,732	1,867	1,742
Malaysia[6]	7	3	3	[e]3	[e]3
Morocco[6]	(7)	(7)	(7)	1	(7)
Philippines[6]	67	117	68	87	105
Singapore[6]	106	61	25	103	120
South Africa, Republic of[6]	20	37	33	19	9
Thailand[6]	294	304	489	884	678
Turkey	94	260	331	356	[2]399
United States[6]	305	507	625	794	838
Total[3]	[r]7,014	[r]6,002	[r]6,451	9,832	9,880
Grand total[3]	[r]22,259	[r]22,020	[r]20,147	26,898	28,080

[e]Estimated. [r]Revised. NA Not available.

[1]Unless otherwise noted, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe, v. 7, 1980, New York, 95 pp. Table includes data available through June 17, 1981.

[2]Source: United Nations Economic Commission for Europe. Quarterly Bulletin of Steel Statistics for Europe, v. 31, No. 3, 1980, New York, 66 pp.

[3]Total of figures only (includes no estimate for other countries in group that are not listed individually).

[4]Series altered; Finland added to "European Free Trade Association" and deleted from "Other European market economy countries."

[5]Partial figures; compiled from export statistics of selected trading partner countries.

[6]Source: Official trade returns of subject country.

[7]Less than 1/2 unit.

Table 16.—Iron and steel scrap exports by selected countries[1]

(Thousand short tons)

Country group and country	1975	1976	1977	1978	1979
European Economic Community:					
Belgium-Luxembourg	586	581	552	585	606
Denmark	100	128	63	89	100
France	3,097	3,772	3,702	4,038	3,887
Germany, Federal Republic of	2,432	2,863	2,735	3,048	3,305
Ireland	9	9	9	60	79
Italy	6	26	12	8	14
Netherlands	1,032	1,055	1,021	1,311	[2]1,259
United Kingdom	1,010	660	1,034	1,725	1,475
Total[3]	8,272	9,094	9,128	10,864	10,725
European Free Trade Association:					
Austria	57	50	9	9	17
Finland	6	4	3	1	3
Norway	21	20	14	40	46
Portugal	2	3	4	11	[2]6
Sweden	12	10	83	86	19
Switzerland	129	77	68	97	110
Total[3] [4]	[r]227	[r]164	[r]181	244	201
Other European market economy countries:					
Greece	(5)	(5)	[r]1	(5)	(5)
Iceland	3	4	2	[6]11	4
Spain	1	(5)	(5)	1	(2) (5)
Yugoslavia	24	22	46	87	[2]52
Total[3] [4]	[r]28	[r]26	[r]49	99	56
European centrally planned economy countries:					
Bulgaria	134	149	67	184	143
Czechoslovakia[5]	243	58	89	126	137
German Democratic Republic	1	(5)	1	[7]15	[7]2
Hungary	34	41	78	46	41
Poland	313	101	1	[7]15	[7]12
Romania	--	--	--	[7]3	[7]1
U.S.S.R	1,256	2,025	[7]2,412	[7]1,849	[7]2,190
Total[3]	1,981	[r]2,374	[r]2,648	2,238	2,526
Latin America:					
Mexico	3	1	2	(5)	[e] (5)
Other	[r]10	[r] [e]10	[r] [e]10	[e]10	[e]10
Total[3]	[r]13	[r]11	[r]12	10	10
Other countries:					
Australia[6]	[r]573	[r]769	713	755	63
Canada	463	[r]1,117	[r]768	963	[2]1,139
India	[6]139	[r] [6]240	[6]168	[e]150	[e]150
Japan	105	224	233	181	166
Korea, Republic of[6]	(5)	21	1	9	14
Malaysia	[6]4	[6]18	[6]12	[e]10	[e]10
Morocco[6]	--	55	21	50	98
New Zealand	[e]2	[6]1	[e]1	[e]4	[6]9
Singapore[6]	2	3	8	4	2
South Africa, Republic of[6]	7	3	3	8	2
Taiwan[6]	39	69	40	172	79
United States[6]	[r]9,442	[r]7,877	[r]5,854	9,039	11,054
Total[3]	[r]10,776	[r]10,397	[r]7,822	11,345	12,786
Grand total[3]	[r]21,297	[r]22,066	[r]19,840	24,800	26,304

[e]Estimated. [r]Revised.

[1]Unless otherwise noted, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe, v. 7, 1980, New York, 95 pp. Table includes data available through June 17, 1981.

[2]United Nations Economic Commision for Europe. Quarterly Bulletin of Steel Statistics for Europe, v. 31, No. 3, 1980, New York, 66 pp.

[3]Total of listed figures only (includes no estimates for other countries in group that are not listed individually).

[4]Series altered; Finland added to "European Free Trade Association" and deleted from "Other European market economy countries."

[5]Less than 1/2 unit.

[6]Source: Official trade returns of subject country.

[7]Partial figure; compiled from import statistics of selected trading partner countries.

Kyanite and Related Materials

By Michael J. Potter[1]

Kyanite, andalusite, and sillimanite are anhydrous aluminum silicate minerals that are alike in both composition and use patterns and have the same chemical formula, $Al_2O_3 \cdot SiO_2$. Related materials include synthetic mullite, dumortierite, and topaz, also classified as aluminum silicates, although the last two additionally contain substantial proportions of boron and fluorine, respectively. All of these kyanite-group substances can serve as raw materials for manufacturing special high-performance, high-alumina refractories, but there has been no record in recent years of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics are incomplete, it appears that the United States, India, and the Republic of South Africa are the leading world producers of kyanite-group minerals. It can be presumed that the U.S.S.R. and perhaps a few other industrialized nations also produce significant quantities of these materials.

U.S. kyanite output in 1980 was estimated to be approximately the same tonnage as in 1979. Export and import data since 1977 for kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census.

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1980, were 22% for domestic production and 14% for foreign operations.

DOMESTIC PRODUCTION

Kyanite was produced in the United States in 1980 at three open pit mines, two in Virginia and one in Georgia. Kyanite Mining Corp. operated the Willis Mountain and East Ridge mines in Buckingham County, Va. C-E Minerals, Inc., operated the Graves Mountain Mine in Lincoln County, Ga.

The tonnage of domestic kyanite in 1980 was estimated to have been about the same as in 1979. Kyanite production statistics for 1980 (and for all previous years since 1949) are withheld to avoid disclosing company proprietary data.

There are three types of synthetic mullite. Fused synthetic mullite is made by melting Bayer process alumina and silica, or bauxite and kaolin, in an electric furnace at around 3,450°F. High-temperature sintered synthetic mullite is prepared by sintering mixtures of alumina and kaolin, bauxite and kaolin, or alumina, kaolin, and kyanite above 3,180°F. Low-temperature sintered synthetic mullite is made by sintering siliceous bauxite or mixtures of bauxite and kaolin above 2,820°F.

Output of synthetic mullite in 1980 was largely of the high-temperature sintered variety, and the four producers of this material were A. P. Green Refractories Co. at Philadelphia, Pa.; C-E Minerals, Inc., at Americus, Ga.; Didier Taylor Refractories Corp. at Greenup, Ky.; and Harbison-Walker Refractories Co. at Eufala, Ala. Electric-furnace-fused mullite was produced by The Carborundum Co. at Niagara Falls, N.Y.

Table 1.—Synthetic mullite production in the United States

Year	Quantity (short tons)	Value (thousands)
1976	42,230	$5,453
1977	40,280	5,283
1978	38,080	5,442
1979	40,660	6,675
1980	40,540	8,012

CONSUMPTION AND USES

Conforming to established end-use patterns, kyanite and related materials were consumed in 1980 mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in some ceramic compositions. Domestic kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed either in the raw form or, after heat treatment, as mullite, which was sometimes further reduced in particle size before use. In the 35- to 48-mesh range, the mineral was used mostly in monolithic refractory applications such as for high-temperature mortars or cements, ramming mixes, and castable refractories, or with clays and other ingredients in refractory compositions for making kiln furniture, insulating brick, firebrick, and a wide variety of other articles. More finely ground material, minus 200 mesh, for example, was used in body mixes for sanitary porcelains, wall tile, investment-casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1980, listed prices for kyanite, f.o.b. Georgia, ranging from $70 to $128 per short ton for bulk shipments and $9 more per ton for bagged material.

Price ranges quoted for kyanite-group materials in Ceramic Industry magazine, January 1981, follow:

	Per short ton
Andalusite	$180-$280
Mullite, calcined kyanite	105- 114
Mullite, calcined	162
Mullite, fused	725- 810

The December 1980 issue of Industrial Minerals (London) quoted kyanite-group prices approximately equivalent to the following (converted from pounds sterling per metric ton to dollars per short ton):

	Per short ton
Andalusite, Transvaal, 52% to 54% Al_2O_3, bulk c.i.f. main European port	$152
Andalusite, Transvaal, 60% Al_2O_3, c.i.f. main European port	196
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	370

FOREIGN TRADE

Export data of kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census. Data had been collected up until 1977, and these export figures were published in this section in what was then table 2 (U.S. exports and imports for consumption of kyanite and related minerals). However, these Census figures did not distinguish between synthetic mullite and materials that were in part mullite.

Import data for kyanite-group minerals have likewise not been collected as a separate category since 1977.

WORLD REVIEW

France.—Andalusite ("Kerphalite") production capacity at Société Denain-Anzin Minéraux's plant at Glomel was increased in 1979 from 27,000 tons to 55,000 tons by erecting another plant. There are basically two grades of product: One containing 59% Al_2O_3 and the other 53% Al_2O_3. Proven reserves at Glomel were said to be from around 4.4 to 5.5 million tons.[2]

Germany, Federal Republic of.—Imports of kyanite-group minerals in 1978 amounted to 63,000 tons. Principal countries of origin and the share supplied were the United States, 61%; the Republic of South Africa, 15%; and France, 6%. In 1979, imports of kyanite-group minerals were 72,000 tons. Principal countries of origin and quantities supplied were the United States, 62%; the Republic of South Africa, 26%; and France, 4%.[3]

Japan.—Imports in 1978 of kyanite-group minerals (including andalusite and kyanite) were 25,000 tons. Principal countries of origin and percentage supplied were the Republic of South Africa, 71%; the United States, 22%; and India, 5%. In 1979, imports of kyanite-group minerals were also 25,000 tons. Principal countries of origin and percentage supplied were the Republic of South Africa, 57%; the United States, 33%; and India, 8%.[4]

United Kingdom.—Imports of kyanite-group minerals in 1978 were estimated to be around 41,000 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 65%; France, 19%; and the United States, 10%. In 1979, imports of kyanite-group minerals were estimated at 39,000 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 57%; France, 27%; and the United States, 16%.[5]

Table 2.—Kyanite, sillimanite and related materials: World production, by country[1]

(Short tons)

Country[2] and commodity	1976	1977	1978	1979[p]	1980[e]
Australia: Sillimanite[3]	625	606	780	626	660
Brazil: Kyanite	282	121	7,615	8,800	9,900
France: Kyanite-andalusite	19,986	29,579	[r] [e]29,800	[r] [e]31,500	32,000
India:					
Andalusite	NA	427	248	--	--
Kyanite	53,770	46,433	34,058	43,008	44,100
Sillimanite	16,379	16,560	14,849	17,346	17,600
Korea, Republic of: Andalusite	573	127	67	--	NA
South Africa, Republic of:					
Andalusite	85,389	124,645	123,503	147,905	209,000
Sillimanite	28,366	17,036	10,516	21,577	22,000
Spain: Andalusite	[r]6,331	[r]3,286	5,607	5,903	6,000
United States:					
Kyanite	W	W	W	W	W
Synthetic mullite	42,230	40,280	38,080	40,660	[4]40,540

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Owing to incomplete reporting, this table has not been totaled. Table includes data available through Apr. 10, 1981.
[2]In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively and no reliable basis is available for estimation of output levels.
[3]In addition, sillimanite clay (also called kaolinized sillimanite) is produced, but output is not reported quantitatively, and available information is inadequate for the formulation of reliable estimates of output levels.
[4]Reported figure.

TECHNOLOGY

Fly ash specimens from four powerplants in the Tennessee Valley Authority system were separated into three matrices: Glass, mullite-quartz, and magnetic spinel. The mullite-quartz phase was relatively pure and could possibly be recovered as a resource.[6]

[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Clarke, G. Industrial Minerals of France. Ind. Miner. (London), No. 159, December 1980, pp. 25-26.
[3]Industrial Minerals (London). West German Industrial Mineral Imports, 1978 and 1979. No. 155, August 1980, p. 61.
[4]———. Japanese Industrial Mineral Imports, 1978 and 1979. No. 155, August 1980, p. 59.
[5]———. United Kingdom Industrial Mineral Statistics. No. 150, March 1980, p. 80.
[6]Hulett, L. D., Jr., A. J. Weinberger, K. J. Northcutt, and M. Ferguson. Chemical Species in Fly Ash from Coal-Burning Power Plants. Science, v. 210, No. 4476, Dec. 19, 1980, pp. 1356-1358.

Lead

By John A. Rathjen[1]

U.S. mine output of recoverable lead rose to 549,484 metric tons in 1980, reflecting a full year of production with no strikes or unexpected interruptions. Primary refinery output of lead from domestic and foreign raw materials, including lead in antimonial lead, decreased to 548,441 tons. Production of secondary lead dropped sharply from 801,368 tons in 1979 to 675,578 tons in 1980 and was attributed to a continuing high level of scrap exports and a shortage of domestic scrap for processing.

Total U.S. stocks of refined and antimonial lead rose in 1980, with an increase in primary refinery stocks partially offset by a drop in secondary and consumer inventories.

The U.S. producer price declined in a series of changes from a range of 49 cents to 50 cents per pound at the beginning of the year to 39 cents per pound in December. The average price for lead in 1980 was 42.46 cents per pound compared with 52.64 cents per pound in 1979. London Metal Exchange (LME) quotations for lead paralleled the U.S. price, beginning the year at about 50 cents per pound and declining to about 33 cents per pound of metal at yearend.

World mine production of lead decreased slightly in 1980. Total production from world smelter-refineries decreased in 1980 to 5.3 million tons, reflecting strikes at the refinery of Britannia Lead Co. Ltd. in the United Kingdom, the Belledune works of Brunswick Mining and Smelting Corp. Ltd. in Canada, and the El Paso, Tex., lead smelter operated by ASARCO Incorporated in the United States.

Legislation and Government Programs.—The Federal Emergency Management Agency revised the national defense stockpile goal for lead in April 1980. The new goal was established at 998,000 tons, and the inventory at yearend was 545,000 tons, indicating a net shortage.

The standard promulgated by the Environmental Protection Agency (EPA) which limits lead in gasoline to 0.5 gram per gallon became effective October 1, 1980.

Petitions filed by industry and labor representatives concerning the ambient air lead standard set by EPA and the standard for workplace exposure of lead promulgated by the Occupational Safety and Health Administration (OSHA) were set aside by the U.S. Court of Appeals. New appeals relating to both standards were filed in the Supreme Court by the Lead Industries Association, Inc. (LIA), and a number of concerned lead-operating companies. On December 8, the Supreme Court ruled in favor of EPA, maintaining a standard of 1.5 micrograms per cubic meter of ambient air promulgated by the Agency. This ruling was in response to appeals filed by LIA and St. Joe Minerals Corp., which argued that the standard went beyond known levels of health risks and exceeded the authority of EPA.

In another action, the Supreme Court granted a partial stay to portions of the lead standard promulgated by OSHA, pending decision on a comprehensive appeal filed by the lead industry. Under the stay it was not necessary for the lead-smelting industry and certain manufacturers to undertake major engineering construction and manufacturing programs that limited lead levels at the workplace, provided they continue to protect workers through the use of respirators and ventilation systems. The section of the rule that provided for employment at full pay if a worker was transferred for health reasons was continued.

On December 11, 1980, the President signed the Comprehensive Environmental Response, Compensation and Liability Act of 1980, Public Law 96-510, commonly called the Superfund. The tax, which is to be collected beginning April 1981 on a number of materials, was set at $4.14 per short ton for lead oxide. A major provision of the law is to establish a $16 billion fund to clean up disposal sites and spills of hazardous substances. The tax terminates on September 30, 1985.

At its 25th session in Geneva, Switzerland, the International Lead and Zinc Study Group found that the supply and demand of lead metal in 1980 and 1981 were expected to be in close balance. World consumption was growing slowly, and there was indication of growth in developing countries.

Table 1.—Salient lead statistics

(Metric tons unless otherwise specified)

	1976	1977	1978	1979	1980
United States:					
Production:					
Domestic ores, recoverable lead content	552,971	537,499	529,661	525,569	549,484
Value ---- thousands	$281,613	$363,789	$393,516	$609,929	$514,363
Primary lead (refined):					
From domestic ores and base bullion	515,767	486,659	501,643	529,970	508,163
From foreign ores and base bullion	76,513	62,041	63,530	45,641	39,427
Antimonial lead (primary lead content)	4,211	2,987	2,914	2,596	851
Secondary lead (lead content)	659,132	757,592	769,236	801,368	675,578
Exports (lead content):					
Lead ore and concentrates	NA	NA	54,231	32,902	27,615
Lead materials excluding scrap	5,332	8,931	8,225	10,646	164,458
Imports, general:					
Lead in ore and matte	69,277	66,533	52,985	39,998	44,095
Lead in base bullion	2,117	7,319	4,307	1,681	296
Lead in pigs, bars, and reclaimed scrap	136,391	243,164	226,926	198,344	88,995
Stocks Dec. 31 (lead content):					
At primary smelters and refineries	110,406	91,113	98,665	89,322	125,994
At consumers and secondary smelters	117,580	121,387	125,234	153,195	126,214
Consumption of metal, primary and secondary	1,351,771	1,435,473	1,432,744	1,358,335	1,070,303
Price: Common lead, average, cents per pound[1]	23.10	30.70	33.65	52.64	42.46
World:					
Production:					
Mine ---- thousand metric tons	r3,344.7	r3,442.1	r3,478.7	r3,523.3	3,517.7
Smelter[2] ---- do	r3,237.1	r3,227.1	r3,289.4	r3,339.9	3,259.4
Secondary smelter ---- do	r1,753.2	r1,931.2	r1,937.8	r2,049.0	1,871.4
Price: London, common lead, average, cents per pound	20.46	28.00	29.86	54.52	41.21

rRevised. NA Not available.
[1]Quotation on a nationwide, delivered basis.
[2]Primary metal production only. Includes secondary metal production where inseparably included in country total.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine production of recoverable lead increased in 1980, reversing a downward trend that began in 1975. Production from Missouri mines accounted for about 90% of the total. Mine production in Idaho declined slightly but was offset by increased production in Colorado as some mines were returned to full production levels. These three States accounted for over 99% of total domestic mine production.

The Buick Mine, jointly owned by AMAX Lead Co. of Missouri and Homestake Lead Co., continued as the largest single producing unit, milling a record 1.9 million tons of ore which generated over 205,000 tons of concentrates. Total reserves at the Buick Mine were estimated to be 43 million tons with an average grade of 5.9% lead.

The St. Joe Lead Co., a subsidiary of St. Joe Minerals Corp., produced 213,777 tons of lead in concentrates during 1980, slightly less than in the previous year; however, it maintained its position as the Nation's largest lead-producing company. St. Joe Lead operated six mines and four mills in the southeast Missouri lead belt and announced plans to open a new mine, Viburnum No. 35, in 1984.

The Magmont Mine in Missouri, jointly owned by Cominco American, Inc., and Dresser Industries Inc., produced about 100,000 tons of lead concentrates from ore which averaged 8.0% lead. The concentrates were tolled at the Buick smelter in Missouri operated by AMAX-Homestake lead tollers, and the resulting lead was sold by the respective partners on an equal-share basis.

Asarco completed site clearing and began shaft sinking at its new West Fork Mine in Missouri. The underground ore body contains 15 million tons of ore assaying 5.5% lead, 1.2% zinc, and recoverable amounts of silver and copper. Full production was expected to be achieved by 1984. When completed at an estimated cost of $77 million, West Fork will produce 51,000 tons of lead in concentrates annually.

Hecla Mining Co. reported that its Lucky Friday Mine produced 172,000 tons of ore which assayed 10.0% lead in 1980. The Star-Morning Unit area produced 256,000 tons of ore with a lead grade of 4.6%. The Star-Morning Unit is owned jointly by Hecla (30%) and The Bunker Hill Co. (70%), and production was shared accordingly. Reserves at the Lucky Friday Mine were estimated at 577,000 tons, and 1.2 million tons at the Star-Morning Unit at yearend 1980.

The Bunker Hill Co., a subsidiary of Gulf Resources & Chemical Corp., reported that lead production from company-owned and controlled mines was 21,000 tons in 1980, including the 70% portion of the Star-Morning Unit.

SMELTER AND REFINERY PRODUCTION

Primary.—Domestic production of primary lead including lead in antimonial lead from the five primary refineries in 1980 was slightly lower than that of 1979. About 80% of the total refined production was corroding-grade lead (99.94+%) and the balance was in common, chemical, antimonial, and miscellaneous specification metal. Calcium-tin and other special alloys for the maintenance-free battery industry were introduced as primary lead smelter products.

St. Joe Lead operated its lead smelter-refinery at Herculaneum, Mo., without interruption through 1980 and produced 213,777 tons of lead metal. The smelter processed concentrates from company mines in Missouri.

The AMAX-Homestake smelter-refinery at Boss, Mo., produced 119,914 tons of lead metal from concentrates originating at the Buick and Magmont Mines in Iron County, Mo.

The Bunker Hill smelter-refinery produced 108,000 tons of lead in 1980, an increase of 21% over the 1979 total. Raw material feed to the plant came from Bolivia, Canada, Peru, the Republic of South Africa, and the United States. In 1980, Bunker Hill installed a process called the Constant Volume Air Control System for which patents have been applied. The new process was partially responsible for the increase in metal production.

Asarco reported that its Omaha, Nebr., and Glover, Mo., refineries produced 133,538 tons of lead metal during 1980, a decline of 19% from the 1979 total, which was attributed to the 5-month strike at the El Paso, Tex. smelter. The El Paso, Tex., and East Helena, Mont., smelters, which ship bullion to Omaha for refining drew their crude ore and concentrate feed from Australia, Canada, Colombia, Honduras, Mexico, and the United States. The Glover, Mo., smelter-refinery complex contributed 62,142 tons of refined lead to the total of refined lead reported by the company. At the Glover plant a second blast furnace for smelting lead was started in 1980 which will provide for continuous operation when the existing furnace is down for maintenance and repair. Construction of a new 325-foot concrete stack was also begun in 1980 which is expected to provide for efficient dispersion of blast furnace gases to the atmosphere.

Secondary.—Production of lead from recycled materials declined sharply in 1980, reflecting a shortage of available scrap and a strong export market. Several new facilities were under construction, including a new 54,000-ton-per-year plant in Los Angeles, Calif., to be operated by Gould Inc., and a 27,000-ton plant in St. Helens, Oreg., by the Bergsoe Metal Corp., a wholly owned subsidiary of Paul Bergsoe & Son A/S and East Asiatic Co. of Denmark.

RAW MATERIAL SOURCES

In 1980, the United States was virtually self-sufficient in mine production of primary raw material from output in Missouri and Idaho. Imports of lead in ore and concentrates accounted for approximately 8% of total refined lead production and were received principally from Australia, Canada, Honduras, and Peru. Secondary lead production was curtailed due to the lack of recycled lead materials.

CONSUMPTION AND USES

Domestic consumption of lead declined for the third consecutive year to 1.07 million tons and was at the lowest recorded level since 1963 when 1.06 million tons was used. The very sharp drop in 1980 was attributed to standards promulgated by EPA which limited the use of lead as a gasoline additive, curtailed production of new automobiles that require lead for batteries and other applications, and a decline in the replacement battery industry, brought on by a mild 1979-80 winter season. There were declines in virtually all of the other use categories except for lead used in nonelectrical machinery and pipes, traps, and other extruded products used in the construction industry.

LEAD PIGMENTS

Consumption of pig lead in the manufacture of lead oxides and pigments in 1980 decreased 30% from the 1979 total. The largest reduction was in production of litharge and leady oxide, which was attributed to a downturn in the lead acid battery manufacturing industry. Use of pig lead for production of red lead and other basic lead chemicals also declined reflecting a slowdown in the construction, glass and ceramics, and paint industries.

Prices.—The quoted price for lead chemicals in 1980 was based on the selling price for pig lead in a given period; however, premium adjustments were made by the individual companies to reflect differences in manufacturing technique, freight considerations, quality requirements, and other factors. The average premium during 1980 for litharge was 6.5 cents per pound and for red lead, 9 cents per pound.

Foreign Trade.—Imports of lead chemicals and pigments in 1980 declined 34% from the 1979 receipts, and was attributed essentially to a reduction of litharge shipments from Mexico due to a downturn in the battery industry.

PRICES

The U.S. producer price for lead dropped sharply from about 50 cents per pound to a low of 34 cents per pound during the first half of 1980. Asarco was the principal price leader with other producers following either on an average Metals Week price basis or by withdrawal of quotations, which effectively established the Asarco price as the official U.S. producer price. Beginning in the third week of July, there was a flurry of activity in which Asarco and St. Joe Lead advanced prices to 40 cents per pound. Bunker Hill and most of the secondary producers reestablished their quotations, and the market firmed at that level. The trend continued upward due to higher prices on the LME and a need for higher U.S. prices to slow the export of scrap materials. On August 14, the secondary lead producers increased their selling price to 44 cents per pound. St. Joe Lead followed on August 20, with an increase of 2 cents which established a two-tier market of 42 cents to 44 cents per pound. The trend continued upward and by October 1, all producers were at a level of 45 cents per pound. On November 11, Asarco lowered its selling price to 43 cents which precipitated another decline resulting in a yearend price of 39 cents per pound. The average annual price for 1980 was 42.46 cents per pound.

In terms of U.S. currency, the LME price essentially paralleled the U.S. producer price, beginning the year at 51 cents per pound, dropping to 33 cents in July, and then rising again to 40 cents per pound in September. The decline in the last quarter was much sharper than that in the United States, with the yearend quotation at 34 cents resulting in a disparity of about 5 cents per pound. The average annual lead price on the LME was 41.21 cents per pound.

FOREIGN TRADE

In 1980, the United States was a net exporter of lead. The largest segment of outgoing shipments was in the form of unwrought pigs and bars, which increased from 7,380 tons in 1979 to 156,500 tons in 1980. A substantial portion of these shipments reportedly went to LME warehouses at Antwerp, Rotterdam, and London where the metal was transshipped to consumers in Europe and the centrally planned economies for ultimate consumption. Exports of lead in ore and concentrates declined slightly, and shipments of scrap were relatively unchanged. Imports of lead in all forms decreased from the 1979 totals and was attributed to the lack of domestic demand and strong pricing in the world market. Australia, Canada, Mexico, and Peru continued as primary suppliers, supplementing domestic requirements.

Changes in tariff regulations resulting from the Tokyo negotiations of 1979, on lead content basis, are given in the following tabulation:

Item	Number	Most Favored Nation (MFN) Jan. 1, 1980	Non-MFN Jan. 1, 1980
Ore	602.10	0.75 cent per pound	1.5 cents per pound.
Lead bullion	[1]624.02	3.5% ad valorem	10.5% ad valorem.
Other unwrought	[1]624.03	3.5% ad valorem	10% ad valorem.
Waste and scrap	[1]624.04	3.6% ad valorem	11.5% ad valorem.

[1]The minimum duty shall not be less than 1.0625 cents per pound of lead.

WORLD REVIEW

Total world consumption of refined primary and secondary metal dropped to 5.3 million tons in 1980 according to the World Bureau of Metal Statistics.[2] Total world stocks, excluding those in centrally planned economy countries rose to about 524,000 tons in 1980, according to the International Lead and Zinc Study Group.[3]

The lead and zinc industry in the U.S.S.R. was revised with an assessment of future Soviet production, consumption, and trade.[4] The report stated that demand was rising, but ore quality was declining, mines were being depleted, and mining and smelting developments were not keeping pace. The International Lead and Zinc Study Group published a world directory of lead and zinc mines and smelters showing ownership, production rates, and capacities.[5]

Australia.—Both mine and smelter production declined in 1980 as a result of depressed world demand and a prolonged industrial stoppage at the Tasmanian west coast mines in the third quarter of the year. In July, Broken Hill Associated Smelters Proprietary Ltd. commissioned its new bismuth extraction plant, which will enable the plant to maintain output of 99.99% lead as the bismuth content of concentrates increases. Mount Isa Mines Ltd. (MIM) reported results of drilling at the Balcooma prospect in North Queensland. One intersection graded 5.5% lead, 11.7% zinc, 0.4% copper, and 75.8 grams of gold per ton. Another smaller band recorded 15.7% lead, 22.8% zinc, 0.7% copper, and 108 grams of gold per ton. MIM also reported that the McArthur River deposit is not viable under present known technology because of the fine grain size of the mineralization which prevents satisfactory metal recovery. Further metallurgical research at this property is planned. The Electrolytic Zinc Co. of Australasia Ltd. announced its intention to proceed with development of the Elura lead-zinc-silver deposit, near Cobar, New South Wales. Plans call for production of 100,000 tons of a lead-silver concentrate and 130,000 tons of zinc concentrate annually.

Canada.—During 1980, Canadian mine and primary and secondary smelter production were down from the levels reported in 1979.

A 4-month strike at Brunswick Mining and Smelting Corp. Ltd. delayed completion of a $53 million expansion at its Brunswick No. 12 Mine, which will provide an additional 10,000 tons of lead and 30,000 tons of zinc annually, providing enough replacement raw material to keep the lead smelter operating. Reserves at the Brunswick No. 6 Mine were near exhaustion.

Cominco Ltd. began development of its $150 million Polaris lead-zinc mine. The mine, which is about 45 kilometers southwest of the magnetic North Pole, is expected to produce 30,000 tons of lead and 130,000 tons of zinc in concentrates when it becomes fully operational. Production is expected to begin in 1982. Reserves are estimated to be 23 million tons averaging 14.1% zinc and 4.3% lead.

Germany, Federal Republic of.—Three base metal mines producing lead continued operations during 1980. The Meggen Mine operated by Sachtleben Bergbau GmbH, a subsidiary of Metallgesellschaft AG, and the Bad Grund and Rammelsberg Mines operated by Preussag Aktiengesellschaft Metall were the only domestic producers. Declining ore grades and continued low pricing could cause a shutdown of the 100-year-old lead mine at Meggen, according to Metallgesellschaft, but no suspension plans were announced.

Mexico.—Industrial Minera Mexico S.A. de C.V. (IMMSA) continued development of the Rosario project in southeastern Sinaloa. The lead-copper-zinc ore is scheduled to be mined at the rate of 910 tons per day beginning in March 1982. IMMSA also began a 4-year, $60 million project to increase mine and mill output at the Santa Barbara Unit, 400 kilometers south of Chihuahua,

Chihuahua State. Reserves were estimated at 21 million tons averaging 2.6% lead, 4.7% zinc, and 0.65% copper.

Industrias Peñoles S.A. de C.V. was developing an open pit mine at Michoacan, which reportedly will produce 2,000 tons per day of lead-zinc-silver ore. The mine is scheduled to start production in 1981. Peñoles was also exploring the La Ciénega deposit between Tepehuanes and Topia in the State of Durango, which may have the potential of producing 2,000 tons per day of lead-zinc-silver ore. Miners completed an adit to the vein and began exploration drifting to determine the nature of the ore body prior to further development.

South Africa, Republic of.—The Black Mountain Mineral Development Co. (Pty.) Ltd., owned 49% by the Phelps Dodge Corp. and 51% by Consolidated Gold Fields (South Africa), completed its first year of full operation. The mine produced approximately 85,100 tons of lead in concentrates and operated its mill at about 90% of design capacity.

Spain.—Exploración Minera Internacional, España S.A., continued to develop its property at La Troya, near Rubiales in northern Spain. Mine production was considered possible after 1983, and output should reach 6,000 tons of contained metal. During 1980, Andalusa de Piritas S.A. produced about 21,000 tons of lead at its Aznalcollar Mine.

According to a report prepared by Centro Nacional de Investigaciones Metallurgicas, Madrid, and Asociación Nacional del Plomo, a new lead smelter may be constructed in 1985. With this new smelter, total annual lead smelter capacity of Spain could reach 120,000 tons. Specific location was not mentioned, but it appeared that the general area of Seville may be selected, as the new smelter would treat lead concentrates from mines in southern Spain.

Yugoslavia.—During 1980, efforts were made to increase domestic mine production. The Trepca Mine in Kosovo, Serbia, and the Blagodat, Kisnica, and Novo Brdo Rudnik, Srebrenica Mines were planning higher output, but faced difficulties in securing adequate financing. Development of the recently discovered Veovaca deposit near Vares in Bosna i Hercegovina continued. Tailings of some mines were also assayed and their metal content indicated some possibility of economic recovery of lead and zinc. In the past, significant quantities of metals were lost because of low recovery during beneficiation.

[1]Mineral specialist, Section of Nonferrous Metals.

[2]World Bureau of Metal Statistics (London). World Metal Statistics. V. 34, No. 4, May 1981, p. 73.

[3]International Lead and Zinc Study Group (London). Lead and Zinc Statistics. Monthly Bull., v. 21, No. 5, May 1981, p. 17.

[4]U.S. Central Intelligence Agency. The Lead and Zinc Industry in the U.S.S.R. Report ER 80-10072, March 1980. Available as PB 80-928106 from National Technical Information Service, Springfield, VA 22161.

[5]International Lead and Zinc Study Group (London). World Directory: Lead and Zinc Mines and Metallurgical Works. August 1980, 82 pp.

Table 2.—Mine production of recoverable lead in the United States, by State

(Metric tons)

State	1976	1977	1978	1979	1980
Arizona	307	288	416	354	401
California	49	3	W	W	W
Colorado	24,266	20,860	15,151	7,554	10,272
Idaho	48,658	42,872	44,761	42,636	38,607
Illinois	W	W	W	W	W
Kentucky	--	--	W	--	--
Maine	196	161	--	--	--
Missouri	454,492	453,824	461,762	472,054	497,170
Montana	83	96	132	258	295
Nevada	528	674	653	24	26
New Mexico	W	W	W	W	--
New York	2,899	2,520	990	458	876
Oklahoma	W	W	--	--	--
Oregon	--	--	--	(1)	--
Tennessee	--	--	--	(1)	--
Texas	--	--	W	--	--
Utah	14,784	9,749	2,541	W	--
Virginia	1,765	1,998	1,803	1,596	1,563
Washington	W	1,090	W	(1)	W
Wisconsin	W	W	W	W	--
Other States	4,944	3,364	1,452	635	274
Total	552,971	537,499	529,661	525,569	549,484

W Withheld to avoid disclosing company proprietary data; included in "Other States."
[1]Less than 1/2 unit.

Table 3.—Production of lead and zinc in the United States in 1980, by State and class of ore from old tailings, etc., in terms of recoverable metal

(Metric tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc
Arizona	1,763	35	--	--	--	--	--	--	--
Colorado	39,818	280	--	--	--	--	297,876	8,533	([1])
Idaho	1,642	224	--	([1])	([1])	([1])	754,895	24,796	26,097
Missouri	9,091,559	497,170	65,214	--	--	--	--	--	--
Montana	9,140	178	([1])	--	--	--	--	--	--
Nevada	([1])	([1])	([1])	--	--	--	--	--	--
New Jersey	--	--	--	162,158	--	28,859	--	--	--
New York	--	--	--	394,843	876	33,629	--	--	--
Pennsylvania	--	--	--	492,491	--	22,556	--	--	--
Tennessee	--	--	--	5,056,929	--	125,028	--	--	--
Virginia	--	--	--	476,391	1,563	12,038	--	--	--
Other States[2]	205	41	--	--	--	--	--	--	--
Total	9,144,127	497,928	65,214	6,582,812	2,439	222,110	1,052,771	33,329	26,097
Percent of total lead-zinc	XX	91	20	XX	--	66	XX	6	8

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources[3]			Total		
	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc	Gross weight (dry basis)	Lead	Zinc
Arizona	--	--	--	35,237,458	366	W	35,239,221	401	W
Colorado	([1])	([1])	--	[1]209,869	[1]1,459	[1]13,823	547,563	10,272	13,823
Idaho	--	--	--	[1]697,760	[1]13,587	[1]1,625	1,454,297	38,607	27,722
Missouri	--	--	--	--	--	--	9,091,559	497,170	65,214
Montana	--	--	--	20,990	117	[1]71	30,130	295	71
Nevada	--	--	--	[1]1,272	[1]26	[1]2	1,272	26	2
New Jersey	--	--	--	--	--	--	162,158	--	28,859
New York	--	--	--	--	--	--	394,843	876	33,629
Pennsylvania	--	--	--	--	--	--	492,491	--	22,556
Tennessee	1,901,533	--	3,694	--	--	--	6,958,462	--	128,722
Virginia	--	--	--	--	--	--	476,391	1,563	12,038
Other States[2]	--	--	--	2,556,583	233	2,226	2,556,788	274	2,226
Total	1,901,533	([1])	3,694	38,723,932	15,788	17,747	57,405,175	549,484	334,862
Percent of total lead-zinc	XX	--	1	XX	3	5	XX	100	100

W Withheld to avoid disclosing company proprietary data; included in "Other States." XX Not applicable.
[1]Lead ore, zinc ore, lead-zinc ore, copper-lead ore, and ore from "All other sources" combined to avoid disclosing company proprietary data.
[2]Other States includes Alaska, California, Illinois, New Mexico, and Washington.
[3]Lead and zinc recovered from copper, gold, silver, and fluorspar ores and from mill tailings and miscellaneous cleanups.

Table 4.—Mine production of recoverable lead in the United States, by month

(Metric tons)

Month	1979	1980
January	48,352	51,432
February	44,673	50,278
March	43,097	49,838
April	37,315	48,904
May	42,046	49,893
June	42,571	46,101
July	41,520	43,409
August	49,403	41,541
September	35,213	39,178
October	50,455	48,300
November	46,776	39,508
December	44,148	41,102
Total	525,569	549,484

Table 5.—Twenty-five leading lead-producing mines in the United States in 1980, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Buick	Iron, Mo	AMAX Lead Co. of Missouri	Lead ore.
2	Fletcher	Reynolds, Mo	St. Joe Lead Co	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Milliken	Reynolds, Mo	Ozark Lead Co	Do.
5	Viburnum No. 29	Washington, Mo	St. Joe Lead Co	Do.
6	Brushy Creek	Reynolds, Mo	do	Do.
7	Viburnum No. 28	Iron, Mo	do	Do.
8	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
9	Lucky Friday	do	Hecla Mining Co	Silver ore.
10	Star Unit	do	do	Lead-zinc ore.
11	Indian Creek	Washington, Mo	St. Joe Lead Co	Lead ore.
12	Leadville Unit	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
13	Sunnyside	San Juan, Colo	Standard Metals Corp	Do.
14	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Zinc ore.
15	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
16	Balmat	St. Lawrence, N.Y	St. Joe Lead Co	Zinc ore.
17	Sherman Tunnel	Lake, Colo	Leadville Corp.-Day Mines	Silver ore.
18	Galena	Shoshone, Idaho	ASARCO Incorporated	Do.
19	Mission Unit	Pima, Ariz	do	Copper ore.
20	Clayton	Custer, Idaho	Clayton Silver Mines	Silver ore.
21	Hilltop	Lemhi, Idaho	Petro Chemical Co	Lead ore.
22	Nellie Grant	Lewis and Clark, Mont	Sparrow Resources	Do.
23	Hock Hocking	Park, Colo	Silver State Mining Corp	Do.
24	Moose	do	do	Lead tailings.
25	Rosiclare	Hardin, Ill	Ozark-Mahoning Co	Fluorspar.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Metric tons)

	1976	1977	1978	1979	1980
Refined lead:[1]					
From primary sources:					
Domestic ores and base bullion	515,767	486,659	501,643	529,970	508,163
Foreign ores and base bullion	76,513	62,041	63,530	45,641	39,427
Total	592,280	548,700	565,173	575,611	547,590
From secondary sources	26	86	1,244	2,862	2,117
Grand total	592,306	548,786	566,417	578,473	549,707
Calculated value of primary refined lead (thousands)[2]	$301,628	$371,371	$419,277	[r]$668,004	$512,590

[r]Revised.
[1]GSA metal is not included in refined lead production.
[2]Value based on average quoted price and excludes value of refined lead produced from scrap at primary refineries.

Table 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (metric tons)	Antimony content		Lead content by difference (metric tons)			
		Metric tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1976	6,117	662	10.8	2,099	2,112	1,244	5,455
1977	6,855	816	11.9	2,459	528	3,052	6,039
1978	5,006	710	14.2	2,384	530	1,382	4,296
1979	3,402	271	8.0	2,491	105	535	3,131
1980	881	27	3.1	711	140	3	854

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1980

(Metric tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption New scrap	Consumption Old scrap	Consumption Total	Stocks Dec. 31
Smelters and refiners:						
Soft lead	1,334	31,819	--	31,165	31,165	1,988
Hard lead	1,334	18,290	--	17,940	17,940	1,684
Cable lead	4,800	11,469	--	11,565	11,565	4,704
Battery-lead plates	42,381	719,438	--	727,095	727,095	34,724
Mixed common babbitt	254	6,851	--	6,938	6,938	167
Solder and tinny lead	1,315	11,564	--	10,948	10,948	1,931
Type metals	2,528	13,793	--	14,413	14,413	1,908
Drosses and residues	20,145	125,525	133,186	--	133,186	12,484
Total	74,091	938,749	133,186	820,064	953,250	59,590
Foundries and other manufacturers:						
Soft lead	--	--	--	--	--	--
Hard lead	--	--	--	--	--	--
Cable lead	--	--	--	--	--	--
Battery-lead plates	--	--	--	--	--	--
Mixed common babbitt	44	3,782	--	3,783	3,783	43
Solder and tinny lead	--	--	--	--	--	--
Type metals	--	--	--	--	--	--
Drosses and residues	--	--	--	--	--	--
Total	44	3,782	--	3,783	3,783	43
All consumers:						
Soft lead	1,334	31,819	--	31,165	31,165	1,988
Hard lead	1,334	18,290	--	17,940	17,940	1,684
Cable lead	4,800	11,469	--	11,565	11,565	4,704
Battery-lead plates	42,381	719,438	--	727,095	727,095	34,724
Mixed common babbitt	298	10,633	--	10,721	10,721	210
Solder and tinny lead	1,315	11,564	--	10,948	10,948	1,931
Type metals	2,528	13,793	--	14,413	14,413	1,908
Drosses and residues	20,145	125,525	133,186	--	133,186	12,484
Grand total	74,135	942,531	133,186	823,847	957,033	59,633

Table 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1980, by type of product

(Metric tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	295,342	--	--	--	295,342
Remelt lead	19,836	--	--	--	19,836
Total	315,178	--	--	--	315,178
Refined pig tin	--	1,678	--	--	1,678
Remelt tin	--	26	--	--	26
Total	--	1,704	--	--	1,704
Lead and tin alloys:					
Antimonial lead	306,686	856	15,393	884	323,819
Common babbitt	4,828	267	535	7	5,637
Genuine babbitt	9	111	12	--	132
Solder	26,351	4,422	680	25	31,478
Type metals	8,176	525	1,383	1	10,085
Cable lead	1,951	--	23	--	1,974
Miscellaneous alloys	975	119	18	--	1,112
Total	348,976	6,300	18,044	917	374,237
Tin content of chemical products	--	321	--	--	321
Grand total	664,154	8,325	18,044	917	691,440

[1]Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Metric tons)

	1976	1977	1978	1979	1980
As metal:					
At primary plants	26	86	1,244	2,862	2,117
At other plants	282,117	303,063	281,340	349,359	313,061
Total	282,143	303,149	282,584	352,221	315,178
In antimonial lead:					
At primary plants	1,244	3,052	1,382	535	3
At other plants	308,983	380,335	408,528	378,295	306,683
Total	310,227	383,387	409,910	378,830	306,686
In other alloys	66,762	71,056	76,742	70,317	53,714
Grand total:					
Quantity	659,132	757,592	769,236	801,368	675,578
Value (thousands)[1]	$335,675	$512,753	$570,662	$930,019	$632,397

[1]Value based on average quoted price of common lead.

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1979	1980
KIND OF SCRAP		
New scrap:		
Lead-base	123,596	89,934
Copper-base	4,944	4,162
Tin-base	85	95
Total	128,625	94,191
Old scrap:		
Battery-lead plates	495,551	480,624
All other lead-base	160,345	87,966
Copper-base	16,845	12,796
Tin-base	2	1
Total	672,743	581,387
Grand total	801,368	675,578
FORM OF RECOVERY		
As soft lead:		
At primary plants	2,862	2,117
At other plants	349,359	313,061
Total	352,221	315,178
In antimonial lead[1]	378,830	306,686
In other lead alloys	51,271	41,531
In copper-base alloys	19,043	12,174
In tin-base alloys	3	9
Total	449,147	360,400
Grand total	801,368	675,578

[1]Includes 535 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1979 and 3 tons in 1980.

Table 12.—Lead consumption in the United States, by product

(Metric tons)

SIC Code	Product	1979	1980
	Metal products:		
3482	Ammunition: Shot and bullets	53,236	48,662
	Bearing metals:		
35	Machinery except electrical	905	1,634
36	Electrical and electronic equipment	79	39
371	Motor vehicles and equipment	3,814	2,242
37	Other transportation equipment	4,832	3,893
	Total bearing metals	9,630	7,808
3351	Brass and bronze: Billets and ingots	18,748	13,981
36	Cable covering: Power and communication	16,393	13,408
15	Calking lead: Building construction	8,017	5,684
	Casting metals:		
36	Electrical machinery and equipment	1,121	776
371	Motor vehicles and equipment	2,573	1,267
37	Other transportation and equipment	14,553	12,380
3443	Nuclear radiation shielding	4,498	4,598
	Total casting metals	22,745	19,021
	Pipes, traps, and other extruded products:		
15	Building construction	6,237	7,734
3443	Storage tanks, process vessels, etc	949	863
	Total pipes, traps, and other extruded products	7,186	8,597
	Sheet lead:		
15	Building construction	14,173	12,943
3443	Storage tanks, process vessels, etc	6,259	6,853
3693	Medical radiation shielding	(1)	(1)
	Total sheet lead	20,432	19,796
	Solder:		
15	Building construction	9,777	4,507
341	Metal cans and shipping containers	14,485	10,268
367	Electronic components and accessories	10,344	8,232
36	Other electrical machinery and equipment	2,711	2,733
371	Motor vehicles and equipment	16,961	15,626
	Total solder	54,278	41,366
	Storage battery grids, post, etc.:		
36911	Storage batteries: SLI automotive	350,301	276,996
36912	Storage batteries: Industrial and traction	25,253	25,244
	Total storage battery grids, post, etc	375,554	302,240
	Storage battery oxides:		
36911	Storage batteries: SLI automotive	418,883	328,234
36912	Storage batteries: Industrial and traction	19,895	14,883
	Total storage battery oxides	438,778	343,117
371	Terne metal: Motor vehicles and equipment	4,557	2,861
27	Type metal: Printing and allied industries	10,019	8,997
34	Other metal products[2]	12,091	10,506
	Total metal products	1,051,664	846,044
	Pigments:		
285	Paints	26,717	20,736
32	Glass and ceramic products	48,758	45,361
28	Other pigments[3]	15,315	12,333
	Total pigments	90,790	78,430
2911	Chemicals: Petroleum refining	186,945	127,903
	Miscellaneous uses	28,936	17,926
	Grand total	1,358,335	1,070,303

[1]Included in "Storage tanks" to avoid disclosing company proprietary data.
[2]Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, and fishing weights.
[3]Includes color, lead content of leaded zinc oxide, and other pigments.

Table 13.—Lead consumption in the United States, by month[1]

(Metric tons)

Month	1979	1980
January	121,756	100,852
February	116,924	85,423
March	132,956	91,294
April	117,091	83,587
May	121,803	84,199
June	112,047	73,181
July	88,060	64,814
August	110,636	78,979
September	114,304	99,253
October	118,477	112,607
November	108,150	94,413
December	96,131	101,701
Total[2]	1,358,335	1,070,303

[1]Monthly totals include monthly reported consumption plus the monthly distribution for companies that report on an annual basis only.
[2]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 14.—Lead consumption in the United States in 1980, by State[1]

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	75,149	39,180	5,413	516	120,258
Colorado	688	317	23	--	1,028
Connecticut	10,267	11,566	--	633	22,466
District of Columbia	43	--	--	--	43
Florida	10,701	7,689	443	--	18,833
Georgia	42,815	18,952	3,748	10	65,525
Illinois	21,844	29,389	7,270	1,330	59,833
Indiana	85,323	16,873	4,655	675	107,526
Kansas	15,879	8,846	462	59	25,246
Kentucky	6,726	8,921	2	--	15,649
Maryland	367	1,425	865	1	2,658
Massachusetts	837	263	51	329	1,480
Michigan	8,919	9,862	1,714	1	20,496
Missouri	15,976	10,862	1,324	--	28,162
Nebraska	1,110	617	1,536	1,534	4,797
New Jersey	70,505	3,876	6,655	359	81,395
New York	20,032	4,168	5,068	92	29,360
Ohio	6,661	3,325	1,849	463	12,298
Pennsylvania	71,895	39,348	18,493	1,101	130,837
Rhode Island	4,205	50	5	--	4,260
Tennessee	2,682	10,930	95	125	13,832
Virginia	159	1,938	46	--	2,143
Washington	5,422	1,520	--	--	6,942
West Virginia	92	--	--	--	92
Wisconsin	5,283	9,716	45	392	15,436
Alabama and Mississippi	7,886	4,243	916	1,485	14,530
Arkansas and Oklahoma	2,275	3,021	54	--	5,350
Hawaii and Oregon	3,851	5,049	1	--	8,901
Iowa and Minnesota	9,735	15,524	65	--	25,324
Louisiana and Texas	140,158	26,770	1,297	345	168,570
Montana and Idaho	755	--	--	1,134	1,889
New Hampshire, Maine, Vermont, Delaware	8,704	11,706	--	127	20,537
North Carolina and South Carolina	18,758	15,486	208	--	34,452
Utah, Nevada, Arizona	15	16	124	--	155
Total	675,717	321,448	62,427	10,711	1,070,303

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 15.—Lead consumption in the United States in 1980, by class of product and type of material

(Metric tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	85,570	59,134	45,272	10,711	200,687
Storage batteries	369,563	259,712	16,082	--	645,357
Pigments	78,430	--	--	--	78,430
Chemicals	127,903	--	--	--	127,903
Miscellaneous	14,251	2,602	1,073	--	17,926
Total	675,717	321,448	62,427	10,711	[1]1,070,303

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 16.—Production and shipments of lead pigments[1] and oxides in the United States

Product	1979			1980		
	Production (metric tons)	Shipments		Production (metric tons)	Shipments	
		Metric tons	Value[2]		Metric tons	Value[2]
White lead, dry	1,458	1,506	$2,444,183	1,111	1,056	$1,406,310
Red lead	13,904	18,146	17,055,901	12,533	13,110	15,562,624
Litharge	95,723	100,970	89,961,690	41,412	47,060	47,419,465
Black oxide	466,587	--	--	361,130	--	--

[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.
[2]At plant, exclusive of container.

Table 17.—Lead content of lead pigments[1] and oxides produced by domestic manufacturers, by source

(Metric tons)

Product	Lead in pigments from pig lead	
	1979	1980
White lead	1,167	889
Red lead	12,653	11,405
Litharge	89,022	38,514
Leady oxide	443,500	329,151
Total	546,342	379,959

[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.

Table 18.—Distribution of red lead shipments, by industry

(Metric tons)

Industry	1976	1977	1978	1979	1980
Paints	6,415	5,914	5,993	5,300	3,241
Ceramics	--	--	--	--	2,597
Storage batteries	W	W	W	W	6,068
Other	11,090	11,870	13,234	12,846	995
Total	17,505	17,784	19,227	18,146	12,901

W Withheld to avoid disclosing company proprietary data; included with "Other."

Table 19.—Distribution of litharge shipments, by industry

(Metric tons)

Industry	1976	1977	1978	1979	1980
Ceramics	29,302	27,161	33,865	37,620	36,560
Chrome pigments	--	--	--	--	3,015
Oil refining	W	W	W	W	170
Paints	7,579	2,455	3,200	3,038	3,362
Rubber	3,465	2,868	2,153	1,520	943
Other	70,750	78,789	62,887	58,792	784
Total	111,096	111,273	102,105	100,970	44,834

W Withheld to avoid disclosing company proprietary data; included with "Other."

Table 20.—U.S. imports for consumption of lead pigments and compounds

Kind	1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
White lead	112	$346	116	$252
Red lead	1,356	1,664	1,298	1,420
Litharge	16,524	18,673	9,414	9,195
Chrome yellow	1,241	2,915	1,214	3,050
Other lead pigments	15	100	35	164
Other lead compounds	470	679	857	1,144
Total	19,718	24,377	12,934	15,225

Tabie 21.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Metric tons)

Stocks	1976	1977	1978	1979	1980
Refined pig lead	36,169	12,044	17,001	45,448	54,728
Lead in antimonial lead	3,490	1,945	556	646	122
Lead base bullion	6,066	5,312	5,818	5,683	5,398
Lead in ore and matte	64,681	71,812	75,290	37,545	65,746
Total	110,406	91,113	98,665	89,322	125,994

Table 22.—Stocks of lead at consumers and secondary smelters in the United States, December 31, by type of material

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1976	79,627	30,941	5,443	1,569	117,580
1977	74,004	39,247	6,669	1,467	121,387
1978	72,065	44,417	7,564	1,188	125,234
1979	95,655	49,188	7,346	1,006	153,195
1980	72,601	44,820	7,851	942	126,214

Table 23.—Average monthly and annual quoted prices of lead[1]

(Cents per pound)

Month	1979		1980	
	U.S. producer	London Metal Exchange	U.S. producer	London Metal Exchange
January	40.76	44.97	49.88	50.66
February	43.63	47.79	49.56	52.93
March	45.75	53.32	49.22	50.72
April	48.00	52.60	44.02	43.88
May	48.81	56.16	36.00	35.49
June	56.51	62.63	34.19	33.44
July	58.07	57.64	35.60	36.74
August	57.91	54.96	40.96	38.65
September	58.00	55.77	42.26	40.01
October	61.06	59.77	45.00	39.50
November	57.26	55.49	43.81	36.89
December	55.95	53.33	38.97	33.68
Average	52.64	54.52	42.46	41.21

[1]Metals Week. Quotations for United States on a nationwide, delivered basis.

Table 24.—U.S. exports of lead, by country

Destination	1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates:				
Belgium-Luxembourg	79	$39	437	$416
Brazil	13,280	7,908	--	--
Canada	1,578	1,868	24,840	9,051
Italy	993	1,083	--	--
Japan	--	--	522	276
Mexico	5,704	1,598	812	352
Netherlands	--	--	752	817
Taiwan	--	--	169	108
United Kingdom	36	53	38	41
U.S.S.R	11,178	7,035	--	--
Other	54	93	45	57
Total	32,902	19,677	27,615	11,118
Unwrought lead and lead alloys:				
Argentina	299	437	397	322
Australia	7	23	15	26
Belgium-Luxembourg	194	412	30,175	34,092
Brazil	6	13	--	--
Canada	978	1,233	2,910	3,028
Chile	--	--	160	149
Colombia	1	3	14	39
Costa Rica	6	17	7	12
Denmark	(1)	1	79	76
Dominican Republic	2	3	1	2
Ecuador	27	64	42	88
Egypt	43	159	4	21
El Salvador	10	30	1	7
France	20	34	1,000	749
Germany, Federal Republic of	102	140	1,386	1,647
Haiti	18	19	2	1
Honduras	55	81	21	22
Hong Kong	--	--	16	18
India	--	--	1,429	1,015
Indonesia	--	--	130	109
Israel	(1)	9	14	32
Italy	19	19	2,890	2,780
Japan	416	461	2,667	2,502
Korea, Republic of	163	220	2,051	1,838
Mexico	117	367	1,033	1,671
Mozambique	--	--	208	183
Netherlands	754	648	93,124	88,118
Netherlands Antilles	47	58	15	12
Nicaragua	--	--	1	27
Norway	15	22	--	--
Panama	8	20	(1)	1
Peru	71	157	--	--

See footnotes at end of table.

Table 24.—U.S. exports of lead, by country —Continued

Destination	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Unwrought lead and lead alloys —Continued				
Philippines	53	$67	94	$104
Saudi Arabia	75	132	75	189
Spain	156	211	87	149
Switzerland	--	--	1,004	850
Taiwan	388	402	1,746	1,649
Thailand	43	43	656	620
Turkey	--	--	529	583
United Arab Emirates	--	--	5,414	4,502
United Kingdom	66	179	6,716	6,009
U.S.S.R	3,049	3,857	--	--
Venezuela	21	55	270	357
Other	151	253	117	151
Total	7,380	9,849	156,500	153,750
Wrought lead and lead alloys:				
Algeria	2	34	--	--
Argentina	(1)	1	3	4
Australia	3	16	17	31
Bahamas	(1)	2	--	--
Bahrain	--	--	21	29
Belgium-Luxembourg	1,372	579	1,531	790
Brazil	726	192	6	14
Canada	191	319	818	1,087
Chile	27	38	16	39
Colombia	25	34	3	6
Costa Rica	2	6	4	10
Dominican Republic	8	29	19	38
Ecuador	56	106	7	25
El Salvador	5	17	--	--
Finland	11	19	3	6
France	3	6	9	3
Germany, Federal Republic of	1	6	83	92
Guatemala	3	12	9	32
Honduras	11	29	7	26
Hong Kong	3	9	3	9
India	--	--	32	142
Indonesia	3	15	--	--
Iran	7	44	--	--
Israel	4	21	3	5
Italy	56	64	4	88
Japan	95	177	195	214
Jordan	(1)	2	--	--
Korea, Republic of	3	8	37	24
Mexico	215	966	925	3,262
Netherlands	6	64	3,023	3,056
Netherlands Antilles	1	6	5	7
Panama	24	89	6	10
Philippines	55	130	7	25
Saudi Arabia	19	59	79	215
Singapore	21	38	9	57
South Africa, Republic of	1	4	(1)	2
Spain	52	127	112	384
Sweden	10	18	2	18
Switzerland	(1)	2	--	--
Taiwan	46	155	30	351
United Arab Emirates	1	3	--	--
United Kingdom	93	311	836	740
Venezuela	29	77	13	30
Other	76	246	81	214
Total	3,266	4,080	7,958	11,085
Scrap:				
Argentina	684	434	606	296
Austria	33	44	16	12
Belgium-Luxembourg	6,702	3,052	495	369
Brazil	7,016	5,369	1,118	538
Canada	34,019	13,994	28,643	10,552
Denmark	1,819	814	5,561	2,855
Egypt	--	--	1,066	740
France	--	--	348	362
German Democratic Republic	--	--	1,810	933
Germany, Federal Republic of	4,157	1,927	9,255	5,814
India	--	--	172	109
Ireland	--	--	165	127
Italy	112	96	3,621	3,047
Jamaica	--	--	49	17
Japan	6,807	1,817	6,316	3,918

See footnotes at end of table.

Table 24.—U.S. exports of lead, by country —Continued

Destination	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Scrap —Continued				
Korea, Republic of	14,428	$5,608	9,924	$4,550
Kuwait	--	--	249	164
Mexico	9,352	1,852	8,143	2,519
Namibia	1,612	1,141	--	--
Netherlands	503	660	6,626	5,499
Philippines	194	56	139	75
Saudi Arabia	--	--	459	278
South Africa, Republic of	10,752	6,186	945	724
Spain	36	37	77	122
Sweden	160	120	108	64
Taiwan	16,116	6,257	15,033	6,068
Thailand	--	--	252	111
Turkey	--	--	699	339
Trust Territory of the Pacific Islands	--	--	54	18
United Kingdom	3,122	2,965	16,280	11,250
Venezuela	1,579	915	1,300	654
Yugoslavia	498	129	--	--
Other	47	41	122	97
Total	119,748	53,514	119,651	62,221
Grand total	163,296	87,120	311,724	238,174

[1]Less than 1/2 unit.

Table 25.—U.S. exports of lead, by class

Year	Blocks, pigs, anodes, etc.: Unwrought Quantity (metric tons)	Unwrought Value (thousands)	Unwrought alloys Quantity (metric tons)	Unwrought alloys Value (thousands)	Wrought lead and lead alloys: Sheets, plates, rods, other forms Quantity (metric tons)	Sheets, plates, rods, other forms Value (thousands)	Foil, powder, flakes Quantity (metric tons)	Foil, powder, flakes Value (thousands)	Scrap Quantity (metric tons)	Scrap Value (thousands)
1978	2,145	$1,643	1,022	$1,305	4,787	$6,027	271	$295	98,633	$27,654
1979	6,585	8,383	795	1,466	2,349	3,456	917	624	119,748	53,514
1980	147,356	143,458	9,144	10,292	7,522	10,507	436	578	119,651	62,221

Table 26.—U.S. imports[1] of lead, by country

Country	1978 Quantity (metric tons)	1978 Value (thousands)	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Argentina	161	$130	152	$160	61	$56
Australia	6,522	3,823	1,923	1,828	2,971	2,309
Bolivia	1,218	227	--	--	571	477
Canada	19,587	8,467	12,762	10,954	8,520	6,901
Chile	--	--	--	--	2,236	1,927
Colombia	86	57	136	145	211	154
Honduras	13,424	8,899	10,923	11,619	3,974	3,943
Mexico	4,578	1,426	1,646	1,606	781	665
Netherlands	335	131	--	--	--	--
Nicaragua	725	474	12	10	--	--
Peru	6,347	3,042	12,444	11,287	17,980	13,169
South Africa, Republic of	--	--	--	--	6,790	5,514
Other	2	1	--	--	--	--
Total	52,985	26,677	39,998	37,609	44,095	35,115
Base bullion (lead content):						
Belgium-Luxembourg	40	29	(2)	1	--	--
Canada	3,993	2,705	1,654	1,654	247	219
Denmark	14	11	27	36	--	--
Mexico	260	185	--	--	27	30
Other	--	--	--	--	22	260
Total	4,307	2,930	1,681	1,691	296	509
Pigs and bars (lead content):						
Australia	16,327	10,575	17,275	18,597	11,338	12,365
Belgium-Luxembourg	7,479	11,424	1,981	11,026	846	5,567
Canada	70,378	53,224	71,342	79,512	34,929	31,649
Denmark	658	588	521	726	619	591
France	1,500	865	2,000	2,041	--	--
Germany, Federal Republic of	8,458	9,481	574	5,529	446	4,342
Mexico	80,213	54,818	73,643	76,488	28,636	27,987
Morocco	6,007	3,916	--	--	--	--
Namibia	--	--	3,913	4,231	--	--
Netherlands	514	371	--	--	56	590
Poland	101	57	--	--	--	--
Peru	25,725	17,004	17,903	19,387	3,298	2,974
South Africa, Republic of	--	--	1,299	1,260	--	--
Spain	1,000	636	--	--	1,036	1,313
Sweden	1,007	605	--	--	14	13
Thailand	181	963	--	--	--	--
United Kingdom	1,724	1,963	801	1,979	468	1,085
Other	41	22	410	535	47	32
Total	221,313	166,512	191,662	221,311	81,733	88,508
Reclaimed scrap, etc. (lead content):						
Australia	2,306	1,769	2,676	2,349	4,747	3,458
Bahamas	19	17	18	3	26	7
Barbados	37	31	3	2	--	--
Canada	2,747	1,761	2,661	2,720	1,639	1,570
Dominican Republic	27	12	56	39	86	32
Guatemala	--	--	102	62	8	5
Haiti	6	14	5	12	13	3
Jamaica	12	4	48	7	--	--
Mexico	366	134	896	652	551	405
Panama	35	58	19	16	18	8
Spain	--	--	36	157	108	637
United Kingdom	27	44	17	16	--	--
Other	31	12	145	94	66	20
Total	5,613	3,856	6,682	6,129	7,262	6,145
Grand total	284,218	199,975	240,023	266,740	133,386	130,277

[1]Data are "general imports;" that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2]Less than 1/2 unit.

Table 27.—U.S. imports for consumption of lead, by country

Country	1978 Quantity (metric tons)	1978 Value (thousands)	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Argentina	161	$130	152	$160	61	$56
Australia	8,542	2,653	5,780	1,831	365	322
Bolivia	1,218	226	--	--	571	477
Canada	13,502	4,156	7,866	4,822	2,985	2,873
Chile	--	--	--	--	2,236	1,927
Colombia	86	57	136	145	211	154
Denmark	1,304	273	--	--	--	--
Honduras	15,912	10,050	15,048	12,814	3,973	3,943
Mexico	4,578	1,426	1,646	1,606	781	665
Nicaragua	571	413	12	10	--	--
Peru	16,062	5,835	13,761	11,638	18,141	13,292
South Africa, Republic of	--	--	--	--	291	218
Other	2	1	--	--	--	--
Total	61,938	25,220	44,401	33,026	29,615	23,927
Base bullion (lead content):						
Belgium-Luxembourg	40	29	(1)	1	--	--
Canada	3,993	2,705	1,654	1,654	247	219
Denmark	14	11	27	36	--	--
Mexico	260	185	--	--	27	30
Other	--	--	--	--	22	260
Total	4,307	2,930	1,681	1,691	296	509
Pigs and bars (lead content):						
Australia	20,419	13,929	8,163	6,737	10,884	11,464
Belgium-Luxembourg	7,479	11,424	1,981	11,026	846	5,567
Canada	70,378	53,224	71,342	79,512	34,929	31,649
Denmark	658	588	521	726	619	591
France	1,500	865	2,000	2,041	--	--
Germany, Federal Republic of	8,458	9,481	574	5,529	446	4,342
Mexico	80,213	54,818	73,643	76,488	28,657	28,009
Morocco	6,007	3,916	--	--	--	--
Namibia	--	--	3,913	4,231	--	--
Netherlands	514	371	--	--	56	590
Peru	25,725	17,004	17,903	19,387	3,298	2,974
Poland	101	57	--	--	--	--
South Africa, Republic of	--	--	1,299	1,260	--	--
Spain	1,000	636	--	--	1,036	1,313
Sweden	1,007	605	--	--	14	13
Thailand	181	963	--	--	--	--
United Kingdom	1,724	1,963	801	1,979	468	1,085
Other	42	22	410	535	47	32
Total	225,406	169,866	182,550	209,451	81,300	87,629
Reclaimed scrap, etc. (lead content):						
Australia	--	--	(1)	2	353	218
Bahamas	19	17	18	3	26	7
Canada	2,748	2,555	2,661	2,720	1,639	1,570
Dominican Republic	27	12	56	39	86	32
Guatemala	--	--	102	62	8	5
Jamaica	12	4	48	7	--	--
Mexico	366	132	896	652	551	405
Panama	34	58	19	16	18	8
Spain	--	--	36	157	108	637
United Kingdom	27	44	17	16	--	--
Other	74	56	153	108	79	23
Total	3,307	2,878	4,006	3,782	2,868	2,905
Sheets, pipe, shot:						
Canada	1,027	946	201	305	280	544
Germany, Federal Republic of	42	62	1	8	57	119
Mexico	--	--	--	--	588	647
Spain	366	1,100	--	--	--	--
United Kingdom	1	4	3	4	8	36
Other	2	4	10	11	17	162
Total	1,438	2,116	215	328	950	1,508
Grand total	296,396	203,010	232,853	248,278	115,029	116,478

[1]Less than 1/2 unit.

Table 28.—U.S. imports for consumption of lead, by class

(Thousand metric tons and thousand dollars)

Year	Ore (lead content)		Base bullion (lead content)		Pigs and bars (lead content)		Sheets, plates, strip, other forms	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1978	62	25,220	4	2,930	225	169,866	1	2,116
1979	44	33,026	2	1,691	183	209,451	(1)	328
1980	30	23,927	(1)	509	81	87,629	(1)	888
	Waste and scrap (lead content)		Dross, skimmings, residues, n.s.p.f. (lead content)		Powder and flakes		Total value	
	Quantity	Value	Quantity	Value	Quantity	Value		
1978	3	2,086	1	806	(1)	64	203,088	
1979	4	3,207	(1)	575	(1)	288	248,566	
1980	2	2,144	1	761	1	620	116,478	

[1]Less than 1/2 unit.

Table 29.—U.S. imports for consumption of miscellaneous products containing lead[1]

Year	Gross weight (metric tons)	Lead content (metric tons)	Value (thousands)
1978	560	262	$3,683
1979	362	107	3,565
1980	968	388	11,144

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Table 30.—Lead: World mine production, by country[1]

(Thousand metric tons)

Continent and country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	256.3	281.0	319.8	310.7	[3]273.8
Guatemala	.1	.1	[e].1	[e].1	[3].1
Honduras	[r]21.1	[r]20.6	21.8	16.4	16.0
Mexico[4]	200.0	163.5	170.6	173.5	[3]145.5
Nicaragua	1.3	1.0	.4	--	--
United States[5]	553.0	537.5	529.7	525.6	[3]549.5
South America:					
Argentina	33.0	33.6	30.3	34.0	[3]34.8
Bolivia	16.4	19.3	18.0	15.4	[3]17.2
Brazil	22.6	24.0	31.2	29.6	34.0
Chile	1.8	.9	.4	.3	.3
Colombia	.1	.1	.1	.1	.1
Ecuador	.2	.2	.2	.2	.2
Peru[6]	159.8	166.1	182.7	184.0	[3]189.3
Europe:					
Austria	4.4	4.3	4.6	4.5	[3]4.3
Bulgaria	110.0	117.0	[e]117.0	116.0	116.0
Czechoslovakia	4.2	4.3	4.0	4.0	[3]3.3
Finland	1.1	.6	.8	1.4	1.4
France	28.0	31.5	32.5	29.3	[3]28.4
German Democratic Republic	4.0	--	--	--	--
Germany, Federal Republic of	31.7	31.1	23.2	25.2	25.0
Greece	28.2	16.4	22.6	21.7	22.0
Greenland	27.0	28.8	30.6	31.9	30.2
Hungary	.9	1.3	1.0	1.0	1.0
Ireland	32.6	41.0	47.8	71.1	59.0
Italy	29.4	31.5	30.0	27.3	[3]16.6
Norway	3.9	3.3	3.6	3.6	3.5
Poland	60.0	63.0	63.9	61.9	58.8
Romania	[e]35.0	[e]35.0	33.3	33.3	33.3
Spain	62.2	[r]65.5	71.3	72.3	76.8
Sweden	81.6	88.1	81.9	79.4	[3]72.2
U.S.S.R.[e]	500.0	510.0	520.0	525.0	525.0
United Kingdom	7.1	7.6	4.6	4.7	5.0
Yugoslavia	122.5	130.0	124.5	129.8	[3]119.0
Africa:					
Algeria	2.1	.9	1.8	2.3	2.4
Congo (Brazzaville)	2.5	2.4	4.2	[e]8.0	8.0
Kenya[e]	.5	--	--	--	--
Morocco	60.2	93.4	100.2	115.7	130.0
Namibia	46.4	41.2	38.6	46.0	46.0
Nigeria	.1	.1	.1	.1	.1
South Africa, Republic of	--	--	--	--	[3]86.1
Tunisia	10.4	10.2	8.0	10.0	10.0
Zambia	15.5	13.5	15.8	17.6	14.0
Asia:					
Burma	7.1	[r]8.0	9.2	6.5	9.6
China, mainland[e]	[r]130.0	[r]135.0	145.0	155.0	155.0
India	[r]11.5	12.7	12.8	16.0	10.0
Iran	35.0	40.0	[e]30.0	[re]15.0	15.0
Japan[7]	51.7	54.8	56.5	46.9	44.6
Korea, North[e]	110.0	110.0	105.0	[r]100.0	100.0
Korea, Republic of	14.5	16.6	16.1	11.1	[3]11.5
Philippines	4.5	3.7	1.4	2.0	2.2
Thailand	.9	.5	1.7	8.7	10.0
Turkey	4.9	8.7	9.5	7.5	6.4
Oceania: Australia[8]	397.4	432.2	400.3	421.6	[3]395.2
Total	[r]3,344.7	[r]3,442.1	3,478.7	3,523.3	3,517.7

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 15, 1981.
[2]In addition to the countries listed, Egypt and Uganda may produce lead, but available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.
[4]Recoverable metal content of lead in concentrates for export plus lead content of domestic smelter products (refined lead, antimonial lead, mixed bars, and other unspecified items).
[5]Recoverable.
[6]Recoverable metal content of lead in concentrates for export plus lead content of domestic smelter products (refined lead, antimonial lead, and bismuth-lead bars).
[7]Content of concentrates.
[8]Content by analysis.

Table 31.—Lead: World smelter production by country[1]

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada:					
Primary (refined)	175.7	187.5	194.1	183.9	165.9
Secondary (refined)[2]	55.3	53.1	60.0	68.5	65.0
Total	231.0	240.6	254.1	252.4	[3]230.9
Guatemala, primary	.1	.1	.1	.1	[3].1
Mexico:					
Primary	189.7	153.9	166.1	173.0	[3]145.0
Secondary (refined)[2]	45.0	62.3	49.3	50.0	50.0
Total	234.7	216.2	215.4	223.0	195.0
United States:					
Primary (refined)	592.3	548.7	565.2	575.6	547.6
Secondary (refined)[2]	659.1	757.6	769.2	801.4	675.6
Total	1,251.4	1,306.3	1,334.4	1,377.0	1,223.2
South America:					
Argentina:					
Primary (refined)	50.0	45.0	34.0	33.6	33.8
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]50.0	[r]45.0	34.0	33.6	33.8
Brazil:					
Primary (refined)	43.7	48.3	47.3	55.1	44.9
Secondary (refined)[2]	[r]25.5	[r]29.0	33.2	42.2	40.0
Total	[r]69.2	[r]77.3	80.5	97.3	84.9
Peru, primary (refined)	74.1	[r]79.2	74.6	85.7	78.3
Venezuela, secondary	(4)	(4)	(4)	(4)	--
Europe:					
Austria:					
Primary	6.3	6.3	5.8	6.0	5.4
Secondary	9.9	10.5	9.3	10.8	12.4
Total	16.2	16.8	15.1	16.8	[3]17.8
Belgium:					
Primary[e 5]	[r]65.7	[r]31.6	44.7	33.7	54.7
Secondary[2]	[r]26.0	[r]42.0	30.0	27.0	27.0
Total	[r]91.7	[r]73.6	74.7	60.7	81.7
Bulgaria:					
Primary (refined)	104.0	112.0	115.0	115.0	115.0
Secondary (refined)[2]	8.0	8.0	5.0	4.0	4.0
Total	112.0	120.0	120.0	119.0	119.0
Czechoslovakia, primary and secondary	(4)	(4)	(4)	(4)	--
France:					
Primary[e 5]	[r]115.2	[r]127.1	134.6	120.9	124.0
Secondary (refined)[2]	[r]76.3	[r]80.2	82.3	90.6	89.7
Total	[r]191.5	[r]207.3	216.9	211.5	213.7
German Democratic Republic:					
Primary[e]	(6)	(6)	(6)	(6)	--
Secondary (refined)[e 2]	[r]36.0	[r]37.0	[r]38.0	[r]40.0	40.0
Total[e]	36.0	37.0	38.0	40.0	40.0
Germany, Federal Republic of:					
Primary	101.0	105.1	105.2	103.4	111.9
Secondary (refined)[2]	177.3	[r]214.8	200.9	213.1	189.5
Total	278.3	[r]319.9	306.1	316.5	301.4
Greece:					
Primary (refined)	16.8	[r]18.7	21.1	20.4	19.5
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]16.8	18.7	21.1	20.4	19.5
Hungary, secondary	(4)	(4)	(4)	(4)	--

See footnotes at end of table.

Table 31.—Lead: World smelter production by country[1] —Continued

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
Europe —Continued					
Italy:					
Primary[e 5]	[r]31.0	[r]24.0	23.2	19.4	23.0
Secondary (refined)[2]	72.2	83.5	85.1	101.0	101.0
Total	[r]103.2	[r]107.5	108.3	120.4	124.0
Netherlands:					
Primary[e 5]	[r]5.0	[r]3.3	.5	6.8	6.0
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]5.0	[r]3.3	.5	6.8	6.0
Norway, secondary	(4)	(4)	(4)	(4)	--
Poland:					
Primary (refined)[e]	58.6	63.4	61.7	59.2	56.0
Secondary (refined)[e 2]	22.0	22.0	25.0	25.0	24.0
Total[e]	80.6	85.4	86.7	84.2	80.0
Portugal:					
Primary	.2	.2	.1	--	--
Secondary	(4)	(4)	(4)	(4)	--
Total	[r].2	[r].2	.1	--	--
Romania:					
Primary (refined)	36.5	34.7	34.0	35.0	35.0
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]36.5	[r]34.7	34.0	35.0	35.0
Spain:					
Primary[e 5]	73.2	[r]89.2	88.4	104.8	105.0
Secondary (refined)[e 2]	[r]28.5	[r]29.4	38.8	39.8	39.7
Total	[r]101.7	[r]118.6	127.2	144.6	144.7
Sweden:					
Primary	[r]27.6	[r]28.1	31.7	[e]26.8	26.0
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]27.6	[r]28.1	31.7	26.8	26.0
U.S.S.R.:					
Primary (refined)[e]	500.0	510.0	520.0	525.0	525.0
Secondary (refined)[e 2]	100.0	100.0	100.0	100.0	100.0
Total[e]	600.0	610.0	620.0	625.0	625.0
United Kingdom:					
Primary	16.5	35.0	30.4	32.3	[3]30.0
Secondary (refined)[2]	209.7	211.4	223.0	244.2	[3]211.4
Total	226.2	246.4	253.4	276.5	[3]241.4
Yugoslavia:					
Primary	[r]98.5	[r]111.7	100.3	92.0	91.0
Secondary	[r]41.8	[r]33.3	40.1	41.6	42.0
Total	[r]140.3	145.0	140.4	133.6	133.0
Africa:					
Morocco:					
Primary (refined)	[r]24.7	[r]33.1	28.5	35.2	[3]40.3
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]24.7	33.1	28.5	35.2	[3]40.3
Namibia, primary	[r]39.6	42.7	39.5	41.7	45.0
South Africa, Republic of, secondary[2]	[r]22.4	[r]24.3	23.6	23.3	[3]33.6
Tunisia:					
Primary (refined)	[r]23.9	19.2	16.1	16.2	[3]19.2
Secondary	(4)	(4)	(4)	(4)	--
Total	[r]23.9	[r]19.2	16.1	16.2	19.2
Zambia, primary (refined)	13.6	13.1	12.9	12.8	[3]10.0

See footnotes at end of table.

Table 31.—Lead: World smelter production by country[1] —Continued

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
Asia:					
Burma:					
Primary[e]	3.1	4.3	5.1	6.0	5.7
Secondary[e]	([4])	([4])	([4])	([4])	--
Total[e]	[r]3.1	[r]4.3	5.1	6.0	5.7
China:					
Mainland:					
Primary (refined)[e]	125.0	135.0	140.0	150.0	150.0
Secondary (refined)[e 3]	15.0	15.0	20.0	20.0	20.0
Total[e]	[r]140.0	[r]150.0	160.0	170.0	170.0
Taiwan, secondary	([4])	([4])	([4])	([4])	--
India:					
Primary (refined)	5.4	7.6	10.1	9.8	[3]14.9
Secondary	([4])	([4])	([4])	([4])	--
Total	[r]5.4	[r]7.6	10.1	9.8	[3]14.9
Japan:					
Primary	[r]182.5	[r]187.4	188.9	187.8	185.0
Secondary (refined)[2]	[r]123.2	[r]117.8	105.0	106.5	[3]106.5
Total	[r]305.7	[r]305.2	293.9	294.3	291.5
Korea, North:					
Primary (refined)[e]	85.0	75.0	85.0	75.0	75.0
Secondary[e]	([4])	([4])	([4])	([4])	--
Total[e]	[r]85.0	[r]75.0	85.0	75.0	75.0
Korea, Republic of, primary (refined)	7.8	6.7	7.2	7.6	[3]5.5
Thailand, secondary	([4])	([4])	([4])	([4])	--
Turkey, primary	[r]2.2	[r]2.0	2.0	4.9	5.0
Oceania:					
Australia, primary:					
Bullion for export	160.7	156.4	152.0	169.5	160.2
Refined	181.9	181.5	204.0	215.7	200.5
Total	342.6	337.9	356.0	385.2	360.7
Grand total	[r]4,990.3	[r]5,158.3	5,227.2	5,388.9	5,130.8
Of which:					
Primary	3,237.1	3,227.1	3,289.4	3,339.9	3,259.4
Secondary	1,753.2	1,931.2	1,937.8	2,049.0	1,871.4

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 24, 1981. Figures presented represent, to the extent possible, production of crude (or unrefined) lead, including bullion and impure lead derived from scrap. The figures for secondary crude lead for a number of countries are undoubtedly high, but insufficient information is available to separate impure secondary lead from lead merely re-refined. Countries for which this is the case have been footnoted. (See footnote 2.) For those countries for which crude lead production is not reported, but where available information suggests that there is little if any import or export of bullion for refining and refined lead output has been reported, noted parenthetically, because it is believed that the difference between crude (or smelter) output and refined output is negligible.

[2]A significant part of the total entered may be merely re-refined, and as such probably should not be included here, but a substantial part of the total presumably was recovered from sufficiently impure materials to qualify as a secondary smelter product. Available information is inadequate to permit differentiation, and the total has been included, although it is recognized that this produces an overly large figure.

[3]Reported figure.

[4]Revised to zero; material previously included is regarded as being merely re-refined. (Now entered in refined lead world production table.)

[5]Data not reported, derived from reported primary refined lead output minus imports of lead bullion plus exports of lead bullion and checked against sum of lead content of domestically produced ores plus lead content of imported ores (estimated) minus lead content of exported ores (estimated).

[6]Revised to zero; material previously counted among primary output but now regarded as secondary output and accordingly added to next line entry in table.

Table 32.—Lead: World refined production by country[1]

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada:					
Primary	175.7	187.5	194.1	183.9	175.9
Secondary	55.3	53.1	51.8	68.5	55.0
Total	231.0	240.6	245.9	252.4	[2]230.9
Jamaica, secondary[e]	1.5	1.5	2.0	2.0	2.0
Mexico:					
Primary	172.7	143.7	159.3	167.1	[2]140.3
Secondary	45.0	62.3	49.3	50.0	50.0
Total	217.7	206.0	208.6	217.1	190.3
Trinidad and Tobago, secondary[e]	1.5	1.5	1.5	2.0	2.0
United States:					
Primary	592.3	548.7	565.2	575.6	547.6
Secondary	659.1	757.6	769.2	801.4	675.6
Total	1,251.4	1,306.3	1,334.4	1,377.0	1,223.2
South America:					
Argentina:					
Primary	50.0	45.0	34.0	33.6	33.8
Secondary[e]	10.0	7.0	4.0	6.0	6.0
Total	60.0	52.0	38.0	39.6	39.8
Brazil:					
Primary	43.7	48.3	47.3	55.1	44.9
Secondary	25.5	29.0	33.2	42.2	40.0
Total	69.2	77.3	80.5	97.3	84.9
Colombia, secondary[e]	1.5	1.5	1.5	2.0	2.5
Peru:					
Primary	74.1	79.2	74.6	85.7	78.3
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total	79.1	84.2	79.6	90.7	83.3
Venezuela, secondary[e]	7.0	8.0	9.0	10.0	10.0
Europe:					
Austria:					
Primary	9.8	8.4	7.1	7.5	5.5
Secondary	8.6	10.7	10.5	12.4	11.6
Total	18.4	19.1	17.6	19.9	[2]17.1
Belgium:					
Primary	79.7	62.1	74.2	65.2	[2]78.9
Secondary	26.0	42.0	30.0	27.0	[2]27.0
Total	105.7	104.1	104.2	92.2	[2]105.9
Bulgaria:					
Primary	104.0	112.0	115.0	115.0	115.0
Secondary	8.0	8.0	5.0	4.0	4.0
Total	112.0	120.0	120.0	119.0	119.0
Czechoslovakia, secondary	19.1	19.0	19.0	19.0	[2]20.0
Denmark, secondary	14.6	24.2	26.2	29.8	24.5
Finland, secondary	5.0	5.0	5.0	6.0	6.0
France:					
Primary	118.4	125.6	125.9	129.1	[2]126.8
Secondary	76.3	80.2	82.3	90.6	[2]89.7
Total	194.7	205.8	208.2	219.7	[2]216.5
German Democratic Republic, secondary[e]	36.0	37.0	38.0	40.0	40.0
Germany, Federal Republic of:					
Primary	160.1	158.7	168.1	160.2	[2]172.8
Secondary	177.3	214.8	200.9	213.1	[2]189.5
Total	337.4	373.5	369.0	373.3	[2]362.3
Greece:					
Primary	16.8	18.7	21.1	20.4	19.5
Secondary	1.9	1.7	1.5	1.6	1.6
Total	18.7	20.4	22.6	22.0	21.1

See footnotes at end of table.

Table 32.—Lead: World refined production by country[1] —Continued

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
Europe —Continued					
Hungary, secondary	.3	.2	.3	.1	.1
Ireland, secondary[e]	5.0	5.0	5.0	5.0	5.0
Italy:					
Primary	46.0	34.2	31.1	25.2	[2]32.7
Secondary	72.2	83.5	85.1	101.0	[2]101.0
Total	118.2	117.7	116.2	126.2	[2]133.7
Netherlands:					
Primary	21.9	21.1	18.2	21.1	20.0
Secondary	14.8	12.7	13.7	9.0	10.0
Total	36.7	33.8	31.9	30.1	30.0
Norway, secondary	.6	.9	.3	.4	[2].4
Poland:					
Primary	58.6	63.4	61.7	59.2	56.0
Secondary	22.0	22.0	25.0	25.0	24.0
Total	80.6	85.4	86.7	84.2	80.0
Portugal:					
Primary	.2	.2	.1	--	--
Secondary[e]	1.4	.4	.3	.3	1.0
Total	1.6	.6	.4	.3	1.0
Romania:					
Primary[e]	36.5	34.7	34.0	35.0	35.0
Secondary[e]	6.0	7.0	8.8	10.0	10.0
Total[e]	42.5	41.7	42.8	45.0	45.0
Spain:					
Primary	73.2	89.2	83.4	87.2	[2]84.3
Secondary	28.5	29.4	38.8	39.8	[2]39.7
Total	101.7	118.6	122.2	127.0	[2]124.0
Sweden:					
Primary	21.8	23.8	26.9	22.7	21.0
Secondary	15.4	17.4	18.1	18.9	19.0
Total	37.2	41.2	45.0	41.6	40.0
Switzerland, secondary[e]	5.0	5.0	5.0	5.0	5.0
U.S.S.R.:					
Primary[e]	500.0	510.0	520.0	525.0	525.0
Secondary[e]	100.0	100.0	100.0	100.0	100.0
Total[e]	600.0	610.0	620.0	625.0	625.0
United Kingdom:					
Primary	132.2	139.7	122.8	124.1	[2]113.4
Secondary	209.7	211.4	223.0	244.2	[2]211.4
Total	341.9	351.1	345.8	368.3	[2]324.8
Yugoslavia:					
Primary	93.5	111.6	97.7	92.0	84.7
Secondary	17.7	18.3	19.0	19.0	17.0
Total	111.2	129.9	116.7	111.0	[2]101.7
Africa:					
Morocco:					
Primary	24.7	33.1	28.5	35.2	[2]40.3
Secondary	1.6	1.5	1.5	1.6	[2]2.1
Total	26.3	34.6	30.0	36.8	[2]42.4
Namibia, primary	39.6	42.7	39.5	41.7	45.0
Nigeria, secondary[e]	--	--	--	1.5	1.2
South Africa, Republic of, secondary	22.4	24.3	23.6	23.3	[2]33.6

See footnotes at end of table.

Table 32.—Lead: World refined production by country[1] —Continued

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
Africa —Continued					
Tunisia:					
Primary	23.9	19.2	16.1	16.2	[2]19.2
Secondary[e]	.7	.5	.5	.6	.6
Total	24.6	19.7	16.6	16.8	19.8
Zambia, primary	13.6	13.1	12.9	12.8	[2]10.0
Asia:					
Burma:					
Primary[e]	3.1	4.3	5.1	6.0	5.7
Secondary[e]	.2	.2	.2	.2	.2
Total[e]	3.3	4.5	5.3	6.2	[2]5.9
China:					
Mainland:					
Primary[e]	125.0	135.0	140.0	150.0	150.0
Secondary[e]	15.0	15.0	20.0	20.0	20.0
Total[e]	140.0	150.0	160.0	170.0	170.0
Taiwan, secondary[e]	8.0	10.0	14.0	20.0	16.8
Cyprus, secondary[e]	2.5	2.5	2.5	2.5	2.5
India:					
Primary	5.4	7.6	10.1	9.8	[2]14.9
Secondary	9.6	12.4	10.9	10.8	[2]10.7
Total	15.0	20.0	21.0	20.6	[2]25.6
Indonesia, secondary[e]	1.0	1.0	2.0	2.0	2.0
Iran, secondary[e]	.3	.3	--	--	--
Japan:					
Primary	158.3	119.9	186.1	176.2	[2]174.4
Secondary	123.2	117.8	105.0	106.5	[2]106.5
Total	281.5	237.7	291.1	282.7	[2]280.9
Korea, North:					
Primary[e]	65.0	65.0	70.0	65.0	65.0
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total	70.0	70.0	75.0	70.0	70.0
Korea, Republic of:					
Primary	7.8	6.7	7.2	7.6	[2]5.5
Secondary[e]	.1	.3	1.0	5.8	1.3
Total[e]	7.9	7.0	8.2	13.4	6.8
Malaysia, secondary[e]	2.0	2.0	2.0	2.0	2.0
Pakistan, secondary[e]	1.5	1.5	1.5	1.5	1.5
Philippines, secondary	3.1	3.3	3.4	3.5	3.6
Sri Lanka, secondary[e]	1.0	1.0	1.0	1.0	1.0
Thailand, secondary	.8	1.1	1.1	.8	1.2
Turkey:					
Primary	2.2	2.0	2.0	4.9	5.0
Secondary	1.0	1.0	1.0	1.0	1.0
Total	3.2	3.0	3.0	5.9	6.0
Oceania:					
Australia:					
Primary	181.9	181.5	204.0	215.6	[2]200.5
Secondary	29.6	36.5	35.1	42.0	[2]32.6
Total	211.5	218.0	239.1	257.6	[2]233.1
New Zealand, secondary[e]	3.0	3.0	4.0	5.0	4.0
Grand total	5,146.1	5,318.4	5,425.9	5,597.8	5,301.9
Of which:					
Primary	3,231.7	3,195.9	3,303.3	3,330.9	3,246.9
Secondary	1,914.4	2,122.5	2,122.6	2,266.9	2,055.0

[e]Estimated. [p]Preliminary.
[1]Table includes data available through June 24, 1981. Data included represent the total output of refined lead by each country, whether derived from ores and concentrates (primary) or scrap (secondary), and include the lead content of antimonial lead, but exclude, to the extent possible, simple remelting of scrap, particularly new scrap, unless otherwise noted.
[2]Reported figure.

Lime

By J. W. Pressler[1]

Lime output in 1980, including that for Puerto Rico, decreased 9% to 19.0 million tons, compared with that of 1979, and was the lowest since 1968. Total value was $847 million, a 2% decrease compared with that of 1979.

In 1980, output of agricultural lime increased 11%, while output of refractory lime, construction lime, and chemical and industrial lime decreased 38%, 12%, and 8%, respectively.

Legislation and Government Programs.—On May 19, 1980, in the United States Court of Appeals, the National Lime Association successfully challenged the new source performance standards for lime manufacturing plants as issued by the Environmental Protection Agency (EPA) under Section 111 of the Clean Air Act. The standards limited the mass of particulate that may be emitted in the exhaust gas from lime hydrating and limited the permitted visibility of exhaust gas emission from some facilities manufacturing lime. The court concluded that the administrative record did not support the "achievability" of the promulgated standards for the industry as a whole, and that a uniform standard must be capable of being met under the most adverse conditions which can be reasonably expected to recur, and which are not or cannot be taken into account in determining the costs of compliance. The EPA's failure to consider the representativeness of the data relied upon was the primary reason for the court's remand.[2]

Table 1.—Salient lime statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Number of plants	163	161	155	154	153
Sold or used by producers:					
Quicklime	16,924	16,281	16,845	17,553	15,972
Hydrated lime	2,298	2,698	2,582	2,599	2,544
Dead-burned dolomite	1,007	968	1,016	793	494
Total	20,229	19,947	20,443	20,945	19,010
Value[2]	$609,010	$666,472	$749,667	$862,459	$842,922
Average value per ton	$30.11	$33.41	$36.67	$41.18	$44.34
Lime sold	14,024	14,202	15,062	15,423	13,809
Lime used	6,205	5,745	5,381	5,522	5,201
Exports[3]	56	33	45	45	42
Imports for consumption[3]	365	423	610	640	480

[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Selling value, f.o.b. plant, excluding cost of containers.
[3]Bureau of the Census.

DOMESTIC PRODUCTION

Lime producers sold or used 19.0 million tons in 1980, compared with 21.0 million tons in 1979. Commercial sales of lime decreased 11% in 1980 to 13.8 million tons. Captive lime used by producers continued its long-term decline, with a 6% reduction in 1980 to 5.2 million tons. This was a 28% decrease from the record year of 1971.

In 1980, output of quicklime decreased 10% to 16.5 million tons. Production of hydrated lime decreased 2% to 2.6 million tons. Output of dead-burned dolomite decreased 38%, 80% below the 1956 record level of 2.4 million tons.

In 1980, five States—Ohio, Pennsylvania, Missouri, Texas, and Alabama—accounted for 47% of the total output. Compared with that of 1979, production increased 1% in Texas, but decreased 18% in Pennsylvania and Ohio, 11% in Alabama, and 7% in Missouri.

Leading producing companies in 1980 were Marblehead Lime Co. with two plants in Illinois and one each in Indiana, Michigan, Pennsylvania, and Utah; Mississippi Lime Co. in Missouri; Dravo Corp. with one plant each in Alabama, Kentucky, Louisiana, and Texas; Allied Chemical Corp. in New York; Bethlehem Steel Corp. with two plants in Pennsylvania and one in New York; Martin Marietta Corp.'s Chemical Div. in Alabama and Ohio; The Flintkote Co. with two plants in California, two in Nevada, and one each in Arizona, Utah, and Virginia; Black River Lime Co. in Kentucky; Allied Products Co. with two plants in Alabama; and United States Gypsum Co. with one plant each in Louisiana, Ohio, and Texas. These 10 companies, operating 33 plants, accounted for 47% of the total 1980 lime production.

In 1980, the seven largest lime plants, each producing more than 400,000 tons, accounted for 25% of the total lime output. Thirty-five plants produced more than 200,000 tons each and accounted for 63% of the total.

Leading individual plants in 1980 were Mississippi Lime's Ste. Genevieve plant, Allied Chemical's Syracuse plant, Dravo's Maysville plant, Marblehead's Buffington plant, and Martin Marietta's Woodville plant.

A total of 485 kilns were operational during 1980: 248 vertical kilns, 183 rotary kilns, 27 pot kilns (primitive vertical), 16 Calcimatic traveling-hearth kilns, 6 fluidized-bed kilns, 4 Ellernan kilns, 1 Maerz two-shaft vertical kiln, and 1 traveling-grate rotary kiln. Hydrators for the production of hydrate lime totaled 119 during 1980; 23 were of the batch type and 96 were of the continuous type.

In 1980, the number of lime plants in the United States decreased by 1 to 154, and compared with production in 1979, the average output per plant decreased from 135,400 to 123,600 tons per year, a 9% reduction and a reflection of poor demand during the recession year.

New Plants and Expansions.—Chemical Lime Inc., Fort Worth, Tex., announced a $10 million expansion program in mid-1980. Initial projects called for the expansion of lime production at the firm's Clifton, Tex., facility to 1,800 tons per day. A new Allis-Chalmers 10-1/2-foot-diameter by 300-foot-long rotary kiln with a capacity of 800 tons of lime per day was installed, and another kiln was modified. Phase I, new construction, is scheduled for startup in September 1981 and Phase II, kiln modification, is to begin in March 1982. Coal, provided by Chemical Coal Inc., a wholly owned subsidiary, will be pulverized for firing, with natural gas as a standby fuel. When completed, the facility will have three identical 10-1/2- by 300-foot rotary kilns in operation.[3]

United States Gypsum Co. announced plans in September 1980 for a major expansion of its New Braunfels lime plant in Comal County, Tex., which would make it the largest of 11 lime plants in Texas. The company indicated it was part of a record $150 million earmarked for capital spending projects for the year. When completed in mid-1982, it will be one of only two plants in the United States producing both high calcium and dolomitic lime. New equipment, including a 600-ton-per-day rotary kiln, will nearly double quicklime and hydrate production capacity.[4]

As part of The Anaconda Company's $20 million expansion of ore-processing facilities at its Weed concentrator in Butte, Mont., the air pollution control equipment on the lime plant will be improved by the addition of two baghouses and a wet scrubber. The project will cost $5.5 million.[5]

St. Regis Paper Co. announced in October 1980 that a Fuller Co. rotary kiln, rated at 175 tons per day, will be installed at the company's plant in Lufkin, Tex. The kiln will process recycled sludge for the production of quicklime for plant use. Startup is scheduled for the third quarter of 1981.[6]

In late 1979, Can-Am Corp. completed the

Table 2.—Lime sold or used by producers in the United States, by State and kind[1]

(Thousand short tons and thousand dollars)

State	1979 Plants	1979 Hydrated	1979 Quicklime	1979 Total[2]	1979 Value	1980 Plants	1980 Hydrated	1980 Quicklime	1980 Total[2]	1980 Value
Alabama	5	147	1,126	1,273	54,182	5	131	997	1,128	53,685
Arizona	6	--	673	673	27,186	6	--	514	514	23,904
Arkansas	3	W	W	160	6,287	3	W	W	175	7,785
California	13	W	W	r564	25,545	12	W	W	554	29,444
Colorado, Nevada, Wyoming	12	94	374	468	20,643	13	79	390	469	20,878
Connecticut	1	13	20	33	2,053	1	11	8	19	1,352
Florida	3	W	W	210	11,440	3	W	W	195	12,434
Hawaii, Idaho, Oregon, Washington	9	33	403	436	20,757	8	28	432	461	24,899
Illinois and Indiana	5	83	2,004	2,087	73,304	5	75	1,625	1,699	69,332
Iowa, Kansas, Nebraska, North Dakota, South Dakota	9	72	281	353	12,445	9	57	316	373	12,954
Kentucky, New York, Tennessee, West Virginia	9	38	2,163	2,202	87,576	9	54	2,309	2,363	99,152
Louisiana, New Mexico, Oklahoma	5	119	330	449	r21,391	5	144	294	438	23,411
Maryland	1	5	7	12	444	1	5	8	12	497
Massachusetts	2	17	181	198	9,918	2	15	165	180	10,806
Michigan	9	--	1,057	1,057	43,373	8	--	836	836	36,750
Minnesota	4	--	140	140	5,133	4	--	162	162	3,562
Mississippi	1	--	70	70	1,571	1	--	31	31	707
Missouri	3	389	1,401	1,790	70,187	3	W	W	1,667	63,733
Montana	3	--	216	216	8,965	3	--	223	223	9,001
New Jersey	1	1	--	1	61	--	--	--	--	--
Ohio	14	164	3,229	3,392	141,663	15	130	2,656	2,786	122,817
Pennsylvania	10	414	1,739	2,153	96,569	10	409	1,360	1,768	84,291
Puerto Rico	1	35	2	37	3,307	1	25	2	27	4,131
Texas	11	656	851	1,507	59,520	11	667	848	1,515	67,075
Utah	3	W	W	198	8,250	4	W	W	259	13,293
Virginia	7	102	770	872	34,935	7	105	719	824	33,872
Wisconsin	5	120	309	429	19,060	5	103	254	357	17,287
Other[3]	(4)	131	1,001	(4)	(4)	(4)	539	2,311	(4)	(4)
Total[2]	155	2,634	18,349	20,983	865,766	154	2,579	16,458	19,037	847,053

rRevised.
W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes States indicated by symbol W and exports.
[4]Included with data for each individual State.

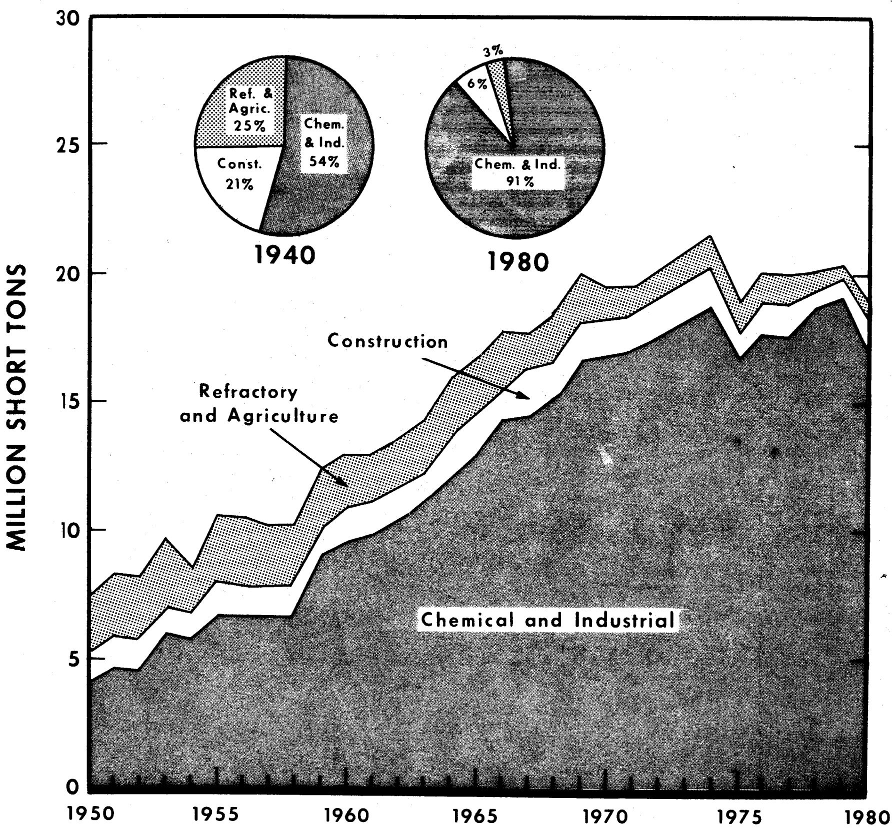

Figure 1.—Trends in major uses of lime.

installation of its new double-shaft regenerative Maerz lime kiln at its Douglas, Ariz., plant, at a cost of $5 million. The new kiln has resulted in a 440-ton-per-day increase in quicklime production and is producing lime using half of the British thermal units (Btu) necessary to calcine lime in a rotary kiln.[7]

Mississippi Lime Co. of Alton, Ill., announced in 1980 that it was adding two 12-foot-diameter by 320-foot-long rotary kilns to its plant at Ste. Genevieve, Mo. These additions are expected to be online in late 1981.[8]

Three Canadian companies were active in U.S. lime operations: Domtar Chemicals Group's Lime Div. expanded and modernized its Bellefonte, Pa., plant at a cost of $3.5 million; Steetley Industries, Ltd., through its U.S. subsidiary, Steetley Resources Inc., operated the Gibsonburg, Ohio, dolomitic lime plant and also initiated part-time operation of its dormant dolomitic quicklime plant located at Woodville, Ohio; and Steel Bros. Canada Ltd., through its U.S. subsidiary, Continental Lime, Inc., brought its lime plant onstream in Delta, Utah in late 1980.

As reported by the National Lime Association, fuel sources for the commercial lime industry through yearend 1980 were coal and coke, 66.1%; natural gas, 24.6%; oil (No. 2 and No. 6), 3.9%; electricity, 3.1%; and other and propane, 2.3%. Compared with 1978 fuel consumption, improvements were made through 1980 with a 23% reduction in the use of natural gas and a 9% decrease in the use of coal and coke.

Table 3.—Lime sold or used by producers in the United States, by size of plant[1]

(Thousand short tons)

Size of plant	1979			1980		
	Plants	Quantity	Percent of total	Plants	Quantity	Percent of total
Less than 10,000 tons	17	103	(2)	9	57	(2)
10,000 to 25,000 tons	27	428	2	29	461	2
25,000 to 50,000 tons	25	958	5	30	1,026	5
50,000 to 100,000 tons	23	1,678	8	25	1,810	10
100,000 to 200,000 tons	24	3,484	17	26	3,644	19
200,000 to 400,000 tons	31	8,711	41	28	7,192	38
More than 400,000 tons	8	5,621	27	7	4,847	25
Total	155	20,983	100	154	19,037	(3)100

[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States were Pennsylvania, Ohio, Indiana, Texas, Michigan, and New York, each of which consumed more than 1 million tons. These six States accounted for 52% of the total lime consumed.

Lime consumption in the steel industry decreased 19% in 1980 to 7.2 million tons, and equaled 38% of all lime consumed in the United States. Low housing and building starts during 1980 caused severe decreases in the sales of mason's and finishing lime, 16% and 49%, respectively. Environmental uses of lime continued to appreciate rapidly. Lime consumption in flue gas desulfurization processes and effluent water cleanup increased 39% during 1980.

Leading quicklime-consuming States in 1980 were Pennsylvania, Ohio, Indiana, Michigan, and New York, each of which consumed more than 1 million tons. These five States accounted for 48% of the total quicklime consumed.

Leading hydrate-consuming States in 1980 were Texas, Pennsylvania, Louisiana, Ohio, Illinois, and Missouri, each of which consumed more than 100,000 tons. These six States accounted for 57% of the total hydrate consumed.

Lime sold by producers in 1980 was utilized for chemical and industrial uses, 91%; construction, 6%; refractories, 3%; and agriculture, less than 1%. Captive lime used by producers was 27% of the total, compared with 26% in 1979. Captive lime was used mainly in basic oxygen furnace (BOF) steel, 28%; alkalies, 22%; and sugar, 17%.

Leading individual uses in 1980 were for BOF steel, water purification, alkalies, paper and pulp, sugar refining, and sewage treatment, which together accounted for 60% of the total consumption.

Of the main chemical and industrial uses in 1980, lime for BOF's was produced principally in Ohio (27%), Indiana and Illinois (combined, 25%), and Pennsylvania (12%). Lime for water purification was produced mainly in Missouri (35%), Alabama (11%), Pennsylvania (9%), and Texas (8%). Lime for alkalies was produced mainly in New York (70%) and Michigan (26%). Lime used for paper and pulp, excluding regenerated lime, was produced mainly in Alabama (28%), Texas (15%), and Virginia and Wisconsin (11% each). Lime for sugar refining was produced mainly in California (20%), Minnesota (17%), and Idaho (11%). Lime used for sewage treatment was produced mainly in Pennsylvania (21%), Missouri and Texas (12% each), and Alabama (9%).

Mason's lime was produced at 30 plants in 16 States, including Puerto Rico; leading States were Pennsylvania (23%) with three plants, and Wisconsin (18%) with four plants. Finishing lime was produced in six States at nine plants; the leading State was Ohio with two plants (65%).

The use of lime in agriculture increased slightly from its long-term decline to 79,000 tons in 1980, an 11% increase compared with that of 1979. Compared with its high of 250,000 tons per year in 1956, agricultural use of lime has become of small significance. Conversely, the less reactive, pulverized limestone continued its long-term upward trend with 32 million tons used in 1980.

Table 4.—Destination of shipments of lime sold or used by producers in the United States, by State[1]

(Thousand short tons)

State	1979			1980		
	Quicklime	Hydrated lime	Total[2]	Quicklime	Hydrated lime	Total[2]
Alabama	548	65	612	483	46	530
Alaska	W	W	1	W	W	1
Arizona	493	27	520	366	23	389
Arkansas	167	24	191	176	27	203
California	787	112	898	724	94	819
Colorado	212	17	230	242	15	257
Connecticut	47	17	64	33	16	49
Delaware	40	6	46	39	5	43
District of Columbia	W	W	1	W	W	1
Florida	382	60	441	386	53	439
Georgia	196	31	227	186	39	225
Hawaii	2	5	7	2	5	6
Idaho	97	3	100	116	4	119
Illinois	910	157	1,068	777	117	893
Indiana	2,023	74	2,097	1,629	70	1,699
Iowa	85	23	108	67	19	86
Kansas	97	24	120	87	18	105
Kentucky	399	20	419	443	17	460
Louisiana	209	140	349	192	161	353
Maine	34	1	35	36	1	37
Maryland	449	24	473	373	23	396
Massachusetts	59	15	74	57	16	73
Michigan	1,566	37	1,603	1,333	22	1,355
Minnesota	229	18	247	254	16	271
Mississippi	146	25	171	118	29	147
Missouri	172	51	223	155	104	259
Montana	227	11	237	241	9	250
Nebraska	69	7	76	120	6	126
Nevada	20	--	20	43	9	52
New Hampshire	W	W	1	W	W	1
New Jersey	82	58	140	88	52	140
New Mexico	89	10	99	105	13	118
New York	1,102	51	1,153	1,024	54	1,077
North Carolina	164	28	192	163	30	193
North Dakota	104	8	111	110	7	117
Ohio	2,237	144	2,380	1,798	161	1,959
Oklahoma	102	23	126	102	16	118
Oregon	109	20	130	137	11	148
Pennsylvania	2,413	249	2,662	2,067	239	2,306
Rhode Island	7	10	17	5	3	8
South Carolina	121	11	132	109	19	128
South Dakota	11	19	30	31	17	49
Tennessee	164	70	234	156	71	227
Texas	866	672	1,537	862	673	1,535
Utah	140	22	161	153	12	166
Vermont	W	W	1	W	W	1
Virginia	140	66	206	132	76	208
Washington	257	18	275	262	16	277
West Virginia	387	42	429	290	37	327
Wisconsin	126	51	177	108	52	160
Wyoming	34	17	50	35	14	48
Other States[3]	3	36	39	4	14	18
Total United States[2]	r18,321	2,619	20,940	16,414	2,551	18,965
Exports:						
Canada	19	10	29	20	10	31
Mexico	--	--	--	20	--	20
Other countries	9	5	14	4	17	22
Total exports[2]	28	15	43	44	28	72
Grand total	18,349	2,634	20,983	16,458	2,579	19,037

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other States."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes Puerto Rico, the Virgin Islands, and States indicated by symbol W.

Table 5.—Lime sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1979				1980			
	Sold	Used	Total[2]	Value	Sold	Used	Total[2]	Value
Agriculture	71	--	71	3,286	79	--	79	3,727
Construction:								
Road stabilization	--	--	--	--	554	--	554	26,845
Soil stabilization[3]	695	--	695	32,340	170	--	170	8,226
Mason's lime	350	41	391	18,209	288	40	328	15,916
Finishing lime	195	--	195	9,093	99	--	99	4,777
Other construction uses	34	35	69	3,203	16	27	44	2,111
Total[2]	1,274	76	1,350	62,845	1,126	68	1,194	57,872
Chemical and industrial:								
Steel, BOF	5,611	1,706	7,317	295,493	4,409	1,441	5,850	256,469
Water purification	1,631	9	1,640	66,225	1,487	9	1,496	65,603
Alkalies	6	1,252	1,258	50,804	6	1,167	1,173	51,407
Paper and pulp	1,149	109	1,258	50,788	1,039	116	1,156	50,658
Sugar refining	47	727	774	31,277	58	909	967	42,414
Sewage treatment	799	16	815	32,902	848	12	860	37,705
Steel, electric	964	28	992	40,066	755	34	789	34,556
Sulfur removal	604	--	604	24,393	743	--	743	32,566
Copper ore concentration	427	344	771	31,133	340	318	658	28,859
Magnesia from seawater or brine	W	W	682	27,544	W	W	648	28,414
Steel, open-hearth	603	49	652	26,321	564	38	602	26,407
Acid mine water	215	70	285	11,515	419	70	490	21,467
Aluminum and bauxite	162	111	273	11,031	160	114	275	12,036
Magnesium metal	W	W	177	7,145	W	W	187	8,193
Calcium carbide	146	72	218	8,823	121	63	185	8,103
Glass	191	--	191	7,715	180	--	180	7,910
Precipitated calcium carbonate	67	52	119	4,778	65	47	112	4,905
Petrochemicals	71	--	71	2,867	99	--	99	4,327
Petroleum refining	53	--	53	2,125	59	--	59	2,567
Oil well drilling	62	--	62	2,504	39	--	39	1,689
Food products	90	30	120	4,829	37	--	37	1,602
Metallurgy, other	55	3	58	2,359	31	4	35	1,518
Oil and grease	W	W	W	W	32	--	32	1,395
Tanning	28	--	28	1,140	28	--	28	1,243
Ore concentration, other	15	--	15	620	18	--	18	773
Wire drawing	2	1	3	101	13	--	13	581
Brick, sand-lime	9	--	9	358	6	--	6	262
Fertilizer	W	W	W	W	5	--	5	209
Insecticides	2	--	2	63	3	--	3	152
Paint	3	--	3	103	2	--	2	102
Calcium silicate	11	--	11	429	--	--	--	--
Gelatin	7	--	7	266	--	--	--	--
Rubber	5	--	5	219	W	W	W	W
Other uses[4]	411	742	296	12,024	645	714	523	23,053
Total[2]	13,446	5,323	18,769	757,960	12,211	5,059	17,269	757,145
Refractory dolomite	670	123	793	41,676	420	75	494	28,308
Grand total[2]	15,461	5,522	20,983	865,766	13,836	5,201	19,037	847,053

W Withheld to avoid disclosing company proprietary data; included in "Other uses."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes road stabilization (1979).
[4]Includes chrome, coke and gas, explosives, manganese (1980), silica brick, other uses, and uses indicated by symbol W.

PRICES

The average value of lime sold or used by producers in 1980 was $44.50 per ton, an increase of 8% over the 1979 price of $41.26 and an increase of 155% over the 1973 price of $17.42. Values ranged from $43.84 for chemical and industrial lime to $48.47 for construction lime, $57.29 for refractory dolomite, and $47.04 for lime used in agriculture.

Values for quicklime sold ranged from $43.82 for chemical lime to $51.53 for construction lime, $36.67 for lime used in agriculture, and $54.27 for dead-burned dolomite, and averaged $44.30, an increase of 11% over the 1979 value.

Values for hydrated lime sold ranged from $49.01 for construction lime to $49.35 for chemical lime and $51.91 for lime used in agriculture, and averaged $49.39, an increase of 3% over the 1979 price.

FOREIGN TRADE

Exports of lime decreased 8% to 41,843 tons, 39% below the 1968 record. Of the total exports, Canada received 57%, Mexico received 28%, Guyana received 5%, and Trinidad received 4%. The remaining 6% went to 29 countries. The order of shipments was as follows: Bahamas, the Philippines, Bermuda, Venezuela, Guatemala, Brazil, Saudi Arabia, Italy, Kuwait, Angola, Israel, Japan, Panama, the Netherlands Antilles, the Republic of South Africa, Peru, the Netherlands, Sweden, Western Samoa, Chile, Costa Rica, Nigeria, the Leeward and Windward Islands, New Zealand, Australia, Colombia, the Federal Republic of Germany, the Republic of Korea, and Ireland.

Imports of lime have grown at an average rate of over 14% during the last 10 years. Imports from Canada (96%) and Mexico (4%) were 480,000 tons, a decrease of 25% compared with that of 1979. Net import reliance, expressed as a percentage of apparent consumption, was 2%.

Table 6.—U.S. exports of lime

Year	Quantity (short tons)	Value (thousands)
1978	44,794	$3,082
1979	45,421	3,827
1980	41,843	3,990

Table 7.—U.S. imports for consumption of lime

	Hydrated lime		Other lime		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	62,290	$2,491	547,830	$16,663	610,120	$19,154
1979	85,169	3,450	554,332	19,165	[1]639,500	[1]22,614
1980	62,423	3,129	417,792	16,044	480,215	19,173

[1]Data do not add to total shown because of independent rounding.

WORLD REVIEW

Lime is produced all over the world, mainly in the heavily industrialized nations. Large quantities of lime are produced in many countries of the world in small, primitive pot and vertical kilns. The quicklime is used in the manufacture of mortar and plaster in the construction of homes and buildings. Production statistics are not reported and estimates can only be made that the quantities are substantial. Source materials are adequate. The United States, with 15% of the total, ranked second in world production in 1980, following the U.S.S.R.

A complete coverage of the United Kingdom and 12 other Western European lime-producing countries was presented in the May 1981 issue of Industrial Minerals magazine of London. Detailed description of plants, locations, production statistics, end-use patterns, and trade statistics for the latest year were given.[9]

Canada.—Canadian producer lime shipments in 1980 were 2.3 million tons, a 1% decrease compared with that of 1979. More resistant to the economic slowdown than U.S. domestic shipments, markets were good in the eastern and western Provinces and stable in the central Provinces. In 1979, 18 companies operated 23 lime plants in Canada: 1 in New Brunswick; 4 in Quebec; 10 in Ontario; 2 in Manitoba; 4 in Alberta; and 2 in British Columbia. Eighty-three kilns were available: 30 rotary, 50 vertical, and 3 rotary-grate. Principal uses were in iron and steel plants (48%), pulp mills (19%), uranium plants (3%), nonferrous smelters (3%), cyanide and flotation mills (3%), and other (24%). Energy consumption averaged 5.8 gigajoules per short ton of production (5.5 million Btu per short ton).[10]

Germany, Federal Republic of.—The Federal Republic of Germany ranked fourth in world production of lime in 1980 with 9.9 million tons. The Wülfrath Group of German companies dominated West German lime production with approximately 28% of the total and was a leader in the European rock products field. Wülfrath's principal operations are located in the Flandersbach area in central Germany, where two lime plants are fed by conveyor belts from the quarries. The main source of energy is natural gas. Most lime deliveries are made by rail, and construction materials are delivered by truck. Roughly half the sales are to the iron and steel industry; the other half is divided between the chemical and associated industries, the building material industry, the building trade industry, mining, agriculture, and the animal feedstuff industry.[11]

Ghana.—A Ghanaian joint venture with Ceramica Cordeiro of Brazil to develop a limestone quarry and install a lime kiln and hydrator at Buipe in northern Ghana was announced in 1980. The $11.3 million project, including a 44,000-ton-per-year lime kiln, was scheduled to attain production by 1982.[12]

Ireland.—The old Drogheda wet-process cement plant of Irish Cement, Ltd., was converted to a new 100,000-ton-per-year dead-burned-magnesia-from-seawater plant and was placed onstream in 1980. The new company, Premier Periclase, Ltd., is now producing high-quality, dead-burned periclase for the refractory industry. To produce milk of lime for the process, the F. L. Smidth 13-foot-diameter by 425-foot-long oil-fired rotary kiln, retained from the former cement plant, was converted to a 500-ton-per-day quicklime manufacturing unit and was followed by a slaking unit to produce a 20% milk of lime for the seawater reactor.[13]

Libya.—A new 300-ton-per-day quicklime and hydrated lime manufacturing facility is being set up in Souk el Khamis near Tripoli to produce products for the building industry. Babcock Krauss-Maffei Industrieanlagen GmbH of München received an order from the Secretary of Heavy Industries for a turnkey operation. Production is scheduled for mid-1982.[14]

Mexico.—Mexico produced 4.8 million tons of lime in 1980, equal to 4% of the world production, making it the second largest producer in North America next to the United States. In 1979, 27 plants were spread throughout 16 States, but almost 80% of the production was restricted to just 5 States: At Monclova in Coahuila State; Calera in Hidalgo State; Huescalpa and Tamazulita in Jalisco State; Apasco in Mexico State; and Monterrey in the State of Nuevo Leon. The construction industry consumed over 76% of the total supply, distantly followed by soil amendment (11%), sugar refining (6%), pulp and paper (3%), and other (4%). In 1978, Fideicomiso Minerales No Metalicos Mexicanos initiated production of a lime plant through its subsidiary, Sonocal S.A. de CV. Located at Naco, just on the Mexican side of the U.S. border in the State of Sonora, production was principally designed for export to the United States with an initial capacity of 250 tons per day of lime and was scheduled to increase to 770 tons per day with the commissioning of a second kiln in 1980. The principal market was the copper mining industry in Arizona.[15]

Mongolia.—The Mongolian Komplexim-port Association signed a contract in 1980 with the Al-Union Teckhnostraveksport Association in Ulan Bator for the construction of the Hotd cement and lime complex. The lime facility will have a capacity of 70,000 tons per year, and the cement plant, a capacity of 550,000 tons per year.[16]

Paraguay.—Industria Nacional Del Cemento is building a 550,000-ton-per-year agricultural lime plant at Puerto Vallemi for Phoenix Agricola. Production was expected to start in May 1980.[17]

Tunisia.—The Société Tunisienne De Chaux is planning the construction of two lime plants with capacities of 200,000 tons per year each.[18]

United Arab Emirates.—The Ra's al Khaymah Lime Co. produced 44,000 tons of hydrated lime in 1980. All production was marketed in the United Arab Emirates and other gulf Arab countries.[19]

United Kingdom.—For the first time, lime production statistics were made available for Great Britain. A 1974-79 historical time-series was presented in the May 1981 issue of Industrial Minerals magazine of London. Detailed plant descriptions, locations, and end-use patterns were given. Production statistics are given in table 8 in this chapter.[20]

Pioneer Mortars (UK) Ltd., a wholly owned subsidiary of Pioneer Concrete Services Ltd., opened their seventh British lime-sand mortar plant at Charlton in 1980. This plant is the first of a new purpose-built range of plants designed for the efficient production of lime-sand mortars for the building industry.[21]

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	[r]1,765	2,094	2,242	2,306	[3]2,274
Costa Rica[e]	6	7	8	10	8
Dominican Republic	[r]24	[r]23	[e]28	42	44
Guatemala	50	[r]50	49	45	[3]39
Jamaica	134	[r]159	173	225	[3]175
Mexico	[e]3,850	[e]4,575	[e]4,900	5,047	4,800
Nicaragua[e]	29	40	41	40	44
United States, including Puerto Rico (sold or used by producers)	20,257	19,987	20,484	20,983	[3]19,037
South America:					
Brazil[e]	4,740	4,960	4,960	4,960	4,960
Chile[e]	660	680	680	700	700
Colombia[e]	1,100	1,430	1,430	1,430	1,430
Paraguay	35	[r]59	42	36	40
Peru	([4])	([4])	([4])	([4])	([4])
Uruguay	77	77	94	89	88
Europe:					
Austria	1,057	1,068	1,120	1,127	[3]1,213
Belgium	[r]2,770	[r]2,743	2,723	2,919	3,090
Bulgaria	1,763	1,901	1,964	2,059	[3]2,049
Czechoslovakia	3,292	3,330	3,393	3,272	[3]3,327
Denmark	255	191	179	195	187
Finland	[r]276	259	214	300	275
France	5,124	[r]4,904	5,116	[r] [e]5,200	5,300
German Democratic Republic	3,752	3,711	3,795	3,825	3,860
Germany, Federal Republic of	[r]10,390	9,667	9,910	10,183	9,900
Hungary	807	819	816	787	761
Ireland	76	88	101	80	77
Italy	2,412	2,421	2,360	2,441	2,650
Malta	30	35	31	33	34
Norway	99	113	139	[r] [e]143	143
Poland[5]	8,947	9,521	10,070	8,435	8,270
Portugal	245	250	286	[e]300	290
Romania	3,660	3,798	4,031	4,221	4,300
Spain[e]	440	440	390	440	500
Sweden[6]	945	[r]847	825	[e]900	880
Switzerland	78	73	75	77	83
United Kingdom[3]	3,986	3,574	3,470	3,649	3,285
U.S.S.R.[e]	25,000	26,000	26,000	[r]26,500	27,000
Yugoslavia	2,124	2,256	2,265	2,647	2,645
Africa:					
Algeria[e]	36	44	55	90	100
Burundi	[r]1	1	([4])	([4])	([4])
Egypt[e]	90	100	100	100	[3]97
Kenya	33	86	[e]55	[e]30	33
Libya	358	[r] [e]330	243	[e]250	255
Malawi	([4])	--	--	--	--
Mauritius	8	[r]8	9	9	9
Mozambique[e]	110	110	10	10	10
South Africa, Republic of (sales)	1,529	1,658	2,067	1,897	2,200
Tanzania[e]	2	2	3	3	3
Tunisia	351	373	471	474	[3]583
Uganda[e]	22	22	28	[r]31	30
Zaire	[e]120	111	110	110	110
Zambia	159	[e]280	[e]280	180	[3]201
Asia:					
Cyprus	35	31	17	20	18
India[e]	200	200	220	450	440
Iran[e]	1,100	1,100	1,000	550	550
Israel	220	112	137	124	123
Japan	10,115	9,945	9,985	10,613	10,700
Jordan	3	3	3	4	4
Korea, Republic of	[e]120	66	[e]66	[e]66	[3]231
Kuwait	13	22	4	13	13
Lebanon	[e]200	179	111	130	130
Mongolia	[e]40	41	40	44	44
Philippines	30	31	37	59	60
Saudi Arabia[e]	17	22	33	[r]165	165
Taiwan	181	[r]196	211	195	[3]220
United Arab Emirates	NA	NA	NA	NA	[3]44

See footnotes at end of table.

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Oceania:					
Australia[7]	r995	r945	981	r e1,200	1,300
Fiji Islands	3	2	1	1	2
New Zealand[e]	180	190	175	190	190
Total	r126,526	r128,360	130,856	132,654	131,623

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 2, 1981.
[2]Lime is produced in many other countries besides those listed. Argentina, mainland China, Iraq, Pakistan, Syria, Turkey, and Venezuela are among the more important countries for which official data are unavailable.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Excludes output by small producers.
[6]Series reflects total production, not sales, as stated in previous editions of this chapter.
[7]Data are for years ending June 30 of that stated.

TECHNOLOGY

Expanded operations, based on a new and unusual calcining system, were launched with the commissioning of a 440-ton-per-day two-shaft regenerative Maerz-Ofenbau kiln in late 1979 at the Paul Spur, Ariz., plant of the Paul Lime Div., Can-Am Corp. The fuel-efficient, vertical kiln is the first of its type on the North American Continent and is producing quicklime with a fuel consumption of less than 4 million Btu per ton of product. Similar units are now operating in Europe, Japan, and South America. A key factor in the choice of this system was the flexibility of the parallel flow regenerative calciner, which permits mid-production changes in feed size without process disruption. This was attractive for the Paul Lime operation because a smaller feed size, processed for one of two existing kilns—a long rotary and a short preheater type—could, if necessary, be accepted by the new two-shaft calciner. The system, natural gas-fired since startup, is adaptable to oil firing and will become coal-fired by 1982.[22]

Skyrocketing fuel prices have caused the combination of the rotary kiln with a convection preheater to become an increasingly popular system for lime calcining during recent years. Lowered exhaust temperatures result in improved efficiencies in the kiln system. Heat losses occur principally from kiln structure radiation and convection, calcining zone terminal temperature, and nonrecuperative cooling of the lime. If the losses in these areas and stack losses are minimized, maximum heat efficiency will be attained. The decomposition of limestone to produce 1 ton of lime requires approximately 2.5 million Btu above the disassociation temperature of 1,700° F. The basic principles of rotary kiln-preheater systems have indicated that the loss due to calcining zone terminal temperature differential is practically eliminated by the preheater. The only large heat loss remaining is the radiation and convection loss from the shell and flue systems and by the flame temperature; this, and further improvements in efficiency will require improvements in material design and techniques for maximizing thermal utilization.[23]

The interaction of small quantities of sodium chloride (NaCl) with limestone during calcination was shown to increase the average pore diameters of the lime particles. For 28 limestones, pore diameters increased from an overall average of 0.14 to 1.8 micrometers for 2.0 weight-percent NaCl addition. These structural changes are thought to result from the formation of trace amounts of liquid phase at high temperatures, which increases the ionic diffusion of the system. Controlled use of salt additives can result in a pore structure favorable to subsequent reactions involving gas or liquid phases. The effectiveness of the salt addition in promoting changes in pore distribution is dependent on the impurity content of the original limestone.[24]

National Lime Association's "Limeographs" described a British application of lime to detoxify a hazardous waste dump. Acid tars and other motor oil process wastes had been placed on a 6-acre site; previous treatment with concentrated sulfuric acid caused the sludge to bubble. Some 16,000 tons of waste were excavated by bucket elevator and mixed with lime in proportions of 4:1 to 8:1, depending on degree of contamination. During treatment, the material occasionally burst into flames. The resultant dry and sandy alkaline material was then sealed, covered with topsoil, and seeded.[25]

The first installation of an industrial dry scrubber was described as a $1.2 million project for Celanese Fibers at Cumberland, Md. A finely atomized lime slurry was injected into a spray dryer, where the gases evaporate the moisture, leaving a fine, dry waste. Wheelabrator-Frye, Inc., and Rockwell International Corp. were responsible for the system.[26]

Two Flintkote Co. lime plants met rigid air quality standards through use of a second generation of dry scrubbers to remove as much as 95% of the particulates in the exhaust gas from the kiln. Electrostatic grids were added in 1979 to scrubbers installed at Nelson, Ariz., and Grantsville, Utah. Diagrams were presented showing the electroscrubber and the design incorporating the pneumatic system. Retrofitting an electrostatic grid was the next step, with the grid voltage as high as 80,000 to 100,000 volts while maintaining minimum power usage of less than 10 watts per 1,000 ambient cubic feet of exhaust gas. The electrical range need not be altered to accommodate various elements such as particle types, inlet gas temperatures, and specific fuels used.[27]

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[1]Physical scientist, Section of Nonmetallic Minerals.

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[18]U.S. Embassy, Tunis, Tunisia. State Department Cable 5585, July 11, 1980.

[19]Industrial Minerals (London). Company News and Mineral Notes. No. 164, May 1981, p. 73.

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Lithium

By James P. Searls[1]

The United States continued as both the world's largest producer and the world's largest consumer of lithium minerals and chemicals. The United States was self-sufficient in this commodity and was the world's largest exporter. Domestic production declined slightly in 1980. Imports were minor in 1980. U.S. exports were estimated to have risen slightly while apparent consumption declined 6%.

World supply declined slightly due to the U.S. decline in production. The rest of the world production did not increase significantly. World consumption was estimated to have declined slightly to 7,400 short tons of contained lithium. Aluminum potlines continued to be the world's largest end use for lithium. About one-third of the U.S. and one-fifth of European aluminum potlines used lithium. Use in aluminum potlines in other countries is unknown.

Japan imported 277 short tons of lithium carbonate and the United States imported 16 short tons of lithium carbonate from mainland China. Japan also imported about 3 short tons of lithium hydroxide from China.

The United States and the U.S.S.R. are the world's primary lithium producers. The United States continued to supply about three-fourths of demand in nonproducing countries; the remainder was supplied by the U.S.S.R. and mainland China as chemicals, and by Zimbabwe as mineral concentrate. Brazil, Portugal, and Argentina produce primarily for internal consumption. The Federal Republic of Germany and Japan are large importers of lithium chemicals, primarily lithium carbonate, which they use or convert for resale to their export markets.

Legislation and Government Programs.—No lithium hydroxide monohydrate was sold from the General Services Administration (GSA) excess stock in 1980. GSA reports that it has 11,500 short tons

Table 1.—Salient statistics on lithium

(Short tons of contained lithium)

	1976	1977	1978	1979	1980
United States:					
Production[1]	W	W	W	W	W
Yearend producers' stocks[1]	W	W	W	W	W
Imports[1]	10	10	10	50	90
Shipments of government stockpile surplus[2]	164	253	5	--	--
Supply[1] [3]	5,200	6,900	6,300	6,300	6,200
Supply[e] [2] [4]	4,400	5,900	5,400	5,600	5,500
Exports[e] [2]	1,600	1,800	2,000	2,400	2,500
Apparent consumption[e] [2]	2,800	4,100	3,400	3,200	3,000
Rest of world: Production[e] [1]	2,000	2,000	2,000	2,250	2,250

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Mineral concentrate.
[2]Chemicals.
[3]Production plus inventory decrease.
[4]A 15% loss was assumed in converting supply from mineral concentrate to the chemical form. Changes in producers' inventories of lithium chemicals were unknown and were assumed to be zero. An estimated 50 short tons of imported chemicals are included.

(1,898 short tons of contained lithium) of virgin material and 28,500 short tons (4,703 short tons of contained lithium) of depleted material (depleted of lithium 6) that may contain 8 to 9 parts per million of mercury. This material was excess from a nuclear weapons program.

A Federal law was passed and signed that could encourage the consumption of lithium in the future. Public Law 96-386 was passed and signed in October 1980. This law provided for an accelerated program of magnetic fusion energy technologies research and development. Fusion energy, as presently planned, would use lithium in large amounts to convert the fusion energy to heat energy for electricity production.

DOMESTIC PRODUCTION

There were two lithium producers in the United States in 1980. Foote Mineral Co., 92% owned by Newmont Mining Corp., produced lithium ore from pegmatite dikes in North Carolina and lithium compounds from subsurface brines in Nevada. Lithium Corp. of America (Lithco), owned by Gulf Resources and Chemical Corp., produced lithium from pegmatite dikes in North Carolina. Production and sales data reported to the Bureau of Mines are withheld to avoid disclosing company proprietary data.

Foote Mineral Co. reported[2] production of approximately 13,850 tons of Li_2CO_3 equivalent (2,604 tons of contained lithium) in 1980; 7,000 tons (1,316 tons of contained lithium) from the North Carolina plant and 6,850 tons (1,288 tons of contained lithium) from the Nevada plant. Foote Mineral Co. raised the North Carolina plant capacity rating from 7,000 tons to 9,000 tons per year of Li_2CO_3 equivalent during late 1980. Lithco reported[3] production of approximately 14,250 tons of Li_2CO_3 equivalent (2,679 tons of contained lithium) from its North Carolina plant. Lithco also reported that, in 1980, 41% of its sales were to foreign customers. Annual mill capacity rating at Lithco's North Carolina plant was raised from 14,000 tons Li_2CO_3 equivalent (2,632 tons of contained lithium) to 15,000 tons Li_2CO_3 equivalent (2,820 tons of contained lithium) during 1980. Lithco expects to increase annual plant capacity to 18,000 tons Li_2CO_3 equivalent (3,384 tons of contained lithium) by mid-1981 and 22,000 tons (4,136 tons contained lithium) by the mid-1980's.

CONSUMPTION AND USES

Some mineral concentrate, possibly as much as 10%, was used directly by the ceramics industry, but most concentrate was converted to lithium chemicals and metal. The Bureau of Mines estimates a 15% loss in conversion from ore to lithium carbonate. Lithium chemicals are used by the aluminum, air-conditioning, ceramics, grease, specialty glasses, synthetic rubber, thermoplastic, and primary battery industries.

Apparent domestic consumption of all lithium-containing products was estimated to have decreased about 6% in 1980. Changes in producers' inventories were unknown and assumed to be zero. Lithium consumption declined due to the decreased demand for frit for whiteware for the home building industry, the decline in rubbermaking, the decline in aluminum production in the Northwest and Texas, lower consumption of aluminum welding supplies, and lower consumption of lithium bromide for large air-conditioning units. The demand for lithium-based greases and lithium metal and salts for batteries increased.

PRICES

Domestic prices for lithium chemicals increased at a rate that was slightly higher than the consumer price index. The price of lithium metal increased at about double the consumer price index, probably owing to energy costs.

Table 2.—Domestic midyear producer's prices of lithium and lithium compounds

(Dollars per pound)

	1979	1980
Lithium bromide, 54% brine: 2,268-pound lots, delivered in drums	2.93	3.31
Lithium carbonate, technical: Truckload lots, delivered	1.025	1.205
Lithium chloride, anhydrous, technical: Truckload lots, delivered	1.70	1.93
Lithium fluoride	3.42	3.90
Lithium hydroxide monohydrate: Truckload lots, delivered	1.40	1.60
Lithium metal ingot: 1,000-pound lots, f.o.b	15.65	17.15
Lithium sulfate, anhydrous	1.93	2.12
N-butyllithium in n-hexane (15%): 3,000-pound lots, delivered	9.08	11.30

FOREIGN TRADE

U.S. exports of lithium chemicals (shown in tables 3 and 4) and metal are not completely reported in available Bureau of Census trade statistics. However, review of trade data of major lithium-importing countries indicates a slight increase in 1980. U.S. imports are shown in table 5.

Table 3.—U.S. exports of lithium compounds

(Gross weight)

Country	1979		1980	
	Quantity (pounds)	Value (dollars)	Quantity (pounds)	Value (dollars)
Australia	251,476	466,190	248,932	615,709
Belgium	127,317	184,512	177,147	234,916
Canada	1,591,898	1,839,050	2,071,414	2,664,753
Germany, Federal Republic of	7,264,390	6,703,216	8,446,484	8,998,095
India	17,137	23,980	235,089	316,147
Japan	4,048,992	3,735,021	3,947,845	4,227,497
Korea, Republic of	261,867	239,844	106,920	132,011
Mexico	413,765	586,497	409,537	802,078
Netherlands	367,924	401,000	193,031	206,510
South Africa, Republic of	59,083	50,975	327,777	316,767
Spain	2,320	6,972	264,124	489,290
United Kingdom	683,843	1,154,946	391,397	448,120
Venezuela	3,158,386	3,135,315	3,220,641	3,622,307
Other	342,484	586,572	526,456	1,010,076
Total	[r]18,590,882	[r]19,114,090	20,566,794	24,084,276

[r]Revised.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 4.—U.S. exports of lithium hydroxide

Destination	1979 Quantity (pounds)	1979 Value (dollars)	1980 Quantity (pounds)	1980 Value (dollars)
Argentina	123,000	172,790	89,646	140,781
Australia	140,400	192,496	248,913	346,077
Belgium	60,800	70,528	249,200	345,024
Brazil	726,667	896,088	517,018	655,982
Canada	352,342	478,565	285,665	441,063
Egypt	--	--	77,074	115,945
France	123,258	170,524	187,046	299,377
Germany, Federal Republic of	890,164	1,153,727	1,573,400	2,170,239
India	30,020	42,848	353,400	465,113
Italy	11,000	14,925	90,468	144,452
Japan	1,004,263	1,402,752	852,391	1,255,327
Kenya	--	--	66,112	98,155
Mexico	296,800	394,086	389,411	602,432
Philippines	43,825	60,454	151,967	233,703
South Africa, Republic of	306,789	401,764	271,600	382,765
Spain	33,002	45,342	184,200	263,840
Sweden	163,572	212,951	64,920	93,776
United Kingdom	1,101,537	1,484,108	511,456	787,823
Venezuela	65,600	88,528	105,600	143,896
Other	324,958	445,246	411,231	614,673
Total	5,797,997	7,727,722	6,680,718	9,600,443

Source: U.S. Department of Commerce, Bureau of the Census.

Table 5.—U.S. imports for consumption of lithium-bearing materials

Commodity and country	1979 Gross weight (pounds)	1979 Value (thousand dollars) Customs	1979 Value (thousand dollars) C.I.F.	1980 Gross weight (pounds)	1980 Value (thousand dollars) Customs	1980 Value (thousand dollars) C.I.F.
Lithium ores:						
Canada	1,010,540	19	23	902,280	17	23
Netherlands	--	--	--	45,680	1	1
Norway	2,442,180	44	63	2,879,540	51	72
South Africa, Republic of	5,328,518	353	369	7,739,844	459	576
Total	8,781,238	416	455	11,567,344	528	672
Lithium compounds:						
Bahamas	--	--	--	72	1	2
Belgium	--	--	--	44,092	48	50
Canada	1,000	1	1	500	(1)	1
China, mainland	--	--	--	32,805	32	38
France	43,399	1,821	1,837	30,003	1,477	1,496
Germany, Federal Republic of	10,234	162	167	13,617	249	254
Israel	44	1	1	--	--	--
Japan	5	2	3	37	17	17
Switzerland	--	--	--	2,205	1	1
United Kingdom	35	8	8	268	16	17
Total	54,717	1,995	2,017	123,599	1,841	1,876
Lithium salts:						
Denmark	58	2	2	48	2	2
Germany, Federal Republic of	55	20	20	10	5	5
Switzerland	198	1	1	--	--	--
United Kingdom	17	(1)	(1)	--	--	--
Total	328	23	23	58	7	7

[1]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 6.—Lithium minerals: World production, by country[1]

(Short tons)

Country[2] and minerals produced	1976	1977	1978	1979^p	1980^e
Argentina (minerals not specified)	744	454	885	200	550
Brazil:					
Amblygonite	204	539	478	206	500
Lepidolite	1,468	638	353	64	330
Petalite	1,067	1,133	2,200	1,655	2,220
Spodumene	455	^{r}136	976	^{e}880	880
Canada, spodumene[3]	68	--	--	--	--
China, mainland (minerals not specified)^e [4]	10,000	11,000	11,000	11,000	15,000
Mozambique:					
Lepidolite^e	800	--	--	--	--
Spodumene^e	30	--	--	--	--
Namibia (minerals not specified)[5]	6,520	2,809	NA	NA	NA
Portugal, lepidolite	^{r}1,300	^{r}1,300	1,300	1,100	1,050
Rwanda, amblygonite^e	^{r}33	^{r}33	31	NA	NA
U.S.S.R. (minerals not specified)^e [4]	50,000	55,000	55,000	55,000	55,000
United States (minerals not specified)	W	W	W	W	W
Zimbabwe (minerals not specified)	^{e}10,000	^{e}10,000	^{r} ^{e}11,000	14,405	16,500

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 5, 1981.

[2]In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.

[3]Data represent U.S. imports from Canada; official Canadian sources report no production since 1965, but the United States has imported lithium minerals in most years since that time. It is not clear whether these imports are from (1) accumulated stocks (2) test production quantities not reported in official Canadian statistics (3) Canadian imports, or (4) any combination of these sources.

[4]These estimates denote only an approximate order of magnitude; no basis for more exacting estimates is available. Output by mainland China and the U.S.S.R. have never been reported.

[5]Output has not been officially reported since 1966, but presumably production has continued because a number of countries record imports from "South Africa," which no longer produces lithium minerals. Data given represent imports by the United States. EC and Spain reported imports as originating in South Africa, but the reader is cautioned that a portion of this material may have been mined in Zimbabwe. In 1966 actual output from Namibia totaled 1,739 short tons including amblygonite—30, lepidolite—365, and petalite—1,344.

WORLD REVIEW

Chile.—In August, Foote Mineral Co. announced the formation of Sociedad Chilena de Lithio Ltda. as a partnership with Corporacíon de Fomento de la Producción (CORFO), the Chilean Government development company. Foote Mineral Co. owns 55% of the partnership and CORFO owns 45%. A detailed engineering study was the next step, reportedly to lead to a final decision on construction of a plant to produce lithium salts from the brines of the Salar de Atacama. Initial plant capacity is put at 1,128 tons of contained lithium in the form of lithium carbonate.

European Community (EC).—Following the provisional antidumping duty of 1979 concerning lithium hydroxide monohydrate, the EC Council of Ministers in 1980 imposed a definitive duty equal to the difference between the normal price ($1.59 per pound in February, later $1.66 per pound in September) and the free-at-frontier price. The EC sole producer, Metallgesellschaft AG, was considering halting production if protective measures were not introduced. The procedure was terminated for Foote Mineral Co. since Foote had agreed to respect the normal price. In 1979, the EC market for lithium hydroxide was placed at 409 tons of contained lithium.

United Kingdom.—In December, Lithco opened its organometallic catalyst (butyllithium) plant near Liverpool. This plant was established to supply Europe with organometallic catalysts for specialty rubber and polymers. Plant capacity was put at 200,000 pounds of butyllithium per year, expandable to 600,000 pounds.

TECHNOLOGY

The Bureau of Mines Salt Lake City Research Center continued its efforts to extract lithium from hectorite clays available in the McDermot Caldera on the Nevada-Oregon border. Lime-gypsum roasting and selective chlorination processes (followed by a water leach) were tested. These processes do not convert the magnesium, aluminum, or silicon present to water-soluble products.

The Bureau of Mines Reno Research Center was studying the recovery of lithium, among other metals, from the brines of the Imperial Valley, Calif., geothermal wells. The brine would be brought to the surface in large volumes for electricity production. Should the lithium recovery process be economic with a reasonable lithium recovery rate, there is a potential for significant amounts of lithium production.

The Bureau of Mines Albany Research Center published a Report of Investigations[4] concerning the "Thermodynamic Properties of Petalite." Gibbs energies of formation and equilibrium constants of formation were calculated.

A new use for lithium was announced. The D-H Titanium Co., a partnership of The Dow Chemical Co. and Howmet Turbine Components Corp., revealed the completion of research into the electrowinning of metallic titanium from titanium tetrachloride using lithium chloride-potassium chloride as the eutectic. The first cell of the pilot plant was brought onstream in December in Freeport, Tex. The titanium product was reported to have half the oxygen and carbon impurities and one-tenth the iron and chloride impurities of conventional processes. The process was reported to consume about half of the energy of conventional processes.

The rising cost of lithium carbonate for aluminum electrowinning relative to the benefits of its use has had a dampening effect on this market. Recent research has reduced the lithium carbonate requirement from 5 to 6 pounds per ton of aluminum to 2.5 to 3 pounds per ton.

A conference was held on aluminum-lithium alloys in May by the Georgia Institute of Technology. The benefits of the alloys were reported to be lower density, higher stiffness, and higher modulus of elasticity. Problems of aluminum-lithium alloys were reported to be low ductility and fracture toughness.

A new automotive headlamp has been developed that may replace the standard, lithium-containing glass, sealed-beam headlamp. The new headlamp is molded of polycarbonate plastic with a small tungsten-halogen bulb. The new headlamp is lighter in weight and brighter than the present sealed-beam headlamp.

There were more than 25 battery manufacturers in the Western World investigating lithium batteries in 1980. There was a large variety of cell types and sizes available. By cathode materials, the lithium batteries available or under development were carbon, iodine, titanium disulfide, vanadium disulfide, vanadium pentoxide, manganese dioxide, iron sulfide, and silver oxide. By electrolyte, the lithium batteries available or under development were thionyl-chloride, dimethyl sulfite monofluoride, a bromine complex, and sulfuryl chloride.

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[1]Physical scientist, Section of Nonmetallic Minerals.

[2]See company 10-K reports for 1980 filed with the Securities and Exchange Commission, Washington, D.C.

[3]Work cited in footnote 2.

[4]Bennington, K. D., J. M. Stuve, and M. J. Ferrante. Thermodynamic Properties of Petalite ($Li_2Al_2Si_8O_{20}$). BuMines RI 8451, 1980, 20 pp.

Magnesium

By Benjamin Petkof[1]

Primary domestic magnesium metal production continued its upward trend in 1980. Secondary metal recovery also increased. Consumption of magnesium metal declined from consumption in 1979. Exports of metal increased slightly in both quantity and value in 1980. Imports of metal were nominal. The quoted metal price advanced in 1980. World primary metal production also increased.

Table 1.—Salient magnesium statistics

(Short tons)

	1976	1977	1978	1979	1980
United States:					
Production:					
Primary magnesium[1]	119,957	125,958	r149,463	r162,464	169,867
Secondary magnesium	30,553	32,694	36,228	37,222	40,461
Shipments: Primary	W	W	W	W	W
Exports	13,444	28,061	41,807	r54,280	56,761
Imports for consumption	14,907	5,964	6,668	4,754	3,757
Consumption	104,453	103,576	108,958	108,844	95,788
Price per pound	$0.87-$0.92	$0.96-$0.99	$0.99-$1.01	$1.01-$1.09	$1.07-$1.25
World: Primary production	r274,882	r283,554	r318,187	r340,646	350,875

rRevised. W Withheld to avoid disclosing company proprietary data.

[1]Derived from data reported by The Magnesium Association and the Canadian Department of Mines and Natural Resources. Figures are the difference between total North American production reported by the International Magnesium Association and Canadian production reported by the Canadian Department of Mines and Natural Resources.

DOMESTIC PRODUCTION

Domestic primary ingot production increased slightly over production in 1979. During 1980, four companies accounted for the entire domestic output. Three of these companies, The American Magnesium Co. (Snyder, Tex.), The Dow Chemical Co. (Freeport, Tex.), and NL Industries, Inc. (Rowley, Utah), produced magnesium from magnesium chloride solution obtained from brine by the electrolytic method. Northwest Alloys, Inc. (Addy, Wash.), used the silicothermic process.

In December 1980, the American Magnesium Co. ceased producing primary magnesium metal. The shutdown of the plant was attributed to lack of brine feed. It was not known if the plant would resume production in the future.

As of December 1, 1980, the magnesium plant of NL Industries was sold to the AMAX Specialty Metals Corp. AMAX continued to produce primary magnesium metal. The expansion of the plant's production will be dependent on future metal demand.

Secondary magnesium continued to supply a significant portion of the domestic supply of this metal. Secondary magnesium metal recovery increased in 1980 over that of 1979.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1976	1977	1978	1979	1980
Kind of scrap:					
New scrap:					
Magnesium-base	2,838	3,363	4,634	5,025	5,929
Aluminum-base	16,186	16,807	17,501	18,315	16,978
Total	19,024	20,170	22,135	r23,340	22,907
Old scrap:					
Magnesium-base	5,500	5,255	5,522	4,778	5,275
Aluminum-base	6,029	7,269	8,571	9,104	12,279
Total	11,529	12,524	14,093	13,882	17,554
Grand total	30,553	32,694	36,228	37,222	40,461
Form of recovery:					
Magnesium alloy ingot[1]	3,569	3,785	4,272	3,739	4,205
Magnesium alloy castings (gross weight)	836	859	956	790	836
Magnesium alloy shapes	335	932	1,909	2,176	3,144
Aluminum alloys	23,595	25,211	27,301	r28,857	29,612
Zinc and other alloys	15	21	19	13	13
Chemical and other dissipative uses	28	43	48	47	9
Cathodic protection	2,175	1,843	1,723	1,600	2,642
Total	30,553	32,694	36,228	37,222	40,461

rRevised.
[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

Total consumption of magnesium metal declined from consumption in 1979, reflecting the lower economic activity of 1980. Magnesium metal was used to fabricate structural products that included cast and wrought items and was used for sacrificial use where advantage was taken of the metal's chemical and alloying properties. The metal's useful structural properties, such as low specific gravity, good machinability, hot formability, and high strength-to-weight ratio, resulted in almost one-fifth of 1980 consumption being used in aircraft, automotive, and other types of transportation equipment, material-handling equipment, and the manufacture of items such as power tools. Almost three-fifths was used for alloying with other metals. The remainder was used for other sacrificial purposes such as cathodic protection, nodular iron production, chemicals, and reducing agents for metals such as titanium, zirconium, uranium, and beryllium.

Table 3.—Consumption of primary magnesium in the United States, by use

(Short tons)

	1976	1977	1978	1979	1980
For structural products:					
Castings:					
Die	4,759	5,011	5,575	5,182	3,190
Permanent mold	1,059	1,048	1,012	1,069	922
Sand	1,233	1,142	1,064	1,209	1,735
Wrought products:					
Extrusions	6,449	([1])	6,301	6,420	6,855
Sheet and plate	([1])	([1])	4,375	4,925	4,704
Other (includes forgings)	3,792	12,632	399	217	61
Total	17,292	19,833	18,726	19,022	17,467
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	54,320	56,086	58,798	60,549	54,490
Copper	14	10	12	9	6
Zinc	29	23	21	15	11
Other	10	8	8	8	7
Cathodic protection (anodes)	7,809	4,083	6,600	6,769	3,930
Chemicals	10,140	9,941	9,192	9,044	6,278
Nodular iron	7,584	7,297	7,956	4,335	4,176
Scavenger and deoxidizer	([1])	([1])	([1])	([1])	([1])
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	5,985	5,235	6,230	7,435	7,957
Other, including powder	1,270	1,060	1,415	1,658	1,466
Total	87,161	83,743	90,232	89,822	78,321
Grand total	104,453	103,576	108,958	108,844	95,788

[1]Included with "Other."

PRICES

Magnesium metal prices increased incrementally during 1980 as follows:

Jan. 1-Mar. 31, 1980	$1.07 per pound
Apr. 1-Sept. 30, 1980	1.16 per pound
Oct. 1-Dec. 31, 1980	1.25 per pound

STOCKS

Consumer stocks of primary magnesium totaled 14,393 short tons at yearend 1980. Stocks of primary alloy ingot at yearend 1980 were 774 short tons. New and old magnesium scrap stocks are shown in table 4.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States

(Short tons)

	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
1979:						
Cast scrap	1,051	5,725	447	5,250	5,697	1,079
Solid wrought scrap[1]	95	1,240	1,102	--	1,102	233
Total	1,146	6,965	1,549	5,250	6,799	1,312
1980:						
Cast scrap	[r]1,077	6,815	680	5,797	6,477	1,415
Solid wrought scrap[1]	233	791	864	--	864	160
Total	[r]1,310	7,606	1,544	5,797	7,341	1,575

[r]Revised.
[1]Includes borings, turnings, drosses, etc.

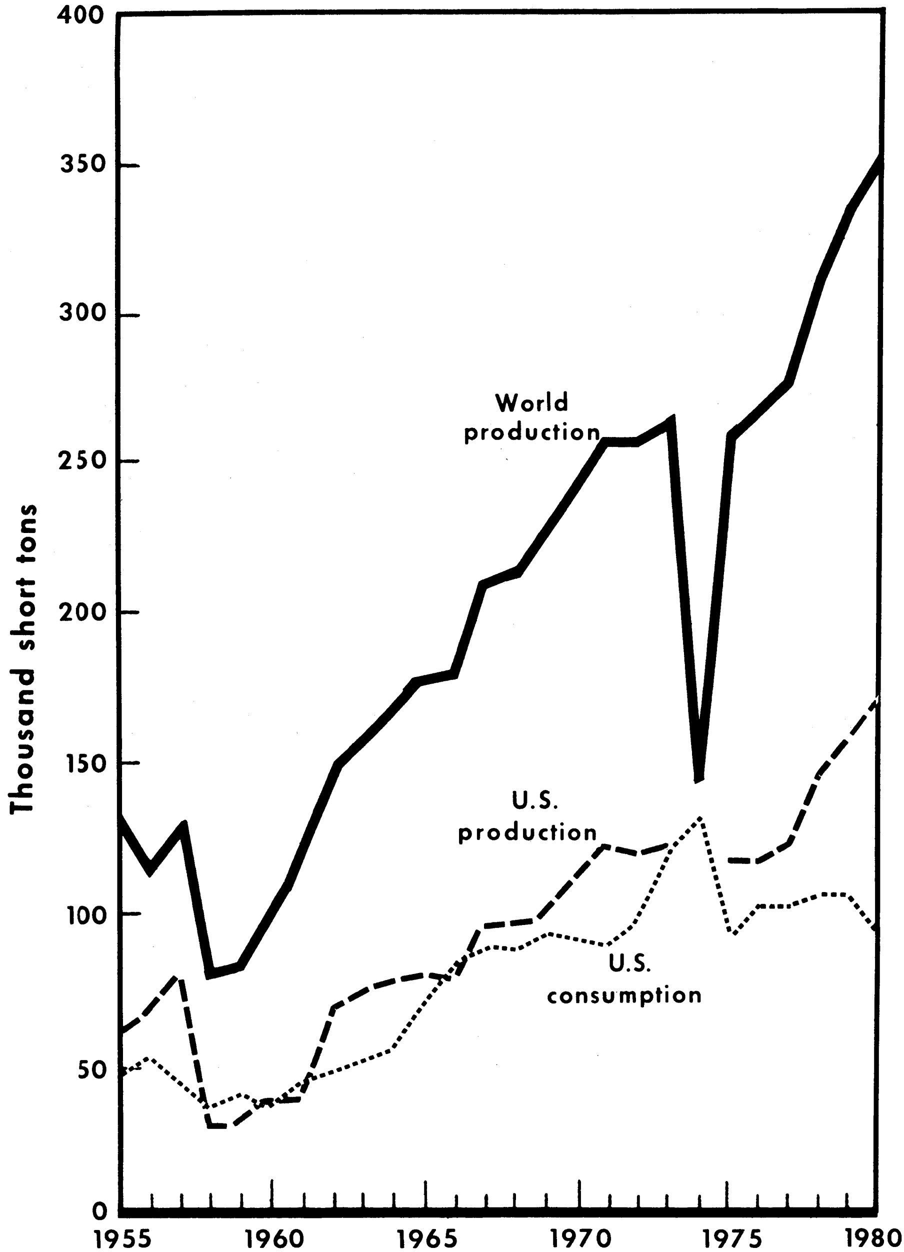

Figure 1.—U.S. and world production and U.S. consumption of primary magnesium.

FOREIGN TRADE

U.S. exports of magnesium were slightly above exports of 1979 in both quantity and value. The United States was a net exporter of magnesium metal during 1980. Major quantities of metal were exported to industrialized nations.

Imports of metal were low during 1980 and accounted for only a small fraction of the domestic metal supply.

Table 5.—U.S. exports and imports for consumption of magnesium

Year	Exports					
	Waste and scrap		Metals and alloys in crude form		Semifabricated forms n.e.c.	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	1,434	$2,397	37,082	$63,008	3,291	$10,382
1979	688	794	r47,456	90,788	6,136	22,246
1980	250	587	49,584	104,086	6,927	23,033

Year	Imports							
	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, other forms (magnesium content)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	4,798	$5,018	1,271	$2,150	542	$1,897	57	$1,013
1979	2,757	2,958	1,460	3,127	412	1,767	125	1,190
1980	2,384	2,806	940	2,242	344	1,770	89	1,443

rRevised.

Table 6.—U.S. exports of magnesium, by class and country

Destination	Waste and scrap		Primary metals alloys		Semifabricated forms n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979						
Argentina	--	--	470	$932	76	$261
Australia	56	$163	678	1,171	743	2,734
Austria	--	--	--	--	267	598
Belgium-Luxembourg	--	--	83	145	557	1,738
Brazil	1	4	9,885	18,651	5	19
Cameroon	--	--	144	298	--	--
Canada	47	160	2,655	5,559	119	1,135
China:						
Mainland	--	--	5,118	8,282	--	--
Taiwan	15	21	--	--	2	6
Colombia	--	--	28	59	23	72
France	([1])	1	2	31	63	617
Germany, Federal Republic of	214	296	2,261	4,443	903	3,355
Ghana	--	--	1,001	1,861	--	--
Hong Kong	--	--	6	13	69	155
India	--	--	227	395	65	158
Israel	--	--	110	447	80	354
Italy	2	16	48	168	414	1,386
Japan	106	26	8,045	15,514	606	1,948
Korea, Republic of	242	84	199	352	164	1,224
Mexico	--	--	1,572	3,122	181	878
Netherlands	--	--	13,188	25,171	1,232	2,604
New Zealand	--	--	89	169	11	140
Norway	--	--	232	738	6	24
Romania	--	--	434	876	12	31
Saudi Arabia	--	--	104	207	24	69
Singapore	--	--	190	732	1	7
South Africa, Republic of	--	--	590	1,169	65	292
Spain	--	--	15	62	60	255

See footnotes at end of table.

Table 6.—U.S. exports of magnesium, by class and country —Continued

Destination	Waste and scrap		Primary metals alloys		Semifabricated forms n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1979 —Continued						
Sweden	--	--	5	$19	19	$168
United Kingdom	1	$12	26	75	116	629
Venezuela	1	1	2	4	57	327
Other	3	10	49	123	196	1,062
Total	688	794	47,456	90,788	6,136	22,246
1980						
Argentina	6	24	407	898	37	160
Australia	--	--	1,600	3,341	401	2,481
Austria	--	--	46	117	218	545
Belgium-Luxembourg	--	--	--	--	401	1,112
Brazil	--	--	10,124	21,709	1	10
Canada	17	34	3,391	7,639	272	1,339
China:						
Mainland	--	--	5,123	8,688	--	--
Taiwan	12	24	11	19	18	58
Colombia	--	--	33	102	12	46
France	--	--	42	115	105	504
Germany, Federal Republic of	12	25	2,156	5,079	1,338	3,380
Ghana	--	--	1,423	2,874	--	--
Hong Kong	--	--	10	11	41	138
India	--	--	517	1,089	67	183
Israel	--	--	41	215	222	1,033
Italy	--	--	226	895	267	886
Japan	7	34	9,334	18,871	641	2,163
Korea, Republic of	38	85	73	174	161	431
Mexico	10	54	2,792	6,288	288	1,323
Netherlands	20	43	10,221	20,342	1,263	2,892
New Zealand	--	--	74	155	6	54
Norway	--	--	199	451	1	17
South Africa, Republic of	2	25	737	2,473	210	619
Spain	--	--	49	139	51	190
Sweden	--	--	115	293	33	208
United Kingdom	1	2	265	658	202	1,144
Venezuela	2	4	109	252	36	234
Other	123	233	466	1,199	635	1,883
Total	250	587	49,584	104,086	6,927	23,033

[1]Less than 1/2 unit.

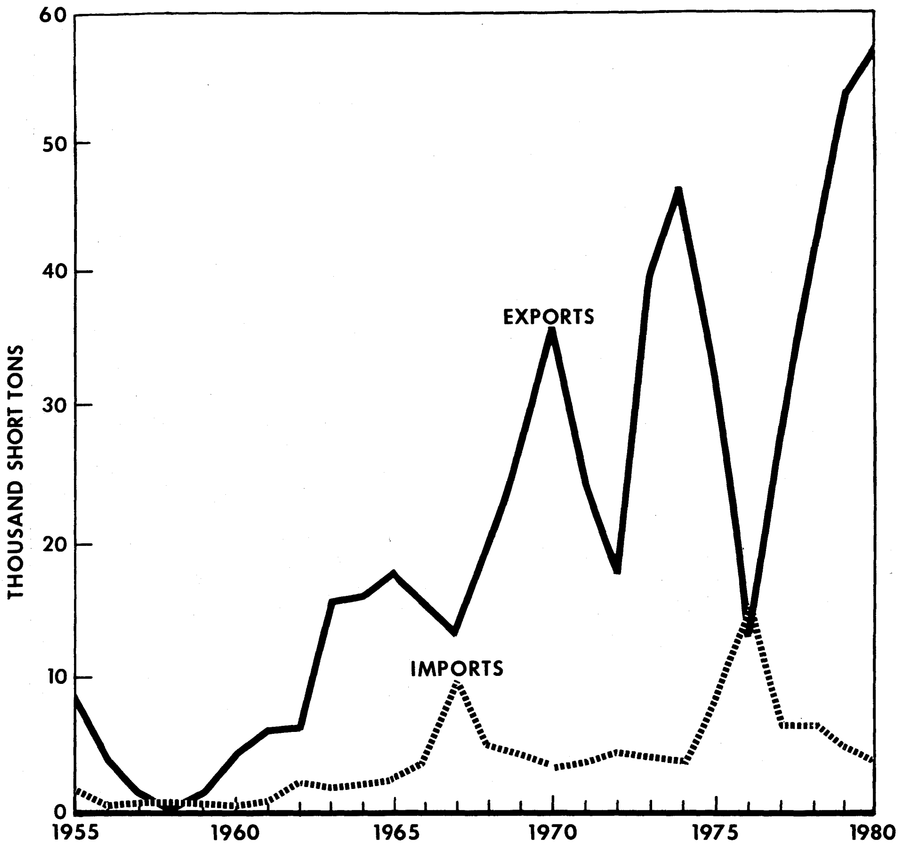

Figure 2.—U.S. imports and exports of magnesium.

WORLD REVIEW

Primary magnesium production has increased steadily since 1975 to supply world demand. The United States was the largest primary metal producer in 1980, followed by the U.S.S.R. and Norway. Other producing countries are identified in table 7.

Available data on the recovery of secondary magnesium appear in table 8. In 1980, the United States and Japan were the major sources of secondary magnesium.

Table 7.—Magnesium: World primary production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Canada	6,715	8,414	9,159	9,937	[2]9,809
China, mainland[e]	[r]5,500	[r]5,500	6,600	[r]6,600	7,700
France	[r]8,857	[r]9,570	9,370	9,965	10,100
India	(3)	(3)	(3)	(3)	--
Italy	9,740	9,663	10,688	9,653	9,700
Japan	12,335	10,379	12,252	12,531	[2]10,199
Norway	42,778	42,070	43,155	48,496	48,500

See footnotes at end of table.

Table 7.—Magnesium: World primary production, by country[1] —Continued

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
U.S.S.R.[e]	69,000	[r]72,000	77,000	79,000	83,000
United States[4]	119,957	[r]125,958	149,463	162,464	[2]169,867
Yugoslavia	--	--	500	[e]2,000	2,000
Total	[r]274,882	[r]283,554	318,187	340,646	350,875

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 6, 1981.
[2]Reported figure.
[3]Data deleted; information now available indicates that Indian production reported in previous editions as primary is actually secondary.
[4]Derived figure; United States production is not officially reported by the Bureau of Mines in order to avoid dislosing company proprietary data; figures reported represent the difference between total North American production reported by the International Magnesium Association and Canadian production reported by the Canadian Department of Mines and Natural Resources.

Table 8.—Magnesium: World secondary production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Germany, Federal Republic of	550	660	[e]660	[e]660	660
India	33	118	25	31	32
Japan	8,379	8,360	12,057	18,058	23,800
United Kingdom	3,300	3,000	3,000	3,000	3,000
United States	30,553	32,694	36,228	37,222	[2]40,461

[e]Estimated. [p]Preliminary.
[1]Table summarizes available information on world secondary magnesium production, but has not been totaled because of the omission of other producers for which data are not available and for which no reliable basis for estimations are available. Most notable among omitted secondary producers (and probably the only one of significance) is the U.S.S.R. Table includes data available through May 6, 1981.
[2]Reported figure.

TECHNOLOGY

The historic use of magnesium in the automotive field was reviewed. The current and future potential for automotive magnesium alloy use was discussed.[2]

The safety and hazards related to handling and machining magnesium were discussed.[3]

A series of papers were published describing current metal market conditions and other aspects of magnesium metal technology.[4]

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[1]Physical scientist, Section of Nonferrous Metals.
[2]Mezoff, J. G. Magnesium for Automobiles in Perspective. Annual Congress and Exposition of the Society of Automotive Engineers, Detroit, Mich., Feb. 25-29, 1980, 16 pp.
[3]Morales, J. M. Magnesium, Machinability and Safety. Annual Congress and Exposition of the Society of Automotive Engineers, Detroit, Mich., Feb. 25-29, 1980, 3 pp.
[4]International Magnesium Association. Proceedings from the 37th Ann. World Conference on Magnesium, Salt Lake City, Utah, June 8-11, 1980, 53 pp.

Magnesium Compounds

By Benjamin Petkof[1]

The United States maintained its status as a major world producer of magnesium compounds in 1980. Domestic output was based chiefly on the production of synthetic magnesia derived from natural brines. Most of the classes of magnesium compounds shipped and used declined in quantity from those of the previous year. Total exports of magnesite and magnesia increased slightly over those of 1979. Total imports of magnesite decreased from those of 1979. Austria, Greece, mainland China, North Korea, and the U.S.S.R. were major sources of magnesite.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments by producers:					
Quantity	134	129	156	164	157
Value	$28,277	$29,574	$43,008	$50,047	$51,282
Exports: Value[2]	$5,422	$6,336	$7,741	$16,433	$17,692
Imports for consumption: Value[2]	$808	$566	$793	$1,169	$2,122
Refractory magnesia:					
Sold and used by producers:					
Quantity	768	690	796	847	736
Value	$106,522	$94,799	$125,082	$125,289	$127,253
Exports: Value	$13,466	$16,477	$10,617	r$8,183	$13,279
Imports: Value	$13,976	$12,332	$14,421	$13,546	$16,672
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	1,007	968	1,016	793	494
Value	$37,079	$37,992	$45,881	$41,676	$28,308
World: Crude magnesite production: Quantity	r9,988	r10,733	r10,702	11,886	11,933

rRevised.
[1]Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Natural brine solutions from seawater, lakes, and wells served as the primary source of domestically produced magnesium compounds. Natural magnesite was produced in Nevada. Olivine was produced in North Carolina and Washington. Natural magnesite was converted to magnesium compounds. Olivine was comminuted to various grades for foundry and other uses. Most of the firms that produced magnesium oxide also produced other magnesium compounds. Current domestic magnesium compounds producers by raw material source, location, and capacity follow:

Raw material source and producing company	Location	Capacity (short tons of MgO equivalent)
Magnesite: Basic, Inc	Gabbs, Nev	150,000
Lake brines:		
Great Salt Lake Minerals & Chemicals Corp	Ogden, Utah	100,000
Kaiser Aluminum & Chemical Corp	Wendover, Utah	50,000
Well brines:		
The Dow Chemical Co	Ludington, Mich	300,000
Do	Midland, Mich	75,000
Martin Marietta Chemicals	Manistee, Mich	300,000
Morton Chemical Co	do	5,000
Seawater:		
Barcroft Co	Lewes, Del	5,000
Basic Magnesia, Inc	Port St. Joe, Fla	100,000
Corning Glass Works, Ceramic Products Division	Pascagoula, Miss	40,000
The Dow Chemical Co	Freeport, Tex	75,000
Harbison-Walker Refractories Co	Cape May, N.J	100,000
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif	150,000
Merck & Co., Inc	South San Francisco, Calif	15,000
Western Magnesium Corp	Chula Vista, Calif	5,000
Total		1,470,000

CONSUMPTION AND USES

The quantities of magnesium compounds shipped and used of almost all classes of magnesium compounds in 1980 were below those of 1979. However, the values were above those of 1979 for almost all classes of magnesium compounds. The manufacture of refractory products was the major end use for magnesia. Caustic-calcined and specified magnesias were in strong demand by the chemical processing and pharmaceutical industries. Some major uses for caustic-calcined and specified magnesias were in the preparation of animal feeds, fertilizers, construction materials, chemicals, electrical heating rods, fluxes, petroleum additives, rayon, and uranium.

Table 2.—Magnesium compounds shipped and used in the United States

	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	163,565	$50,047	157,303	$51,282
Refractory magnesia	846,612	125,289	736,307	127,253
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	511,370	47,475	493,326	50,791
Magnesium sulfate (anhydrous and hydrous)	48,325	10,271	42,878	11,280
Precipitated magnesium carbonate[1]	4,020	1,224	5,144	1,456

[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

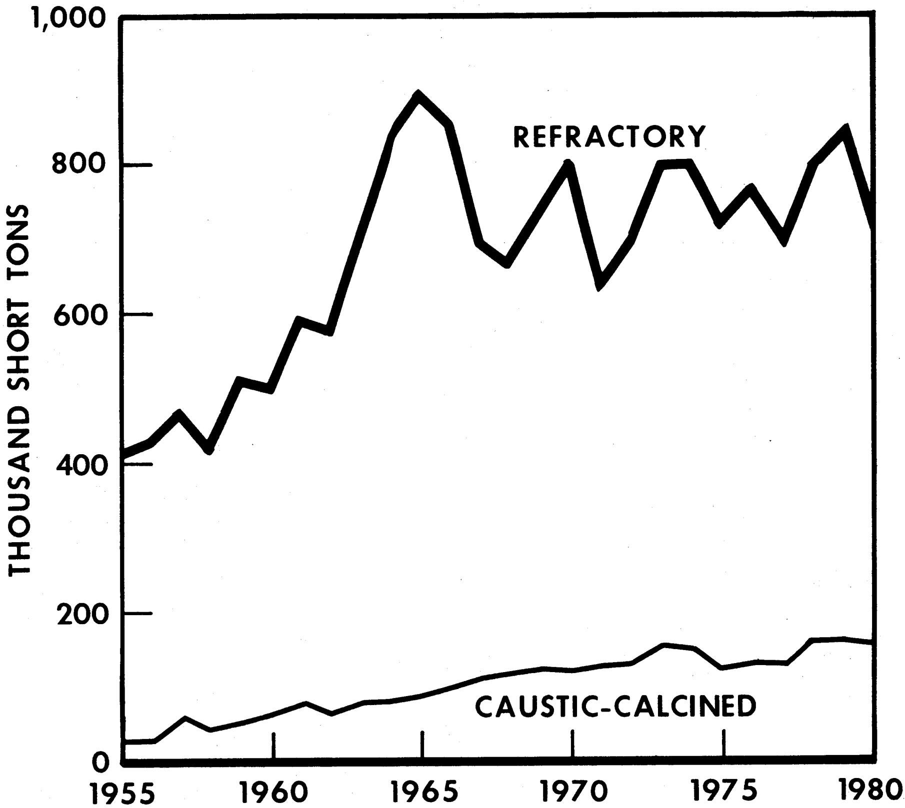

Figure 1.—Consumption and shipments of magnesia in the United States.

Table 3.—Domestic shipments of caustic-calcined and specified magnesias, by use

(Short tons)

Use	1978	1979	1980
Agriculture, nutrition, and pharmaceuticals:			
Animal feed	35,776	W	W
Fertilizer	16,506	W	W
Medicinals and pharmaceuticals	1,923	701	598
Sugar and candy	W	W	W
Winemaking	W	--	W
Total	54,205	701	598
Construction materials:			
Insulation and wallboard	(1)	W	W
Oxychloride and oxysulfate cement	3,753	W	W
Total	3,753	W	W
Chemical processing, manufacturing, and metallurgical:			
Chemical	12,070	9,660	23,632
Electrical heating rods	W	}	}
Flux	W	} 37,071	} 26,012
Petroleum additive	20,652	}	}
Pulp and paper	} 25,983	28,081	29,406
Rayon	}		
Rubber	12,568	14,209	13,688
Stack gas scrubbing	}		
Uranium processing	} r4,764	6,513	4,322
Water treatment	}		
Total	76,037	95,534	97,060
Unspecified uses	r22,197	r67,359	59,645
Grand total	156,192	163,594	157,303

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Unspecified uses."

[1]Included with "Oxychloride and oxysulfate cement."

PRICES

At yearend, the Chemical Marketing Reporter reported the following price quotations for magnesium compounds: Magnesia, natural, technical, heavy, 85% and 90% (bulk, carlot, and truckload, f.o.b. Nevada), $184 and $210 per ton, respectively; magnesium chloride, hydrous, 99%, flake (bags, carlot, works), $240 per ton; magnesia, technical, neoprene-grade, light (bags, carlot, and truckload, works), $55 per ton; magnesium carbonate, technical (bags, carlot, and truckload, works, freight-equalized), $0.52 to $0.54 per pound; magnesium hydroxide, NF, powder (drums, carlot, and truckload, works, freight-equalized), $0.54 to $0.58 per pound; magnesium sulfate, technical (bags, mixed carlot, 10,000-pound minimum, works), $0.121 per pound.

FOREIGN TRADE

The United States exported magnesium materials such as dead-burned magnesite and magnesia and crude caustic-calcined lump or ground magnesite. Large quantities of these magnesium commodities were shipped to Canada, Argentina, and Venezuela.

Total imports of crude and processed magnesite remained under 100,000 tons in quantity and $20 million in value during 1980. Additional magnesium compounds, valued at $5.9 million, were also imported.

Table 4.—U.S. exports of magnesite and magnesia, by country

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1979		1980		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	26	$18	65	$15	4,887	$1,314	6,368	$2,204
Australia	225	152	212	112	683	585	530	464
Belgium-Luxembourg	--	--	170	38	1,187	281	291	217
Brazil	105	79	459	132	33	30	89	69
Canada	26,053	5,929	48,163	11,093	51,238	8,869	35,240	9,962
Chile	--	--	--	--	113	48	8	6
Colombia	1,466	170	1,389	161	64	60	146	114
Costa Rica	--	--	10	3	--	--	112	25
Dominican Republic	649	112	--	--	3	4	6	4
Ecuador	--	--	--	--	96	22	31	17
Finland	--	--	--	--	--	--	199	186
France	37	20	102	34	1,078	431	312	287
Germany, Federal Republic of	3	3	3,411	1,118	593	402	444	347
Guatemala	--	--	--	--	40	26	15	10
Guyana	360	30	--	--	--	--	--	--
Italy	21	18	6	2	587	362	515	445
Japan	36	33	24	25	157	187	69	34
Korea, Republic of	42	39	--	--	78	77	37	25
Mexico	1,114	273	251	56	711	166	73	50
Netherlands	286	85	183	54	327	591	190	158
New Zealand	20	24	191	43	149	148	168	133
Peru	8	2	--	--	8	13	41	28
Philippines	9	11	2	1	17	6	111	94
Singapore	410	106	--	--	11	5	15	15
South Africa, Republic of	104	102	142	100	87	60	237	156
Spain	22	9	--	--	94	38	153	120
Sweden	43	51	254	80	194	210	200	161
Taiwan	73	71	17	27	203	85	238	158
United Kingdom	100	101	171	81	675	532	394	291
U.S.S.R.	--	--	--	--	1,102	336	--	--
Venezuela	1,716	724	783	93	3,824	1,414	5,238	1,718
Other	r107	r21	33	11	r136	r131	233	194
Total	33,035	8,183	56,038	13,279	68,375	16,433	51,703	17,692

r Revised.

Table 5.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Lump or ground caustic-calcined magnesia:[1]				
Australia	1,063	$221	556	$121
Germany, Federal Republic of	25	6	--	--
Greece	3,732	628	7,619	1,419
India	428	39	1,782	212
Netherlands	114	26	203	67
Spain	--	--	1,635	162
Turkey	1,123	249	551	125
United Kingdom	--	--	60	16
Total	6,485	1,169	12,406	2,122
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Brazil	6,283	867	463	221
Canada	--	--	83	6

See footnotes at end of table.

Table 5.—U.S. imports for consumption of crude and processed magnesite, by country —Continued

Country	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Dead-burned and grain magnesia and periclase —Continued				
Not containing lime or not over 4% lime —Continued				
France	(2)	$3	1	$7
Germany, Federal Republic of	(2)	(2)	--	--
Greece	9,095	2,209	9,211	2,019
Ireland	24,183	4,809	49,731	11,505
Israel	2,330	617	--	--
Japan	23,171	5,041	10,887	2,914
Total	65,062	13,546	70,376	16,672
Containing over 4% lime:				
Canada	1,424	163	2,288	143
Germany, Federal Republic of	341	90	55	15
Ireland	24,572	4,727	--	--
Mexico	1,527	54	--	--
United Kingdom	1	(2)	--	--
Total	27,865	5,034	2,343	158
Total dead-burned and grain magnesia and periclase	92,927	18,580	72,719	16,830

[1]In addition, crude magnesite was imported as follows: 1979—Canada 96 short tons ($3,771), India 11 short tons ($800), and Japan 2 short tons ($801). 1980—Canada 2 short tons ($343), the United Kingdom 40 short tons ($17,337), Greece 3 short tons ($1,683), and Australia 1 short ton ($366).
[2]Less than 1/2 unit.

Table 6.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate[1] (precipitated)		Magnesium chloride (anhydrous)		Magnesium chloride (other)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds, n.s.p.f.[2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1978	705	$795	80	$149	48	$12	215	$55	28,984	$1,650	7,892	$1,803
1979	3,216	1,772	95	187	26	15	164	73	25,950	1,530	6,988	2,042
1980	1,468	1,871	117	211	61	20	355	93	30,031	1,674	4,092	2,038

[1]In addition, magnesium carbonate not precipitated, was imported as follows: 1978—65 short tons ($39,824); 1979—32 short tons ($24,942); 1980—41 short tons ($36,357).
[2]Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesium.

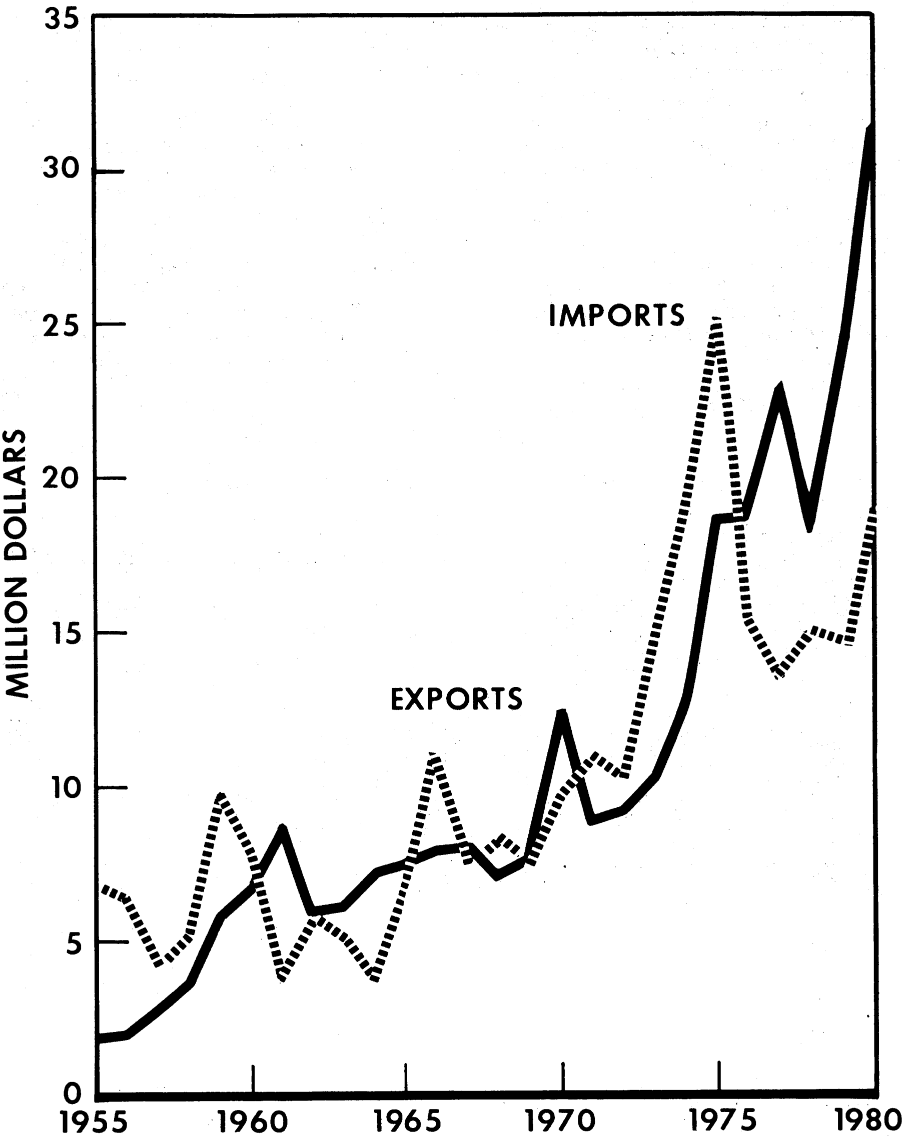

Figure 2.—Value of U.S. exports and imports of magnesia.

WORLD REVIEW

World production of magnesite rose in 1980 to meet the demand for refractory and caustic-calcined and specified magnesias. Countries such as the United States, Ireland, and Israel recovered magnesium compounds from natural brines.

Brazil.—A proposal was made to establish an industrial complex in Rio Grande Do Norte to produce magnesium metal, magnesium compounds, and other compounds from saltwater bitterns. If construction of this complex is implemented, the resulting output will be consumed by Brazilian industry.

China, Mainland.—This nation has large deposits of magnesite in Da Shih-Oiao, Liaoning Province, with estimated reserves in excess of 1 billion tons. Magnesite from these deposits was quarried, crushed to the required size and calcined or dead-burned in shaft or rotary kilns.

Ireland.—Premier Periclase Ltd. began production of high-quality dead-burned magnesia from seawater in a 100,000-ton-per-year operation at Drogheda. Plant output was aimed at the refractories industry as the primary market.

Mexico.—Two subsidiaries of Industrias Penoles produced magnesia. Quimica del Ray S.A. produced magnesia and sodium sulfate from underground brines at Laguna del Ray, Coahuila. The company produced over 45,000 tons per year of high-quality magnesia. Production was expected to be increased to more than 100,000 tons per year. The other company, Quimica del Mar, S.A., produced over 42,000 tons per year of magnesia from seawater at Cuidad Madero, Tamaulipas.

Table 7.—Magnesite: World production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada[e]	26,000	41,000	39,000	58,000	65,000
Mexico	25,558	73,193	83,814	84,000	84,000
United States	W	W	W	W	W
South America:					
Brazil[2]	215,917	226,766	246,169	292,851	300,000
Colombia	1,909	1,951	1,543	1,744	1,750
Europe:					
Austria	1,021,334	1,105,662	1,082,821	1,216,563	1,210,000
Czechoslovakia	720,911	728,627	725,320	720,911	[3]720,911
Greece	1,415,730	1,146,903	903,421	1,189,908	1,210,000
Poland	28,990	[r]27,999	26,896	[e r]22,000	20,000
Spain	383,694	464,338	337,911	420,936	430,000
U.S.S.R.[e]	1,980,000	2,040,000	2,090,000	2,150,000	2,200,000
Yugoslavia	431,003	380,297	367,069	322,977	[3]288,805
Africa:					
Kenya	3	3,941	[e r]4,400	[e]4,400	4,400
South Africa, Republic of	69,289	54,255	41,234	72,021	66,000
Zimbabwe	[e r]77,000	[e r]83,000	[e r]83,000	93,680	94,000
Asia:					
China, mainland[e]	1,100,000	1,700,000	2,000,000	2,200,000	2,200,000
India	363,429	443,136	456,539	424,020	[3]408,486
Iran[4]	5,500	5,500	5,500	5,500	4,400
Korea, North[e]	1,650,000	[r]1,615,000	[r]1,720,000	[r]2,010,000	2,040,000
Pakistan	3,578	1,727	2,945	3,029	2,500
Turkey	451,149	568,971	459,885	[e r]562,000	550,000
Oceania:					
Australia	16,211	20,426	23,534	31,015	32,000
New Zealand	887	[r]661	925	937	960
Total	[r]9,988,092	[r]10,733,353	10,701,926	11,886,492	11,933,212

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria produced magnesite, but output is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels. Table includes data available through Apr. 27, 1981.

[2]Series reflects output of marketable concentrates. Production of crude ore was as follows: 1976—414,612; 1977—481,154; 1978—409,936; 1979—650,627; 1980—660,000.

[3]Reported figure.

[4]Year beginning Mar. 21 of that stated.

TECHNOLOGY

The formation and petrology of the Vavdos cryptocrystal-line magnesite deposits of the Chalkidiki Peninsula of northern Greece were described.[2]

The recovery of magnesium oxide from concentrated brines obtained from seawater desalination plants was investigated. In contrast to the usual process for magnesium oxide recovery from seawater, the impurity, calcium sulfate, had to be removed from the precipitated hydroxide by a carbonation-decarbonation stage. The added capital and operating costs of the carbonation-decarbonation stage were offset by the elimination of the seawater intake and seawater feed pretreatments required by conventional seawater recovery plants.[3]

The effect of the addition of magnesium hydroxide to polypropylene were described. The addition of 57% magnesium hydroxide by weight caused the magnesium hydroxide-polypropylene composite to become nonflammable, but with changes in the physical characteristics of the original material.[4]

A process was described for the recovery of freshwater and mineral compounds including magnesium hydroxide, oxide, and chloride from agricultural waste water.[5]

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[1]Physical scientist, Section of Nonferrous Metals.
[2]Dabitzias, S. G. Petrology and Genesis of the Vavdos Cryptocrystalline Magnesite Deposits, Chalkidiki Peninsula, Northern Greece. Econ. Geol., v. 75, 1980, pp. 1138-1151.
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Manganese

By Gilbert L. DeHuff[1] and Thomas S. Jones[2]

There was neither production nor shipment of manganese ore containing 35% or more manganese in the United States in 1980. Lower grade manganiferous ores were produced and shipped in Minnesota, New Mexico, and South Carolina. Imports of manganese contained in ferromanganese continued to exceed those contained in ore; the former dropping, the latter increasing from those of the preceding year. This was a reversal of the situation in 1979 with respect to 1978. Domestic ferromanganese production and consumption, together with ore consumption, were all lower in 1980 than in 1979. The trend of the past 2 years for acquisition of U.S. manganese ferroalloy producers by foreign firms continued with Union Carbide Corp. signing an agreement-in-principle to sell its manganese ferroalloy and metal plants to Norwegian and Canadian interests. Deliveries of ore continued to be made by the General Services Administration (GSA) from Government stockpile excesses. On May 2, the Federal Emergency Management Agency (FEMA) announced new stockpile goals for various manganese items.

Legislation and Government Programs.—New stockpile goals for manganese were announced May 2, 1980, by FEMA as follows, with the immediately preceding goals shown in parentheses: Manganese dioxide, battery-grade group, 87,000 (31,841) short tons, gross weight; and manganese, chemical and metallurgical group, 1,500,000 (1,423,374) short tons of contained manganese. The battery group was broken down into the following "desired inventory mix" (short tons, gross weight): Natural battery ore, 62,000; and battery-grade synthetic dioxide, 25,000. The chemical and metallurgical group was similarly broken down as follows (short tons, gross weight): Chemical-grade ore, 170,000; metallurgical-grade ore, 2,700,000; and high-carbon ferromanganese, 439,000. Medium- and low-carbon ferromanganese, silicomanganese, and electrolytic manganese metal were set at zero.

GSA reported sales of Government manganese stockpile excesses as follows (short tons, gross weight): Natural battery ore of stockpile-grade, 16,397; and nonstockpile-grade metallurgical ore, 24,304. An earlier sale of 35,401 short tons of stockpile-grade metallurgical ore was cancelled.

Changes over the year for manganese items in Government stockpile physical inventories were significant for nonstockpile-grade natural battery ore which decreased to 49,835 short tons; stockpile-grade metallurgical ore which decreased to 3,013,722 tons; and nonstockpile-grade metallurgical

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1976	1977	1978	1979	1980
Manganese ore (35% or more Mn):					
Imports, general	1,316,812	930,947	547,820	499,782	697,516
Consumption	1,600,873	1,358,811	1,281,479	1,372,190	1,070,775
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	256,633	215,893	312,124	240,696	173,887
Ferromanganese:					
Production	482,662	334,134	272,530	317,102	189,472
Exports	6,789	6,051	9,433	25,344	11,686
Imports for consumption	537,409	534,423	680,399	821,213	605,703
Consumption	896,775	886,299	985,623	976,482	789,076

ore decreased to 968,952 tons (all gross weight). The following items, unchanged or subject to minor inventory adjustments, closed the year at the following levels (short tons, gross weight): Stockpile-grade natural battery ore, 206,533 tons; synthetic manganese dioxide, 3,011 tons; chemical ore, 221,045 tons; high-carbon ferromanganese, 599,978 tons; medium-carbon ferromanganese, 28,920 tons; silicomanganese, 23,574 tons; and electrolytic metal, 14,172 tons. The physical inventory for stockpile-grade metallurgical ore included an appreciable quantity sold under long-term contract but not shipped as of the end of the year.

On June 28, President Carter signed the Deep Seabed Hard Mineral Resources Act (Public Law 96-283) establishing an interim procedure for the orderly development of manganese nodules and other hard mineral resources of the deep seabed, pending adoption of an international regime. The act authorized the Administrator of the National Oceanic and Atmospheric Administration (NOAA) to issue to eligible U.S. citizens licenses for exploration and permits for commercial recovery of these seabed resources. Commercial recovery may not begin before January 1, 1988. NOAA established an Office of Ocean Minerals and Energy, and made it responsible for implementing this act together with the Ocean Thermal Energy Conversion Act. Implementation includes licensing and regulatory responsibilities.

A draft environmental impact statement was prepared by NOAA for that area of the Pacific Ocean floor that was studied, in cooperation with industry over a period of 6 years, by the Deep Ocean Mining Environmental Study (DOMES). It concluded that no significant environmental problems are foreseen for the exploration stage of deep seabed manganese nodule mining, but that operations will continue to be monitored to have more information to assess the effects that might be expected from commercial exploitation.[3] Proposed regulations for exploration were also drafted.[4]

DOMESTIC PRODUCTION

No manganese ore, concentrate, or nodules, containing 35% or more manganese, was produced or shipped in the United States. Ferruginous manganese ores or concentrates containing 10% to 35% manganese were produced and shipped in New Mexico and in the Cuyuna Range of Minnesota. Manganiferous schist, clay, or other earthy material associated with the manganiferous member of the Battleground schist of the Kings Mountain area was mined in Cherokee County, S.C., by brick manufacturers or contractors for use in coloring brick. The material reported in table 2 ranged in manganese content from 5% to 15%, but averaged less than 10%.

Table 2.—Manganese and manganiferous ore shipped[1] in the United States, by State

(Short tons)

Type and State	1979		1980	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35% or more Mn, natural)	--	--	--	--
Manganiferous ore:				
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	181,503	25,579	119,029	16,712
New Mexico	33,152	3,315	35,198	4,069
Total	214,655	28,894	154,227	20,781
Manganiferous iron ore (5% to 10% Mn, natural):				
South Carolina[2]	26,041	1,969	19,660	1,875
Total manganiferous ore	240,696	30,863	173,887	22,656
Value of manganese and manganiferous ore	$2,902,233	XX	$2,443,753	XX

XX Not applicable.

[1]Shipments are used as the measure of manganese production for compiling U.S. mineral production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

[2]Miscellaneous ore.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continuous- or pressure-cast blooms, billets, slabs, etc., and including steel castings), consumption of manganese as ferroalloys, metal, and direct-charged ore, as reported to the Bureau of Mines by consumers, was 12.6 pounds per short ton of raw steel produced. Of this total, 10.8 pounds was contained in ferromanganese; 1.6 pounds, silicomanganese; negligible, spiegeleisen; 0.2 pound, metal; and none as manganese ore (containing 35% or more manganese). The comparable 1979 total, on the same basis, was 12.7 pounds with ferromanganese at 11.0, silicomanganese at 1.5, spiegeleisen negligible, metal at 0.2, and ore at 0.01. In addition to the aforementioned consumption of manganese in 1980, there was consumed per ton of raw steel produced approximately 1.0 pounds of manganese contained

Table 3.—Consumption and industry stocks of manganese ore[1] in the United States

(Short tons)

	Consumption		Stocks,
	1979	1980	Dec. 31, 1980
By use:			
Manganese alloys and metal	913,491	727,530	546,840
Pig iron and steel	230,742	131,516	158,422
Dry cells, chemicals and miscellaneous	227,957	211,729	325,225
Total	1,372,190	1,070,775	1,030,487
By origin:			
Domestic	144,404	60,701	52,332
Foreign	1,227,786	1,010,074	978,155
Total	1,372,190	1,070,775	1,030,487

[1]Containing 35% or more manganese (natural).

Table 4.—Consumption, by end use, and industry stocks of manganese ferroalloys and metal in the United States in 1980

(Short tons, gross weight)

End use	Ferromanganese		Silico-manganese	Spiegel-eisen	Manganese metal[1]
	High carbon	Medium and low carbon			
Steel:					
Carbon	501,743	93,834	92,196	301	5,706
Stainless and heat-resisting	10,980	840	5,456	--	2,353
Full alloy	79,985	13,965	32,873	--	861
High-strength low-alloy	51,753	11,838	8,319	--	1,006
Electric	2	73	69	--	3
Tool	471	31	42	--	167
Unspecified	640	111	1,015	--	1
Total steel	645,574	120,692	139,970	301	10,097
Cast irons	15,317	1,050	11,695	--	8
Superalloys	232	W	W	--	193
Alloys (exclude alloy steels and superalloys)	1,574	451	2,576	2	14,112
Miscellaneous and unspecified	3,492	694	1,576	--	682
Total consumption	666,189	122,887	155,817	303	25,092
Stocks, Dec. 31:					
Consumer	139,164	20,872	11,250	W	4,017
Producer	23,250	22,785	42,190	W	3,064
Total stocks	162,414	43,657	53,440	20	7,081

W Withheld to avoid disclosing company proprietary data, included in "Miscellaneous and unspecified" where applicable.
[1]Virtually all electrolytic.

Table 5.—Ferromanganese and silicomanganese produced in the United States and manganese ore[1] consumed in their manufacture

Year	Production				Manganese ore[1] consumed (gross weight, short tons)		
	Ferromanganese			Silicomanganese (gross weight, short tons)	Foreign[2]	Domestic[2]	Per ton of ferromanganese and silicomanganese made[3]
	Gross weight (short tons)	Manganese content: Percent	Manganese content: Short tons				
1976	482,662	79.0	381,328	129,000	1,208,336	53,632	2.0
1977	334,134	78.8	263,136	120,000	889,296	35,769	1.9
1978	272,530	80.6	219,707	142,000	740,906	90,660	1.9
1979	317,102	80.2	254,389	165,000	785,664	125,130	1.8
1980	189,472	79.7	150,982	188,000	691,250	34,877	1.9

[1]Containing 35% or more manganese (natural).
[2]Includes ore used in producing silicomanganese and metal.
[3]Ratio of ore consumed to ferromanganese produced if silicomanganese is considered a special grade of ferromanganese. Includes ore used in producing silicomanganese.

in manganese ore used in making pig iron or equivalent hot metal. The comparable figure was 1.4 pounds for both 1979 and 1978.

Consumption of manganese ore and both production and consumption of ferromanganese were all down from 1979. Continuing the trend of the past 2 years for domestic manganese ferroalloy producers to sell their plants to, or be acquired by, foreign firms, Union Carbide Corp. early in June signed an agreement-in-principle to sell all of its manganese ferroalloy and metal plants, both domestic and foreign, to a group composed of Norway's Elkem-Spigerverket A/S; Canada's Shielding Investments, Ltd.; and a group of Norwegian investors. Details involved in the transaction, including makeup of the minor buying interests, had not been finalized at yearend.

Electrolytic Manganese Metal.—All of the manganese metal produced domestically and virtually all of that imported was electrolytic metal. Virtually all of the metal consumed was electrolytic metal, although some low- or medium-carbon ferromanganese (such as the domestically produced "Massive Manganese" or the imported "Gimel Metal") and some manganese-aluminum additives may have been erroneously reported by consumers as manganese metal. The metal that was used to make manganese-aluminum additives is included in table 4 under the "Alloys (excludes alloy steels and superalloys)" category. These additives are not knowingly included in the table, since it is desired to report consumption at the metal rather than the additive level of the usage cycle.

Production of electrolytic manganese metal was 26,740 short tons compared with 27,690 tons in 1979. Production continued to be by the same three companies: Foote Mineral Co., New Johnsonville, Tenn.; Kerr-McGee Chemical Corp., Hamilton (Aberdeen), Miss.; and Union Carbide Corp., Marietta, Ohio.

Ferromanganese.—No ferromanganese was produced domestically in blast furnaces in 1980. Electric furnaces were used to produce ferromanganese for shipment by four companies in six plants: Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Ltd., Rockwood, Tenn.; SKW Alloys, Inc., Calvert City, Ky.; and Union Carbide Corp., Alloy, W. Va., Marietta, Ohio, and Portland, Oreg. Fused-salt electrolysis was used by Chemetals Corp. at Kingwood, W. Va., to make low- and medium-carbon ferromanganese sold under the trade name of Massive Manganese. Shipments of ferromanganese from U.S. furnaces dropped to 194,000 short tons in 1980 from 330,000 tons in 1979, 318,000 tons in 1978, and 338,000 tons in 1977.

The ferromanganese production reported in the various tables is net production; that is, the quantity of ferromanganese produced for shipment outside the producing ferroalloy facility. It does not include the remelt material; that is, the fines, offgrade, or other ferromanganese output of the furnace that was fed back to the furnace or lost in the plant, and which is included in gross production data reported by the furnace operator.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States in 1980, by source of ore

Source	Gross weight (short tons)	Mn content, natural (percent)
Domestic[1]	34,877	45
Foreign:		
Africa	288,991	46
Australia	49,021	52
Brazil	204,580	46
Chile[1]	18,754	45
India	39,676	48
Mexico	32,957	39
U.S.S.R.[1]	7,452	48
Unidentified	49,819	--
Total or average	726,127	46

[1]Most, if not all, from U.S. Government excess stockpile disposals.

Silicomanganese.—Domestic production of silicomanganese increased to 188,000 short tons from 165,000 tons in 1979, 142,000 tons in 1978, and 120,000 tons in 1977. This is net production produced for shipment and does not include silicomanganese produced for use in the same plant as an intermediate for the production of medium- or low-carbon ferromanganese. Silicomanganese shipments from furnaces totaled 162,000 tons in 1980, compared with 167,000 tons in 1979. Six companies used eight plants to produce silicomanganese for shipment in 1980: Autlan Manganese Corp., Theodore (Mobile), Ala.; Globe Metallurgical Div., Interlake Inc., Beverly, Ohio; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Ltd., Rockwood, Tenn.; SKW Alloys, Inc., Calvert City, Ky.; and Union Carbide Corp., Alloy, W. Va., Marietta, Ohio, and Portland, Oreg. These were the same eight plants that produced for shipment in 1979 and 1978, but ownership had changed in some instances. End use consumption of silicomanganese—that is, consumption outside the ferroalloy plants—was 19.7% that of ferromanganese in 1980, compared with 17.6% in 1979 and 16.7% in both 1978 and 1977.

Spiegeleisen.—There was no domestic production of spiegeleisen.

Pig Iron.—A total of 439,000 short tons of manganese-bearing ores containing 5% or more manganese (natural) was consumed in the production of pig iron (or its equivalent hot metal). Domestic sources supplied 307,000 tons, of which 267,000 tons was manganiferous iron ore containing 5% to 10% manganese and 40,000 tons was ferruginous manganese ore containing 10% to 35% manganese. Foreign sources supplied 132,000 tons, all of which contained more than 35% manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide by both electrolytic and chemical means, but it does not include consumption of synthetic dioxide. Although some synthetic dioxide is used for chemical purposes, most of it is used in the manufacture of dry-cell batteries, particularly for the manganese-alkaline type, for premium or heavy-duty Leclanché (manganese dioxide-ammonium chloride-zinc) cells, and for blending with natural ore in the ordinary Leclanché cells.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P-81-R for chemical-grade ore.

PRICES

Manganese Ore.—All manganese ore prices are negotiated. In addition to manganese content, they are dependent on chemical analysis otherwise, physical character, quantity, delivery terms, ocean freight rates, insurance, inclusion or exclusion of duties if applicable, buyer's needs, and availability of ores having the specifications desired. Trade journal quotations reflect the paper's evaluation of the market. Contract prices for 1980 delivery of metallurgical ore containing 48% manganese were finalized after the first quarter of the year within a range of about $1.66 to $1.75 per long ton unit, c.i.f. U.S. ports, with $1.70 being representative of the average. This compares with $1.40 for 1979 and 1978.

Manganese Alloys.—The published domestic producer price for standard high-carbon ferromanganese, with a minimum manganese content of 78%, was $530 per long ton of alloy f.o.b. shipping point throughout the year for Union Carbide Corp., and $490 for most of the other producers. Prices for imported high-carbon ferromanganese of the same manganese content (although not necessarily comparable in quality, delivery terms, or other respects) began the year at $430 to $440 f.o.b. Pittsburgh or Chicago warehouse. Trade journals reported that a low of $360 was reached in the summer with recovery ranging between $390 and $425 in December.

Manganese Metal.—The domestic producer price for standard and comparable grades of electrolytic manganese metal remained at 62 cents per pound, f.o.b. producer plant, shipments of 30,000 pounds or more, until April 1 when it was increased 4 cents to 66 cents per pound. A further increase of 4 cents, effective December 1, brought it to 70 cents, at which price it closed the year.

FOREIGN TRADE

Ferromanganese exports were 11,686 short tons valued at $7,656,934 in 1980, compared with 25,344 tons valued at $19,251,732 in 1979. Of the 1980 total, 4,599 tons went to the Federal Republic of Germany, 3,213 tons to Canada, 1,688 tons to the Netherlands, and 1,165 tons to Venezuela. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" totaled 12,320 tons with a value of $11,459,925, compared with 6,634 tons valued at $7,463,116 in 1979. This classification included electrolytic manganese metal and manganese-copper alloys, but it did not include ferromanganese or silicomanganese. Silicomanganese exports in 1980 were 6,489 tons with a value of $3,468,192, compared with 5,243 tons valued at $2,627,474 in 1979. The principal recipients were Venezuela, 1,819 tons; Federal Republic of Germany, 1,702 tons; Canada, 1,287 tons; and Japan, 1,213 tons. The Netherlands and Mexico received the remainder. Exports of ore and concentrate containing 5% or more manganese amounted to 52,537 tons, valued at $6,328,371, after adjustment by the Bureau of Mines for an obviously erroneous export entry. Of the total, large quantities with relatively low average values went to Canada (18,000 tons) and Mexico (10,642 tons). Much of these tonnages is believed to have been metallurgical ore obtained from excess Government stocks, whereas most of the remainder appears to have been imported manganese dioxide ore that may or may not have been ground, blended, or otherwise classified in the United States.

The average grade of imported manganese ore was 47% manganese in 1980, compared with 49% in 1979 and 51% in 1978. The Republic of South Africa and Australia each supplied approximately 30% of the total in 1980; Gabon provided 23%, while Brazil dropped to 10%. Manganiferous ore (more than 10% but less than 35% manganese) in the amount of 500 tons was imported from Mexico.

The rising trend of ferromanganese imports was stopped and they were actually down 26% from those of 1979. The Republic of South Africa supplied 37% of the total in 1980; France supplied 36%. Mexico was the third most important supplier with 7%. Silicomanganese imports for consumption totaled 74,975 short tons containing 49,158 tons of manganese in 1980; 94,671 tons containing 62,608 tons in 1979. Sources and gross weight tonnages in 1980 were reported as follows: Republic of South Africa, 24,014; Norway, 14,372; Yugoslavia, 12,919; Brazil, 12,177; Portugal, 7,584; France, 2,842; Belgium, 387; Canada, 349; and Taiwan, 331. Imports for consumption classified as unwrought manganese metal totaled 7,508 short tons, all of which came from the Republic of South Africa except for 9 tons from Hong Kong. In addition, 407 tons classified as manganese metal waste and scrap were imported: 297 tons from the Republic of South Africa, 54 tons from the Federal Republic of Germany, 36 tons from Canada, and 20 tons from Belgium. Unit values for the material imported in the two classes were not very different.

Manganese dioxide imports for consumption totaled 11,512 short tons in 1980, compared with 9,862 tons in 1979. Approximately 11,000 tons in 1980 was apparently battery-grade synthetic dioxide: 6,046 tons from Japan; 2,725 tons from Greece; 1,250 tons from Ireland; 875 tons from Belgium; and 96 tons from mainland China. Manganese sulfate imports totaled 23 tons with 22 tons from Japan and 1 ton split between the Federal Republic of Germany and Mexico.

Tariffs.—Manganese ore, and manganiferous ores, were free of duty from Most-Favored-Nations. Moreover, Public Law 96-467, October 17, 1980, provided for refund of duties that had been paid on manganese ore and manganiferous ores for the period in 1979 when duty suspension had lapsed, July 1 through December 31. Request for refund was to be made within 90 days of the act's enactment. The statutory rate for these ores remained at 1 cent per pound of contained manganese throughout 1980, and continued to apply to ores from the U.S.S.R. Effective February 1, mainland China, which had previously been subject to the statutory rate, received Most-Favored-Nation trade status. The respective rates of duty for metal and for the principal manganese ferroalloys are shown below. The duty on metal waste and scrap remained suspended.

Tariff item	TSUS number	Most Favored Nation (MFN)		Non-MFN
		Jan. 1, 1980	Jan. 1, 1987	Jan. 1, 1980
Ore and concentrate	601.27	Free	Free	1 cent per pound Mn.
Metal	632.30	14% ad valorem	14% ad valorem	20% ad valorem.
Ferromanganese:				
High-carbon	606.30	0.3 cent per pound Mn.[1]	1.5% ad valorem	10.5% ad valorem.
Medium-carbon	606.28	0.46 cent per pound Mn.[1]	1.4% ad valorem	6.5% ad valorem.
Low-carbon	606.26	0.3 cent per pound Mn plus 2% ad valorem.[1]	2.3% ad valorem	22% ad valorem.
Silicomanganese	606.44	0.46 cent per pound Mn plus 3.5% ad valorem.[1]	3.9% ad valorem	23% ad valorem.

[1]Free from certain countries under Generalized System of Preferences.

The U.S. Department of the Treasury determined that the Spanish Government had been subsidizing exports to the United States of high-carbon ferromanganese, medium-carbon ferromanganese, and silicomanganese. Beginning January 2, 1980, the Department levied countervailing duties, equal to the subsidies, against imports from Spain of these alloys. The additional duty was 2.4% ad valorem for medium-carbon ferromanganese, and 3.36% ad valorem for each of the other two.

In another action involving subsidies of exports by foreign governments, The Ferroalloys Association withdrew the petition which it had instituted for countervailing duties on imports of ferromanganese and silicomanganese from Brazil. In so doing, the association stated that the Brazilian Government had acted to eliminate more than 90% of its ferroalloy subsidy programs. In view of this withdrawal, the U.S. International Trade Commission terminated its investigation of the matter.

Table 7.—U.S. imports[1] of manganese ore (35% or more Mn), by country

Country	1979			1980		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	109,505	55,316	$5,413	205,388	106,043	$14,467
Brazil	104,632	51,660	5,471	69,670	33,648	3,663
Congo[2]	44,920	22,460	2,563	--	--	--
Gabon[3]	98,913	49,222	6,721	159,959	79,858	13,610
Mexico	4,590	2,059	245	43,707	[4]18,568	2,216
Morocco	21,790	[4]10,719	2,121	[5]9,821	[5]5,260	[5]1,161
South Africa, Republic of	115,433	52,117	4,951	208,970	86,373	11,296
Total[6]	499,782	243,553	27,485	697,516	329,750	46,413

[1]Quantities for general imports and imports for consumption were identical.
[2]Believed to have originated in Gabon.
[3]In addition, in 1979, the 44,920 tons credited to the Congo were believed to have originated in Gabon.
[4]In part, Bureau of Mines conversion of reported data (from apparent MnO_2 content to Mn content).
[5]Data include 4,559 tons gross weight, 2,416 contained weight (calculated by Bureau of Mines from reported 3,830 tons apparent MnO_2 content), with a value of $535,000 reported as manganiferous ore. Morocco doesn't produce or export maganiferous ore.
[6]Data may not add to totals shown because of independent rounding.

Table 8.—U.S. imports for consumption of ferromanganese, by country

Country	1979			1980		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	27,658	21,595	$6,104	20,206	15,674	$5,976
Belgium-Luxembourg	6,212	4,721	2,254	5,427	4,311	1,920
Brazil	29,573	22,493	9,590	12,566	9,553	3,884
Canada	11,133	8,073	2,029	17,148	13,514	4,872
France	150,623	117,225	50,553	218,214	170,189	78,410
Germany, Federal Republic of	11,029	8,708	[1]3,045	25	21	21
India	16,999	12,858	5,462	--	--	--
Japan	28,532	22,785	13,222	15,220	12,174	8,784
Mexico	39,088	30,535	12,238	41,967	32,949	13,598
Norway	61,821	48,250	18,673	22,265	17,528	9,858
Portugal	37,395	28,997	11,717	12,049	9,398	3,443
South Africa, Republic of	363,744	283,558	106,213	224,118	174,894	73,176
Spain	12,694	10,156	6,406	11,923	9,639	5,880
Taiwan	--	--	--	276	201	110
United Kingdom	5,367	4,079	1,169	--	--	--
Yugoslavia	19,345	14,701	6,169	4,299	3,353	1,432
Total[2]	821,213	638,734	[1]254,843	605,703	473,399	211,365

[1]Bureau of Mines figure (reported figures were 5,045 and 256,843.)
[2]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

Argentina.—Production of rhodochrosite was 89 metric tons in 1980 and 73 tons in 1979. In mid-1980, mine development and mill testing was reported as almost completed for the state-owned Farallon Negro deposit of Yacimientos Mineros Agua de Dionisio in Catamarca Province. Development includes a 230-meter shaft and four levels on the nearly vertical vein which has a width of 0.8 to 2.2 meters. Pyrolusite is the principal vein mineral. Mill heads are figured at 11% manganese and annual production is planned for 25,000 metric tons of 40% manganese concentrate, 80,000 troy ounces of gold, and 19,000 troy ounces of silver. Mill capacity is projected to be 350 to 400 metric tons per day of ore with the manganese recovered by flotation and the precious metals recovered by cyanidation. The bulk of Argentina's recent manganese production has come from mines in Santiago del Estero, Cordoba, and Mendoza Provinces.

Australia.—Exports of manganese ore from the Groote Eylandt Mine, Northern Territory, in 1980 were 1,328,000 metric tons, of which Japan received 625,000 tons, Europe 427,000 tons, South Korea 131,200 tons, and the United States 119,700 tons. Shipments for domestic consumption were 525,000 tons. In February, the parent Broken Hill Proprietary Co. Ltd. announced that annual production capacity at Groote Eylandt would be expanded by its subsidiary to the extent of 130,000 metric tons per year by the installation of a heavy medium plant to upgrade fines. Later, it was announced that "on present schedules" production capacity at Groote Eylandt would reach 3 million tons per year by 1985 or 1986. In 1979, 1,395 tons of metallurgical-grade ore, averaging 47.5% manganese, were produced in the Peak Hill area of Western Australia.

Belgium.—Sedema, S.A., a large producer of manganese compounds, subsidiary of Société Carbochimique S.A., was installing a new production line at its Tertre works to increase its capacity for chemically produced battery-grade synthetic manganese dioxide, sold under the trade names of Faradiser M and Faradiser WS, from 28,000 metric tons per year to 40,000 by 1982.

Bolivia.—In 1980, manganese ore production at the Mutun deposit was 3,200 metric tons; ore from small mines totaled 425 tons.

Brazil.—Industria e Comércio de Minerios S.A. (ICOMI) shipped 1,230,164 metric tons of manganese ore products, including pellets, in 1980 from its Serra do Navio operations, Amapa Territory. Of this quantity, 793,000 tons went to Europe, 138,000 to Japan, 73,000 to North America, and 22,000 to South America other than Brazil. These were loaded out of Porto de Santana in 53 vessel cargoes. The remaining 204,000 tons

Table 9.—Manganese ore: World production, by country[1]

(Short tons)

Country[2]	Percent Mn[e]	1976	1977	1978	1979[p]	1980[e]
North America: Mexico[3]	35+	499,579	[r]536,409	576,692	543,108	[4]492,874
South America:						
Bolivia[3 5]	28-54	[r]13,520	9,464	1,364	11,574	4,960
Brazil[6]	38-50	1,869,738	1,670,741	2,113,239	2,490,483	2,400,000
Chile	36-40	26,058	19,843	25,621	27,524	24,900
Peru	26	676	--	--	--	--
Europe:						
Bulgaria	30-	44,100	44,100	44,100	46,300	44,100
Greece	48-50	9,075	8,631	7,727	6,338	6,600
Hungary[7]	30-33	138,000	132,000	126,000	91,000	97,000
Italy	22+	4,917	10,267	10,738	9,921	[4]10,103
U.S.S.R.[8]	35	9,520,000	9,470,000	9,984,000	11,292,000	[4]11,300,000
Yugoslavia	30+	20,944	27,282	30,203	33,235	33,000
Africa:						
Egypt	28+	4,691	4,225	191	--	--
Gabon	50-53	2,443,556	2,039,857	1,830,959	2,535,417	[4]2,366,386
Ghana	30-50	343,780	321,417	347,864	298,481	[4]278,279
Morocco	53-50	129,305	125,164	139,112	149,017	165,000
South Africa, Republic of	30-48+	[r]6,010,079	5,564,411	4,758,721	5,712,615	[4]6,278,125
Sudan	48	505	504	496	[e]500	400
Zaire	30-57	200,824	42,216	--	--	--
Asia:						
China, mainland[e 9]	20+	1,100,000	[r]1,200,000	1,400,000	1,650,000	1,750,000
India[10]	10-54	[r]2,022,405	2,055,865	1,784,503	1,934,641	[4]1,813,692
Indonesia	47-56	10,839	6,593	6,492	6,514	7,700
Iran[11]	33+	44,100	44,100	33,100	[e]25,000	22,000
Japan	26-28	156,244	[r]139,063	114,802	96,925	85,900
Korea, Republic of	23-40	1,524	732	823	39	[4]89
Pakistan	35-	71	58	317	121	110
Philippines	35-45	11,658	22,706	4,311	5,508	5,500
Thailand	46-50	55,364	[r]84,836	79,599	38,984	[4]54,299
Turkey	35-46	18,696	21,275	[e]22,000	[r e]26,000	26,000
Oceania:						
Australia	37-53	2,374,560	1,531,113	1,376,699	1,836,752	[4]2,161,511
Vanuatu (formerly New Hebrides)	40-44	[12]38,664	[13]25,397	[13]22,853	[13]11,663	--
Total	NA	[r]27,113,472	[r]25,158,269	24,842,526	28,879,660	29,428,528

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 1, 1981.
[2]In addition to the countries listed, Colombia, Cuba, and the Territory of South-West Africa (Namibia) may have produced manganese ore and/or manganiferous ore, but available information is inadequate to make reliable estimates of output levels. Low-grade ore not included in this table has been reported as follows in short tons: Argentina (16% to 22% Mn) 1976—58,517, 1977—90,814, 1978—20,389, 1979—11,233, 1980—10,692; Czechoslovakia (about 17% Mn) 1976—1,211, 1977—1,003, 1978—[e]1,000, 1979—[e]1,000; 1980—[e]1,000; Malaysia (grade unspecified but apparently a manganiferous ferruginous ore) 1976—103,741, 1977—50,040, 1978—47,092, 1979—34,839, 1980—4,413; Romania (about 22% Mn) an estimated 90,000 in each year; the Republic of South Africa (15% to 30% Mn, in addition to material listed in table) 1976—56,178, 1977—266,930, 1978—105,490, 1979—nil, 1980—nil.
[3]Estimated on the basis of reported contained manganese.
[4]Reported figure.
[5]Exports.
[6]Figures are the sum of (1) sales of direct shipping manganese ore and (2) production of beneficiated ore, both as reported in the 1977 through 1980 editions of Annuario Mineral Brasileiro.
[7]Concentrate. Crude ore tonnages (18% to 26% Mn) as previously reported were 1976—181,963, 1977—177,061, 1978—172,160, 1979—115,000, 1980—[e]120,000.
[8]Source: 1976-79, The National Economy of the U.S.S.R., Central Statistical Administration, Moscow; 1980, Pravda, Moscow. Grade represents the annual averages obtained from reported metal contents of the gross weights shown in the table for 1976-79.
[9]Includes manganiferous ore.
[10]Much of India's production grades below 35% Mn; recent details on output by grade are not available, but in 1976, 65% of total exports of 787,533 short tons were below 35% Mn.
[11]Reported as if data are for calendar years, but may actually represent output for Iranian calendar years beginning March 21 of the year stated.
[12]Japanese imports.
[13]Figures revised from Japanese imports to reported production.

went to Brazilian ports in 32 coastwise vessel cargoes.[5]

Bulgaria.—Manganese ore produced in 1980 had an average manganese content of 29.1%.

Gabon.—Of the total 1980 manganese ore shipments of 2,150,000 metric tons, 2,040,000 tons were metallurgical ore and 110,000 tons were battery-grade ore.[6] Battery-grade ore (battery and chemical) produced in 1980 amounted to 102,703 metric tons. Manganese ore export earnings were 7% of Gabon's total in 1979, compared with 10% in 1978. In 1979, France was the largest importer; Norway, which had not purchased in 1978, was the second largest.

Ghana.—Ghana National Manganese Corp., the country's only manganese ore producer, exported 236,000 long tons in 1980 from the Nsuta Mine through the Port of Takoradi. Shipments went to seven countries: Belgium, Ireland, Japan, the Netherlands, Norway, Spain, and the United Kingdom.[7]

India.—The state-owned Manganese Ore India Ltd. (MOIL) planned to appoint Seltrust Engineering to design new manganese mines to supply metallurgical ore for ferromanganese production, although consideration was to be given to manganese dioxide production as well. In spite of problems of power availability, MOIL was given permission to consider setting up a 60,000-ton-per-year ferromanganese plant at Balaghat, Madhya Pradesh. A 2,500-ton-per-year synthetic manganese dioxide plant and a 1,000-ton-per-year electrolytic manganese metal plant, both to be at Dongri Buzurg, were being considered also.[8] The drought-induced power shortages of 1979 carried over into 1980 with power cuts ranging from 30% to 70% by April in the states in which ferroalloy production is concentrated. There were expectations that a large part of the nation's steel industry requirements for ferromanganese and other ferroalloys would have to be met by imports.[9]

Israel.—The 6,000-year-old Timna copper mines, last operated about 1976, were reopened in September, and construction was started on a $6 million plant to produce manganese sulfate, copper sulfate, and copper oxide, with completion targeted for 1982. Solar evaporation ponds, using newly developed technology, will be used to obtain the two sulfate products most of which will be exported.[10]

Japan.—Japan Metals & Chemicals Co., Ltd., will become Japan's fourth producer of electrolytic (synthetic) manganese dioxide upon completion of a new 6,000-metric-ton-per-year facility at its Takaoka plant, Toyama Prefecture, in 1981. The plant's entire production will go to the United States to supply Inco ElectroEnergy Corp. (formerly ESB Inc.) under a long-term contract. Japan's three present producers are Mitsui Mining & Smelting Co., Ltd., Toyo Soda Manufacturing Co., Ltd., and Daiichi Carbon Co., Ltd. According to the Ministry of International Trade and Industry (MITI), their production in fiscal 1978 aggregated 32,892 tons while domestic consumption amounted to 18,305 tons and exports were 16,779 tons.[11] Because of increased demand, particularly from abroad, Mitsui Mining & Smelting Co., Ltd., planned to increase annual production capacity of its Takehara, Hiroshima Prefecture, plant by 6,000 metric tons, from 19,000 metric tons to 25,000 tons, by September 1981.[12]

Korea, Republic of (South).—The small quantity of manganese ore produced in 1980 was reported to have an average manganese content of 40%.

Madagascar.—Rhodonite production in 1980 amounted to 350 kilograms.

Mexico.—Cia. Minera Autlán, S.A. de C.V., planned to open a new open pit mine in the Molango district of Hidalgo to increase the feed to its rotary kilns that convert the carbonate ore to oxide nodules at Ayotetla near the company village of Otongo. The nodules are feed for the company's manganese ferroalloy plants in Mexico at Teziutlan, Puebla, and Tamos, Vera Cruz; and its plant at Theodore (Mobile), Ala.; also, for the manganese ferroalloy plant of Hornos Electricos de Venezuela S.A. (Hevensa), near Matanzas, State of Bolivar, Venezuela, in which the company has a major interest.[13] In 1979, the company produced 28,559 metric tons of battery-grade oxide ore at its Nonoalco Mine in the Molango district, and joined with Japan's Matsushita Industrial Electric Co. Ltd. to form Baterias Panasonic-Autlán S.A. de C.V., for the purpose of producing dry-cell batteries in Mexico at some time in the future.[14]

Philippines.—Manganese ore produced in 1979 had an average manganese content of 35% to 38%.

South Africa, Republic of.—Delta Manganese (Pty.) Ltd. announced that it will build a 20,000-metric-ton-per-year electrolytic (synthetic) manganese dioxide plant, the country's first, next to its existing manganese metal plant at Nelspruit, Eastern Transvaal. The new plant's capacity was expected to be sufficient to supply domestic demand with enough excess to become a significant exporter.[15] Delta also was increasing its annual production capacity of electrolytic manganese metal from 20,500 metric tons to 28,500 tons by mid-1981 with plans for later expansion to 32,000 tons if market conditions permit.

Production of the various grades of ore in 1980 follow, in metric tons: Metallurgical ore—30% to 40% manganese, 3,149,955; 40% to 45%, 921,816; 45% to 48%, 971,515; over 48%, 289,764; chemical ore—less than 35% manganese dioxide, 194,931; 35% to 65%, 171,608; 65% to 75%, 150 tons. No ferruginous manganese ore containing 15%

to 30% manganese and 20% to 35% iron was produced in 1980.

Thailand.—Production of battery-grade manganese ore in 1980 was 2,716 metric tons and only 11 tons of chemical-grade ore was reported.

Turkey.—The manganese ore produced in 1979 was estimated to have a manganese content between 35% and 46%.

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[1]Supervisory physical scientist, Section of Ferrous Metals.

[2]Physical scientist, Section of Ferrous Metals.

[3]Office of Ocean Minerals and Energy, National Oceanic and Atmospheric Administration. Deep Seabed Mining. Draft Programmatic Environmental Impact Statement, March 1981, 283 pp.

[4]National Oceanic and Atmospheric Administration. Deep Seabed Mining Regulations for Exploration Licenses. Federal Register, v. 46, No. 56, Mar. 24, 1981, pp. 18,448-18,475.

[5]Skillings' Mining Review. V. 70, No. 14, Apr. 4, 1981, p. 27.

[6]——. V. 70, No. 13, Mar. 28, 1981, p. 16.

[7]——. V. 70, No. 13, Mar. 28, 1981, p. 19.

[8]Metal Bulletin (London). No. 6507, July 18, 1980, p. 21.

[9]——. No. 6482, Apr. 18, 1980, p. 25.

[10]American Metal Market. V. 88, No. 186, Sept. 24, 1980, p. 8.

[11]Japan Metal Journal (Tokyo). V. 10, No. 30, July 28, 1980, p. 9.

[12]——. V. 10, No. 38, Sept. 22, 1980, p. 6.

[13]Skillings' Mining Review. V. 69, No. 27, July 5, 1980, p. 8.

[14]Engineering & Mining Journal. Autlan: Huge Resources Will Feed Steel Industry's Manganese Demand. V. 181, No. 11, November 1980, pp. 107-108.

[15]Industrial Minerals (London). No. 156, September 1980, pp. 14-15.

Mercury

By Harold J. Drake[1] and Linda C. Carrico[2]

U.S. mine production of mercury increased slightly over that of 1979, owing primarily to higher prices. Production was reported by four mines, two each in California and Nevada. In 1980, mine production and industrial secondary production accounted for 44% of the total U.S. supply of mercury.

Mercury consumption in 1980 fell slightly from the 1979 level. The decline was led by reduced consumption for mercury in catalysts, chlorine and caustic soda manufacture, general laboratory use, and paints. Increased consumption was reported for uses in agriculture, electrical apparatus, and dental preparations. Due partly to decreased demand, producer (mine), consumer, and dealer stocks were above the 1979 level.

New York dealer and London prices increased dramatically in 1980, owing mainly to the restriction of sales and decline in output by some foreign producers.

Imports for consumption decreased 64% from the 1979 level and accounted for 11% of domestic supply and 16% of demand. Japan and Spain were the principal suppliers of imported mercury.

During most of 1980, producers in Italy, Spain, and the U.S.S.R. reportedly continued to restrict sales of mercury. Italian, Yugoslavian, and Mexican producers continued to sharply curtail or completely shut down mercury mining operations. Canadian mining operations, suspended because of low prices in 1975, remained closed during 1980. An international association of mercury producers met intermittently during 1980. The group continued to advocate price stabilization by curtailing production, withholding supplies from the market, restricting sales to dealers, and closely controlling sales agents. According to reports, as the price of mercury continued to rise, some foreign producers were planning to reopen their closed mines in 1981.

Legislation and Government Programs.—General Services Administration (GSA) offered 1,000 flasks[3] of mercury for sale each month and sold 10,013 flasks during 1980. Since 1965, GSA has been releasing to industry, on a bid basis, the surplus mercury obtained from other Government agencies. In May 1980, the Federal Emergency Management Agency (FEMA) announced a new stockpile goal of 10,500 flasks of mercury, 43,504 flasks less than the 1976 goal of 54,004 flasks. According to FEMA, the goal was decreased because of a substantial increase in domestic production. At yearend, the stockpile contained 191,391 flasks, leaving 180,891 flasks available for disposal.

On December 11, the President signed Public Law 96-510,[4] the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, which will establish a $1.6 billion "superfund" to clean up hazardous chemical and petroleum waste sites and spills. This law will impose a tax starting April 1, 1981, on 42 designated hazardous chemicals and petroleum products, of which mercury was included; the tax will terminate September 30, 1985.

In 1978, the Environmental Protection Agency (EPA) proposed plans to implement the Toxic Substances Control Act of 1976. Mercury was not included in the list of toxic substances by yearend 1980, but the metal was being evaluated by EPA to determine if there is a need for its regulation.

Collection of data on the production, geology, and ore reserves of mercury deposits in the United States was planned for inclusion in the Bureau of Mines Minerals Availability System (MAS). Under the MAS program at the Bureau, a computerized Supply Analysis Model (SAM) was developed. SAM's analytical capabilities include evaluating mineral deposits, updating changes in costs and prices to reflect inflation, and conducting sensitivity analysis to determine impacts on mineral supply under various conditions.[5]

Table 1.—Salient mercury statistics

	1976	1977	1978	1979	1980
United States:					
Producing mines	7	5	2	3	4
Production ___ flasks	23,133	28,244	24,163	29,519	30,657
Value ___ thousands	$2,806	$3,833	$3,705	$8,299	$11,939
Exports ___ flasks	501	852	NA	NA	NA
Reexports ___ do	12	101	NA	NA	NA
Imports:					
For consumption ___ do	44,415	28,750	r41,693	26,448	9,416
General ___ do	43,964	28,750	r42,874	r28,818	11,564
Stocks, Dec. 31 ___ do	31,734	34,178	38,749	27,582	33,069
Consumption ___ do	64,870	61,259	r59,393	r62,205	58,983
Price: New York, average per flask	$121.35	$135.71	$153.32	$281.10	$389.45
World:					
Production ___ flasks	r234,614	r190,736	r181,434	r190,039	191,069
Price: London, average per flask	$91.97	$140.70	$131.57	$291.73	$398.07

rRevised. NA Not available.

DOMESTIC PRODUCTION

Mine production of mercury in the United States increased slightly in 1980. Four mines accounted for total output; the Carlin gold mine and the McDermitt mercury mine located in Nevada and the Knoxville and Houser Mines located in California. Of the total output, Nevada supplied 30,431 flasks and California supplied 226 flasks. With rising prices in recent years, some mercury miners in California were planning to reopen properties. In 1980, the average grade of ore processed was 6.5 pounds of mercury per ton of ore, compared with 9.2 pounds per ton in 1979.

Secondary mercury production in 1980 was 16,806 flasks, the highest level since 1968. Most of the increase in secondary production was attributed to higher mercury prices, which made recovery from low-grade scrap economical. Major sources of secondary mercury were batteries, dental amalgams, sludges, and industrial and control instruments.

Table 2.—Mercury produced in the United States

Year and State	Producing mines	Flasks	Value[1] (thousands)
1979:			
California and Nevada	3	29,519	$8,299
1980:			
California and Nevada	4	30,657	11,939

[1]Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced: Flasks	Mercury produced: Pounds per ton of ore
1976	185,103	23,042	9.5
1977	216,577	28,244	9.9
1978	256,197	24,144	7.2
1979	r242,564	29,499	r9.2
1980	356,043	30,623	6.5

rRevised.
[1]Excludes mercury produced from old surface ores, dumps, and placers, and as a byproduct.

Table 4.—Production of secondary mercury in the United States

(Flasks)

Year	Industrial production	GSA releases	Total
1976	2,843	520	3,363
1977	5,566	1,000	6,566
1978	3,560	5,702	9,262
1979	4,287	11,300	15,587
1980	6,793	10,013	16,806

CONSUMPTION AND USES

Mercury consumption in 1980 decreased slightly from the 1979 level. Primary mercury accounted for 67% of total consumption, redistilled mercury for 23%, and secondary mercury for the remainder.

Table 5.—Mercury consumed in the United States, by use

(Flasks)

Use	1976	1977	1978	1979	1980
Agriculture[1]	607	584	W	W	W
Amalgamation	11	W	--	--	--
Catalysts	1,264	1,545	W	548	265
Dental preparations	1,990	1,230	512	793	947
Electrical apparatus	27,498	29,180	(2)	(2)	(2)
Electrolytic preparation of chlorine and caustic soda	16,054	10,744	11,166	12,180	9,470
General laboratory use	595	406	420	410	363
Industrial and control instruments	5,067	5,221	(2)	(2)	(2)
Paint, mildew proofing	7,845	8,365	8,956	9,979	8,621
Pharmaceuticals	60	W	W	W	--
Other[3]	2,909	2,589	(2)	(2)	(2)
Total known uses	63,900	59,864	r59,393	r62,205	58,983
Total unknown uses	970	1,395	--	--	--
Grand total	64,870	61,259	r59,393	r62,205	58,983

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Includes fungicides and bactericides for industrial purposes.
[2]Due to format change, see table 6 for 1980 SIC end-use data.
[3]Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 6.—Mercury consumed in the United States in 1980

(Flasks)

Use	Primary	Redistilled	Secondary	Total
Chemicals and allied products:				
Chlorine and caustic soda preparation	9,470	--	W	9,470
Pigments	W	--	--	W
Catalysts	W	265	--	265
Laboratory uses	159	184	20	363
Plastic materials and synthetic (processing and resins)	W	--	--	W
Pharmaceuticals	--	--	--	--
Paint	8,621	--	--	8,621
Agricultural chemicals	W	--	--	W
Chemicals and allied products, n.e.c	W	W	W	W
Electrical and electronic instruments:				
Electrical lighting	W	W	--	1,036
Wiring devices and switches	2,139	923	--	3,062
Batteries	14,966	W	W	27,829
Other electrical and electronic equipment	W	W	--	W
Instruments and related products:				
Measuring and control devices	1,201	1,848	W	3,049
Dental equipment and supplies	W	947	W	947
Other instruments and related products	W	94	--	94
Other identified end uses:				
Refining lubricating oils	--	W	--	W
Other	52	W	W	52
Other	2,837	9,212	6,045	4,195
Total known uses	39,445	13,473	6,065	58,983

W Withheld to avoid disclosing company proprietary data; included in "Other."

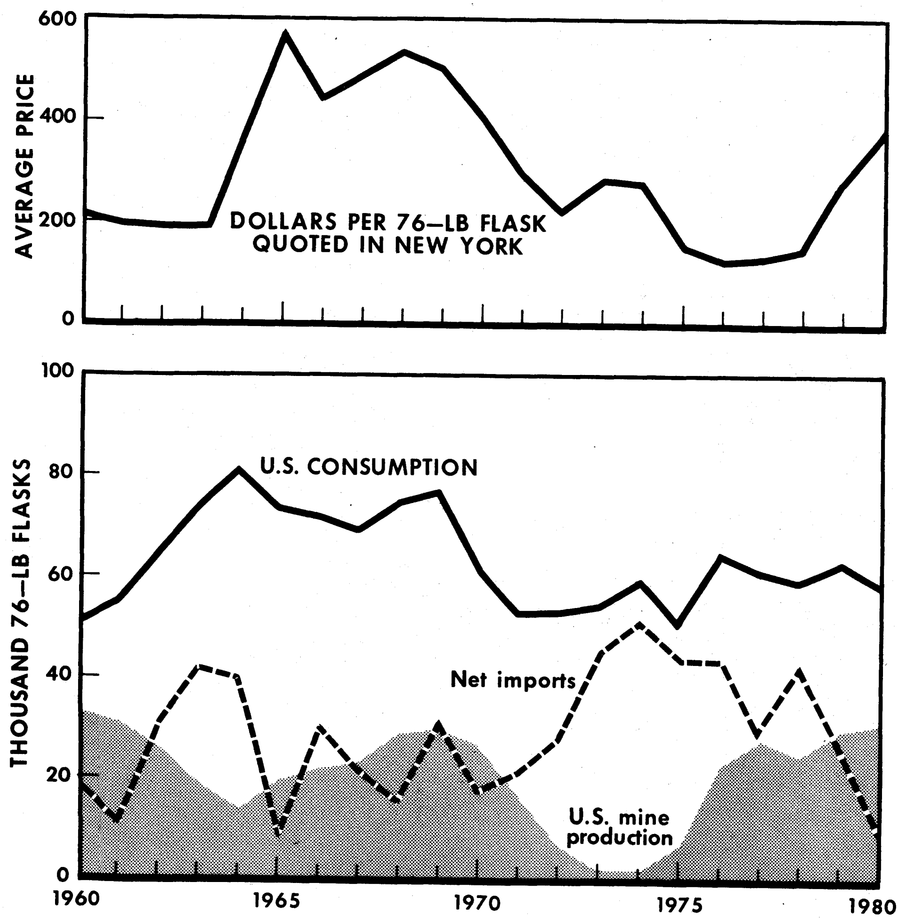

Figure 1.—Trends in production, consumption, net imports, and price of mercury, in the United States.

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer (mine)	Consumer and dealer	Total
1976	9,494	22,240	31,734
1977	11,275	22,903	34,178
1978	16,600	22,149	38,749
1979	9,181	18,401	27,582
1980	11,095	21,974	33,069

PRICES

U.S. mercury prices rose for the first 4 months of 1980, then fluctuated for the remainder of the year. The annual average New York price for primary mercury was $389.45 per flask, an increase of $108.35 over the 1979 average and the highest since 1970. At yearend 1980, the New York price of mercury was $355 to $360 per flask, compared with $360 to $370 per flask in January. London prices showed a similar pattern during 1980. The annual average price of $398.07 per flask was $106.34 over that of 1979. At the beginning of 1980 the London price was $370 to $380 per flask, compared with $360 to $370 per flask at yearend 1980.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

	1979		1980	
	New York[1]	London[2]	New York[1]	London[2]
January	$186.14	$196.00	$378.64	$390.06
February	200.00	218.49	390.00	393.33
March	218.91	241.50	393.81	396.56
April	255.48	262.29	402.05	404.39
May	296.59	301.86	389.52	394.17
June	334.76	343.89	381.43	386.88
July	299.05	301.00	389.32	399.33
August	289.13	301.63	387.62	408.11
September	303.95	310.76	394.05	415.00
October	315.00	324.46	404.77	414.72
November	328.58	333.34	398.53	399.31
December	355.00	365.63	363.64	374.94
Average	281.10	291.73	389.45	398.07

[1]Metals Week, New York.
[2]Metal Bulletin, London; reported in terms of U.S. dollars.

FOREIGN TRADE

Statistical data on exports of mercury are not reported, but were estimated at 1,000 flasks valued at $389,500 in 1980.

During the year, imports for consumption decreased dramatically from the 1979 level. The average unit value for the year was $301.72 per flask compared with $196.88 per flask in 1979. Mercury imports during 1980 were principally from Japan and Spain, however, compared with the previous year, imports from Japan and Spain decreased 52% and 61%, respectively.

The U.S. rate of duty on mercury metal, imports from "most favored nation" (MFN) countries during 1980 was 11.9 cents per pound ($9.04 per flask). The suspension of duty on waste and scrap for MFN countries was extended until June 30, 1981, as provided by Public Law 95-508. The statutory rate of 25 cents per pound ($19 per flask) applied to other countries.

Table 9.—U.S. imports for consumption[1] of mercury, by country

Country	1978		1979		1980	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Algeria	8,751	$1,248	100	$34	--	--
Canada	895	130	3,943	783	843	$197
China, mainland	3,329	398	--	--	204	61
Dominican Republic	200	26	611	129	200	73
France	73	10	470	127	--	--
Germany, Federal Republic of	--	--	--	--	15	24
Italy	5,913	757	4,429	675	--	--
Japan	4,428	442	7,960	1,755	3,813	1,260
Mexico	813	70	403	60	989	206
Netherlands	369	59	25	4	--	--
Spain	13,923	1,723	8,507	1,640	3,352	1,020
Turkey	2,999	377	--	--	--	--
Total	41,693	5,240	26,448	5,207	9,416	2,841

[1]General imports: 1978—42,874 ($5,386,767), mainland China 4,010 flasks ($481,095), and Spain 14,423 ($1,786,744); 1979—28,818 ($5,659,206), mainland China 1,400 ($182,674), Italy 5,369 ($926,522), Japan 8,611 ($1,919,543), and Spain 8,356 ($1,621,083); 1980—11,564 ($3,618,781), mainland China 200 ($60,635), Japan 5,464 ($1,840,377), and Spain 3,853 ($1,218,025).

WORLD REVIEW

World mine production of mercury has increased for 2 consecutive years due primarily to rising prices. During 1980, the international association of mercury producers, Assimer, met periodically to review the mercury market situation and to try to bolster prices.

Spain.—The Spanish Government has decided to nationalize Minas de Almáden Arrayanes, the world's largest mercury producer. The nationalization was scheduled to take effect January 1, 1981.

U.S.S.R.—It was reported that the Soviet suppliers will not have any mercury to export in 1981. Although the U.S.S.R. was a large producer in 1980, it required most of its own production for domestic use.

Yugoslavia.—The Idria Mine, Yugoslavia's principal producer, closed in 1977 because of low prices and declining grade of ore. In 1980, there were reports that restoration work on the Idria Mine was under way, with plans for reopening in 1981. The mine output is expected to be 300 tons (7,895 flasks) annually, with 80% used domestically.

Table 10.—Mercury: World production, by country[1]

(Flasks)

Country	1976	1977	1978	1979[p]	1980[e]
Algeria	30,915	30,429	30,603	[e]30,000	30,000
Australia	4	1	(2)	(2)	--
Chile	13	20	--	--	--
China, mainland	[r]18,000	20,000	20,000	20,000	20,000
Czechoslovakia	[r]5,540	[r]5,309	5,686	4,960	[3]4,612
Dominican Republic	--	495	500	500	500
Finland	383	630	1,145	1,360	1,300
Germany, Federal Republic of	3,191	2,872	2,437	2,639	2,500
Italy	22,278	406	87	--	--
Mexico	15,026	9,660	2,205	[e]2,000	1,500
Spain	42,729	[r]26,851	29,588	33,275	33,000
Turkey	4,899	4,686	5,020	4,786	5,000
U.S.S.R.[e]	56,000	58,000	60,000	61,000	62,000
United States	23,133	28,244	24,163	29,519	[3]30,657
Yugoslavia	12,503	3,133	--	--	--
Total	[r]234,614	[r]190,736	181,434	190,039	191,069

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 27, 1981.
[2]Revised to zero.
[3]Reported figure.

TECHNOLOGY

The geology and ore mineralization of the Blackbutte mercury mine in Oregon were described.[6] The brief discussion detailed host rocks, ore minerals, and structural features that controlled mineralization.

A new device was developed for collecting mercury vapor samples during geochemical exploration for mercury deposits.[7] Gold, which has been deposited on a gas-chromatography diatomite support, collects the mercury vapor from soil or water samples, and the resultant change in weight of the device is used to determine the presence of mercury.

Mercury was determined using an atomic absorption spectrometric technique that utilized an argon gas-purged monochromator.[8] In another experimental study using atomic absorption spectrometry, alkylmercury and inorganic mercury in river sediments were effectively differentiated and measured.[9] The extreme sensitivity of the atomic absorption spectrometry technique for the determination of mercury was shown in an investigation of mercury concentration in natural waters. The technique was sensitive to 0.5 part per trillion for a 20-milliliter sample.[10]

Industrial wastes in lacustrine sediments of the Finger Lakes District of New York were investigated with emphasis on base metals, such as mercury, and on organic residues from local manufacturing operations.[11]

Mercury concentration in soil adjacent to geothermal activity, such as hot springs and gas vents, was investigated to develop techniques for exploration of calderas. Results of the investigation concerning the use of mercury soil concentrations as an exploration tool were inconclusive.[12]

Attempts to eliminate mercury from wastewater in chloralkali plants continued. Maintaining tight pH control, metallic mercury was converted to sulfide and filtered out.[13]

Research on mercury lamps continued, with a view to improving their color appearance and luminous efficacy using europium-activated phosphors.[14]

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[1]Physical scientist, Section of Nonferrous Metals.

[2]Mineral specialist, Section of Nonferrous Metals.

[3]Flask as used throughout this chapter refers to the 76-pound flask.

[4]U.S. Congress. Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Public Law 96-510, Dec. 11, 1980, 94 Stat. 2767.

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Mica

By Valentin V. Tepordei[1]

In 1980, a total of 117,000 tons[2] of scrap and flake mica was reported produced in the United States, a 13% decrease from 1979 production. Output of ground mica, sold or used, was 109,000 tons, an 11% decrease from the previous year.

Consumption of mica block decreased by 48% to 143,000 pounds and that of mica film decreased by 20% to 4,000 pounds. Consumption of mica splittings decreased by 10% from that of 1979 to 4.4 million pounds.

Exports of unmanufactured mica increased 17% to 14,500 tons and imports of all forms of mica increased 20% to 12,100 tons.

Legislation and Government Programs.—The total government stockpile inventory of natural sheet mica was reduced to 27.8 million pounds by December 31, 1980. Sales of sheet mica by the General Services Administration (GSA) during 1980 totaled 48,000 pounds, all muscovite splittings. There were no sales of block or film mica.

Table 1.—Salient mica statistics

	1976	1977	1978	1979	1980
United States:					
Production (sold or used by producing companies):					
Sheet mica ---- thousand pounds	5	1	(1)	1	NA
Value ---- thousands	$3	(1)	(1)	(1)	NA
Scrap and flake mica ---- thousand short tons	2 123	2 129	2 139	2 134	117
Value ---- thousands	2 $5,667	2 $7,039	2 $7,916	2 $7,708	$5,296
Ground mica ---- thousand short tons	2 115	2 122	2 124	2 122	109
Value ---- thousands	2 $10,207	2 $11,906	2 $12,979	2 $14,522	$12,992
Consumption:					
Block ---- thousand pounds	524	439	239	277	143
Value ---- thousands	$1,369	$952	$1,328	$1,841	$1,811
Film ---- thousand pounds	10	9	8	5	4
Value ---- thousands	$44	$38	$34	$25	$18
Splittings ---- thousand pounds	5,025	4,144	5,537	4,877	4,383
Value ---- thousands	$3,226	$2,718	$3,031	$3,248	$3,101
Exports ---- thousand short tons	8	10	9	12	14
Imports ---- do	5	4	7	10	12
World production ---- thousand pounds	r 702,321	r 748,402	r 800,866	r 788,287	726,990

r Revised. NA Not available.
1 Less than 1/2 unit.
2 Data have been revised to exclude low-quality sericite.

Table 2.—Stockpile status, December 31, 1980[1]

(Thousand pounds)

Material	Goal	Total inventory	Available for disposal	Sales 1979-80
Stockpile grade:				
Block:				
Muscovite, Stained and better	6,200	5,006	--	--
Phlogopite	210	17	--	--
Film: Muscovite, 1st and 2d qualities	90	1,274	--	--
Splittings:				
Muscovite	12,630	19,498	463	1,436
Phlogopite	930	2,019	1,058	354

[1]In addition to the data shown, the stockpile contains the following: Material with goals (nonstockpile grade) includes 206,740 pounds muscovite block, Stained and better; 640 pounds moscovite film, 1st and 2d qualities; and 114,027 pounds phlogopite block. Other material, without goals, includes 181,373 pounds moscovite block, Stained or lower.

DOMESTIC PRODUCTION

Scrap and Flake Mica.—U.S. production of scrap (flake) mica[3] in 1980 was 117,000 tons valued at $5,296,000. North Carolina was again the major producing State with 78,000 tons or 67% of the total. The remaining 33% was produced in Alabama, Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota. Most of the scrap (flake) mica was obtained by flotation of kaolin, feldspar, and mica ores.

Leading producers in 1980 were Harris Mining Co., Spruce Pine, N.C.; Mineral Industrial Commodities of America, Inc. (M.I.C.A.), Santa Fe, N. Mex., Kings Mountain Mica Corp., Kershaw S.C.; and Deneen Mica Co., Micaville, N.C.

Ground Mica.—Production (sold or used) of ground mica, from scrap and flake mica, decreased in 1980 by 11% to 109,000 tons. Dry-ground mica, which represented 92% of the total ground mica production, decreased by 7% and wet-ground mica production decreased by 29%. Value of total ground mica production decreased by 11% to $12,992,000.

M.I.C.A. announced plans to expand its New Mexico open pit mica mine and build a new mill to produce mica for use in joint cement, oil well drilling mud, paint, and stucco. The new mill will double the company's production capacity.

Concepts West, Inc., of Custer, S. Dak. purchased in March 1980 the old Crown Mine and will start extracting mica and feldspar sometime in 1981.

During 1980, 13 companies operated 15 plants, producing ground scrap (flake) mica including high-quality sericite; of these, 9 produced dry-ground, 2 produced wet-ground, and 2 produced both wet- and dry-ground material. Leading ground mica producers were the same as those for scrap and flake mica.

In 1980, production of low-quality sericite, primarily for use in brick manufacturing, was 43,300 tons valued at $127,400. Approximately 38,100 tons of ground sericite valued at $173,400 was produced from this crude sericite.

Table 3.—Scrap and flake mica sold or used by producers in the United States[1 2]

Year and State	Quantity (thousand short tons)	Value (thousands)
1976	123	$5,667
1977	129	7,039
1978	139	r7,916
1979	134	7,708
1980:		
North Carolina	78	3,680
Other States[3]	39	1,616
1980 total	117	5,296

rRevised.
[1]Includes finely divided mica recovered from mica and high-quality sericite schist, and mica that is a byproduct of feldspar, kaolin, and lithium beneficiation.
[2]1976-79 data have been revised to exclude low-quality sericite.
[3]Includes Alabama, Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota.

Table 4.—Ground mica sold or used by producers in the United States, by method of grinding[1 2]

(Thousand short tons and thousand dollars)

Year	Dry-ground		Wet-ground		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1976	102	7,100	13	3,107	115	10,207
1977	107	8,233	15	3,673	122	11,906
1978	110	9,039	14	3,940	124	12,979
1979	108	10,193	14	4,329	122	14,522
1980	100	9,738	10	3,254	[3]109	12,992

[1]Domestic and some imported scrap.
[2]1976-79 data have been revised to exclude low-quality sericite.
[3]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Sheet Mica.—Consumption of muscovite block (ruby and nonruby) totaled 142,600 pounds, a decrease of 46% from that of 1979. Of the total muscovite block fabricated, 79% went into electronic uses (52% for vacuum tubes and 27% for capacitators and other uses); the remainder went into nonelectronic uses, with gage glass and diaphragms accounting for 8%.

In 1980, Lower-than-Stained-quality muscovite block was in greatest demand and accounted for 64% of consumption, followed by Stained quality, 28%, and Good-Stained or better, 8%. Consumption by increasing size (grade) was: Smaller than No. 6, 13%; No. 6, 29%; No. 5 1/2, 16%; No. 5, 19%; and larger than No. 4, 23% of the total.

Mica film consumption decreased 36% from that of 1979 to 2,500 pounds. This decline could be attributed to increased fabrication overseas, and substitution by other materials. First-quality film represented about 28% of the total amount fabricated and second-quality film accounted for the remainder.

Muscovite block and film was consumed by nine companies in seven States at two plants in North Carolina, two in Massachusetts, and one each in New Jersey, New York, Ohio, Pennsylvania, and Virginia. New York, Pennsylvania, and Virginia companies consumed 72% of the total block and film used for fabrication in 1980.

Phlogopite block fabrication totaled 13,300 pounds, an increase of 13% over the 1979 total. This amount was consumed by six companies in five States.

Consumption of mica splittings in 1980 totaled 4.4 million pounds, a decrease of 10% from that of 1979. Of this total, 96% was muscovite splittings from India and the remainder phlogopite splittings from Madagascar. The mica splittings were fabricated into various built-up mica products by 11 companies operating 12 plants in 9 States.

Built-up Mica.—The primary use of this mica-base product made by mechanical or hand setting of overlapping splittings and alternate layers of binders and splittings was as electrical insulation material. In 1980, total production, sold or used, of built-up mica decreased by 18% from that of 1979. Molding plate represented the major end use with 33% of the total, followed by segment plate (32%) and tape (17%).

Ground Mica.—In 1980, a total of 109,000 tons of ground mica was sold or used by U.S. producers, a decrease of 11% from 1979 production. The major end uses were joint cement (46%) and paint (15%). Miscellaneous end uses, including ground mica used in oil well drilling muds and roofing, represented 38% of the total.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, in the United States in 1980, by quality and end-product use

(Pounds)

Variety, form, and quality	Electronic uses: Capacitors	Electronic uses: Tubes	Electronic uses: Other	Electronic uses: Total[1]	Nonelectronic uses: Gage glass and diaphragms	Nonelectronic uses: Other	Nonelectronic uses: Total[1]	Grand total[1]
Muscovite:								
Block:								
Good Stained or better	300	--	(2)	400	10,500	1,000	11,500	11,900
Stained	--	10,400	26,800	37,200	700	1,600	2,300	39,500
Lower than Stained[3]	--	64,000	11,100	75,200	(2)	15,900	16,000	91,200
Total[1]	300	74,000	38,000	112,800	11,200	18,600	29,800	142,600
Film:								
1st quality	1,500	--	--	1,500	--	--	--	1,500
2nd quality	2,400	--	--	2,400	--	--	--	2,400
Total[1]	4,000	--	--	4,000	--	--	--	4,000
Block and film:								
Good Stained or better[4]	4,300	--	(2)	4,300	10,500	1,000	11,500	15,900
Stained[5]	--	10,400	26,800	37,200	700	1,600	2,300	39,500
Lower than Stained	--	64,000	11,100	75,200	(2)	15,900	16,000	91,200
Total[1]	4,300	74,400	38,000	116,700	11,200	18,600	29,800	146,500
Phlogopite: Block (all qualities)	--	--	--	--	--	13,300	13,300	13,300

[1]Data may not add to totals shown because of independent rounding.
[2]Insignificant.
[3]Includes punch mica.
[4]Includes 1st- and 2d-quality film.
[5]Includes other-quality film.

Table 6.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1980, by quality and grade

(Pounds)

Form, variety, and quality	No. 4 and larger	No. 5	No. 5 1/2	No. 6	Other[1]	Total[2]
Block:						
Ruby:						
Good Stained or better	4,500	1,000	200	300	--	6,000
Stained	9,600	22,100	21,300	26,300	4,800	84,200
Lower than Stained	10,500	600	1,400	12,900	11,500	36,800
Total[2]	24,600	23,700	22,900	39,500	16,200	126,900
Nonruby:						
Good Stained or better	4,500	1,800	--	--	--	6,300
Stained	1,200	600	400	700	--	2,800
Lower than Stained	3,200	500	--	800	2,000	6,600
Total	8,900	2,900	400	1,500	2,000	15,700
Total block (ruby and nonruby)[2]	33,500	26,500	23,300	41,000	18,200	142,600

See footnotes at end of table.

Table 6.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1980, by quality and grade —Continued

(Pounds)

Form, variety, and quality	No. 4 and larger	No. 5	No. 5 1/2	No. 6	Other[1]	Total[2]
Film:						
Ruby:						
1st quality	--	300	300	100	--	700
2d quality	(3)	400	900	400	--	1,800
Total	(3)	700	1,200	500	--	2,500
Nonruby:						
1st quality	--	--	400	500	--	800
2d quality	--	--	600	--	--	600
Total	--	--	1,000	500	--	1,400
Total film (ruby and nonruby)[2]	(3)	700	2,200	1,000	--	4,000

[1]Figures for block mica include all smaller than No. 6 grade and punch mica.
[2]Data may not add to totals shown because of independent rounding.
[3]Insignificant.

Table 7.—Consumption and stocks of mica splittings in the United States, by source

(Thousand pounds and thousand dollars)

	India		Madagascar		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1976	4,903	3,084	122	142	5,025	3,226
1977	3,979	2,525	165	193	4,144	2,718
1978	5,371	2,837	166	194	5,537	3,031
1979	4,714	2,745	163	503	4,877	3,248
1980	4,216	2,543	167	557	4,383	[1]3,101
Stocks on Dec. 31:						
1976	3,166	NA	124	NA	3,290	NA
1977	3,130	NA	68	NA	3,198	NA
1978	2,695	NA	76	NA	2,771	NA
1979	2,331	NA	110	NA	2,441	NA
1980	2,917	NA	69	NA	2,986	NA

NA Not available.
[1]Data do not add to total shown because of independent rounding.

Table 8.—Built-up mica[1] sold or used in the United States, by product

(Thousand pounds and thousand dollars)

Product	1979		1980	
	Quantity	Value	Quantity	Value
Molding plate	1,549	3,951	1,351	3,554
Segment plate	1,558	4,423	1,309	3,818
Heater plate	168	485	116	402
Flexible (cold)	634	2,276	328	1,314
Tape	744	2,721	719	3,406
Other	402	1,801	299	1,453
Total	5,055	15,657	4,122	[2]13,946

[1]Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2]Data do not add to total shown because of independent rounding.

Table 9.—Ground mica sold or used by producers in the United States, by end use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Roofing	W	W	W	W
Rubber	4	1,177	2	627
Paint	19	2,233	16	1,897
Joint cement	63	6,315	50	5,046
Other uses[1]	36	4,796	41	5,423
Total[2]	122	14,522	109	12,992

W Withheld to avoid disclosing company proprietary data; included with "Other uses."
[1]Includes mica used for agricultural products, molded electric insulation, plastics, welding rods, well drilling mud, textile and decorative coatings, wallpaper, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

STOCKS

Reported yearend consumer stocks of sheet mica in 1980 were 3.3 million pounds. Mica splittings represented 92% and mica block represented 8%.

PRICES

Average reported values of muscovite sheet mica in 1980, based on consumption data were block, $12.70 per pound; film, $4.54 per pound; and splittings, $0.60 per pound. The average values of phlogopite sheet mica for 1980 were $5.58 per pound for block and $3.34 per pound for splittings. Compared with 1979 average reported values, muscovite block increased 96%, muscovite film decreased 13%, and muscovite splittings increased 3%. Compared with 1979, the average values of phlogopite block decreased 12% while phlogopite splittings increased 8%.

The average value of scrap (flake) mica, including high-quality sericite, was $45.07 per ton. The average value per ton for North Carolina scrap (flake) mica, predominantly a flotation product, was $47.00.

The average of reported prices for ground mica are shown in table 10.

Table 10.—Averages of reported prices for dry- and wet-ground mica sold or used by U.S. producers in 1980

(Dollars per short ton)

Wet-ground	337
Dry-ground	98
End uses:	
Roofing	W
Rubber	261
Paint	118
Joint cement	102
Other uses[1]	132

W Withheld to avoid disclosing company proprietary data; included in "Other uses."
[1]Includes mica used for agricultural products, molded electrical insulation, plastics, welding rods, well drilling mud, textile and decorative coatings, wallpaper, and other uses.

FOREIGN TRADE

Unmanufactured mica for export included block, film, splittings, and waste; sometimes small quantities of ground mica were also included in this category. These exports totaled 6,275 tons valued at $1.95 million in 1980. Japan was the leading country of destination receiving 1,990 tons valued at $642,000.

Exports of ground mica totaled 8,187 tons valued at $2,247,000. Canada was the leading country of destination receiving 2,549 tons valued at $484,400.

The total value of stamped or built-up mica exports was $7,665,000, with Canada the leading country of destination accounting for 30% of the total value shipped.

Imports of all classes of mica in 1980 rose 17% to 24.1 million pounds. The main reason for this increase was the introduction of Indian ground mica into the U.S. market. Tables 11-13 list in detail U.S. mica imports and exports, by kind and country.

Table 11.—U.S. exports of mica and manufactures of mica in 1980, by country

(Short tons and thousand dollars)

Destination	Mica, unmanufactured, including block, film, splittings, and waste[1]		Mica, ground or pulverized		Mica, cut or stamped, built-up mica
	Quantity	Value	Quantity	Value	Value
Angola	--	--	957	$261	--
Australia	190	$54	5	6	$259
Brazil	54	15	2	2	736
Canada	563	152	2,549	484	2,335
Egypt	28	8	193	114	--
France	37	10	807	161	40
Germany, Federal Republic of	459	135	508	107	258
Guatemala	30	11	115	33	11
Hungary	--	--	--	--	89
India	7	2	21	10	89
Italy	166	53	458	159	778
Japan	1,990	642	238	82	61
Libya	225	127	421	203	3
Mexico	178	50	267	57	658
Netherlands	--	--	210	67	36
Nigeria	79	25	--	--	--
Peru	110	31	319	76	5
Romania	--	--	--	--	136
Singapore	97	30	228	110	339
South Africa, Republic of	--	--	4	1	146
Spain	184	52	21	7	442
United Arab Emirates	57	20	47	23	--
United Kingdom	1,221	346	67	24	746
Venezuela	286	93	481	135	15
Other[2]	314	97	269	125	482
Total	6,275	1,953	8,187	2,247	7,664

[1]Some shipments of ground mica are included in this category.
[2]Includes Argentina, Austria, Bahamas, Barbados, Belgium, Belize, Bolivia, Cameroon, Chile, Colombia, Costa Rica, the Dominican Republic, El Salvador, Ecuador, Finland, Gabon, Ghana, Greece, Honduras, Hong Kong, Ireland, Israel, the Republic of Korea, Kuwait, Malaysia, Morocco, New Zealand, Nigeria, Norway, Pakistan, Panama, Philippines, Poland, Portugal, Qatar, Saudia Arabia, Sweden, Switzerland, Taiwan, Thailand, Trinidad, and Turkey.

Table 12.—U.S. imports for consumption of mica in 1980, by kind and country

Year and country	Waste and scrap				Block mica		Other			
	Phlogopite		Other				Muscovite		Other, n.e.c.	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1978	--	--	1,220,977	$59	247,929	$605	4,771,392	$770	--	--
1979	--	--	176,368	9	243,480	752	--	--	6,365,888	$846
1980:										
Belgium	1,598	$1	--	--	--	--	--	--	--	--
Brazil	--	--	--	--	25,464	67	--	--	222,159	195
China, mainland	--	--	--	--	--	--	--	--	110,120	10
France	--	--	--	--	--	--	--	--	19,510	32
India	44,092	5	--	--	40,938	346	--	--	7,163,946	800
Madagascar	--	--	--	--	3,638	44	--	--	331	12
Mexico	26,880	1	--	--	--	--	--	--	--	--
United Kingdom	--	--	--	--	551	20	--	--	1,998	36
Other	--	--	--	--	--	--	--	--	50,359	43
Total[1]	72,570	7	--	--	70,591	477	--	--	7,568,423	1,128

Year and country	Splittings		Not cut or stamped not over 0.006 inch in thickness		Cut or stamped			
					Not over 0.006 inch in thickness		Over 0.006 inch in thickness	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1978	3,835,937	$1,254	--	--	96,576	$1,436	72,772	$340
1979	3,977,205	1,547	921	$2	96,717	1,047	109,725	416
1980:								
Canada	--	--	--	--	--	--	2,313	14
France	13,448	31	561	1	1,312	3	--	--

See footnotes at end of table.

Table 12.—U.S. imports for consumption of mica in 1980, by kind and country —Continued

Year and country	Splittings		Not cut or stamped not over 0.006 inch in thickness		Cut or stamped: Not over 0.006 inch in thickness		Cut or stamped: Over 0.006 inch in thickness	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1980 —Continued								
India	4,199,209	$1,611	12,351	$37	98,917	$1,155	74,066	$484
Japan	--	--	--	--	175	2	26,278	161
Netherlands	--	--	--	--	--	--	362	33
Sudan	--	--	541	1	--	--	--	--
Switzerland	--	--	372	1	--	--	--	--
United Kingdom	--	--	--	--	2,141	101	115	4
Other	11,332	17	--	--	240	16	197	4
Total[1]	4,223,989	1,660	13,825	40	102,785	1,277	103,331	700

Year and country	Mica plates and built-up mica		Ground or pulverized		Articles not especially provided for of mica	
	Quantity (pounds)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (pounds)	Value (thousands)
1978	790,896	$1,237	1,728	$263	8,969	$83
1979	558,957	1,349	4,533	743	10,901	122
1980:						
Belgium	362,643	718	--	--	--	--
Canada	3,625	27	4,650	794	3,205	23
France	3,364	16	6	10	13	1
India	169,321	373	772	111	3,552	48
Japan	69,806	258	(2)	(2)	1,151	5
Netherlands	--	--	6	8	72	8
Taiwan	--	--	--	--	132	1
United Kingdom	181	2	235	139	939	8
Other	6,503	18	3	3	81	2
Total[1]	615,443	1,413	5,673	1,065	9,145	95

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 13.—Summation of U.S. mica trade data

	EXPORTS					
	Unmanufactured[1]		Ground or pulverized		Manufactured, cut or stamped, built-up	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1976	[2]7,225	[2]$3,477	NA	NA	1,241	$3,776
1977	[2]9,101	[2]3,557	NA	NA	506	3,267
1978	3,414	2,051	5,848	$1,204	NA	4,697
1979	5,827	1,673	5,846	1,374	NA	5,224
1980	6,275	1,953	8,187	2,247	NA	7,665

	IMPORTS							
	Uncut sheet[3] and punch		Scrap		Ground or pulverized		Manufactured, cut or stamped, built-up	
	Quantity (thousand pounds)	Value (thousands)	Quantity (thousand pounds)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (thousand pounds)	Value (thousands)
1976	3,366	$1,503	4,213	$202	273	$48	1,070	$2,583
1977	4,328	1,680	2,348	112	146	29	827	2,652
1978	8,855	2,629	1,221	59	1,728	263	969	3,096
1979	10,587	3,147	176	9	4,533	743	776	2,929
1980	11,877	3,305	73	7	5,673	1,065	831	3,487

NA Not available.
[1]Includes block, film, splittings, and waste. Sometimes shipments of ground mica are placed in this category.
[2]Includes ground mica.
[3]The "Other" classification included in this category often contains scrap mica shipments.

WORLD REVIEW

World production of mica decreased 6% in 1980 to 509 million pounds. India continued to be the largest producer of mica block and splittings. The United States was once again the world leader in production of scrap (flake) mica.

India.—The declining world demand for high-quality mica, caused by the evolution of synthetic substitutes and transistorization in the electronics industry, has led to the closure of many Indian mica mines in the last few years. Despite this, Mica Trading Corp. of India, Ltd., the major Indian trading company, exported more mica in 1980 than in 1979.[4] Indian ground mica was introduced to the U.S. market for the first time.

The Soviet Union remained India's largest mica customer in 1980, accounting for nearly 50% of all Indian exports, mostly as strategic grades of mica. New contracts were signed in 1980 between India and the U.S.S.R. regarding the supply of high-quality mica, and additional contracts were anticipated.[5]

U.S.S.R.—The estimated output of mica in 1980 was 50,000 tons, still inadequate to meet domestic demand. Irkutsk Oblast continued to account for about 75% of the country's production of mica.[6] Strategic-grade mica continued to be imported from India.

[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Short tons are used throughout unless otherwise stated.
[3]Production of high-quality sericite is included in the totals; however, figures for low-quality sericite, used principally for brick manufacturing, are not included.
[4]Mining Annual Review (London). June 1980, p. 462.
[5]Industrial Minerals (London). No. 148, January 1980, p. 10.
[6]Mining Annual Review (London). June 1980, p. 603.

Table 14.—Mica: World production, by country[1]

(Thousand pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Argentina:					
Sheet	725	666	[r]785	827	820
Waste, scrap, etc.	5,051	4,057	[r]5,018	5,567	5,300
Brazil[3]	6,171	4,310	[r]10,038	8,988	8,800
Colombia[e]	90	100	--	--	--
Egypt	[e]22	190	(4)	--	--
France[e]	[r]14,300	[r]15,400	[r]16,100	15,400	15,400
India:					
Exports:					
Block	1,962	2,423	3,208	[e]3,100	3,100
Film and disk	322	278	271	[r][e]280	330
Splittings	7,791	7,595	9,229	[r][e]9,260	9,480
Scrap	17,758	21,954	[e]21,800	[e]26,450	26,900
Powder	20,366	16,546	[e]18,100	[r][e]18,520	18,740
Manufactured	664	1,036	[r]882	[e]950	1,000
Domestic consumption, all forms[e]	24,500	[r]24,691	25,100	25,600	26,000
Total	73,363	74,523	78,590	84,160	85,550
Korea, Republic of (sericite)	11,715	22,339	37,309	22,057	22,000
Madagascar (phlogopite):					
Block	15	NA	NA	134	NA
Sheet	NA	NA	NA	2,066	2,200
Splittings	137	3,303	3,452	3,748	4,000
Scrap	26	NA	NA	NA	NA
Mexico	2,873	1,700	884	900	880
Mozambique (including scrap)	[e][2]1,984	[e][2]1,764	[e][2]1,984	553	440
Nepal[e]	(4)	(4)	(4)	(4)	--
Norway (including scrap)[5]	6,797	6,213	[r]5,926	6,426	6,400
Peru	20	20	128	[e]110	130
South Africa, Republic of:					
Sheet	(6)	(6)	(6)	(6)	(6)
Scrap	5,247	6,927	5,604	7,974	6,600
Spain	[e]1,100	6,468	[r]7,374	11,395	11,500
Sri Lanka (scrap)	302	[e]220	309	814	880
Sudan	1,213	[e]880	2,200	4,409	3,300
Tanzania (sheet)	15	15	13	13	20
U.S.S.R. (all grades)[e]	95,000	97,000	99,000	100,000	100,000

See footnotes at end of table.

Table 14.—Mica: World production, by country[1] —Continued

(Thousand pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
United States:					
Sheet[e]	5	1	(6)	1	NA
Scrap and flake[7]	[r]246,000	258,000	278,000	268,000	[8]234,000
Ground mica	230,000	244,000	248,000	244,000	218,000
Yugoslavia	150	306	152	745	770
Total	[r]702,321	[r]748,402	[r]800,866	[r]788,287	726,990

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through Apr. 27, 1981.
[2]In addition to the countries listed, mainland China, Pakistan, Romania, the Territory of South-West Africa, Sweden, and Zimbabwe are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[3]Exports.
[4]Revised to zero.
[5]Official Norwegian sources indicate that actual mica output is "not available for publication," but one or two mines evidently were in operation during 1976-80.
[6]Less than 1/2 unit.
[7]Excludes U.S. production of low-quality sericite.
[8]Reported figure.

Molybdenum

By John T. Kummer[1]

The molybdenum market, which had experienced availability problems during the late 1970's, reversed to a condition of plentiful supply in 1980. World mine production exceeded demand and industrial inventories were replenished. U.S. mine output of molybdenum increased to 150.7 million pounds, about 5% over that of 1979, and represented 63% of world production. Reported end-use consumption by domestic firms and apparent domestic demand decreased 12% and 18%, respectively, compared with the same figures for 1979. Total world demand for molybdenum also decreased by an estimated 10% to 15%. The reduced demand resulted in a lesser quantity of U.S. molybdenum exports and about a 150% increase in domestic producer stocks of molybdenum in concentrate and other materials. Despite the shift to an oversupplied market, producer prices on molybdenum materials were increased, although free-market prices were appreciably lower than producer quotes for most of the year. Development of additional mine capacity proceeded, primarily in the United States and Canada, and will assure ready availability of molybdenum for the world market in the 1980's.

Legislation and Government Programs.—The U.S. Government stockpile, maintained by the General Services Administration, contains no molybdenum materials. The stockpile goal of zero for molybdenum was reaffirmed by the Federal Emergency Management Agency in 1980.

The Alaska National Interest Lands Conservation Act (Public Law 96-487) was signed into law on December 2, 1980. A section of this law allows for more extensive exploratory and development work by U.S. Borax & Chemical Corp. on its Quartz Hill molybdenum deposit located in the Tongass National Forest of southeastern Alaska.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Concentrate:					
Production	113,233	122,408	131,843	143,967	150,686
Shipments	114,527	124,974	130,694	143,504	149,311
Value	$333,494	$450,421	$607,950	[1]$871,068	$1,344,181
Consumption	84,966	91,041	96,375	103,152	108,206
Imports for consumption	2,093	1,976	2,705	2,329	1,825
Stocks, Dec. 31: Mine and plant	9,390	9,161	8,980	9,520	18,101
Primary products:					
Production	83,970	90,520	96,052	[r]101,753	106,284
Shipments	99,144	100,626	[r]105,920	109,419	95,391
Consumption	50,448	54,557	61,091	60,388	53,265
Stocks, Dec. 31: Producers	13,210	10,141	7,996	8,502	27,007
World: Production	[r]195,474	[r]209,725	220,988	[p]229,384	[e]238,101

[e]Estimated. [p]Preliminary. [r]Revised.

[1]For 1979, value is based on the average domestic price of molybdenum in technical-grade molybdic oxide ($6.07 per pound) sold by the major domestic producer.

DOMESTIC PRODUCTION

Domestic mine production of molybdenum increased for the fifth consecutive year and exceeded 150 million pounds in 1980. The expansion in output has coincided with the development of capacity operations at AMAX, Inc.'s Henderson Mine in Colorado. Planned capacity at the mine of 50 million pounds of molybdenum per year was achieved in 1980. The country's three primary molybdenum mines (Climax, Henderson, and Questa) provided about 70% of the total U.S. output in 1980. Most of the remainder was supplied as a byproduct or coproduct of copper mining. Byproducts of tungsten and tin were recovered at the Climax molybdenum mine in Colorado. Some rhenium was recovered in the roasting of molybdenite concentrate produced from certain domestic copper ores.

AMAX's Climax and Henderson Mines, the two major molybdenum mines of the world, together produced over 102 million pounds of molybdenum in 1980. This quantity represented about 68% of U.S. output and 43% of total world output. The two mines should continue to provide 100 to 110 million pounds of molybdenum annually for at least the rest of this century. A new 3-year labor contract was ratified by workers at the Climax Mine in July without interruption of normal operations. Output at Molycorp's Questa Mine in New Mexico continued to decline partially due to a lower grade of ore presently being worked by surface mining. The surface mine at Questa was being phased out as development of underground ore proceeded.

Molybdenum produced in association with copper mining was recovered at 17 mines, operated by 10 firms. Duval Corp., a subsidiary of Pennzoil Co., and Kennecott Corp. were the two firms that produced the largest quantity of molybdenum from copper mining operations. In addition to these two, other companies that recovered molybdenum from copper ore were Anamax Mining Co., ASARCO Incorporated, Cities Service Co., Cyprus Mines Corp., Eisenhower Mining Co. (a partnership of Anamax and Asarco), Inspiration Consolidated Copper Co., Magma Copper Co. (a subsidiary of Newmont Mining Corp.), and Phelps Dodge Corp. Duval's Sierrita Mine in Arizona and Kennecott's Bingham Mine in Utah continued as the copper mines producing the largest quantity of byproduct molybdenum in the United States.

Output of byproduct molybdenum was reduced possibly by 3 to 5 million pounds, owing to inactivity at some mines while new labor contracts were being negotiated within the copper industry. A part of this loss was offset by increased production from several other copper mines. In addition, after startup in late 1979, molybdenum recovery circuits operated the entire year at Phelps Dodge's Morenci concentrator. Phelps Dodge also began byproduct recovery at its Ajo Mine in late 1980. Overall, molybdenum produced from copper mining operations accounted for slightly over 29% of total U.S. output and decreased approximately 2 million pounds from that of 1979.

A small amount of molybdenum was also recovered by Union Carbide Corp. at the Pine Creek tungsten mine in California and by Kerr-McGee Corp. from uranium ore in New Mexico. Less than 0.3% of U.S. production was supplied by these two minor sources.

Projects to expand domestic production capacity continued underway during 1980. Significant progress was made by Molycorp in construction of a decline to develop an underground mine at its Questa property. Production from the underground ore was anticipated in 1983, with capacity output of 18 to 20 million pounds of molybdenum annually by 1984. Additional roasting capacity was also being constructed at the firm's conversion facility in Pennsylvania. Cyprus Mines Corp. completed engineering and environmental studies at its Thompson Creek deposit in Idaho and obtained necessary permits for mine development. Construction is to begin in early 1981 with initial output in 1983 or 1984. Annual output was projected to range from 15 to 20 million pounds of molybdenum.

The Anaconda Company was developing the Hall molybdenum-copper deposit in central Nevada. A 20,000-ton-per-day concentrator was projected for completion in the second half of 1981. At capacity operating levels, the surface mine was expected to produce 12 to 15 million pounds of molybdenum annually. Anaconda also announced plans to add molybdenum recovery circuits at its Weed copper concentrating plant in Butte, Mont. The plant processes about 50,000 tons of copper ore per day from the Berkeley open pit mine.

U.S. Borax & Chemical Corp. carried out additional exploration and mine feasibility

Table 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Molybdic oxides[1] 1979	Molybdic oxides[1] 1980	Metal powder 1979	Metal powder 1980	Ammonium molybdate 1979	Ammonium molybdate 1980
Received from other producers	7,277	6,453	7	180	1,391	1,643
Gross production during year	110,259	115,523	6,081	6,093	3,728	3,845
Used to make other products listed here	31,224	30,969	1,135	1,189	1,779	1,878
Net production	79,035	84,554	4,946	4,904	r1,949	1,967
Shipments	84,799	73,759	4,946	4,785	3,487	3,101
Producer stocks, Dec. 31	6,172	22,825	270	560	381	944

	Sodium molybdate 1979	Sodium molybdate 1980	Other[2] 1979	Other[2] 1980	Total 1979	Total 1980
Received from other producers	17	27	134	14	8,826	8,317
Gross production during year	1,542	1,142	14,340	13,793	135,950	140,396
Used to make other products listed here	1	(3)	57	76	34,196	34,112
Net production	1,541	1,142	14,282	13,717	r101,753	106,284
Shipments	1,546	1,179	14,641	12,567	109,419	95,391
Producer stocks, Dec. 31	58	48	1,621	2,630	8,502	27,007

rRevised.
1Includes technical and purified molybdic oxide and briquets.
2Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, molybdic acid, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.
3Less than 1/2 unit.

studies at its large Quartz Hill deposit in southeastern Alaska. Drilling completed as of yearend 1980 established approximately 1.5 billion tons of ore with an average grade of 0.13% molybdenite (MoS_2). Enactment of the Alaskan Lands Act (Public Law 96-487) in 1980 clarified land issues and entitled the company to develop the property provided certain environmental and land-use conditions are met. Early in 1981, U.S. Borax announced that it would spend $870 million to construct a mine and associated facilities at Quartz Hill. Output, to begin in late 1987, would reach 40 million pounds of molybdenum annually.

AMAX Inc. continued its technical and economic evaluation of the Mt. Tolman molybdenum-copper deposit on the Colville Indian Reservation in Washington State. A leasing agreement for mineral rights was concluded by the company and the Colville Confederated Tribes. A draft environmental impact statement on the proposed development was completed by agencies of the Department of the Interior. Construction of an open pit mine at the 900-million-ton deposit, which grades 0.10% MoS_2 and 0.09% copper, was expected to take 3 to 4 years, after a decision to develop is made.

AMAX also proceeded with prefeasibility studies at its Mt. Emmons property near Crested Butte, Colo. About 155 million tons of mineralized rock averaging 0.44% MoS_2 has been indicated by drilling the underground deposit. Construction of a mine at Mt. Emmons was projected to take about 10 years and require considerable capital investment.

Quintana Minerals Corp. and Phibro Mineral Enterprises Inc. formed a partnership to develop and operate an open pit copper mine at Quintana's Copper Flat property near Hillsboro in Sierra County, N. Mex. Construction of a 15,000-ton-per-day mine and concentrator was expected to be completed in 1982. Annual output of about 40 million pounds of copper and 1 million pounds of molybdenum in concentrate, plus gold and silver byproduct values, was anticipated.

CONSUMPTION AND USES

The quantity of molybdenum in concentrate roasted domestically to produce technical-grade molybdic oxide increased to 108.2 million pounds, about 5% over that of 1979. The remainder of the mine production of concentrate, containing about 42.5 million pounds of molybdenum, was either exported for conversion, added to producer inventories, or purified to lubrication-grade molybdenum disulfide. The oxide, or roasted concentrate, is the chief form of molybdenum utilized by industry, particularly steel, cast iron, and superalloy producers. It is also converted to other molybdenum materials such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal powder.

Apparent domestic demand, calculated

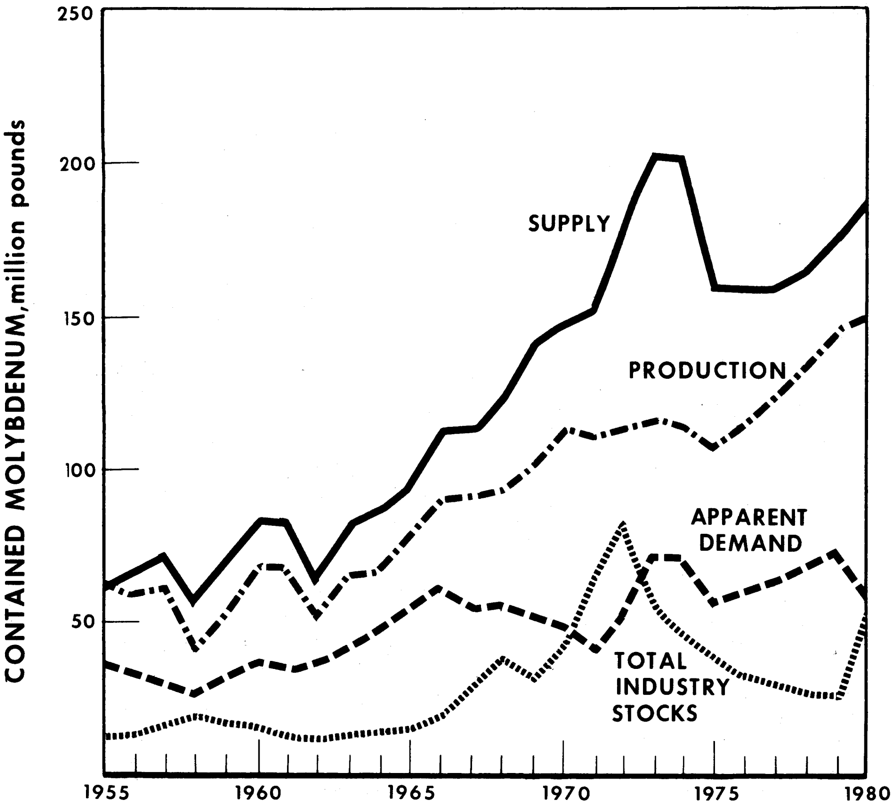

Figure 1.—Apparent demand, supply, production, and total industry stocks of molybdenum in the United States.

from mine production, imports minus exports, and change in industry stocks, decreased over 17% from that of 1979 to 60.8 million pounds of molybdenum. The decrease in apparent demand was the first since 1975 and reflected the general lack of growth in economic activity in 1980. Likewise, total reported end-use consumption of molybdenum in raw materials decreased about 12% from that of 1979. Molybdenum consumed in oxide form (technical-grade, purified, and briquets) accounted for 68% of total reported consumption; in ferromolybdenum and calcium molybdate, 15%; and in other forms, 17%.

Molybdenum reported as consumed in the production of steels accounted for about 66% of total consumption in 1980. Approximately 24% of consumption was attributed to other metallurgical uses, such as in cast irons, superalloys, and as a refractory metal. Catalyst, lubricant, pigment, and other nonmetallurgical applications comprised the final 10% of total consumption. With the sole exception of catalytic applications, all end-use areas exhibited a decline in molybdenum consumption compared with that of 1979. Molybdenum use in the production of steel and cast irons decreased by 14% and 12%, respectively. Molybdenum use in superalloys and in mill products made of powder declined slightly. Although consumption in the catalyst area increased over 14%, other nonmetallurgical uses also experienced a decline in molybdenum use compared with that of 1979.

Table 3.—U.S. consumption of molybdenum, by end use and form

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides	Ferro-molyb-denum[1]	Ammo-nium and sodium molybdate	Other molyb-denum mate-rials[2]	Total
1979					
Steel:					
Carbon	2,511	194	--	37	2,742
Stainless and heat resisting	7,207	1,285	--	109	8,601
Full alloy	21,454	1,893	--	34	23,381
High-strength, low-alloy	1,518	308	--	33	1,859
Tool	2,985	783	--	59	3,827
Cast irons	534	2,737	--	225	3,496
Superalloys	1,956	396	--	2,232	4,584
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	387	--	68	455
Other alloys[3]	229	665	--	138	1,032
Mill products made from metal powder	--	--	--	4,249	4,249
Chemical and ceramic uses:					
Pigments	578	--	541	--	1,119
Catalysts	2,325	--	W	--	2,325
Other	12	--	17	1,109	1,138
Miscellaneous and unspecified	217	212	459	692	1,580
Total	41,526	8,860	1,017	8,985	60,388
1980					
Steel:					
Carbon	2,390	133	--	31	2,554
Stainless and heat resisting	6,582	1,156	--	140	7,878
Full alloy	17,340	2,123	--	35	19,498
High-strength, low-alloy	1,357	311	--	9	1,677
Tool	2,641	559	--	36	3,236
Cast irons	476	2,460	--	132	3,068
Superalloys	1,906	446	--	2,174	4,526
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	305	--	47	352
Other alloys[3]	215	324	--	185	724
Mill products made from metal powder	--	--	--	4,222	4,222
Chemical and ceramic uses:					
Pigments	397	--	268	--	665
Catalysts	2,585	--	W	77	2,662
Other	12	--	17	1,033	1,062
Miscellaneous and unspecified	179	137	483	342	1,141
Total	36,080	7,954	768	8,463	53,265

W Withheld to avoid disclosing company proprietary data.
[1]Includes calcium molybdate.
[2]Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets, and other molybdenum materials.
[3]Includes magnetic and nonferrous alloys.

STOCKS

As a consequence of the decline in consumption and lower exports, domestic producer inventories of molybdenum increased markedly during 1980. The buildup of industrial stocks was the first of any magnitude since 1972. Total industry stocks (including producers' and consumers') increased approximately 94% to 52.5 million pounds of contained molybdenum during 1980. Inventories of molybdenum in concentrate at mines and plants exhibited a rise from 9.5 to 18.1 million pounds, most of which occurred during the last quarter of the year. Producers' stocks of molybdenum in consumer products (oxide, ferromolybdenum, molybdates, metal powder, and others) increased over 200%, from 8.5 million pounds at the start of the year to 27.0 million pounds by yearend. Compared with monthly shipments, yearend producer stocks of these materials totaled an approximate 4-month supply. Domestic consumer firms retained inventories of molybdenum of about 7 to 8 million pounds throughout the year; this quantity represented about a 2-month supply when compared with average monthly reported consumption.

Table 4.—Industry stocks of molybdenum materials, December 31

(Thousand pounds of contained molybdenum)

Material	1976	1977	1978	1979	1980
Concentrate: Mine and plant	9,390	9,161	8,980	9,520	18,101
Producers:					
Molybdic oxides[1]	10,003	6,914	5,275	6,172	22,825
Metal powder	448	327	300	270	560
Ammonium molybdate	752	640	495	381	944
Sodium molybdate	71	97	47	58	48
Other[2]	1,936	2,163	1,879	1,621	2,630
Total	13,210	10,141	7,996	8,502	27,007
Consumers:					
Molybdic oxides[1]	6,958	5,761	5,893	5,102	3,816
Ferromolybdenum[3]	1,501	1,940	1,864	1,872	1,507
Ammonium and sodium molybdate	183	338	444	325	280
Other[4]	1,235	1,421	1,824	1,761	1,813
Total	9,877	9,460	10,025	9,060	7,416
Grand total	32,477	28,762	27,001	27,082	52,524

[1]Includes technical and purified molybdic oxide and briquets.
[2]Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, molybdic acid, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.
[3]Includes calcium molybdate.
[4]Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets, and other molybdenum materials.

PRICES

Lower worldwide demand and increased supplies resulted in a reversal of the high dealer prices for molybdenum that had prevailed since late 1976. Dealer quotes for molybdic oxide, which had ranged between $20 and $30 (all price quotes per pound of contained molybdenum) during most of 1979, dropped to about $15 by the beginning of 1980. During the first half of 1980, the dealer oxide quote steadily declined to a range of about $7.50 to $8.00 by midyear; it then stabilized and ended the year at $7.60 to $8.40.

In contrast, the domestic price listing for molybdic oxide of the major producer (Climax Molybdenum Co.) increased from $7.50 at the beginning of the year to $9.00 on February 27, then to $9.70 on October 1. Thus, after the middle of the year, and in contrast to the 3 prior years, the producer list price exceeded the dealer quote. This reversal reflected the soft market conditions during the year. Other major U.S. producers, after having listed oxide prices slightly higher than the Climax price, adjusted their price to match the Climax level in October.

Another major price adjustment made by domestic producers during 1980 was to lower prices on exported molybdenum products. Although the differential between the export and domestic price on oxide was about $2.00 at the start of the year, it decreased to 50 cents ($10.20 versus $9.70) by yearend. The price differential between export and domestic sales of ferromolybdenum was also decreased by U.S. producers during the year. Major foreign producers generally listed prices in the same range as those for export sales by U.S. producers.

Yearend published prices for products, per pound of contained molybdenum, were as follows:

	1979	1980
Climax concentrate (export only)	$8.84	$9.20
Byproduct concentrate	$20.00-23.00	$5.80-7.00
Climax oxide/cans	7.50	9.70
Dealer oxide	14.25-15.90	7.60-8.40
K-2 oxide/cans	9.50	9.70
Ferromolybdenum/Climax lump	8.40	11.52
Ferromolybdenum/dealer export	16.50-17.75	8.00-9.00

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxides decreased to 68.2 million pounds, about 6% less than those of 1979. These exports represented 45% of domestic mine output during 1980 and, in terms of calculable molybdenum content, 97% of total exports. The Netherlands, Japan, Belgium-Luxembourg, and the Federal Republic of Germany received 85% of the concentrate and oxide exported. As in previous years, exports of other molybdenum materials were relatively minor and did not vary appreciably from those of 1979. The calculated molybdenum content of all exports decreased from 72.4 million pounds in 1979 to 70.4 million pounds in 1980. Despite the decreased quantity of exports, total value increased from $809 million in 1979 to $854 million in 1980 because of higher unit value, especially for concentrate and oxide.

Imports.—Approximately 5.9 million pounds of molybdenum, in a variety of forms, was imported in 1980, an increase of 48% over that of 1979. This quantity represented 3% of total U.S. supply and 10% of apparent demand for 1980. Total value of all forms of molybdenum imported increased slightly to $70 million in 1980. In terms of both quantity and value, the major forms of molybdenum imported were as concentrate, miscellaneous materials in chief value molybdenum, and ammonium molybdate. The principal source countries for these imports were Canada, Chile, mainland China, and Peru. Mainland China was notable as the chief supplier of ammonium molybdate imports in 1979 and 1980.

Table 5.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1979	1980
Molybdenite concentrate	36,405	35,026
Molybdic oxide	33,920	33,167
All other primary products	1,853	2,390

Table 6.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	--	--	--	--	2,034	20,407
Belgium-Luxembourg	6,140	27,769	14,834	117,879	11,412	129,004
Brazil	375	1,858	439	4,667	445	4,762
Canada	1,353	6,128	600	4,798	314	2,593
Chile	32	206	430	3,691	312	2,055
France	485	2,281	([1])	7	901	8,430
Germany, Federal Republic of	6,136	26,555	6,733	87,212	9,077	94,824
Japan	10,520	51,305	12,369	111,509	12,654	134,099
Mexico	735	3,333	865	10,231	624	5,471
Netherlands	33,938	162,939	27,938	226,700	24,642	252,911
Sweden	2,621	10,740	2,049	23,207	2,601	27,536
Switzerland	4	35	317	4,019	83	1,215
United Kingdom	1,217	5,813	1,398	16,187	2,003	20,974
U.S.S.R	4,840	26,065	3,463	41,098	277	2,802
Other	754	3,267	807	7,677	838	8,348
Total	69,150	328,294	72,242	658,882	68,217	715,431

[1]Less than 1/2 unit.

Table 7.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1979		1980	
	Quantity	Value	Quantity	Value
Ferromolybdenum:[1]				
Australia	385	2,553	426	3,178
Canada	339	1,400	118	867
Colombia	17	89	4	33
India	47	222	--	--
Japan	628	4,184	161	1,268

See footnotes at end of table.

Table 7.—U.S. exports of molybdenum products —Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Ferromolybdenum:[1] —Continued				
Malaysia	5	19	31	42
Mexico	31	149	20	149
Netherlands	141	893	403	4,652
Philippines	3	41	102	793
Poland	--	--	114	1,600
South Africa, Republic of	44	231	366	4,450
Other	41	249	15	72
Total	1,681	10,030	1,760	17,104
Metal and alloys in crude form and scrap:				
Belgium	39	414	10	98
Canada	53	250	16	190
France	14	289	5	55
Germany, Federal Republic of	489	3,788	172	899
India	4	97	8	104
Japan	44	575	159	1,845
Mexico	72	827	16	164
Netherlands	140	1,615	15	163
Spain	--	--	5	47
Sweden	167	874	18	198
United Kingdom	110	1,104	176	996
Other	10	164	14	111
Total	1,142	9,997	614	4,870
Wire:				
Argentina	5	96	10	151
Australia	15	199	19	380
Austria	11	151	8	183
Bahamas	--	--	19	27
Barbados	10	41	--	--
Belgium-Luxembourg	8	170	6	199
Brazil	46	918	39	827
Canada	60	872	51	1,060
France	43	740	66	2,008
Germany, Federal Republic of	146	2,371	167	3,807
India	8	170	4	99
Ireland	7	49	9	88
Italy	48	784	60	1,305
Japan	116	1,574	138	2,766
Mexico	13	439	6	323
Netherlands	18	467	11	484
South Africa, Republic of	8	142	11	235
Singapore	21	447	12	311
Spain	21	328	19	450
Sweden	1	20	21	565
United Kingdom	32	470	14	332
Other	27	574	15	384
Total	664	11,022	705	15,984
Powder:				
Argentina	3	103	3	49
Australia	8	38	([2])	4
Austria	6	25	--	--
Belgium-Luxembourg	([2])	4	60	423
Canada	13	155	14	87
France	6	85	5	85
Germany, Federal Republic of	9	158	66	708
Italy	2	32	6	52
Japan	113	790	109	592
Mexico	10	168	--	--
Netherlands	80	778	21	117
Sweden	3	27	7	77
Taiwan	18	160	80	1,043
United Kingdom	17	309	40	734
Other	8	150	14	132
Total	296	2,982	425	4,103
Semifabricated forms, n.e.c.:				
Australia	4	77	1	27
Austria	--	--	51	501
Belgium-Luxembourg	--	--	11	213
Brazil	8	161	16	412
Canada	16	360	23	638
France	34	999	19	843

See footnotes at end of table.

Table 7.—U.S. exports of molybdenum products —Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Semifabricated forms, n.e.c. —Continued				
Germany, Federal Republic of	31	845	63	1,799
Japan	13	306	46	674
Mexico	27	126	1	46
Netherlands	66	1,287	16	879
Philippines	9	86	3	44
Singapore	24	52	(2)	17
South Africa, Republic of	19	239	14	249
United Kingdom	19	640	21	673
Other	19	370	21	456
Total	289	5,548	306	7,471
Molybdenum compounds:				
Argentina	161	2,717	--	--
Australia	254	2,373	135	907
Belgium-Luxembourg	160	1,879	578	4,261
Brazil	142	2,478	63	486
Canada	439	2,676	382	2,548
German Democratic Republic	--	--	386	5,449
Germany, Federal Republic of	2,004	23,402	1,075	13,162
Japan	3,903	38,287	5,256	43,997
Mexico	111	1,319	83	450
Netherlands	2,148	24,656	811	6,477
Sweden	366	4,044	127	712
Switzerland	39	466	180	2,284
Taiwan	51	400	127	706
United Kingdom	312	2,530	603	4,276
Other	203	2,936	348	3,588
Total	10,293	110,163	10,154	89,303

[1]Ferromolybdenum contains about 60% to 65% molybdenum.
[2]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of molybdenum products

(Thousand pounds and thousand dollars)

TSUS No.	Material	1979 Gross weight	1979 Contained molybdenum	1979 Value	1980 Gross weight	1980 Contained molybdenum	1980 Value
601.33	Ore and concentrate	5,309	2,329	26,211	4,520	1,825	10,475
603.40	Material in chief value molybdenum	1,171	690	12,060	3,264	1,953	18,701
606.31	Ferromolybdenum	62	47	636	45	29	243
628.70	Waste and scrap	336	NA	5,596	373	NA	7,246
628.72	Unwrought	NA	85	1,566	NA	163	2,637
628.74	Wrought	104	NA	2,305	137	NA	4,031
417.28	Ammonium molybdate	1,068	613	13,153	3,140	1,805	23,307
419.60	Molybdenum compounds	332	196	3,218	185	115	1,520
421.10	Sodium molybdate	98	45	287	50	23	568
423.88	Mixtures of inorganic compounds, chief value molybdenum	5	2	11	(1)	(1)	2
473.18	Molybdenum orange	823	NA	1,065	1,056	NA	1,637
	Total	9,308	4,007	66,108	12,770	5,913	70,367

NA Not available.
[1] Less than 1/2 unit.

Table 9.—U.S. import duties on molybdenum articles

TSUS No.	Article	Most Favored Nation (MFN)		Non-MFN
		Jan. 1, 1981	Jan. 1, 1987	Jan. 1, 1981
601.33	Ore and concentrate	11.3 cents per pound	9 cents per pound	35 cents per pound.
603.40	Material in chief value molybdenum.	9 cents per pound plus 2.7% ad valorem	6 cents per pound plus 1.9% ad valorem	50 cents per pound plus 15% ad valorem.
606.31	Ferromolybdenum	10 cents per pound plus 3% ad valorem	4.5% ad valorem	31.5% ad valorem.
	Molybdenum:			
628.70	Waste and scrap	9.4% ad valorem[1]	6% ad valorem	50% ad valorem.[1]
628.72	Unwrought	9 cents per pound plus 2.7% ad valorem	6.3 cents per pound plus 1.9% ad valorem	50 cents per pound plus 15% ad valorem.
628.74	Wrought	11% ad valorem	6.6% ad valorem	60% ad valorem.
	Molybdenum chemicals:			
417.28	Ammonium molybdate	5.7% ad valorem	4.3% ad valorem	29% ad valorem.
418.26	Calcium molybdate	4.8% ad valorem	4.7% ad valorem	24.5% ad valorem.
419.60	Molybdenum compounds.	3.9% ad valorem	3.2% ad valorem	20.5% ad valorem.
420.22	Potassium molybdate	3.6% ad valorem	3% ad valorem	23% ad valorem.
421.10	Sodium molybdate	4.8% ad valorem	3.7% ad valorem	25.5% ad valorem.
423.88	Mixtures of inorganic compounds, chief value molybdenum.	3.4% ad valorem	2.8% ad valorem	18% ad valorem.
473.18	Molybdenum orange	5% ad valorem	5% ad valorem	25% ad valorem.

[1]Duty on waste and scrap temporarily suspended.

WORLD REVIEW

World mine production of molybdenum increased about 4% over that of 1979; most of the increase was accounted for by the United States and Canada. Nearly 97% of world output was supplied by the United States, Canada, Chile, and the U.S.S.R. (production estimated). Although comprehensive statistics on world consumption are not available, market evidence clearly affirmed that production appreciably exceeded demand for the first time since 1972. The surplus-market condition of 1980 was primarily caused by decreased consumption in the United States and Western European countries.

Argentina.—Metallurgical and mining feasibility studies were being prepared for potential development of the El Pachon copper deposit, owned by Cia. Minera Aguilar, S.A., a subsidiary of St. Joe Minerals Corp. Preliminary plans for the concentrating plant include circuits for recovery of about 4 million pounds of byproduct molybdenum concentrate annually. Development cost of the mine-mill-smelter complex was estimated to exceed $1 billion and will be dependent on the acquisition of the necessary capital.

Canada.—Mine output of molybdenum increased to approximately capacity levels after having been appreciably reduced in 1979 owing to labor strikes at major mines. Previously initiated development of Canadian mine and conversion capacity also progressed during 1980.

At Canada's largest molybdenum producer, the Endako Mine, operated by Placer Development Ltd., a program to upgrade the flotation circuits and to install additional roasting capacity was largely completed. The new roaster, which will increase conversion capacity at Endako from about 17 to 24 million pounds of molybdic oxide, was to be operational early in 1981. The increased capacity will be used to convert concentrates produced at other mines in British Columbia on a toll basis. A facility to produce lubrication-grade molybdenum disulfide at a rate of about 1 million pounds per year was started up at the Endako property in 1980.

In late 1980, the first of two mill circuits was brought onstream at the Highmont copper-molybdenum mine developed by Teck Corp. Ltd. in the Highland Valley of British Columbia. The second circuit, to be completed early in 1981, will increase the designed capacity to 25,000 tons of ore per day. Initial operations indicated that the capacity was likely to be exceeded. At rated capacity, the open pit mine and concentrator plant was expected to produce at least 40 million pounds of copper and 4.5 million pounds of molybdenum per year. Reserves at the Highmont property were estimated at 150 million tons of ore grading 0.27% copper and 0.047% molybdenum.

AMAX of Canada, Ltd., a subsidiary of AMAX Inc., continued work to reopen and expand its Kitsault open pit molybdenum

Table 10.—Molybdenum: World mine production, by country[1]

(Thousand pounds contained molybdenum)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Bulgaria[e]	300	330	330	330	330
Canada (shipments)	32,229	36,526	31,015	24,636	[3]26,892
Chile	24,028	24,114	29,092	29,892	[3]29,412
China, mainland[e]	3,300	3,300	4,400	4,400	4,400
Japan	485	401	271	258	260
Korea, Republic of	[r]265	[r]223	485	417	[3]581
Mexico	35	2	24	105	130
Peru	999	1,021	1,607	2,606	2,200
Philippines	--	--	121	273	310
U.S.S.R.[e]	20,600	21,400	21,800	22,500	22,900
United States	113,233	122,408	131,843	143,967	[3]150,686
Total	[r]195,474	[r]209,725	220,988	229,384	238,101

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 21, 1981.
[2]In addititon to the countries listed, Mongolia, Niger, North Korea, Romania, Turkey, and Yugoslavia are believed to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.
[3]Reported figure.

mine in the Alice Arm area of British Columbia. During 1980, mine stripping was initiated and construction of an expanded concentrating facility, maintenance shops, roadways, and a renovated townsite proceeded. The mill was scheduled to startup in April 1981 with a rated capacity of 12,000 tons of ore per day. Annual output of 9 to 10 million pounds of molybdenum was expected from the mine, which has projected life of about 26 years.

Lornex Mining Corp. Ltd. was involved in a $160 million program to expand mining and milling capacity to nearly 80,000 tons of ore per day at its Lornex copper-molybdenum mine in British Columbia. Completion of the project was expected in mid-1981, after which molybdenum production was estimated to be able to reach 6.5 million pounds per year. Noranda Mines Ltd. was also expanding milling capacity from 1,800 to 3,000 tons of ore per day at its Boss Mountain molybdenum mine in British Columbia. The expansion will include development of an open pit mine on the property, which has been operated as an underground mine.

Brunswick Tin Mines Ltd. (89% controlled by Sullivan Mining Group Ltd.) was developing the Mount Pleasant Mine in New Brunswick in joint venture with Billiton Exploration Canada Ltd. After completion in late 1981, or early 1982, the mine was expected to produce about 3 million pounds of tungsten and 1.3 million pounds of molybdenite in concentrate per year.

Exploratory drilling and evaluation work continued at several molybdenum properties in British Columbia and the Yukon Territory. Among such prospects were the Ruby Creek property near Atlin (by Placer Development Ltd. on option from Adanac Mining and Exploration Ltd.), the Logjam Creek tungsten-molybdenum deposit in southern Yukon Territory (by Amax Minerals Exploration Ltd. on option from Logtung Resources Ltd.), the Trout Lake property near Revelstoke (by Newmont Mining Corp. and Esso Minerals Canada), and the Gambier Island copper-molybdenum prospect near Vancouver (by Twentieth Century Energy Corp.).

Chile.—Chilean production of molybdenum in concentrate decreased slightly from that of 1979. All output was as a byproduct of the copper mines operated by the State-owned Corporación Nacional del Cobre de Chile (CODELCO). CODELCO planned considerable investment at its mines during the 1980's to expand ore processing capacity and thereby maintain production at current levels. A roasting facility was being built at the Chuquicamata mill site, with operation expected in 1982.

An extensive drilling program was carried out in 1980 at the Los Pelambres copper-molybdenum deposit, acquired by The Anaconda Company in 1979. Development of a mine at Los Pelambres, with byproduct molybdenum recovery, will depend on studies of its economic feasibility and availability of financing. EXXON Minerals Corp. initiated plans to expand processing capacity at its Los Bronces copper mine. Byproduct molybdenum recovery from the mine's concentrator was expected in the mid-1980's. Other Chilean copper-molybdenum properties were being explored and evaluated by major mining firms and the Chilean Government.

Mexico.—Molybdenum recovery circuits were being installed at the concentrating plant of the La Caridad copper mine in Sonora State. Initial recovery was expected in 1981, with an approximate annual output of 2 million pounds of molybdenum. Copper production at the mine, operated by Cía. Mexicana de Cobre, S.A., began in 1979.

Production of copper and molybdenum concentrates was initiated in late 1980 at the Cumobabi deposit, also in Sonora State. The property has been developed by Minera Frisco, S.A., since 1978. Output of molybdenum was expected to total about 3 million pounds per year from surface-mined ore. Expansion of ore processing capacity from the initial 2,000 ton per day rate was anticipated. The project also included construction of a roasting plant near Cumpas, Sonora, to convert the mine output of molybdenite concentrate to molybdic oxide.

Niger.—Recovery of some molybdenum as a byproduct of uranium mining by Compagnie Minière d'Akouta (Cominak) was reportedly initiated in 1979.

Panama.—Rio Tinto-Zinc Corp. Ltd. and the Panamanian Government held discussions concerning the possible development of the large Cerro Colorado deposit. Reported reserves at the deposit exceed 1.5 billion tons of ore averaging 0.78% copper and 0.015% molybdenum. A feasibility study of the mine would be conducted before a final development decision is made.

Peru.—Byproduct molybdenum recovery began at the concentrating plant of the Cuajone copper mine, operated by Southern Peru Copper Corp. (SPCC). Annual output was expected to total 3 to 4 million pounds of molybdenum in concentrate. SPCC's Toquepala copper mine has accounted for most of Peruvian molybdenum output in past years.

TECHNOLOGY

Most industrial research concerning molybdenum in 1980 involved studies that could eventually lead to expanded usage of molybdenum in various applications. The activity and selectivity of molybdenum-carbon and molybdenum-alumina catalysts were determined for hydrocarbon reforming reactions involving the conversion of cyclohexane, n-hexane, methylcyclopentane, and n-heptane.[2] The molybdenum catalysts were tested by pulse and flow techniques and their performance compared with platinum-alumina catalysts. The potential value of molybdenum catalysts in certain reforming reactions was demonstrated. Work was in progress to characterize the active sites of the catalysts and to improve methods for their preparation.

Additions of sodium molybdate to simulated and synthetic commercial metalworking fluids were found to improve rust and corrosion resistance.[3] Tests performed on cast iron chips, low-carbon steel, copper, and brass showed that molybdate additions to the commonly used sodium nitrite-alkanolamine inhibiting systems enhanced corrosion protection. Wider use of molybdates in metalworking fluids may be promoted because of the increased concern over the possible toxicity of nitrites.

Other applications research reported on during the year included a study of the effects of molybdenum, chromium, and silicon on the cooling rates and transformation characteristics of as-rolled, dual-phase steels.[4] Continuous-cooling transformation (CCT) diagrams were constructed to determine an optimum composition for allowable cooling rates and good dual phase structure. The performance of molybdate pigments in the prevention of corrosion was examined.[5] Molybdate pigments were seen as possible substitutes for more toxic pigments containing lead and chromium.

Some work on the recovery of molybdenite at flotation plants was reported. Design factors that affect byproduct molybdenite recovery at copper concentrating plants were reviewed.[6] Recommendations were made regarding thickening, storage, and conditioning of concentrate feed, operation of rougher flotation cells and cleaner circuits, and the use of regrind mills. Another study found that molybdenite has fast floating and slow floating components.[7] The effects of agitation and aeration on behavior of the fast and slow floating components as influencing recovery and grade of molybdenite concentrate product were examined in a laboratory flotation cell.

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[1]Physical scientist, Section of Ferrous Metals.

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Nickel

By Scott F. Sibley[1]

The market for nickel deteriorated significantly in 1980. Domestic consumption declined about 20% compared with that of 1979, as stainless steel and corrosion-resistant alloy producers and electroplaters operated below capacity. One exception to the downward trend was consumption of nickel for superalloys, which increased during the year because of continued strong demand for commercial and military aircraft. A similar decline in overall demand was experienced by Japan, where the decline in consumption of stainless steel was particularly acute. High interest rates resulted in maximum efforts to reduce inventories. Consumer inventories plummeted to their lowest level in several years. Producer inventories in the United States swelled above relatively normal levels owing to the dropoff in demand. Producers operated on the average at about 75% of capacity for those mines and smelters that remained in operation, but some operations were completely shut down for varying periods.

Major consumption occurred in stainless and alloy steel, 46%; nonferrous alloys, 39%; and electroplating, 12%. Cathode nickel prices were raised from $3.20 to $3.45 per pound on February 28, during a period of relatively high demand. Domestic ferronickel sold for about $3.40 per pound. On November 7, an industrywide discount of 6% was announced, effectively lowering the price of Class I nickel forms (cathode, briquets, and pellets) to $3.24 per pound.

Legislation and Government Programs.—The Superfund Act of 1980, under which producers of metals and chemical substances are to be taxed in order to fund toxic waste cleanup, became effective April 1, 1981. Industry will provide 88% of the 5-year $1.6 billion fund. The Environmental Protection Agency will administer the act, but the Internal Revenue Service will be responsible for collection of the industry tax. Nickel companies will pay a tax of 0.225 cents per pound on pure nickel products produced or brought into the United States. The tax is expected to be absorbed by some producers, while others may pass on the added cost to consumers.

A bill that would permit U.S. seabed nodule mining companies to begin commercial operation after January 1, 1988, was

Table 1.—Salient nickel statistics

(Short tons)

	1976	1977	1978	1979	1980
United States:					
Mine production[1]	16,469	14,347	13,509	15,065	14,653
Plant production:					
Domestic ores	13,869	12,897	11,298	11,691	11,225
Imported materials	20,070	25,000	26,000	32,500	33,000
Secondary[2]	13,273	12,449	12,304	13,201	11,338
Exports (gross weight)	47,166	39,412	36,293	50,810	56,675
Imports for consumption	188,147	194,770	r234,352	r177,205	189,168
Consumption (primary)	162,927	155,260	180,723	196,293	156,299
Stocks, Dec. 31: Consumer	31,690	18,581	20,443	r19,248	15,398
Price, cents per pound	220	241-208	210-193	193-320	320-345
World: Mine production	r873,357	r886,738	r727,936	r753,214	850,366

rRevised.
[1]Mine shipments.
[2]Nonferrous scrap only; does not include nickel from stainless or alloy steel scrap.

signed into law June 28. According to the legislation, the National Oceanic and Atmospheric Administration (NOAA) was assigned the task of administering seabed licenses and regulations. NOAA will grant licenses only to U.S. citizens, and any consortium applying for a license had to be U.S. controlled. Designated the Deep Seabed Hard Mineral Resources Act (Public Law 96-283), the bill also requires that U.S. companies process ores in the United States and that processing vessels and at least one transport vessel fly the U.S. flag. Shortly after passage of this legislation, the Ninth Session of the Third United Nations Conference on the Law of the Sea was concluded in August in Geneva. No final treaty emerged from the meeting and another negotiating session was scheduled for March 1981.

The major nickel producers organized an association to develop and publish scientific information on occupational health and safety as well as environmental concerns within the industry. The newly formed Nickel Producers Environmental Research Association was to contract out much of its research and meet annually.

A Canadian Government control order was issued in September setting limits on sulfur dioxide emissions from the nickel smelter at Sudbury, Ontario, thereby restricting production capacity at the facility to 140,000 tons of nickel per year.

DOMESTIC PRODUCTION

The domestic nickel mine of Hanna Mining Co., Riddle, Oreg., shipped 14,000 short tons of nickel in laterite ore in 1980. Nickel recovered at the smelter as ferronickel, and byproduct nickel salts and metal produced at copper and other metal refineries, totaled 11,225 tons. The Port Nickel domestic nickel refinery of AMAX Nickel, Inc., at Braithwaite, La., was operated at about 75% of capacity, processing matte from Botswana, New Caledonia, the Republic of South Africa, and Australia. Production of nickel at the facility totaled about 33,000 tons. A 5-month strike at Port Nickel was settled in January, and members of the United Steelworkers of America reportedly voted overwhelmingly in favor of a 32-month contract, which expires August 31, 1982. Matte for the refinery came from Bomangwato Concessions, Ltd., in Botswana; Rustenburg Platinum Mines, Ltd., in the Republic of South Africa; Société Métallurgique le Nickel (SLN) in New Caledonia; and Western Mining Corp. in Australia.

AMAX Exploration, Inc., continued evaluation of the Duluth gabbro sulfide deposit in northeast Minnesota, near Babbitt, and the first phase of a feasibility study was completed at a cost of $7.4 million. AMAX negotiated with Bear Creek Mining Co., a subsidiary of Kennecott Copper Corp., for a renewed lease of the Babbitt site. Bear Creek and Longyear Mesaba Co. hold the rights to the Babbitt find. Minnamax is working the project under a development lease. Related to this development, Barr Engineering Co., Minneapolis, received a contract from the Bureau of Mines to evaluate the effectiveness of 10 different kinds of plants in stabilizing copper-nickel mining wastes from this site and in inhibiting the release of toxic elements into the environment through the natural weathering of these wastes. The firm will also evaluate the costs involved in mined-land reclamation.

Exploration of the Gasquet Mountain nickel-cobalt laterite prospect in northern California by California Nickel Corp. continued. About $2 million reportedly was spent on the property during the year. A preliminary feasibility study was completed by Davy McKee Corp. and an environmental impact report was completed in the summer and filed with the Del Norte County Planning Commission. Exploration delineated total resources of about 37 million tons of laterite and saprolite ore, with an average grade of 0.86% nickel, and 0.09% cobalt. Plans called for a project with an annual production capacity of 27 million pounds of nickel and 2.5 million pounds of cobalt, if the property is developed. California Nickel is the wholly owned subsidiary of Ni-Cal Development, Ltd., of Canada. The company also holds claims in nearby Rattlesnake Mountain, Red Mountain, and the area referred to as the Judy claims.

International Metals Reclamation Co. Inc. (INMETCO), a subsidiary of Inco United States Inc., continued to produce alloy pigs from stainless steel plant particulate wastes at the Ellwood City, Pa., plant. Plant capacity is 47,000 tons of waste per year to produce 27,000 tons of iron-chromium-nickel pigs with a nominal composition of 20% chromium and 10% nickel.[2]

CONSUMPTION AND USES

Demand for nickel declined significantly beginning about midyear. Total demand, including secondary nickel, was estimated at 230,000 tons, the lowest since 1975. Only superalloys and corrosion-resistant copper-nickel alloys showed significant gains. Stainless steel, high-nickel corrosion- and heat-resistant alloys, and electroplating all experienced a reduction in consumption of nickel. Consumer stocks decreased substantially, from 19,518 tons at the end of 1979 to 15,398 tons at yearend 1980.

Pure unwrought nickel increased its share of the total primary nickel market for the second year in a row from 69% in 1979 to 71% in 1980; ferronickel dropped from 20% of the total in 1979 to 19% in 1980; and nickel oxide sinter dropped from 7% to 5% of the market. The pure nickel forms (Class I) were utilized principally in the production of nickel wrought products, high-nickel heat- and corrosion-resistant alloys, copper-base alloys, and in electroplating, whereas ferronickel and oxide sinter were used largely in the production of stainless and alloy steels. The latter is referred to as charge or Class II nickel.

Although primary nickel consumption declined during the year, the pattern of consumption by type of product remained similar, as follows: Stainless and heat-resisting steels, 35%; high-nickel heat- and corrosion-resistant alloys, 23%; electroplating, 12%; alloy steels, 11%; superalloys, 12%; and other, 7%. Consumer stocks declined 20% compared with those held at yearend 1979.

Table 2.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1979	1980
KIND OF SCRAP		
New scrap:		
Nickel-base	2,490	1,585
Copper-base	3,130	1,887
Aluminum-base	1,903	1,750
Total	7,523	5,222
Old scrap:		
Nickel-base	5,016	5,244
Copper-base	484	575
Aluminum-base	178	297
Total	5,678	6,116
Grand total	13,201	11,338
FORM OF RECOVERY		
As metal	633	556
In nickel-base alloys	2,606	2,637
In copper-base alloys	4,661	4,125
In aluminum-base alloys	2,285	2,173
In ferrous and high-temperature alloys[1]	2,053	1,197
In chemical compounds	963	650
Total	13,201	11,338

[1]Includes only nonferrous scrap added to ferrous high-temperature alloys.

Table 3.—Stocks and consumption of new and old nickel scrap in the United States in 1980

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Nickel and nickel alloys	74	6,923	2,283	4,689	6,972	25
Nickel-copper metal	227	880	497	409	906	201
Nickel-silver[1]	644	2,763	357	2,514	2,871	536
Cupronickel[1]	23	7	--	22	22	8
Nickel residues	W	W	W	W	W	W
Total	301	7,803	2,780	5,098	7,878	226
Foundries and other manufacturers:						
Nickel and nickel alloys	137	1,263	872	408	1,280	120
Nickel-copper metal	34	--	--	--	--	34
Nickel-silver[e] [1]	1,421	6,651	5,765	25	5,790	2,282
Cupronickel[e] [1]	2,635	7,435	8,200	382	8,582	1,488
Nickel residues	150	427	182	245	427	150
Total	321	1,690	1,054	653	1,707	304
Grand total:						
Nickel and nickel alloys	211	8,186	3,155	5,097	8,252	145
Nickel-copper metal	261	880	497	409	906	235
Nickel-silver[e] [1]	2,065	9,414	6,122	2,539	8,661	2,818
Cupronickel[e] [1]	2,658	7,442	8,200	404	8,604	1,496
Nickel residues	150	427	182	245	427	150
Total	622	9,493	3,834	5,751	9,585	530

[e] Estimated. W Withheld to avoid disclosing company proprietary data; included in "Nickel and nickel alloys."
[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 4.—Nickel (exclusive of scrap) consumed in the United States, by form

(Short tons, contained nickel)

Form	1976	1977	1978	1979	1980
Metal	104,374	96,058	122,972	135,987	111,609
Ferronickel	31,210	31,784	33,272	39,977	29,919
Oxide powder and oxide sinter	22,198	22,446	19,817	14,189	8,492
Salts[1]	2,437	2,395	2,026	3,944	3,330
Other	2,708	2,577	2,636	2,196	2,949
Total	162,927	155,260	180,723	196,293	156,299

[1] Metallic nickel salts consumed by plating industry are estimated.

Table 5.—U.S. consumption of nickel (exclusive of scrap) in 1980, by use and form

(Short tons, contained nickel)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total
Steel:						
Stainless and heat-resisting	27,790	24,533	2,149	44	222	54,738
Alloys (excludes stainless)	9,007	3,339	4,557	--	33	16,936
Superalloys	17,530	955	278	47	343	19,153
Nickel-copper and copper-nickel alloys	8,329	1	91	19	335	8,775
Permanent magnet alloys	527	--	11	--	--	538
Other nickel and nickel alloys	25,853	813	601	24	153	27,444
Cast irons	1,816	229	358	45	1,599	4,047
Electroplating (sales to platers)[1]	15,747	20	48	2,930	6	18,751
Chemicals and chemical uses	1,092	--	197	96	90	1,475
Other uses[2]	3,918	29	202	125	168	4,442
Total reported by companies canvassed and estimated	111,609	29,919	8,492	3,330	2,949	156,299

[1] Based on monthly estimated sales to platers.
[2] Includes batteries, ceramics, and other alloys containing nickel.

Table 6.—Nickel (exclusive of scrap) in consumer stocks in the United States, by form

(Short tons, contained nickel)

Form	1978	1979	1980
Metal	10,657	14,716	11,198
Ferronickel	5,575	2,467	2,051
Oxide powder and oxide sinter	3,437	1,314	1,553
Salts	392	427	252
Other	382	594	344
Total	20,443	19,518	15,398

Table 7.—Consumption, stocks, receipts, shipments, and/or sales of secondary nickel in 1980, by use

(Short tons, contained nickel)

Use	Receipts	Consumption	Shipments or sales	Stocks, end of year
Steel (stainless and heat-resisting and alloy)	35,556	30,602	5,034	8,575
Nonferrous alloys (super, nickel-copper and copper-nickel, permanent magnet, and other nickel)	7,124	7,147	60	535
Foundry (cast irons)	192	195	--	6
Chemicals (catalysts, ceramics, plating salts, and other chemical uses)	10	9	--	5
Total reported by companies canvassed and estimated	42,882	37,953	5,094	9,121

PRICES

Prices remained relatively stable during the first three quarters but deteriorated during the last quarter. Cathode nickel prices quoted to major consumers (per pound nickel contained) were $3.20 through February for melting cathode, pellets, and briquets ($3.25 for plating-size cathode); $3.15 for domestic ferronickel; $3.19 to $3.26 for the more popular imported ferronickel grades; and $3.11 for nickel oxide sinter and steelmaking grades of powder and briquets.

On February 28, Inco, Ltd., initiated a price increase on nickel of $0.25 per pound or 7.8% to $3.45 per pound for melting cathode, and other producers followed suit. Other forms were raised correspondingly, and the producer list price remained at this level through yearend. However, on November 7, Inco, Ltd., announced a temporary 6% discount to all consumers placing orders for December 1980 and the first quarter of 1981. The move reportedly was made to meet competitors' discounting practices and extended payment terms. Other producers quickly followed Inco's lead. Merchant nickel prices immediately fell about 10 cents per pound in reaction to the announcement from $3.10 to $3.00 per pound.

Inco, Ltd., in its annual report stated that the average realized price for all product forms sold in 1980 was $3.14 per pound, compared with $2.43 in 1979 and $1.98 in 1978.

Yearend list prices for principal product forms, per pound, were $3.50 for plating cathode, $3.45 for melting cathode, $3.40 for domestic and $3.44 for imported ferronickel, and $3.35 for charge nickel. Computed average import prices, based on custom declared value per pound for 1980, were $3.05 for cathode nickel, pellets, and briquets; $3.47 for ferronickel; and $2.60 for nickel oxide.

FOREIGN TRADE

The estimated contained nickel in U.S. exports of unwrought nickel, powders, flakes, and anodes in 1980 was 12% of total primary demand.

Canada remained the principal supplier of nickel to the United States in 1980, and accounted for 38% of total imports. The next most important sources in decreasing order of magnitude were Norway (Canadian matte sources), Australia (matte for domestic refining), Botswana, the Philippines, the Republic of South Africa, and the Dominican Republic. In the aggregate, these seven countries accounted for 85% of U.S. imports. Imports increased in 1980 compared with 1979 in the face of a decline in demand. This was reflected in a rise in domestically held producer stocks, exceeding a decline in consumer stocks. World consumption of primary nickel was approximately 750,000 tons in 1980 compared with 829,000 tons consumed in 1979.

Table 8.—U.S. exports of nickel and nickel alloy products, by class

Class	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Unwrought	11,641	$46,888	19,759	$106,743	13,886	$114,779
Bars, rods, angles, shapes, sections	1,698	18,126	3,162	38,095	3,443	48,270
Plates, sheets, strip	4,337	35,943	5,379	52,558	7,113	82,865
Anodes	144	960	108	725	139	979
Wire	804	6,197	733	7,993	1,087	11,766
Powders and flakes	4,814	22,903	4,082	24,836	5,438	37,101
Foil	--	--	--	--	--	--
Catalysts	4,995	16,941	5,197	19,993	3,530	18,559
Tubes, pipes, blanks, and fittings thereof, hollow bars	3,193	27,531	2,228	23,468	1,416	18,512
Waste and scrap	4,667	7,761	10,162	22,822	20,623	38,652
Total	36,293	183,250	50,810	297,233	56,675	371,483

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore	--	--	4,977	$12	1,124	$13
Unwrought	147,664	$582,776	113,280	510,535	116,193	708,693
Oxide and oxide sinter	6,105	18,897	1,820	8,079	4,182	21,753
Slurry[1]	69,129	141,110	r61,291	r123,060	77,459	208,742
Bars, plates, sheets, anodes	183	1,049	1,937	13,249	2,396	20,918
Rods and wire	2,297	11,810	1,808	11,333	2,635	21,583
Shapes, sections, angles	9	63	14	142	83	892
Pipes, tubes, fittings	1,232	14,021	1,617	21,783	717	11,554
Powder	16,767	r69,547	13,393	66,681	15,129	98,001
Flakes	214	890	784	3,522	115	665
Waste and scrap	3,694	10,117	3,596	16,634	3,572	18,481
Ferronickel	74,860	74,724	62,593	91,340	51,741	104,156
Total (gross weight)	322,154	925,004	r267,110	r866,370	275,346	1,215,451
Nickel content (estimated)[2]	234,352	XX	177,205	XX	189,168	XX

rRevised. XX Not applicable.
[1]Nickel-containing material in slurry, or any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals; principally matte for refining.
[2]Estimated from gross weight of primary nickel products.

Table 10.—U.S. imports for consumption of new nickel products, by country

(Short tons of nickel)

Country	Metal		Powder and flakes		Oxide and oxide sinter		Ferronickel		Slurry and other[e 1]	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
Australia	6,817	6,573	4,371	2,905	--	--	--	--	2,583	9,334
Botswana	--	--	--	--	--	--	--	--	14,607	15,608
Canada	69,705	61,652	5,522	7,795	1,170	3,115	16	65	3,710	1,614
Dominican Republic	47	20	--	--	--	--	9,870	12,077	--	36
Finland	2,649	4,262	--	--	--	--	--	--	--	13
France	15	843	--	--	202	90	--	--	5	5
Germany, Federal Republic of	308	150	22	114	--	--	7	--	17	23
Japan	1,010	737	--	--	--	--	2,040	1,007	14	18
Netherlands	65	72	3	--	--	--	--	--	--	--
New Caledonia	--	--	--	--	--	--	6,840	3,485	3,288	4,408
Norway	16,017	21,055	20	--	7	17	--	15	--	--
Philippines	4,347	10,755	716	2,766	--	--	--	--	--	--
South Africa, Republic of	4,193	3,816	784	790	--	--	--	10	5,285	6,725
Sweden	77	282	--	2	--	--	--	--	31	11
United Kingdom	467	554	2,737	835	7	--	2	--	--	2
U.S.S.R	7,213	3,839	--	--	--	--	--	--	--	--
Zimbabwe	--	1,437	--	--	--	--	--	--	--	--
Other	350	146	1	37	19	--	--	8	29	65
Total	113,280	116,193	14,176	15,244	1,405	3,222	18,775	16,667	29,569	37,862

[e]Estimated nickel content.

[1]Nickel-containing material in slurry or in any other form derived from ore by chemical, physical, or any other means and requiring further processing; principally matte for further refining; includes 96 short tons of nickel in salts in 1979; also includes 50 tons of nickel in laterite ores for testing purposes.

WORLD REVIEW

Delegates from the governments of the major producing and consuming countries met in Paris in June to discuss gaps in the worldwide nickel statistics. Under discussion was the possibility of establishing an international discussion group to ultimately obtain and publish world stocks, consumption, and production of nickel.

Australia.—Western Mining Corp. Ltd. (WMC) considered developing the Carnilya Hill deposit in Western Australia. The deposit contains an estimated 390,000 tons of ore, grading at 3.78% nickel.

At the Greenvale nickel laterite mine, jointly owned by Metals Exploration, Pty., and Freeport Queensland Nickel Pty., Ltd., a project was undertaken to convert the fuel source from oil to coal. To finance the change, Greenvale project lenders agreed to waive the requirement that the companies meet a specific minimum proportion of their debt-servicing obligation for 1980-82. The lenders also agreed to forego interest on the previously scheduled repayment timetable. It was estimated that the conversion project would reduce Greenvale's consumption of oil by 44%.

Cliffs International Ltd., in a joint venture enterprise with Amad N.L., Ltd., and Charterhall, Ltd., reportedly located massive nickel-bearing sulfides grading between 1.7% and 6% nickel over a 4,000 foot strike length at Mt. Keith in Western Australia. The prospect is about 53 miles north of the Agnew nickel project, owned jointly by Mt. Isa Mines, Ltd., and Western Selcast Pty., Ltd. The latter began production in 1979. Earlier exploration by a consortium that included Metals Exploration Pty. Ltd., Freeport Exploration Pty., Ltd., of Australia, and Australian Consolidated Metals Ltd. reported lower grade (0.6%) nickel occurrences. However, partly because of the remoteness of the area and consequent need to build a complete infrastructure, development is not expected in the near future.

Botswana.—Early in the year Botswana RST, Ltd., reportedly was continuing to experience financial difficulties with its Selebi-Pikwe copper-nickel-cobalt mine and smelter. About 44,000 short tons of matte is produced by the smelter annually. Botswana RST is mainly a holding company for BCL Ltd., which operates the facilities. BCL is owned 85% by Botswana RST and 15% by the Botswana Government. Botswana RST, in turn, is owned about 30% by AMAX Inc., and 30% by Anglo American, Ltd. The financial problems were said to be largely the result of crippling interest charges. Added to the problem was the need to borrow to build a rail line, sink a shaft at

Table 11.—Nickel: World mine production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Albania[e]	[r]5,300	[r]5,500	[r]5,600	5,800	6,100
Australia (content of concentrate)	90,976	94,653	90,785	76,841	[3]78,800
Botswana	13,866	13,331	17,691	17,828	17,900
Brazil (content of ore)	5,812	4,675	[r]3,968	3,429	3,600
Burma (content of speiss)	26	19	20	19	20
Canada[4]	265,464	256,300	[r]152,460	139,422	[3]214,892
China, mainland[e]	10,000	11,000	11,000	11,000	11,000
Cuba (content of oxide and sulfide)[e]	40,700	40,800	40,800	38,600	40,800
Dominican Republic	26,896	27,448	15,763	27,680	15,400
Finland:					
Content of concentrate	7,008	6,434	[r]4,858	6,465	6,400
Content of nickel sulfate	209	246	191	NA	NA
German Democratic Republic[e]	2,800	2,800	3,000	2,800	2,800
Greece (recoverable content of ore)[e 5]	[r]18,800	[r]11,000	[r]17,600	15,400	28,700
Guatemala	--	328	[r]1,586	9,111	[3]7,650
Indonesia (content of ore)[5]	31,716	36,468	35,179	41,055	41,000
Mexico (content of ore)	62	37	24	[e]22	22
Morocco (content of nickel ore and cobalt ore)	161	172	192	176	180
New Caledonia (recoverable)[6]	121,157	115,859	72,862	91,344	[3]96,783
Norway (content of concentrate)	579	[r]599	[r]591	550	550
Philippines	[r]16,798	40,544	[r]32,549	31,705	42,200
Poland (content of ore)[e]	[r]2,800	[r]2,600	[r]2,600	2,300	2,300
South Africa, Republic of	24,660	24,201	[r]24,801	32,518	32,000
U.S.S.R. (content of ore)[e]	[r]155,000	[r]159,000	163,000	168,000	170,000
United States (content of ore shipped)	16,469	14,347	13,509	15,065	[3]14,653
Zimbabwe (content of concentrate)	16,098	18,377	17,307	16,084	[2]16,616
Total	[r]873,357	[r]886,738	[r]727,936	753,214	850,366

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Insofar as possible, this table represents recoverable mine production of nickel; where data relate to some more highly processed form, the figure given has been used in lieu of unreported actual mine output to provide some indication of the magnitude of mine output, and is so noted parenthetically following the country name, or by footnote. Table includes data available through May 13, 1981.

[2]In addition to the countries listed, Yugoslavia began producing nickel in small quantities in either 1979 or 1980 but output has not yet been officially reported quantitatively, and no basis is available for estimating the output level.

[3]Reported figure.

[4]Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported mattes and speiss.

[5]Includes a small amount of cobalt not reported nor recovered separately.

[6]Nickel-cobalt content of metallurgical plant products, plus recoverable nickel-cobalt content of exported ores.

Pikwe, and develop the underground mine at Selebi. The latter came into full production on July 1.

By midyear, matte sales of Botswana RST had risen 90% over that of the previous year. Despite the sales increase, production declined about 30% during the first half owing to a 64-day shutdown of the flash smelting furnace for a planned overhaul. However, since the furnace startup on May 17, production levels for both concentrate and matte exceeded goals.

Brazil.—Construction of a $100 million project to produce nickel carbonate by hydrometallurgical methods at a laterite site near Niquelandia was completed. The carbonate was shipped to a new electrolytic refinery near São Paulo, with an annual capacity of 5,500 tons of cathode nickel, doubling to 11,000 tons with completion of a second stage in 1981.

Development of the Barro Alto project in Goiás State remained suspended. Cia. Vale do Rio Doce (CRD) held a promising prospect in the Carajas Mineral Province. Potential production was estimated at 20,000 tons of nickel as ferronickel, basically intended for the domestic market. Cost was estimated at about $150 million. However, no definite plans for development were announced.

Burundi.—The Government of Burundi continued to seek assistance in developing its sizable nickel laterite deposit in the Musongati region. Reserves were estimated at 200 to 300 million tons of ore grading 1.5% nickel.

Canada.—Canadian nickel producers cut back operations drastically again in 1980, reacting quickly to the sharp drop in demand that began about midyear. Inco., Ltd., announced cutbacks in its domestic and foreign operations. Finished nickel production during the first half of the year for both domestic and foreign operations was 105,000 tons. Production in the second half was cut back to about 90,000 tons. In order to produce at the lower level, ore production at Inco's Clarabelle, Ontario, mine was discontinued in late June, and some mine workers were transferred from production to development work. The latter action was also followed at the Manitoba Division. The cutbacks were aimed at limiting the growth of inventories and achieving a better balance between supply and demand.

Table 12.—Nickel: World smelter production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Australia[3]	43,947	37,633	41,146	43,366	36,200
Brazil[4]	2,369	2,789	2,811	2,643	2,800
Canada[5]	[r]185,464	[r]167,515	98,360	97,978	[6]160,717
China, mainland[e]	10,000	11,000	11,000	11,000	11,000
Cuba[e]	20,300	[r]20,500	[r]20,200	[r]20,400	20,400
Czechoslovakia	[r e]2,400	[r e]2,400	[r e]2,400	2,202	2,240
Dominican Republic[4]	26,896	27,448	15,763	27,680	15,400
Finland	8,404	10,414	8,268	13,632	12,100
France[5]	13,573	11,331	8,684	3,660	11,000
German Democratic Republic[e]	3,100	3,100	3,300	3,300	3,300
Germany, Federal Republic of[7]	143	100	993	1,348	1,100
Greece[4]	18,131	10,582	15,645	[e]20,800	27,600
Indonesia[4]	4,252	5,432	4,959	11,811	13,200
Japan	104,499	103,507	87,303	111,333	114,600
Mexico	62	37	24	22	20
New Caledonia[4]	42,055	31,177	21,924	33,480	[6]35,913
Norway	36,029	[r]42,134	26,166	33,778	34,200
Philippines	16,798	24,111	20,654	23,678	27,800
Poland[e]	[r]2,800	[r]2,600	[r]2,600	[r]2,300	2,300
South Africa, Republic of	18,700	19,000	16,500	[r e]22,500	22,500
United Kingdom	36,514	25,525	23,553	20,793	25,400
U.S.S.R.[e]	[r]177,000	[r]181,000	185,000	190,000	192,000
United States[8]	33,939	37,897	37,298	44,191	[6]44,225
Zimbabwe[e]	11,000	14,300	14,300	14,600	15,500
Total	[r]818,375	[r]791,532	668,851	756,495	831,515

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Refined nickel plus nickel content of ferronickel produced from ore and/or concentrates unless otherwise specified. Table includes data available through May 13, 1981.

[2]In addition to the countries listed, Albania is known to have initiated smelter production in 1978, and North Korea is believed to have produced metallic nickel and/or ferronickel, but information is inadequate for formulation of reliable estimates of output levels. Several countries produce nickel-containing mattes, but output of nickel in such materials have been excluded from this table in order to avoid double counting. Countries producing matte include the following, with output indicated in short tons of contained nickel: Australia: 1976—35,260; 1977—36,650; 1978—36,045; 1979—42,626; 1980—not available; Botswana: 1976—13,866; 1977—13,331; 1978—17,691; 1979—17,828; 1980—[e]17,900; Indonesia: 1976—none; 1977—none; 1978—6,315; 1979—9,502; 1980—[e]21,000, New Caledonia: 1976—26,190; 1977—25,395; 1978—18,853; 1979—13,517; 1980—[e]14,900.

[3]Refined nickel plus the nickel content of oxide.

[4]Nickel content of ferronickel only. (No refined nickel is produced.)

[5]Includes nickel content of ferronickel, refined nickel and nickel oxide.

[6]Reported figure.

[7]Includes nickel content of nickel alloys.

[8]Byproduct of metal refining, including that derived from both domestic ores and imported materials.

The Ontario Government issued an order in May limiting sulfur dioxide emissions from Inco's Sudbury operations. The order was finalized in September. Under the order, emissions were to be reduced to 2,500 tons per day effective immediately. This was about 30% lower than the previous limit. By yearend 1983, emissions were to be cut to 1,950 tons per day. The new limit effectively restricted nickel production capacity to 140,000 tons per year compared with a potential 170,000 tons per year without the limit. A new pyrrhotite process that was under development would enable the company to meet the 1,950-ton-per-day limit without a further loss in production. By this process the sulfur-bearing minerals (mainly pyrrhotite) would be removed early in processing through flotation. One problem encountered with this process was that cyanide, the chief chemical reagent for separating the pyrrhotite, did not meet provincial water-quality standards. Under the new regulations, the company is in effect prevented from expanding production as nickel market conditions improve.

In another unrelated measure to control pollution, Inco opened a new $5 million effluent treatment plant at its Port Colborne, Ontario, nickel refinery. The new plant was to process all nickel refinery surface runoff and waste water. First, the waste water was treated with lime, then thickened and filtered to allow smelter recovery of additional nickel. The purified water flows into Lake Erie. Considerable success was also achieved in control of tailings dust at the mines in the Sudbury Basin.

Inco conducted a study, through a consultant organization, of the environmental impact of an open pit operation at Inco's Thompson Mine to replace the Pipe open pit, which was expected to reach optimum depth by 1983. Other options being considered were exploitation of standby mines at Birchtree and Soab, both in the Thompson area. Areas of study were to include removal and disposal of overburden; effects of effluent discharges from the property; noise, dust, and vibration levels from blasting and heavy equipment; and general ecological impact and reclamation in the vicinity of the possible pit area.

Falconbridge Nickel Mines, Ltd., continued development of its Fraser Mine in the Sudbury Basin, with production scheduled to begin in 1981. The North Mine was reactivated during the third quarter. A new circuit was installed in the Strathcona Mill for the production of a high-grade copper concentrate and a second fluid bed roaster-electric furnace in the smelter was brought online in January. The blast furnaces and sinter plant were shut down and the entire concentrate production was handled by a new smelting process. (See "Technology" section). According to the 1980 annual report of Falconbridge, earnings of the integrated nickel operation were 8% lower than in 1979, which reflected a 36% lower volume of nickel sales and an increase in costs.

A proposal to coordinate nickel industry labor negotiations in North America reportedly was considered in October by Local 6500 of the United Steelworkers of America (USW) at Inco, Ltd.'s, Sudbury, Ontario, plant. The plan was developed by delegates to a USW conference in Oregon early in 1980. Local 6500 is composed of about 11,000 workers, and without its participation, coordination among the other locals would be ineffective. No decision was expected before yearend.

Colombia.—Construction of the Econiquel (Cerro Matoso S.A.) project continued on schedule. The target for completion was early 1982. The mine, located about 250 miles northwest of Bogota, will have a capacity of about 21,000 tons of nickel in ferronickel, annually. Participation in the project is distributed as follows: 45% Econiquel, 35% Billiton Overseas NV (a subsidiary of Shell-Netherlands), and 20% Hanna Mining Co. (See "Technology" Section).

Cost of development is estimated at $350 million. In 1980, construction of the rotary kiln electric furnace that will reduce the ore into ferronickel containing between 35% and 40% nickel, neared completion. Heavy equipment was transported from the Atlantic port of Cartagena by barge up the Magdalena River to the site. The deposits are estimated to contain 40 million tons of ore averaging 2.71% nickel.

Cuba.—Nickel-cobalt matte was shipped to Eastern Europe for further refining and a finished nickel oxide sinter (76% nickel) was shipped to Western and Eastern European countries. Smelter production totaled about 20,000 tons of contained nickel. Cuba's plans to produce 110,000 tons per year by 1985 have been altered. The new target date was given as 1990. The revised schedule calls for 40,200 tons production by the end of 1983, 65,600 tons by the end of 1985, and at least 106,400 tons by the end of 1990. In addition to expansion of facilities at the Nicaro and Moa Bay complexes, a new integrated facility at Punta Gorda with a capacity of 23,000 tons is expected to be completed by yearend 1985.

Dominican Republic.—In June, Falconbridge Dominicana C. por A. announced that its ferronickel operations would be shut down for 3 months, beginning in July. This resulted in a 6,000- to 8,000-ton loss of nickel production during the period. The decision to suspend operations was attributed to a weak nickel market. In October, Falconbridge announced a 3-month extension of the shutdown. Falconbridge Dominicana has a capacity of about 32,000 tons of nickel in ferronickel per year. Falconbridge Dominicana is owned 67% by Falconbridge of Canada, Ltd. Falconbridge Dominicana reported total sales of ferronickel for the year as 18,245 tons contained nickel compared with 27,065 tons sold in 1979. The company incurred a loss in 1980 and outside financial support was expected to be required in 1981.

France.—The electrolytic refinery of Société Métallurgique Le Nickel (SLN) near Le Havre continued in operation throughout the year at a relatively low level. Capacity of the facility is 13,000 tons of nickel annually.

Greece.—No facilities were expanded and no action was taken on a project on the island of Euboea or a project planned by Eleusi Bauxite mines. Production in Greece totaled about 28,700 tons.

Guatemala.—During the first three quarters of 1980, Inco Ltd.'s subsidiary Exploraciones y Explotaciones Mineras Izabal S.A. (EXMIBAL) produced about 7,000 tons of nickel in matte. This was about 80% of capacity. However, in November, the facility was shut down completely and it was planned that it would remain closed for all of 1981. EXMIBAL is 80% owned by Inco. The closure was partially attributed to the high cost of oil used to process this lateritic ore. The oil accounts for about 60% of cash operating costs, compared with 10% for sulfide ores. In addition, Inco officials stated that about $14 million would be spent in 1981 to keep the plant on a standby basis. Inco negotiated with the Guatemalan Government over a proposed 5% nickel export tax to replace the current profit tax. However, late in the year, the Guatemalan

Legislature rejected the new export tax.

India.—The Sukinda ultramafic complex in Orissa Province is estimated to contain 72 million short tons of laterite ore averaging about 0.85% nickel, of which 31 million tons is estimated to contain 1.15% nickel. The Government of India again considered seeking foreign technology to construct a nickel pilot plant. If tests proved favorable, a plant with a minimum capacity of 5,300 short tons per year of nickel, 200 tons per year of cobalt, and 18,700 short tons per year of fertilizer-grade ammonium sulfate would be built. At various times, UOP, Inc., Falconbridge Nickel Mines, Ltd., AMAX Nickel, Inc., Sherritt Gordon Mines, Ltd., and Freeport Sulfur, Inc., have expressed interest in the project.

Indonesia.—In April, P.T. International Nickel Indonesia revised downward the annual operating capacity of its Soroako project from 50,000 tons to 37,000 tons. Production for 1980 was estimated to be 23,500 tons and the target production for 1981 was reported to be 30,000 to 33,000 tons. The reduction in output capability was the result of corrosion of refractory linings in electric furnaces due to the acidic nature of the higher-grade nickel ores being processed. A lower-grade, more alkaline ore was blended with this ore, and furnaces have been modified with cooling devices to alleviate the problem. In addition, $15 million had been spent through 1979 in process improvements since the plant came onstream.

The Gag Island project of P.T. Pacific Nikkel Indonesia remained in limbo during the year.

Japan.—The Special Metals Stockpile Association released 90% of its stock of 23,000 tons of pure nickel as of the end of March. The stock was originally purchased in 1978 as part of a temporary government measure to reduce Japan's surplus foreign exchange reserves.

Nippon Mining Co. contracted to convert 12,000 tons per month of nickel ore for Indonesia's Gebe Mine to ferronickel, which would in turn be sold to Philipp Brothers in the United States. Nippon's capacity had been underutilized owing to a lack of domestic demand. In October, Nippon Mining cut its monthly ferronickel output at Saganoseki by 200 tons to 1,000 tons. The reduced production was expected to be continued until March 1981. In October, Sumitomo Metal Mining Co. cut back its nickel production to 1,500 tons per month from 1,900 tons per month, a level at which the company had been producing during the previous year. About 150 tons of the drop was attributed to the renovation of Sumitomo's Niihama refinery at a cost of $4.6 million.

Five Japanese ferronickel smelters made a compromise agreement with exporters of nickel ore in New Caledonia to import 1.9 million tons of ore in 1980, about the same as in 1979. New Caledonia supplies about half of Japan's nickel ore.

New Caledonia.—SLN reportedly planned to renovate one of the three 33,000-kilowatt smelting furnaces at Doniambo. Nickel ores processed at Doniambo are mined on the island at Nepoui, Thio, Poro, and Kouaoua. Because of the temporary deactivation of this furnace, nickel output was expected to fall below the previously expected level of 43,000 tons for 1981. For 1980, smelter output of nickel in ferronickel was expected to range from 44,000 to 48,000 tons. The company's smelter capacity at Doniambo is 75,000 tons. Although technical considerations were cited as the main reason for the furnace phasedown (the furnace is more than 10 years old), the measure will help to reduce excessive inventory levels. The operation was made particularly costly by the relatively high fuel consumption. Serious consideration was being given to building a coal-fired generating plant costing $130 million. A test of this proposed system at SLN research facilities, using coal from Australia and the Republic of South Africa, was to be run for 6 months. Unfavorable dollar-franc exchange rates were also cited as a source of financial problems. Stocks held by SLN in New Caledonia and France were said to be about 12,000 tons. SLN employed about 1,000 in New Caledonia and another 1,000 in France.

Cofremmi, S.A., a French mining company with substantial garnierite ore holdings in the north of New Caledonia, awarded a contract to C. F. Braun & Co., Alhambra, Calif., for engineering, procurement, and construction management for the first phase of construction of a more than $300 million nickel-cobalt production plant near Koumac, New Caledonia. AMAX Inc., Greenwich, Conn., will be a 49% partner in the project, with the balance held by Bureau de Recherche Géologiques et Minières (BRGM). Prior statements suggested the project would be onstream in 1987. In April, AMAX and BRGM were sued by Patino N.V. to recover its previous investment in the project. Patino, which altered its participation in 1976 to 10%, claimed that since its contract called for reimbursement for its investment in the project if a foreign-based company such as AMAX joined the venture, Patino should be paid. The case was to be decided in French court.

Philippines.—Operating costs at the Surigao Mine of Marinduque Mining and Industrial Corp. increased sharply in 1980 because of high fuel prices. Marinduque studied the possibility of converting oil-fired boilers to coal, but no decision was made. Profitability of Marinduque was aided by the relatively high prices for cobalt during the year.

South Africa, Republic of.—Matthey Rustenburg Refiners Pty., Ltd., jointly owned by Rustenburg Platinum Mines, Ltd., and Johnson Matthey and Co., Ltd., announced an improved grade of nickel to be marketed exclusively by Johnson Matthey Chemicals Ltd. as Matthey Nickel. Currently nickel production capacity is about 10,000 tons per year as a byproduct of platinum. The new grade of cut electrolytic cathode nickel was to be officially quoted on the London Metal Exchange. In addition, a new copper-nickel refinery with a capacity of about 21,000 tons per year of nickel was under construction and expected to be completed by the end of 1981. In the new plant, nickel and copper will be extracted from a sulfide matte by leaching to dissolve nickel and copper sulfates. First, a nickel-rich stream is produced, then purified to remove copper and other deleterious elements. This is followed by an electrowinning process producing high-quality cathode. The copper follows a similar process. The ore is mined from the Merensky Reef, which also contains cobalt, other platinum-group metals, gold, and silver.

United Kingdom.—In early June, Inco Europe, Ltd., brought onstream a new $23.3 million expansion of its facilities at Clydach, Wales, near Swansea. The new facility includes a fluid bed roaster and an associated sulfuric acid plant to treat roaster gas. The expansion increases the plant's annual capacity to 60,000 tons of nickel from the previous 50,000 tons. Feedstock was to be supplied by Inco's nickel mines in Guatemala and Canada, but with the Guatemalan plant expected to be shut down through 1981, Canada would temporarily be the sole source. The new facility enables Clydach to produce the three major product forms: Charge nickel for steelmaking, melting nickel for high-temperature and corrosion-resistant alloys, and nickel for electroplating.

A 19-week strike at Clydach was terminated in February. The unions settled for a 31% rise in pay. Resumption of operation was delayed several weeks because of severe flood damage incurred at the end of December 1979. The new contract was to last 1 year.

U.S.S.R.—The Nadzhda copper-nickel flash smelter in the Norilsk mining district of northern Siberia was expected to come onstream by yearend. The smelter was installed by AOR Industries of Finland. In late 1979, an associated concentrator was commissioned. The Norilsk region accounts for about half of the Soviet Union's output of nickel.

Yugoslavia.—The Kavadarci ferronickel facility was virtually completed and was expected to come onstream sometime in 1981, with an annual capacity of 17,600 tons of contained nickel. Davy McKee Corp. of San Mateo, Calif., is the engineering company responsible for development. (See "Technology" section). A second mining and ferronickel production facility at Giogovav, the Kosvo Republic, was under construction, with operations scheduled for 1982. Annual capacity of this operation is 1.1 million tons of ore to produce 13,200 tons of nickel in ferronickel. Capital cost was estimated at $150 million.

Zimbabwe.—Workers at Anglo American Corp., Ltd.'s (AAC), Bindura and Shangani nickel operations returned to work in late November, ending an 11-day wildcat strike. In May, another wildcat strike occurred at the Empress Nickel Mine of Rio Tinto Zinc, Ltd. (RTZ). It was also quickly settled. The latter mine is estimated to contain reserves of 280,000 tons of 1.48% nickel and copper. There are two nickel refineries in Zimbabwe: Bindura operated by AAC and Eiffel Flats (RTZ). The 0.6% to 1.25% nickel sulfide feedstock for these refineries comes from six mines: Empress, Epoch, Trojan, Shangani, Madziwa, and Perseverence. Perseverence was expected to close in 1981. None of the other mines was expected to produce for more than about 10 years. Zimbabwe nickel (99.995% nickel) is among the purest produced, despite its low grade, owing partly to the sulfur concentration in the ore, which is beneficial in processing. Also, power consumption per ton of cathode nickel produced is about 1,900 kilowatt-hours (kWh) in electrowinning compared with 2,500 kWh for Canadian sulfide and 8,500 kWh for laterites.

In May, Northbrook Metals Co. of Northbrook, Ill., was named exclusive U.S. distributor of nickel from RTZ's Empress Mine. The contract was to run for at least 1 year.

TECHNOLOGY

Bureau of Mines scientists investigated the flotation responses of two copper-nickel ore samples from the Duluth complex of Minnesota. The objective of this research was the recovery of bulk sulfide concentrates. One sample, taken from a test pit, analyzed 0.35% copper and 0.11% nickel, while a shaft sample analyzed 0.69% copper and 0.14% nickel. Pilot plant flotation responses were similar for both samples, as copper and nickel recoveries for the pit sample were 87% and 62%, respectively, and 92% and 73% for the shaft sample. This research was conducted at the Twin Cities Research Center, Twin Cities, Minn.[3]

The Albany Research Center, Albany, Oreg., continued development of a method to recover nickel, cobalt, and copper from laterites containing less that 1.2% nickel and 0.25% cobalt. The method consisted of (1) reduction roasting, (2) leaching, (3) solvent extraction, and (4) electrowinning. The process was designed to maximize solution recycling and recovery of strategic and critical metals such as cobalt and nickel. Nickel and copper are co-extracted with the organic solvent LIX64N from an ammoniacal ammonium sulfate leach liquor. Studies carried out in 1980 centered on maximizing recovery efficiency of cobalt.[4]

The Rolla (Mo.) Research Center of the Bureau of Mines continued its research into methods to recover nickel, cobalt, and copper from mattes and drosses generated during the smelting of lead ore concentrates. Beneficiating procedures for recovering cobalt and nickel from commercial lead, zinc, and copper concentrates, by modifying milling procedures now practiced in the Missouri Lead Belt, were also developed.

Corrosion research was conducted by the Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. The corrosion resistance of 31 iron, nickel, aluminum, copper, titanium, and molybdenum-base alloys was characterized and evaluated in laboratory corrosion studies in low- and high-salinity geobrines representative of those found in the Imperial Valley, Calif.[5] Falconbridge Nickel Mines, Ltd., developed a new smelting process in order to reduce SO_2 emissions to the atmosphere and improve the working environment while maintaining smelter production levels and metal recoveries. In the process, concentrate in a slurry form is partially roasted in a fluid bed roaster and the calcine is smelted in an electric furnace. The roaster gases are treated in an acid plant.[6]

Hanna Mining Co. of Cleveland developed an improved ferronickel process to be used on laterites to be produced from the Cerro Matoso project in Brazil, in which Hanna holds 20% interest. In the new process, ore and coal are pelletized together, which permits more selective reduction of iron and nickel and enables better dust control. The process is claimed to yield a higher grade ferronickel. Similarly, a Yugoslavian organization, developing a low-grade nickel laterite project at Kavadarci, planned to concentrate the ore by magnetic separation to remove high-iron particles. The remaining ore was to be pelletized, reduced with lignite in a traveling-grate kiln, and then smelted in an electric furnace.[7]

Development of the zinc-nickel oxide battery continued, as General Motors Corp. (GM), Delco Remy Div., reported achievement of 290 charge-discharge cycles and was expected to make some important decisions by fall of 1981 regarding location of battery production facilities. Gould, Inc., under contract with Ford Motor Corp., worked on a similar battery, but late in the year suspended development. Technical problems and high raw materials cost compared with competitive batteries were cited as reasons for discontinuing the program. GM was expected to have capacity to produce 200 electric cars per year by the mid-1980's. At an average of 150 pounds of nickel per battery, 30 million pounds of nickel would be required for this new application. On a 110-volt line, the batteries would be recharged in about 8 hours. Batteries would have a range of about 100 miles and a lifetime of 30,000 miles.[8] Recycling would be expected to be significant, so that the impact of this new demand would be considerably lessened several years after commercialization of the battery. The Japanese auto manufacturer Daihatsu Motor Co. reported development of a 19-volt nickel-iron battery-powered vehicle with a range of 94 miles. Eagle Picher Industries Electronics Div. in the United States worked on a similar battery.[9]

Researchers at General Electric Co. (GE) succeeded in casting jet engine turbine blades made of composite materials. Strength of the alloys, called oriented eutectic superalloys, is increased by 1-micrometer strands of tantalum carbide in a nickel matrix. GE designates its version of the alloy Nitac. The reinforcing strands for whiskers allow the design of blades that can endure temperatures 240° to 250° F hotter than conventional superalloys. The company molded hollow blades of Nitac for engine demonstration tests in 1982 at its Aircraft Engine Group facilities in Evandale, Ohio. The increased operating temperature could yield a 1% increase in fuel efficiency and 17% increase in thrust.[10]

The relatively high cost of tin reportedly caused the steel industry to seriously consider nickel coating on steel as an alternative, lower cost material. Aluminum gained an increasingly larger share of the can market in recent years, and research by the steel industry was aimed at countering this advance. Nickel is about one-half the price of tin, and nickel can be coated on steel to a thickness of 15 ten-millionths of an inch, about one-tenth that of tin. Also, nickel offers the added benefit of better lubricity in the drawing and ironing process. Another substitute, chromium, is already in use. Although this application for nickel was still in the research stage, advancement in technology and increase in raw materials cost made its use appear increasingly likely. National Steel Corp. rolled the nickel-plated material and sent it to consumers for test runs.[11]

Tests were made of a Type 301 nickel stainless steel bonded to a fiberglass-reinforced thermoplastic backing bar for passenger cars. The bumper weighs only 14 pounds and the stainless steel skin is just 0.015 to 0.018 inches thick. Conventional compression molding techniques were used to form the plastic bar, finish form the stainless facing, and join each together.[12]

Certified Alloy Products of Long Beach, Calif., announced a new process for the direct recovery of superalloy scrap. The process involved use of a pure nickel oxygen lance to blow oxygen into a charge of superalloy scrap at 2,900° F in an electric arc furnace, in tandem with vacuum melting. The reactive metals are thereby oxidized; the melt is purged of low-melting-point metal; and the material is reconstituted by vacuum induction melting and refined directly into superalloys meeting industry specifications.

The Bureau of Mines continued to monitor contracts to study recovery of nickel, cobalt, and chromium from superalloys and other nickel-based alloys. Two reports containing the results of this work were published by the Bureau.[13]

Patents were issued on the extraction of nickel from sulfur-deficient nickel-cobalt-copper matte; the hydrometallurgical extraction of nickel and cobalt from laterites; the extraction of nickel from low-grade complex nickel ores such as peridotite; recovery of nickel, cobalt, copper, molybdenum, and ferromanganese from manganese nodules, and recovery of ferronickel from laterite using liquid hydrocarbon mixture as fuel.

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Nitrogen

By Charles L. Davis[1]

Production of ammonia in the United States remained high the first 2 months of 1980, then declined through midyear. A recovery began in the last quarter, and the yearend production level nearly reached that of 1979. Consumption of ammonia in the United States peaked in the second quarter of 1980, and after fluctuations, ended the year at a high level. Total exports of ammonia were down for the year, compared with the 1979 totals. Imports continued to rise during the first half of 1980, peaked in June, and fell to 1979 yearend levels by December 31.

Legislation and Government Programs.—The 96th Congress enacted into law the Comprehensive Environmental Response Compensation and Liability Act of 1980 (Public Law 96-510), which taxes certain chemical compounds but specifically excludes substances used in the production of fertilizers. Taxes imposed by the act, with exceptions, shall not apply after September 30, 1985. Nitric acid not used in fertilizers was taxed at 24 cents per short ton.

Table 1.—Salient ammonia statistics

(Thousand short tons of contained nitrogen)

	1976	1977	1978	1979	1980[p]
United States:					
Production[1]	13,856	14,712	[r]14,169	15,329	15,733
Exports	361	346	434	649	681
Imports for consumption	599	884	1,247	1,603	1,921
Consumption[2]	13,939	14,831	15,270	16,376	17,236
World: Production	[r]62,697	[r]68,517	[r]72,556	77,305	78,086

[p]Preliminary. [r]Revised.

[1]Synthetic anhydrous ammonia and coke oven ammonia.

[2]Includes producers' stock changes in synthetic anhydrous ammonia and coke oven ammonia.

Following the recommendation of the International Trade Commission, the President acknowledged a market disruption if Soviet ammonia were allowed to enter the United States without limitations. The President, on January 18, 1980, placed a limit of 1 million tons on imports of ammonia from the U.S.S.R. for 1980. The International Trade Commission made a second study of the possible effects on industry of imported Soviet ammonia and determined that market disruption did not exist.

The California State Legislature approved a bill that limited the price of natural gas sold to California ammonia producers to a level 10% higher than the cost of natural gas to utility companies. This provision gives relief from the constantly escalating feedstock cost in California, through January 1, 1983.

Rail deregulation legislation (Public Law 96-448) enacted on October 14, 1980, was expected to adversely affect the transportation cost of some fertilizers.

DOMESTIC PRODUCTION

Production of ammonia in the United States in 1980 increased to 15.7 million tons of contained nitrogen. Throughout the country, production started strongly but declined from a first-quarter high to a low at midyear owing to reduced demand.

Producers were evaluating the effect of anhydrous ammonia imported from the Soviet Union by the Occidental Petroleum Corp. on the domestic ammonia market. They gradually began to adjust to the presence of the imported ammonia and its possible effect on the fertilizer industry.

During 1980, about 25 ammonia plants were out of service, partly owing to high operating costs. International Minerals and Chemical Corp. closed one of its Louisiana plants because of low market prices for ammonia. High production cost, paid by most producers, contributed to raising prices.

Table 2.—Fixed nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1976	1977	1978	1979	1980[p]
Anhydrous ammonia, synthetic plants[1]	13,741	14,602	[r]14,072	15,226	15,644
Ammonium compounds, coking plants:					
Ammonia liquor	4	7	7	7	7
Ammonium sulfate	111	103	90	96	82
Ammonium phosphates	(2)	(2)	(2)	(2)	(2)
Total	13,856	14,712	[r]14,169	15,329	15,733

[p]Preliminary. [r]Revised.
[1]Current Industrial Reports, U.S. Department of Commerce, Bureau of the Census.
[2]Included with ammonium sulfate to avoid disclosing company proprietary data.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compound	1978	1979	1980[p]
Acrylonitrile	876	1,009	915
Ammonium nitrate	7,210	7,543	8,590
Ammonium sulfate[1]	2,900	2,833	[e]2,452
Ammonium phosphates	11,517	12,082	13,378
Nitric acid	7,934	8,465	8,933
Urea	[r]6,273	7,027	7,218

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of anhydrous ammonia

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Agrico Chemical Co. - Williams	Blytheville, Ark	407
Do	Donaldsonville, La	468
Do	Verdigris, Okla	840
Air Products & Chemicals, Inc	New Orleans, La	210
Do	Pace Junction, Fla	100
Allied Chemical Corp	LaPlatte, Nebr	172
Do	Hopewell, Va	340
Do	Geismar, La	340
Do	Helena, Ark	210
American Cyanamid Co	Fortier, La	580
Amoco Oil Co	Texas City, Tex	522
Apache Powder Co	Benson, Ariz	15
Atlas Chemical Industries, Inc	Joplin, Mo	136
Beker Industries Corp	Conda, Idaho	100
Borden Chemical Co	Geismar, La	353
Car-Ren, Inc	Columbus, Miss	68
CF Industries, Inc	Donaldsonville, La	1,590
Do	Fremont, Nebr	48
Do	Terre Haute, Ind	150
Do	Tunis-Ahoskie, N.C	210
Do	Tyner, Tenn	170
Chemical Distributors	Chandler, Ariz	33
Chevron Chemical Co	Pascagoula, Miss	530
Do	Fort Madison, Iowa	95
Do	El Segundo, Calif	20
Columbia Nitrogen Corp	Augusta, Ga	510
Cominco American	Boger, Tex	400
Diamond Shamrock Chemical Co	Dumas, Tex	160
Dow Chemical Co	Freeport, Tex	115
E. I. du Pont de Nemours & Co	Beaumont, Tex	340
Do	Victoria, Tex	100
El Paso Products Co	Odessa, Tex	115
Farmland Industries, Inc	Fort Dodge, Iowa	210
Do	Dodge City, Kans	210
Do	Hastings, Nebr	140
Do	Enid, Okla	840
Do	Lawrence, Kans	340
Do	Pollock, La	420
Felmont Oil Corp	Olean, N.Y	85
First Mississippi Corp	Fort Madison, Iowa	365
First Mississippi Corp (AMPRO)	Donaldsonville, La	400
FMC Corp	S. Charleston, W. Va	24
Gardinier, Inc	Tampa, Fla	120
Georgia Pacific Corp	Plaquemine, La	196
Goodpasture, Inc	Dimmitt, Tex	40
Grace-Oklahoma Nitrogen	Woodward, Okla	400
W. R. Grace & Co	Woodstock, Tenn	340
Green Valley Chemical Co	Creston, Iowa	35
Hawkeye Chemical Co	Clinton, Iowa	138
Hercules, Inc	Louisiana, Mo	70
Hooker Chemical Co	Tacoma, Wash	23
International Minerals & Chemical Corp	Sterlington, La	400
Jupiter Chemical Co	Lake Charles, La	78
Kaiser Agricultural Chemicals Co	Savannah, Ga	100
Do	Pryor, Okla	105
Mississippi Chemical Corp	Yazoo City, Miss	393
Do	Pascagoula, Miss	175
Monsanto Co	Luling, La	850
New Jersey Zinc Gulf & Western	Palmerton, Pa	35
N-Ren Corp	Pryor, Okla	94
Do	East Dubuque, Ill	238
Do	Carlsbad, N. Mex	68
Occidental Agricultural Chemical Co	Taft, La	90
Olin Corp	Lake Charles, La	490
Pennwalt Chemical Co	Portland, Oreg	8
Phillips Pacific Chemical Co	Kennewick, Wash	155
Phillips Petroleum Co	Beatrice, Nebr	210
PPG Industries	Natrium, W. Va	50
Reichhold Chemicals, Inc	St. Helens, Oreg	90
J. R. Simplot Co	Pocatello, Idaho	108
Tennessee Valley Authority	Muscle Shoals, Ala	74
Terra Chemicals International, Inc	Port Neal, Iowa	210
Triad Chemical Co	Donaldsonville, La	340
Union Chemical Co	Kenai, Alaska	1,020
Do	Brea, Calif	280
U.S.A. Petrochem Corp	Ventura, Calif	60
U.S.S. Agri-Chemicals, Inc	Clairton, Pa	325
Do	Cherokee, Ala	175
Do	Geneva, Utah	70
Vistron Corp	Lima, Ohio	475
Wycon Chemical Co	Cheyenne, Wyo	167
Total		20,776

Source: Economics and Marketing Research Section, Tennessee Valley Authority. World Fertilizer Capacity, Ammonia. Muscle Shoals, Ala., Apr. 16, 1980.

CONSUMPTION AND USES

Domestic ammonia consumption increased to 17.2 million tons of contained nitrogen in 1980. The increase was attributed to greater use of nitrogen fertilizers in the United States. Fertilizers amounted to over 83% of ammonia demand, either in direct application or in the manufacture of downstream compounds. Ammonia also was used to produce other chemicals which included explosives, resins, fibers, plastics, and animal feeds.

STOCKS

At yearend 1980, producers' stocks totaled 1.8 million tons of anhydrous ammonia which contained almost 1.5 million tons of nitrogen. This amount of ammonia was down 15% from the previous year's ending inventory.

PRICES

U.S. domestic spot quotes of $128 per short ton for ammonia in the first month of 1980 reflected tight credit and uncertain demand. Prices reached $160 per ton during the spring, when peak consumption occurred. After the peak, the decline in the price of ammonia continued, reaching a low of $115 per ton in November. The year ended with ammonia prices at $120 to $124 per ton, f.o.b. gulf coast.

Table 5.—Price quotations for major nitrogen compounds at yearend 1980

(Per short ton)

Compound	Price
Anhydrous ammonia:	
f.o.b. gulf coast	$120-$124
Delivered Corn Belt	150- 160
Ammonium sulfate: f.o.b. Corn Belt	85
Ammonium nitrate: Delivered Corn Belt	110- 115
Urea:	
f.o.b. gulf coast	170- 175
Delivered Corn Belt	155- 170
Diammonium phosphate: f.o.b. Tampa	190- 195

FOREIGN TRADE

The tonnage of ammonia exported by the United States increased in 1980. Exports of downstream ammonia products also increased. The largest changes in exported nitrogen compounds were increased exports of diammonium phosphate and urea.

U.S. ammonia imports for 1980 were up. The U.S.S.R. remained the leading foreign supplier of ammonia to the United States, followed by Canada, Mexico, Trinidad and Tobago, the Netherlands, the Netherlands Antilles, Venezuela, and the Yemen Arab Republic. The amount of other nitrogen compounds imported remained about the same.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1980

(Thousand short tons and thousand dollars)

Compounds	Gross weight	Nitrogen content	Value
EXPORTS			
Industrial chemicals:			
Ammonia, aqua (ammonia content)	3	2	353
Ammonium nitrate	22	8	1,299
Ammonium phosphate	5	1	6,008
Ammonium sulfate	4	1	185
Fertilizer materials:			
Ammonium nitrate	e79	28	9,907
Diammonium phosphates	5,506	991	1,095,944
Other ammonium phosphates	650	72	122,093
Ammonium sulfates	815	171	60,979
Anhydrous ammonia	828	681	107,122
Sodium nitrate	14	2	2,148
Urea	1,943	874	312,272
Nitrogen solutions	703	225	82,258
Other nitrogen fertilizers	325	62	6,808
Mixed chemical fertilizers	224	22	35,007
Total	e11,121	3,140	1,842,383
IMPORTS			
Industrial chemicals:			
Anhydrous ammonia and chemical-grade aqua	1	(1)	94
Ammonium nitrate	157	54	15,846
Ammonium phosphate	2	(1)	955
Ammonium sulfate	(1)	(1)	29
Fertilizer materials:			
Ammonium nitrate	247	83	25,519
Ammonium nitrate-limestone mixtures	(1)	(1)	7
Diammonium phosphates	148	26	23,857
Other ammonium phosphates	176	19	29,197
Ammonium sulfate	289	61	22,278
Calcium cyanamide or lime nitrogen	2	(1)	326
Calcium nitrate	119	17	6,609
Nitrogen solutions	178	56	23,626
Anhydrous ammonia	2,337	1,921	234,420
Potassium nitrate	39	5	8,639
Potassium nitrate-sodium nitrate mixtures	36	5	4,060
Sodium nitrate	158	26	15,096
Urea	1,017	458	140,348
Other nitrogenous fertilizers	76	15	10,610
Mixed chemical fertilizers	128	13	22,292
Total	5,110	2,759	583,808

eEstimated.
1Less than 1/2 unit.

WORLD REVIEW

Many developing nations have industrial programs encouraging self-sufficiency in ammonia production for fertilizers. The rate of growth in world nitrogen fertilizer consumption was reduced by half in 1980 to 6% compared with 12% the previous year. Total world consumption was about 58 million tons.

A poor autumn season and continued shipments from the U.S.S.R. depressed export prices in the U.S. gulf coast area. Also contributing was the restart of ammonia production in Libya. It was not only abundant supply that held back an upturn of prices; demand for merchant ammonia had slowed.

The cost of naphtha fell during the first 9 months of 1980, which encouraged some marginal plants to keep operating. A combination of widespread feedstock supply problems, aggravated by problems of pricing, power supply, transportation cost, sluggish demand for industrial processing in downstream industry, unfavorable weather, political unrest, and the delayed completion and testing of new facilities, accounted for the slowdown of 1980 world nitrogen production.

Export prices of ammonia in the fourth quarter of 1980 were as low as $160 per ton. Some contract prices in 1980 were as high as $190 per ton. (At the time such a contract price was set it seemed reasonable, but by yearend the fixed price was higher than the spot market price.)

Algeria.—New plants for ammonia, urea, nitric acid, and ammonium nitrate were due onstream at the coastal complex of Arzew in Algeria at the end of 1980.[2]

Bangladesh.—Ashugani Fertilizer and Chemical Co. commissioned a 272,000-ton-per-year ammonia and 242,000-ton-per-year urea complex at Ashuganj, about 100 kilometers northwest of Dacca.[3]

Brazil.—Construction contracts were awarded in Sergipe State for a fertilizer complex. Production facilities for 1,000 tons per day of ammonia and 1,200 tons per day of urea were scheduled to come onstream in 1982.[4]

Canada.—A plant in Brandon, Manitoba, was to bring a 250-ton-per-day ammonia expansion onstream in 1981. The expansion also included 350 tons per day of urea.[5]

Bechtel Canada awarded a contract to build an ammonia and urea complex in Alberta. Capacity was to be about 700 tons per day of ammonia and 1,200 tons per day of urea.[6]

Sherritt Gordon Mines Ltd. has begun construction of a new nitrogen fertilizer facility at Fort Saskatchewan, Alberta. The plant was to produce 1,090 tons per day of ammonia and 100 tons per day of urea. Sherritt Gordon had a 5-year agreement for natural gas for the plant and had received all necessary permits for construction.[7]

China, Mainland.—China planned for nine large (1,000-ton-per-day) ammonia units. Contracts were awarded for five of the plants. One plant was based on a coal gasification process, two on heavy oil, and the others on natural gas.[8]

Egypt.—Facilities for producing 326,000 tons per year of ammonia and 262,000 tons per year of urea were being constructed near existing facilities. Natural gas feedstock for the complex was to come from the Abv Madi Field.[9]

Finland.—Kemira Oy of Helsinki ordered the fourth nitric acid plant at Unsikaupunki, on the Baltic Coast, from Uhde GmbH, part of the Federal Republic of Germany's Hoechst. The capacity was to be 440 tons per day using Uhde's medium-pressure process. The onstream target date was third quarter 1981.[10]

Germany, Federal Republic of.—C. F. Braun and Co. was awarded the engineering construction and startup contract for a new ammonia plant at Ludwigshafen. The 370,000-ton-per-year plant was to use Braun's own process and was to be completed by mid-1982.[11]

Huls' 550,000-ton-per-year ammonia plant, commissioned at Brusnbvetterl in late summer 1978, was seriously affected by two crucial breakdowns during 1979. Huls was attempting to overcome the difficulties in 1980.[12]

India.—An Indian firm was chosen to build seven urea plants in India. Three plants were to have a capacity of 1,500 tons per day, and the other four were to produce 1,200 tons per day of urea.[13]

The Steel Authority of India awarded a contract to modernize its Rourkela ammonia plant. The modification will increase capacity to 225,000 tons per year. It was planned that the plant will be completed by November 1981.[14]

Korea, North.—A 200,000-ton-per-year ammonia and 152,000-ton-per-year urea complex was completed for the Youth Chemical Combine by the North Korean Government. The complex was located on the Changchon-Gang River in the eastern region of the country.[15]

Kuwait.—A contract was awarded for the construction of a new ammonia unit with a 1,000-ton-per-day capacity, located at Shuaiba.[16]

Libya.—Assembly work began on the Libyan National Oil Corp.'s new urea plant at Marsa el Brega. The new plant was planned to be onstream in 1981.[17]

Mexico.—Mexico suffered operating difficulties that affected four plants. Restrictions had to be placed on deliveries scheduled for the spring, and Mexico did not catch up on deliveries of ammonia in the second half of the year. Along the western gulf coast, two 1,500-ton-per-day ammonia plants were being built, and five more plants of approximately the same capacity were planned for the near future.[18]

Norway.—Norsk Hydro installed a unit at its 365,000-ton-per-year ammonia plant which increased ammonia capacity by some 13,000 tons per year.[19]

Portugal.—Uhde GmbH of the Federal Republic of Germany was awarded a con-

Table 7.—Ammonia: World production, by country[1]

(Thousand short tons of contained nitrogen)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	[r]1,387	[r]1,944	2,123	2,184	2,200
Cuba[2]	[r]80	[r]72	43	171	275
Mexico	789	860	1,432	1,498	1,565
Netherlands Antilles	93	[r]34	--	--	--
Trinidad and Tobago	180	195	442	428	440
United States	13,856	14,712	14,169	15,329	[3]15,733
South America:					
Argentina	41	46	52	54	51
Brazil	159	160	224	293	388
Colombia	100	72	70	[e]100	100
Peru[e]	83	91	89	90	90
Venezuela	280	299	299	286	397
Europe:					
Albania[e]	[r]65	[r]72	[r]83	[r]79	83
Austria	503	513	518	573	[3]540
Belgium	594	[r]644	542	586	[3]593
Bulgaria	1,015	1,097	1,058	1,048	1,060
Czechoslovakia	799	872	901	[e]900	900
Denmark	36	36	36	36	[3]34
Finland	[r]186	145	165	126	[3]77
France	1,963	2,242	2,223	2,370	2,300
German Democratic Republic	1,233	[r]1,245	1,253	1,188	1,200
Germany, Federal Republic of	2,053	2,192	2,155	2,382	2,253
Greece	262	248	252	316	320
Hungary	775	804	822	885	[3]865
Iceland[e]	9	7	8	8	8
Ireland	38	31	25	188	[3]280
Italy	1,344	1,287	1,591	1,577	1,540
Netherlands[4]	2,183	2,359	2,368	2,484	[3]2,363
Norway	522	556	580	600	568
Poland	1,903	1,835	1,776	1,681	[3]1,633
Portugal	175	[r]204	278	245	[3]221
Romania	1,829	1,975	2,488	2,570	2,645
Spain	[r]1,159	[r]1,064	970	911	[3]818
Sweden	119	112	105	99	[3]95
Switzerland[e]	50	50	50	50	52
U.S.S.R	11,122	11,843	12,456	13,400	13,700
United Kingdom	1,485	1,798	1,764	1,836	[3]1,800
Yugoslavia	427	460	459	461	457
Africa:					
Algeria	23	[e]35	[e]45	[e]50	55
Egypt	[e]230	231	275	291	441
Libya[e]	--	--	90	147	165
South Africa, Republic of	518	560	621	620	[3]605
Zambia	[e]20	[e]20	[e]20	[e]20	[3]22
Zimbabwe	[e]80	[e]80	[e]70	[e]70	[3]63
Asia:					
Afghanistan[e]	40	40	30	30	11
Bangladesh	163	[r]118	116	184	155
Burma[e]	60	[r]64	[r]61	[r]61	66
China:					
Mainland[e]	4,500	6,200	7,400	7,900	8,300
Taiwan	352	359	483	431	[3]457
India[5]	2,105	2,245	2,425	2,487	2,315
Indonesia	204	[r]453	530	837	[3]796
Iran	254	299	196	202	[3]240
Iraq	[e]150	150	200	500	500
Israel	[e]71	76	75	76	[3]60
Japan	2,465	2,526	2,705	2,662	2,570
Korea, North[e]	300	450	500	500	500
Korea, Republic of	[r]664	799	989	1,059	[3]935
Kuwait	465	443	475	447	300
Malaysia	47	37	44	57	[3]45
Pakistan	360	348	341	425	474
Philippines	[r] [e]45	[r] [e]45	[r] [e]45	45	43
Qatar	[e]100	116	183	327	460
Saudi Arabia	[e]112	138	154	171	184
Syria	[e]25	25	21	24	16
Thailand[e]	8	8	10	--	--
Turkey	[e]100	118	239	285	275
Vietnam[e]	--	10	20	25	NA
Oceania: Australia	339	348	324	340	[3]389
Total	[r]62,697	[r]68,517	72,556	77,305	78,086

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 5, 1981.
[2]Series revised to reflect officially reported Cuban data for 1976-79 (1980 figure is an estimate).
[3]Reported figure.
[4]Data as reported by International Superphosphate Manufacturers' Association (ISMA); official Netherlands statistical publications report production for sale as follows, in thousand short tons: 1976—1,768; 1977—1,962; 1978—1,917; 1979—2,244; 1980 (estimate)—2,205.
[5]Data are for years beginning Apr. 1 of that stated.

tract to build two 400-ton-per-day nitric acid plants for Messrs. Qumigal of Lisbon, a State-owned chemical producer, at Alverca and Lauradio near Lisbon. The plants were to use Uhde's dual-pressure process.[20]

Saudi Arabia.—A contract was awarded to build a fertilizer complex at Al-Jubail, which included a 1,000-ton-per-day ammonia plant and a 1,600-ton-per-day urea unit.[21]

Spain.—Spain completed a second contract with the U.S.S.R. to import 165,300 tons per year of ammonia until 1983. This contract extended the 110,200 tons per year of the Spanish-Soviet accord to 275,500 tons per year.[22]

Syria.—Syria commissioned two new plants that will use naphtha as the ammonia feedstock. One unit was to produce 1,000 tons per day of ammonia, while the other unit was to produce 1,050 tons per day of urea.[23]

Tanzania.—The Tanzanian Government signed an agreement with Agrico Chemical Co. to build an ammonia fertilizer plant at Kilwa Masoko. Feedstock was to come from offshore natural gas.[24]

U.S.S.R.—The Soviets have had an enormous buildup in the ammonia industry. From 6 million tons per year in 1967, Soviet capacity rose to an estimated 26 million tons per year in 1980 and was projected to reach 34 million tons per year by 1982.[25]

New fertilizer plants were scheduled to be commissioned in 1980 at the Cherkassy complex, including a 450,000-ton-per-year ammonia unit, a 330,000-ton-per-year urea facility, and a 400,000-ton-per-year liquid ammonium phosphate plant. A 450,000-ton-per year plant was due onstream at Angarsk in the Irkutsk region. Another 450,000-ton-per-year urea plant was commissioned at Gorlovka, and a large-capacity complex was commissioned at the Dorogobuzh nitrogen fertilizers plant, which was to produce 450,000 tons per year of ammonia.[26]

The plant at Gorlovka, in the Ukraine, was designed based on Montedison technology. Two other Soviet urea plants, at Berezniki on the western flank of the Ural Mountains and at Kemerono in southern Siberia, were nearing final stages of completion. Each of these plants had a rated capacity of 230,000 tons per year.[27]

TECHNOLOGY

The Polish Pulawy Institute of Artificial Fertilizers developed a partial recycle urea process in which unreacted ammonia and carbon dioxide were removed by heating and evaporation.[28]

C. F. Braun's improved purifier process has been claimed the most efficient commercially proven process for the manufacture of ammonia. It saves energy by reducing primary reformer heat requirements, by reducing compression energy requirements, and by synergistic combination of several features.[29]

A spherical catalyst was developed that, according to its developer, had advantages over granular catalysts in low-pressure energy-efficient ammonia synthesis "loops." Energy use and yield were said to improve.[30]

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[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Nitrogen. Plant and Project News. No. 127, September-October 1980, p. 15.
[3]Nitrogen. Plant and Project News. No. 128, November-December 1980, p. 17.
[4]Chemical Week. Brazil Signs Pact of Nitrogen Fertilizer Unit. V. 126, No. 5, Jan. 30, 1980, p. 32.
[5]Nitrogen. Plant and Project News. No. 126, July-August 1980, p. 12.
[6]Chemical Age. Bechtel Canada Awarded Ammonia-Urea Contract. V. 120, No. 3155, Mar. 7, 1980, p. 10.
[7]The Wall Street Journal. Dec. 3, 1980, p. 16.
[8]Chemistry and Industry. New Producers—China. Jan. 5, 1980, p. 40.
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[10]Chemical and Engineering News. New Plants. V. 58, No. 5, Feb. 4, 1980, p. 13.
[11]Page 11 of work cited in footnote 9.
[12]European Chemical News. Huls' Ammonia Plant Hit by Technical Hitches. V. 34, No. 925, Feb. 18, 1980, p. 10.
[13]Chemical Age. Snam Selected To Build Seven Urea Plants in India. V. 120, No. 3163, May 2, 1980, p. 20.
[14]European Chemical News. Uhde Wins Indian Ammonia Contract. V. 34, No. 925, Feb. 18, 1980, p. 27.
[15]Page 13 of work cited in footnote 9.
[16]Page 13 of work cited in footnote 9.
[17]Page 13 of work cited in footnote 9.
[18]Chemical Week. Mexico Is Not Putting Off Until Tomorrow. V. 127, No. 16, Oct. 22, 1980, pp. 45-46.
[19]European Chemical News. V. 34, No. 932, Apr. 7, 1980, p. 23.
[20]Work cited in footnote 10.
[21]Chemical Age. Kellogg Receives Saudi Contract. V. 120, No. 3160, Apr. 11, 1980, p. 10.
[22]Chemical Week. V. 126, No. 17, Apr. 23, 1980, p. 13.
[23]Work cited in footnote 3.
[24]Page 15 of work cited in footnote 3.
[25]Chemical Age. Soviet Ammonia Presence Grows. V. 120, No. 3167, May 30, 1980, pp. 12-13.
[26]European Chemical News. U.S.S.R. Steps Up Chemical Fertilizer Output. V. 34, No. 922, Jan. 28, 1980, p. 14.
[27]Fertilizer International. Gorlovka Start-Up Increases Soviet Urea Capacity. No. 138, December 1980, p. 10.
[28]European Chemical News. Poland Develops Five New Processes for Fertilizers and Chemicals. Mar. 24, 1980, p. 20.
[29]Chemical Age. Synergistic Addition for Efficient Ammonia. Nov. 14, 1980, pp. 18-20.
[30]Chemical Week. Ammonia Catalysts Cuts Energy Use, Boost Yields. V. 126, No. 24, June 11, 1980, p. 38.

Peat

By Charles L. Davis[1]

The United States produced in excess of 785,000 short tons of peat of all types in 1980. Compared with the previous year's production of 825,000 tons of peat, production for 1980 declined by nearly 5%. Michigan produced more peat than in any other State, accounting for 213,000 tons of peat which was 27% of the U.S. total. Michigan, Florida, Illinois, and Indiana were the major peat-producing States in 1980. Reed-sedge peat accounted for 59% of U.S. domestic peat production. Humus peat amounted to 23%, hypnum moss peat to 5%, sphagnum moss peat to 3%, and other unclassified types to 10%.

The sale of peat in the United States totaled $16.2 million, an increase of 4% compared with 1979 sales. About 62% of domestic peat sold in 1980 was packaged. The average apparent peat price in 1980 was $20.54 per ton f.o.b. plant, 6% higher than 1979 averages.

Peat imports increased to 400,000 tons in 1980, 5% greater than 1979 imports. About 99% of the 1980 peat imports were premium-grade sphagnum moss peat from Canada. Apparent consumption of peat increased 1% to 1.19 million tons. Imports contributed about 34% to apparent consumption tonnage in 1980, and contributed 75% of apparent consumption value. World production was approximately 223 million tons. About 95% of the 1980 world production was produced in the U.S.S.R.

Table 1.—Salient peat statistics

	1977	1978	1979	1980
United States:				
Number of active operations	102	100	97	96
Production ___ thousand short tons	781	822	825	785
Sales by producers ___ do	726	750	798	788
Bulk ___ do	325	328	324	298
Packaged ___ do	401	422	474	491
Value of sales ___ thousands	$12,520	$12,988	$15,517	$16,190
Average per ton ___ dollars	17.25	17.32	19.44	20.54
Average per ton—bulk ___ do	12.22	13.98	15.05	15.46
Average per ton—packaged or baled ___ do	21.32	19.92	22.46	23.61
Imports ___ thousand short tons	330	380	381	402
Apparent consumption[1] ___ do	1,056	1,130	1,179	1,190
Yearend producer's stocks ___ do	NA	394	350	330
World: Production ___ do	r223,218	r224,256	r223,186	223,066

rRevised. NA Not available.
[1]Sales plus imports.

DOMESTIC PRODUCTION

Peat was produced by 96 active mines in the United States in 1980. Approximately 46% of U.S. production in 1980 was from seven large mines, with annual capacities greater than 25,000 tons. The seven peat mines included two reed-sedge mines located in Michigan, one reed-sedge mine in each of the States of Florida, Illinois, and

Indiana; one humus mine in New York; and one unclassified peat mine in Florida.

Reed-sedge production decreased 5% in 1980 and was 59% of U.S. total peat production. Humus production declined 8% in 1980 and was 23% of the U.S. total peat production.

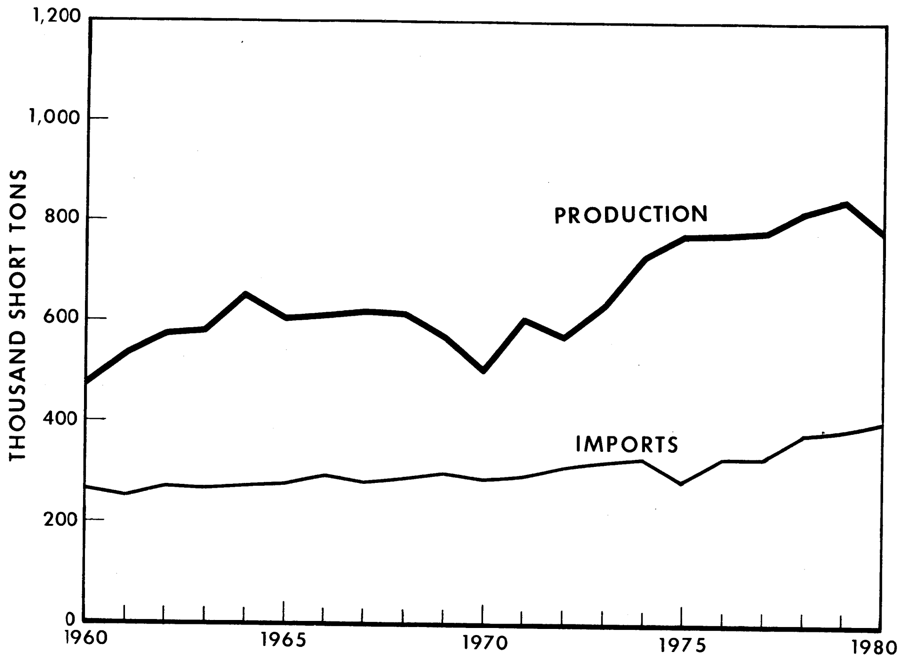

Figure 1.—Production and imports of peat in the United States.

Table 2.—Relative size of peat operations in the United States

Size in tons per year	Number of active plants		Production (thousand tons)	
	1979	1980	1979	1980
25,000 and over	8	7	406	362
15,000 to 24,999	8	10	160	184
10,000 to 14,999	6	4	75	47
5,000 to 9,999	15	15	96	108
2,000 to 4,999	17	17	55	56
1,000 to 1,999	14	12	22	19
Under 1,000	29	31	11	9
Total	97	96	825	785

CONSUMPTION AND USES

Domestic sales by domestic peat producers in 1980 reached 788,000 tons, a decrease of 1.3% from the 1979 sales. The increasing trend of sales in packaged form continued

Table 3.—U.S. peat production and yearend producers' stocks, by kind and State

(Thousand short tons)

State	Active plants	Sphagnum moss		Hypnum moss		Reed-sedge		Humus		Other		Total[1]	
		Production	Yearend stocks	Production	Yearend stocks	Production	Yearend stocks	Production	Yearend stocks	Production	Yearend stocks	Production	Yearend stocks
California	2	--	--	W	W	7	3	--	--	--	--	W	W
Colorado	6	--	--	--	--	W	W	W	W	W	--	37	W
Florida	10	--	--	--	--	106	W	16	W	45	14	168	W
Georgia	2	--	--	--	--	--	--	(2)	--	--	--	(2)	--
Illinois	5	--	--	W	--	W	--	24	W	--	--	81	W
Indiana	9	--	--	--	--	47	W	W	W	14	2	W	66
Iowa	4	--	--	W	--	W	W	(2)	1	--	--	16	6
Maine	3	8	5	--	--	W	--	W	--	--	--	8	5
Maryland	1	--	--	--	--	2	(2)	2	(2)	--	--	4	(2)
Massachusetts	1	--	--	--	--	W	--	--	--	--	--	W	--
Michigan	15	W	W	12	--	174	W	20	W	W	--	213	139
Minnesota	3	W	W	--	--	W	19	--	--	--	--	34	W
Montana	2	--	--	--	--	W	W	--	--	--	--	W	W
New Jersey	6	--	--	--	--	6	W	17	W	--	--	23	8
New Mexico	1	--	--	--	--	--	--	2	--	--	--	2	--
New York	6	--	--	--	--	7	W	35	W	--	10	42	17
North Dakota	1	--	--	--	--	W	--	--	--	--	--	W	--
Ohio	6	1	1	--	--	8	8	3	1	--	--	12	10
Pennsylvania	8	--	--	--	--	7	W	22	W	--	--	29	3
Washington	2	--	--	--	--	--	--	W	W	5	W	W	W
Wisconsin	3	--	--	--	--	16	11	--	--	W	W	W	W
Total[1]	96	25	16	37	7	464	255	177	23	82	30	785	330

W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

in 1980. The increase in packaged sales over 1979 levels was 3.6%. Bulk sales declined 8%. The percentage of each peat type that was packaged in 1980 was sphagnum moss, 98%; hypnum moss, 70%; humus, 38%; reed-sedge, 70%; and other unclassified peat, 6%.

Domestic peat sales for soil conditioning increased from 50% in 1979 to 62% in 1980. Sales of peat in 1980 for potting soils decreased by 28% over 1979 sales. Apparent consumption of peat increased by 1% in 1980 to 1.19 million tons.

Table 4.—U.S. peat sales by producers, by use in 1980

Use	In bulk		In packages		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Earthworm culture medium	3,282	$42	190	$7	3,472	$49
General soil improvement	98,677	1,575	390,064	8,572	488,740	10,148
Golf course	22,620	408	1,540	45	24,160	453
Ingredient for potting soils	86,661	1,228	64,787	1,467	151,448	2,695
Mixed fertilizers	15,588	139	4,640	95	20,228	234
Mushroom beds	1,613	26	4,540	193	6,153	219
Nursery	55,855	996	7,657	239	63,512	1,235
Packing flowers, plants, shrubs, etc	5,086	57	340	24	5,426	81
Seed inoculant	280	32	5,627	539	5,907	572
Vegetable growing	3,735	30	1,292	85	5,027	116
Other	4,409	69	9,916	319	14,324	388
Total[1]	297,806	4,604	490,593	11,585	788,397	16,190

[1]Data may not add to totals shown because of independent rounding.

PRICES AND SPECIFICATIONS

The average price per ton f.o.b. mine, for domestic and imported peat, was $20.54, a price increase of 6%, compared with the 1979 price. Domestic average price per ton for bulk peat was $15.46, a price increase of 3%. Domestic average price per ton for packaged peat in 1980 was $23.61, an increase of 5% compared with 1979.

Table 5.—U.S. peat sales by producers, by State in 1980

Producing State	Quantity (short tons)	Value[1] (thousands)	Percent packaged
California	W	W	55
Colorado	29,473	$327	9
Florida	153,807	2,398	23
Georgia	W	W	--
Illinois	79,415	1,505	92
Indiana	84,053	1,414	63
Iowa	11,243	276	25
Maine	8,050	534	93
Maryland	3,818	W	9
Massachusetts	W	W	10
Michigan	253,016	4,739	83
Minnesota	25,345	1,140	90
Montana	W	W	95
New Jersey	20,341	564	47
New Mexico	2,000	40	50
New York	42,758	917	95
North Dakota	W	31	--
Ohio	10,284	166	75
Pennsylvania	26,124	552	13
Washington	W	W	--
Wisconsin	10,742	535	50
Total[2]	788,397	16,190	62

W Withheld to avoid disclosing company propriety data.
[1]Values are f.o.b. producing plant.
[2]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. peat sales by producers, by use and kind

Use	Sphagnum moss			Hypnum moss			Reed-sedge		
	Quantity		Value (thousands)	Quantity		Value (thousands)	Quantity		Value (thousands)
	Weight (short tons)	Volume[1] (cubic yards)		Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)	
Earthworm culture medium	210	700	$6	--	--	--	506	1,250	$10
General soil improvement	13,243	103,438	1,131	36,882	87,715	$1,120	338,151	765,607	6,174
Golf course	970	5,500	40	--	--	--	16,917	36,000	330
Ingredient for potting soils	340	3,400	24	1,376	3,440	16	75,027	174,200	1,402
Mixed fertilizers	340	3,400	24	--	--	--	200	499	8
Mushroom beds	2,040	20,400	143	--	--	--	518	1,040	13
Nursery	1,360	13,600	95	420	1,050	18	45,078	100,790	891
Packing flowers, plants, shrubs, etc	340	3,400	24	--	--	--	1,081	1,985	17
Seed inoculant	340	3,400	24	--	--	--	5,076	8,000	480
Vegetable growing	340	3,400	24	--	--	--	2,187	5,130	70
Other	--	--	--	1,425	2,850	33	5,850	13,619	206
Total[2]	19,523	160,638	1,534	40,103	95,055	1,187	490,591	1,108,120	9,600

Use	Humus			Other			Total[2]		
	Quantity		Value (thousands)	Quantity		Value (thousands)	Quantity		Value (thousands)
	Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)	
Earthworm culture medium	2,231	3,862	$28	525	1,000	$5	3,472	6,812	$49
General soil improvement	85,720	158,728	1,526	14,744	29,767	197	488,740	1,145,255	10,148
Golf course	6,225	12,070	82	48	80	1	24,160	53,650	453
Ingredient for potting soils	40,121	71,171	566	34,584	76,841	688	151,448	329,052	2,695
Mixed fertilizers	19,655	34,024	202	33	55	1	20,228	37,978	234
Mushroom beds	3,595	7,553	63	--	--	--	6,153	28,993	219
Nursery	12,129	23,617	183	4,525	8,036	49	63,512	147,093	1,235
Packing flowers, plants, shrubs, etc	2,455	5,160	26	1,550	3,000	15	5,426	13,545	81
Seed inoculant	491	675	68	--	--	--	5,907	12,075	572
Vegetable growing	2,500	4,800	22	--	--	--	5,027	13,330	116
Other	2,039	3,745	63	5,010	10,933	86	14,324	31,147	388
Total[2]	177,161	325,405	2,829	61,019	129,712	1,039	788,397	1,818,930	16,190

[1]Volume of nearly all sphagnum moss was measured after compaction and packaging.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Prices for peat, by type in 1980[1]

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other	Total
Domestic:						
Bulk:						
Per ton	26.04	15.07	17.42	11.97	16.79	15.46
Per cubic yard	7.81	7.23	7.92	6.67	7.95	7.54
Packaged or baled:						
Per ton	80.93	38.83	20.33	20.58	21.81	23.61
Per cubic yard	9.58	15.21	8.92	10.91	9.04	9.59
Total:						
Per ton	78.57	29.61	19.57	15.97	17.03	20.54
Per cubic yard	9.55	12.49	8.66	8.69	8.01	8.90
Imported, total, per ton[2]	107.52	XX	XX	XX	XX	107.52

XX Not applicable.
[1]Prices are f.o.b. mine.
[2]Average customs price.

Table 8.—Average density of domestic peat sold in 1980

(Pounds per cubic yard)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	600	960	910	1,115	947
Packaged	237	784	877	1,060	830
Bulk and packaged	243	844	885	1,089	941

FOREIGN TRADE

Peat imports increased 6% to 402,000 tons in 1980. Most of the imports, about 99%, came from Canada. Canadian sphagnum moss peat has more desirable qualities than some domestically produced peat. Minor amounts of peat were imported from the Federal Republic of Germany.

Table 9.—U.S. imports for consumption of peat moss, by grade and country in 1980

Country	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Brazil	--	--	21	$2	21	$2
Bulgaria	3	$1	--	--	3	1
Canada	56,977	5,933	343,946	38,147	400,923	44,080
Germany, Federal Republic of	121	23	312	65	433	88
Ireland	8	6	--	--	8	6
Italy	--	--	19	1	19	1
Mexico	7	5	--	--	7	5
Netherlands	1	([1])	--	--	1	([1])
Norway	57	8	--	--	57	8
South Africa, Republic of	--	--	43	6	43	6
Sweden	30	21	--	--	30	21
United Kingdom	--	--	22	2	22	2
Total	57,204	5,997	344,363	38,223	401,567	44,220

[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of peat moss, by grade and customs district in 1980

Customs district	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Boston, Mass	2	$3	37	$9	39	$12
Buffalo, N.Y.[1]	28,828	2,712	14,273	1,897	43,101	4,609
Detroit, Mich.[1]	26,635	3,014	18,757	2,243	45,392	5,257
Duluth, Minn.[1]	17	2	7,428	1,263	7,445	1,265
Great Falls, Mont.[1]	--	--	30,912	3,972	30,912	3,972
Honolulu, Hawaii[1]	8	2	--	--	8	2
Laredo, Tex.[1]	7	5	29	4	36	9
Los Angeles, Calif	119	19	282	62	401	81
New Orleans, La	30	21	--	--	30	21
New York, N.Y	11	7	--	--	11	7
Nogales, Ariz.[1]	--	--	25	3	25	3
Norfolk, Va	1	(2)	--	--	1	(2)
Ogdensburg, N.Y.[1]	11	1	134,977	12,532	134,988	12,533
Pembina, N. Dak.[1]	438	53	44,909	6,109	45,347	6,162
Portland, Maine[1]	718	107	28,035	2,970	28,753	3,077
St. Albans, Vt.[1]	57	7	26,220	2,521	26,277	2,528
San Francisco, Calif	--	--	30	3	30	3
Seattle, Wash.[1]	297	36	38,430	4,633	38,727	4,669
Tampa, Fla.[1]	22	8	--	--	22	8
Washington, D.C.[1]	3	(2)	19	2	22	2
Total	57,204	5,997	344,363	38,223	401,567	44,220

[1]Predominately of Canadian origin.
[2]Less than 1/2 unit.

WORLD REVIEW

World production of peat was approximately 223 million short tons in 1980. The U.S.S.R. produced more peat than any other country, approximately 95% of the world total. Other significant producers were Ireland, the Federal Republic of Germany, Finland, and the United States.

Burundi.—The Irish agency Bord na Mona, acting as a consultant, helped the Central African Nation of Burundi with a plan to develop its peat deposit. Burundi has peat reserves estimated at 500 million tons.

Venezuela.—Large moss peat bogs have been delineated near the Orinoco River in the Amacuro Federal Territory of Venezuela. Operations began in 1976, and during 1978 nearly 20,000 tons of peat was produced.

TECHNOLOGY

Research to establish acceptable conversion factors for converting measured volumetric peat resources to tonnages was continued in Canada in 1980. In the United States, research was initiated by private contractors to develop reliable, efficient, economical, and environmentally acceptable harvesting and reclamation plans. Finnish scientists studied methods of peat gasification and developed a successful process for creating a high-density, moisture-resistant solid fuel from wet harvested peat. The East Carolina University, Greenville, N.C., and private industry collaborated in an effort to develop and evaluate peat-oil mixtures and peat-methyl alcohol mixtures as fuel to fire standard industrial boilers. Studies at the Hebrew University, Jerusalem, Israel, were conducted to convert peat to oil and gas in the presence of carbonates and alkaline earth metals. Sweden, Finland, and Canada were developing systems to derive gas and liquid products from peat.

[1]Physical scientist, Section of Nonmetallic Minerals.

Table 11.—Peat: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Argentina	11	7	4	4	[3]5
Australia	5	[r]7	8	[r e]8	8
Canada: Agricultural use	435	426	480	529	[3]538
Denmark: Agricultural use[4]	43	44	52	[e]50	50
Finland:					
Agricultural use	218	255	224	852	900
Fuel	[r]397	661	2,061	1,710	1,600
France: Agricultural use	[r]157	[e]155	[e]155	[e]155	155
Germany, Federal Republic of:					
Agricultural use	1,881	2,107	2,257	2,037	2,050
Fuel	250	244	251	253	250
Hungary: Agricultural use[e]	80	80	80	80	80
Ireland:					
Agricultural use	78	91	91	101	100
Fuel	6,564	6,009	5,443	4,041	4,000
Israel: Agricultural use[e]	22	22	22	20	22
Japan[e]	80	80	65	65	65
Korea, Republic of: Agricultural use[e]	4	--	--	--	--
Netherlands[e]	450	450	450	450	450
Norway:					
Agricultural use[e]	66	66	66	276	276
Fuel[e]	1	1	1	6	6
Poland:					
Agricultural use[e]	40	40	40	40	40
Fuel[e]	2	[r]1	1	NA	NA
Spain	34	46	46	44	46
Sweden:					
Agricultural use	98	102	117	[e]120	120
Fuel	35	33	--	--	--
U.S.S.R.:					
Agricultural use	[r]145,100	[r e]145,500	[r e]145,500	[r e]145,500	145,500
Fuel[e]	66,000	66,000	66,000	66,000	66,000
United States: Agricultural use	969	781	822	825	[3]785
Venezuela: Agricultural use[e]	5	10	20	20	20
Total	[r]223,025	[r]223,218	224,256	223,186	223,066
Fuel peat included in total	73,249	[r]72,949	73,757	72,010	71,902

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 15, 1981.
[2]In addition to the countries listed, Austria, Iceland, and Italy produce negligible quantities of fuel peat, and the German Democratic Republic is a major producer, but output is not officially reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Sales.

Perlite

By A. C. Meisinger[1]

U.S. production of processed perlite sold and used by producers in 1980 was 638,000 tons, a 3% decline from the record 660,000 tons set in 1979. Total value increased slightly to $16.5 million.

Perlite ore mined for processing by 11 companies at 13 operations in 7 Western States in 1980 was 824,000 tons, compared with 847,000 tons in 1979; 5 operations in New Mexico accounted for 86% of the total, compared with 88% in 1979.

Processed perlite was expanded in 78 plants in 33 States; production was 544,000 tons, a 1% decrease from that in 1979. The quantity of expanded perlite sold and used declined from 543,000 tons in 1979 to 537,000 tons in 1980, but the value was 13% higher than that of 1979. California, with nine expanding plants, replaced Illinois as the leading State in the quantity of expanded perlite sold and used during the year.

Domestic consumption of expanded perlite was 1% lower than that of 1979. Perlite used in building construction held its market share in 1980 with 69% of the total quantity sold and used. Use as concrete aggregate decreased 19% whereas that used in low-temperature insulation increased 24%, compared with that of 1979.

The average price of processed perlite sold and used in 1980 was $25.86 per ton, a 4% increase over that in 1979. The average value of expanded perlite sold and used increased 14% in 1980 to $128.90 per ton, f.o.b. expanding plants.

Estimated world production of crude and/or processed perlite in 1980 was 1.59 million tons, a slight decline from estimated world production in 1979 (table 4).

Table 1.—Perlite mined, processed, expanded, and sold and used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Perlite mined[1]	Processed perlite: Sold to expanders: Quantity	Processed perlite: Sold to expanders: Value	Processed perlite: Used at own plant to make expanded material: Quantity	Processed perlite: Used at own plant to make expanded material: Value	Processed perlite: Total quantity sold and used	Expanded perlite: Quantity produced	Expanded perlite: Sold and used: Quantity	Expanded perlite: Sold and used: Value
1976	727	288	4,908	265	4,489	553	438	432	41,000
1977	871	298	5,514	299	5,239	597	504	498	53,600
1978	939	320	6,813	321	6,927	641	553	546	64,300
1979	847	322	7,996	338	8,439	660	r551	r543	r61,200
1980	824	334	9,053	304	7,447	638	544	537	69,200

rRevised.
[1]Crude ore mined and stockpiled for processing.

Table 2.—Expanded perlite produced and sold and used by producers in the United States

State	1979				1980			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton[1]		Quantity (short tons)	Value (thousands)	Average value per ton[1]
Arkansas	300	300	([2])	([2])	700	700	$120	$182.00
California	42,900	42,800	[r]$5,300	$124.50	53,600	52,500	7,000	132.80
Florida	[r]28,700	[r]28,700	[r]2,900	[r]100.92	31,700	31,600	3,700	116.11
Illinois	66,200	64,800	[r]9,200	[r]142.69	53,900	51,500	8,500	165.15
Indiana	30,900	29,500	3,600	120.35	44,900	45,100	6,000	134.04
Iowa	1,200	1,200	[r]200	[r]160.00	([2])	([2])	([2])	([2])
Maine	7,200	7,200	([2])	([2])	7,300	7,300	1,100	147.00
Massachusetts	3,600	3,600	610	170.89	3,100	3,100	600	202.34
Michigan	([2])	([2])	([2])	([2])	9,100	9,100	([2])	([2])
Nevada	600	600	50	93.31	2,900	2,900	300	107.39
Ohio	([2])	([2])	([2])	([2])	8,400	8,400	1,100	131.24
Pennsylvania	34,400	34,300	3,900	113.31	39,000	38,900	5,200	133.42
Tennessee	5,900	5,900	990	167.50	4,300	4,400	800	179.00
Texas	[r]42,700	[r]43,000	[r]5,200	[r]121.87	39,800	39,200	6,300	160.13
Other States[3]	[r]286,000	[r]281,000	[r]29,200	[r]101.44	245,000	242,000	28,500	113.50
Total[4]	[r]551,000	[r]543,000	[r]61,200	[r]112.85	544,000	537,000	69,200	128.90

[r]Revised.
[1]Average value per ton based on unrounded data.
[2]Withheld to avoid disclosing company proprietary data. Included with "Other States."
[3]Includes Alabama, Arkansas (1979 value only), Colorado, Georgia, Idaho, Iowa (1980), Kansas, Kentucky, Louisiana, Maine (1979 value only), Michigan (1979 and 1980 value only), Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio (1979), Oregon, Utah, Virginia, Wisconsin, and Wyoming.
[4]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

The quantity of perlite mined for processing by 11 companies from 13 operations in 7 Western States in 1980 was 824,000 tons, a 3% decline from the quantity mined in 1979. Five New Mexico operations accounted for 86% of the total ore mined, compared with 88% in 1979; the remaining 14% in 1980 was mined from deposits in Arizona, California, Colorado, Idaho, Nevada, and Utah.

The quantity of processed perlite sold and used by producers in 1980 was 638,000 tons valued at $16.5 million, a decrease of 3% from the record 1979 quantity of 660,000 tons.

Perlite ore producers in 1980 were Filters International, Inc. and Harborlite Corp. in Arizona; American Perlite Co., in California; Persolite Products, Inc., in Colorado; Oneida Perlite Corp., in Idaho; Delamor Perlite Co. in Lincoln County, Nev.; United States Gypsum Co. in Pershing County, Nev.; Grefco, Inc., Johns-Manville Sales Corp., Silbrico Corp., and United States Gypsum, all with operations in New Mexico; and Mountain Maid, Inc., in Utah.

Expanded perlite was produced in 78 plants in 33 States compared with 79 plants in 33 States in 1979. The quantity of expanded perlite produced was 544,000 tons, a slight decline (1%) from that in 1979 (table 1). The quantity sold and used in 1980 also declined slightly (1%) to 537,000 tons. Value of expanded perlite sold and used, however, increased 13% to $69.2 million.

Leading States in descending order of expanded perlite produced in 1980 were Illinois, California, Mississippi, Indiana, Virginia, Texas, Pennsylvania, Colorado, Florida, New Jersey, and Kentucky. California, with 52,500 tons, replaced Illinois, with 51,500 tons, as the leading State in the quantity of expanded perlite sold and used. The leading States in descending order of value of expanded perlite sold and used in 1980 were Illinois, California, Texas, Indiana, Mississippi, Pennsylvania, Colorado, Virginia, Florida, New Jersey, and Kentucky. California had nine producing plants, followed by Texas with seven, Indiana and Pennsylvania with six each, and Illinois with five.

CONSUMPTION AND USES

Domestic consumption of expanded perlite (quantity sold and used by producers) in 1980 declined 1% to 537,000 tons. The principal product uses of expanded perlite, in descending order of quantity sold and used, were roof-insulation board, filter aid, acoustical ceiling tile, horticultural aggregate, concrete aggregate, plaster aggregate, and masonry and cavity fill insulation (the same order as in 1979).

Consumption of expanded perlite in building construction products, such as concrete and plaster aggregates and insulation (loose fill, board and tiles), accounted for 69% of the total U.S. perlite tonnage, the same as in 1979. The largest end-use category (formed products) for expanded perlite declined less than 1%, compared with that of 1979. Compared with that in 1979, the quantity used for other principal end uses (table 3) decreased 19% for concrete aggregate, 4% for cavity fill insulation, 1% for horticultural aggregate, and 34% for "other" uses, and increased 11% for fillers, 6% for filter aid, 24% for low-temperature insulation, and 3% for plaster aggregate.

Table 3.—Expanded perlite sold and used by producers in the United States, by use

(Short tons)

Use	1979[r]	1980
Concrete aggregate	37,000	29,800
Fillers	9,000	10,000
Filter aid	96,500	102,300
Formed products[1]	291,000	289,900
Horticultural aggregate[2]	41,400	40,900
Low-temperature insulation	6,200	7,700
Masonry and cavity fill insulation	21,800	20,900
Plaster aggregate	23,200	24,000
Other[3]	16,900	11,200
Total	543,000	[4]537,000

[r]Revised.
[1]Includes acoustic ceiling tile, pipe insulation, roof insulation board, and unspecified formed products.
[2]Includes fertilizer carriers.
[3]Includes fines, high-temperature insulation, paint texturizer, refractories, and various nonspecified industrial uses.
[4]Data do not add to total shown because of independent rounding.

PRICES

Processed (crushed, cleaned, and sized) perlite ore was sold by producers to expanders in 1980 at an average price of $27.10 per ton, a 9% increase over the 1979 price of $24.83 per ton. Processed perlite used by producers in their own expanding plants was valued at $24.50 per ton, a small decrease from the 1979 value of $24.97 per ton. The average price of all processed perlite in 1980 was $25.86 per ton, a 4% increase compared with that in 1979.

The value of expanded perlite sold and used in 1980 averaged $128.90 per ton, a 14% increase over the $112.85 per ton (revised) average in 1979. Values for expanded perlite sold and used at plants in 33 States ranged from $79 per ton to $220 per ton, compared with $68 per ton to $197 per ton (revised) in 1979.

WORLD REVIEW

Production of crude and/or processed perlite by the principal producing countries was estimated to be 1.59 million tons in 1980, a slight decline from the 1.60 million tons (revised) estimated for 1979. The United States, the U.S.S.R., and Greece, together, continued to account for nearly three-fourths of the world's output.

Czechoslovakia.—A new perlite deposit was recently discovered at Jastraba in the Ziar Basin;[2] however, no information on the quality and quantity of the perlite resource was reported.

Greece.—Silver and Baryte Ores Mining Co. announced plans at yearend to increase its perlite mine production capacity on the islands of Milos and Kos from 138,000 tons per year to 198,000 tons per year. The company also announced plans for building a new perlite processing facility with an initial capacity of 44,000 tons per year on the island of Kos. With the recent expansion of processing capacity to 276,000 tons per year of perlite on the island of Milos, Greece became the world's leading exporter of processed perlite.

[1]Industry economist, Section of Nonmetallic Minerals.
[2]Kuzvart, M. Industrial Minerals and Rocks in Czechoslovakia. Ind. Miner. (London). No. 162, March 1981, p. 33.

Table 4.—Perlite: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[e]	1980[e]
Australia[3]	4	2	2	3	3
Czechoslovakia[e]	[e]11	[e]11	[r e]22	[r e]33	[4]44
Greece	140	163	148	149	152
Italy[e]	105	100	100	100	100
Hungary[3]	106	114	102	108	108
Japan[e]	72	77	80	83	85
Mexico[3]	16	25	27	[e]28	28
New Zealand[3]	2	1	1	1	1
Philippines	2	2	2	4	4
Turkey	27	33	30	33	39
U.S.S.R.[e]	360	380	400	400	390
United States (processed ore sold and used by producers)	553	597	641	660	[4]638
Total	1,398	1,505	[r]1,555	[r]1,602	1,592

[e]Estimated. [r]Revised.
[1]Unless otherwise specified, figures represent processed ore output. Table includes data available through May 25, 1981.
[2]In addition to the countries listed, Algeria, Bulgaria, mainland China, Iceland, Mozambique, the Republic of South Africa, and Yugoslavia are believed to have produced perlite during the 1976-80 period, but output data are not reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Crude ore.
[4]Reported figure.

Phosphate Rock

By W. F. Stowasser[1]

Production of marketable phosphate rock in the United States continued its historical pattern of annual increases rising to 54 million metric tons in 1980. The value of marketable phosphate rock increased to about $1.2 billion in 1980. Production was concentrated in Florida. The combined production from Florida mines and the single mine in North Carolina was 87% of the total. Production from the Western States of Idaho, Montana, and Utah, including a small tonnage from Alabama, was 10% of the total, and Tennessee accounted for 3% of the total production.

Imports of phosphate rock declined as shipments from Morocco ceased in 1980 and will not likely resume in 1981. Imports include minor tonnages of low-fluorine phosphate rock from the Netherlands Antilles.

Opinions on world food prospects range from that of Thomas Malthus, who predicted in the early 19th century that widespread famine would develop as man's population was forecast to increase exponentially and food supplies could only increase by arithmetic progression for a given region, to those who believe in the "green revolution." The "green revolution" label was applied to practices of expanding food production by using hybrid seeds, fertilizer, and pesticides, particularly in developing countries, to overcome world hunger. The United Nations forecasts world population to increase from 4.5 billion people in 1980, to 5.5 billion in 1990, and 6.5 billion in 2000, an average growth rate from 1980 to 2000 of 1.9% per year. Increased use of phosphate and other fertilizers are one of the answers to increased food demand.

In the United States, grain reserves increased from 30 million metric tons in 1977-78 to 52 million metric tons in 1979-80. By 1980-81, grain stockpiles declined to an

Table 1.—Salient phosphate rock statistics

(Thousand metric tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Mine production	154,278	166,893	173,429	185,757	209,883
Marketable production	44,662	47,256	50,037	51,611	54,415
Value	$949,379	$821,657	$928,820	$1,045,655	$1,256,947
Average per metric ton	$21.26	$17.39	$18.56	$20.26	$23.10
Sold or used by producers	40,522	47,437	48,774	53,063	54,581
Value	$857,189	$829,084	$901,378	$1,063,517	$1,243,297
Average per metric ton	$21.15	$17.48	$18.48	$20.04	$22.78
Exports[1]	9,433	13,230	12,870	14,358	14,276
P_2O_5 content	3,022	4,251	4,118	4,611	4,554
Value	$272,823	$288,603	$297,357	$356,481	$431,419
Average per metric ton	$28.92	$21.81	$23.10	$24.83	$30.22
Imports for consumption[2]	42	158	908	886	486
Customs value	$2,209	$6,079	$24,379	$21,595	$12,856
Average per metric ton	$52.60	$38.47	$26.85	$24.37	$26.45
Consumption[3]	31,131	34,365	36,812	39,591	40,791
World: Production	108,000	117,000	[r]126,000	130,000	[e]135,000

[e]Estimated. [r]Revised.
[1]Exports reported to the Bureau of Mines by companies.
[2]Bureau of the Census data.
[3]Measured by sold or used plus imports minus exports.

estimated 21 million metric tons. World stocks of wheat and rice are projected to be down to 88 million metric tons, a 1-1/2-month supply, in 1980-81. There is concern that crop production may not keep up with demand.

The demand for grains, as populations increase, may well be at levels that will not again permit the accumulation of large grain reserves. As this scenario unfolds, the outlook and demand for fertilizer will probably be high, and selling prices for corn and wheat are expected to increase sharply as grain consumption exceeds production and grain reserves are reduced.

Legislation and Government Programs.—President Carter decided on January 4, 1980, to halt grain shipments to the U.S.S.R. The effect of this decision, made in response to the U.S.S.R.'s invasion of Afghanistan, was that 17 million metric tons of U.S. corn, wheat, and soybeans in inventory would not be available to the U.S.S.R. Further, sales and existing contracts above the 8-million-metric-ton limit originally specified in the U.S.-U.S.S.R. 5-year agreement were canceled.

Of immediate concern was the effect of the grain embargo to the U.S.S.R. on grain trade, the future of the fertilizer market, and where farmers would store embargoed grain. There were even predictions that a land retirement program would be needed and that the fertilizer industry would find it difficult to maintain the sales levels of last year. A reduction in normal crop acreage would diminish fertilizer consumption from the high demand expected when farmers were expected to plant from fence row to fence row. Projections for phosphate consumption anticipated an increase of 3% domestically, but after the embargo, estimates were reduced to 2% or less.

The Government's first action was intended to isolate the grain from the market and restore the grain supply-demand balance to its pre embargo status. The Government offered to buy nearly 10 million metric tons of corn, 3.7 million metric tons of wheat, and 1 million metric tons of soybeans, meal, and oil, under contracts. The U.S. Department of Agriculture increased wheat and corn loan prices and, as an additional incentive for farmers to store rather than sell grain, raised storage payments, waived interest on the next 13 million metric tons of corn entering the reserve, and increased release and call price levels so that grain in storage did not come back into the market too quickly. It was also predicted by the U.S. Department of Agriculture that the U.S. embargo of grain to the U.S.S.R. could lead to a softening of phosphate fertilizer prices in the United States.

On February 4, 1980, Department of Commerce Secretary Philip Klutznick announced that validated licenses would be required for phosphate exports to the U.S.S.R. No licenses would be issued until the Government completed a review of the export control policy ordered by President Carter in January 1980. The impact of this decision for all practical purposes was to restrict the exports of superphosphoric acid (SPA) from Occidental Chemical Co. to the U.S.S.R.

The embargo of SPA from Occidental Chemical Co. to the U.S.S.R. caused revisions in Occidental's marketing plans. Occidental's contract with the U.S.S.R. was for annual shipments of 1 million metric tons of 70% SPA. This left Occidental with an annual 700,000 million metric tons of P_2O_5 capacity to market in world trade and left doubt about the availability of ammonia that Occidental was planning to import from the U.S.S.R. into the United States.

The embargoes on both grain and phosphates were maintained by the Government throughout the year. The Soviets agreed to continue shipments of ammonia to the United States. World trade patterns shifted to a degree as Occidental sold merchant-grade phosphoric acid into various markets. Shipments of merchant-grade phosphoric acid to the U.S.S.R. from Morocco, Tunisia, and the Republic of South Africa were reportedly increased.

Mining wastes were exempted from new regulations that became effective on November 18, 1980, governing the handling and disposal of solid and hazardous wastes under the Resource Conservation and Recovery Act and Solid Waste Disposal Act (RCRA). Congress amended the RCRA in October to exempt phosphate rock and uranium ore.

DOMESTIC PRODUCTION

Marketable phosphate rock production and value are shown in table 1. In 1980, Florida and North Carolina produced 47,243,000 metric tons, 87% of the total marketable phosphate rock; the Western States produced 5,590,000 metric tons, 10%; and Tennessee produced 1,582,000 metric tons, 3%.

Florida and North Carolina.—Production of marketable phosphate rock and value is shown in table 2. Agrico Chemical Co., Amax Phosphate, Inc., Brewster Phosphates, CF Industries, Inc., Gardinier, Inc., W. R. Grace & Co., International Minerals & Chemical Corp. (IMC), Mobil Chemical Co., Estech General Chemical Co., and USS Agri-Chemicals produced marketable phosphate from the Bone Valley Formation in central Florida. Occidental Chemical Co. produced phosphate rock from a similar type matrix in north Florida. Howard Phosphate Co., Kellogg Co., Inc., Loncala Phosphate Co., and Manko Co., Inc., mined an estimated 29,000 metric tons of soft rock in 1980 from tailing ponds remaining from past hard phosphate mines in central Florida.

In North Carolina, Texasgulf, Inc., produced phosphate rock and increased mining capacity to satisfy expansions of phosphoric acid plant capacity. Agrico Chemical Co. purchased the share of North Carolina Phosphate Corp. owned by Kennecott Copper Corp. Agrico plans to start producing phosphate rock in 1983 in North Carolina.

Occidental Chemical Co., a division of Occidental Petroleum Corp., produced phosphate rock in north Florida from the Suwannee River and Swift Creek Mines. After the Federal Government embargoed the export of phosphate products to the U.S.S.R. in early 1980, Occidental Chemical Co. exported merchant-grade phosphoric acid to alternate markets rather than close the Swift Creek chemical complex.

Denial of exports to the U.S.S.R. of phosphate rock, phosphatic fertilizers, and phosphoric acid of all concentrations was an important element in the U.S. response to the Soviet invasion of Afghanistan and reinforced restrictions on grain exports. The U.S.S.R. had started to import SPA from the United States to produce liquid fertilizers with a high phosphorus content. The SPA was to be used in seven new liquid fertilizers and the cutoff of SPA supplies from the United States will probably delay the U.S.S.R.'s liquid fertilizer production capability by 1 or 2 years. In 1979, the U.S.S.R. imported 551,000 metric tons of phosphate materials of which 99% was SPA.

Farmland Industries received approval and permits to develop a 1.8-million-metric-ton-per-year phosphate rock mine near Ona, Hardee County, Fla. Construction will start in 1981 and production will start in 1983. Local authorities refused to issue permits for Farmland's diammonium phosphate plant near Bartow, Fla.

In central Florida, Agrico Chemical Co. operated the Fort Green, Payne Creek, and Saddle Creek Mines. Although the Saddle Creek Mine is scheduled to operate only through 1985, the other two mines are programed to produce into the next decade. Amax Phosphate, Inc., purchased the Big Four Mine and chemical plants in Florida from Borden, Inc. Amax Phosphate expanded their land ownership at the Pine Level Mine by acquiring the Noranda Phosphate, Inc., property. Beker Industries started construction of a washer and flotation plant in Manatee County. The mine is scheduled to start up in 1981. Brewster Phosphate continued to produce from the Haynesworth and Fort Lonesome Mines in Polk and Hillsborough Counties, respectively. CF Industries produced phosphate rock from the Stuart tract in Hardee County.

Estech General Chemicals Corp. produced phosphate rock from the Silver City and Watson Mines in Polk County. The Duette Mine was planned to start producing in Manatee County in 1984, but the county has refused to issue mining permits. The development of the Duette Mine in Manatee County was to include participation by Royster Co., who was to receive 20% of the annual production from the mine, and by the National Federation of Agriculture Cooperative Associations of Japan (Zen-Noh) for 11.25% of the mine's production.

Gardinier, Inc., continued to mine phosphate rock from its Fort Meade Mine. Gardinier and USS Agri-Chemicals considered a partnership to mine adjacent properties in north Hardee County but decided not to pursue this course. Gardinier will independently develop a mine in north Hardee County toward the end of this decade. W. R. Grace & Co. produced phosphate rock from Bonny Lake and Hookers Prairie Mines. The Bonny Lake Mine is programed to close in 1982 and Hookers Prairie will produce into the early 1990's. W. R. Grace & Co. and IMC completed the formation of a 50-50 joint venture to produce phosphate rock from Grace's reserves in Manatee and Hillsborough Counties. The mine will be called Four Corners.

IMC was the largest producer of phosphate rock in 1980. IMC operates the Clear Springs, Kingsford, and Noralyn Mines in Polk County. These mines will, on the average, produce until the end of this decade from existing reserves and reserves acquired adjacent to the respective mines.

Mobil Chemical Co. plans to continue production from the Fort Meade and Nichols Mines in Polk County. The Fort Meade Mine will produce at a declining rate through 1987 and a new South Fort Meade Mine is planned to start in the mid 1980's to replace the Fort Meade Mine.

USS Agri-Chemicals produced phosphate rock concentrates from the Rockland Mine and expects to increase the mine's capacity in 1983.

Western States.—Production tonnage and value of marketable phosphate rock are shown in table 2. Production of phosphate rock for agricultural purposes was 2,155,000 metric tons, and 2,337,000 metric tons were designated for electric furnace feed.

Conda Partnership, Monsanto Industrial Chemicals, J. R. Simplot Co., and Stauffer Chemical Co. mined and processed phosphate rock in Idaho for both electric furnace feed and phosphate fertilizers. In Montana, Cominco American, Inc., operated the only underground phosphate rock mine in the United States. The mine is located near Garrison, Mont.

Stauffer Chemical Co. sold its phosphate mine at Vernal, Utah, a fertilizer plant at Garfield, Utah, and a rail terminal at Phoston, Utah, to Standard Oil Co. of California for $130 million. The purchase was made by Chevron U.S.A., a Standard Oil unit, and the transfer will be made in the first quarter of 1981.

The acquisition of the Vernal phosphate reserves, one of the most attractive in the Western States, will, for the first time, give Chevron its own source of phosphate rock. Chevron is constructing a desulfurization plant north of Evanston, Wyo., to recover sulfur from the "overthrust belt" gas wells. It is speculated that recovered sulfur, after conversion to sulfuric acid, will be used to produce phosphoric acid from the Vernal Mine phosphate rock.

The J. R. Simplot Co. plans to expand its phosphate mining operations by developing the Smokey Canyon Mine on 2,520 acres of Federal land in the Caribou National Forest.

The Smokey Canyon Mine will be developed to augment production from the Conda Mine, a distance of about 25 miles from Smokey Canyon. Simplot will construct an 8-inch-diameter pipeline to carry a slurry from the mine site, about 8 miles west of Afton, Wyo., to the benefication plant at Conda, Idaho. A production level of 0.5 million short tons is scheduled for 1984 and this is planned to increase to 1 million short tons per year in the future.

Tennessee.—Production and value of marketable phosphate rock are shown in table 2. Hooker Chemical Co., Monsanto Industrial Chemicals Co., and Stauffer Chemical Co. mined and beneficiated phosphate rock in Tennessee for reduction to elemental phosphorus in electric furnaces. It is probable that with the phosphate rock reserves held by the Tennessee Valley Authority, the phosphate industry in Tennessee will be able to continue operating through 1995 on Tennessee mined rock.

Table 2.—Production of phosphate rock in the United States, by State

(Thousand metric tons and thousand dollars)

	Mine production		Mine production used directly		Beneficiated production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1979:									
Florida and North Carolina	174,430	20,360	25	5	44,231	13,776	44,256	13,781	918,555
Tennessee	3,211	670	--	--	1,873	467	1,873	467	14,770
Western States[1]	8,117	2,027	2,750	728	2,732	867	5,482	1,595	112,329
Total[2]	185,757	23,056	2,775	733	48,835	15,110	51,611	15,843	1,045,655

See footnotes at end of table.

Table 2.—Production of phosphate rock in the United States, by State —Continued

(Thousand metric tons and thousand dollars)

	Mine production		Mine production used directly		Beneficiated production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1980:									
Florida and North Carolina	198,332	21,020	29	6	47,214	14,652	47,243	14,658	1,124,929
Tennessee	2,981	602	--	--	1,582	410	1,582	410	12,765
Western States[1]	8,570	2,146	2,535	666	3,055	977	5,590	1,643	119,254
Total[2]	209,883	23,767	2,564	672	51,851	16,039	54,415	16,711	1,256,947

[1]Includes Alabama, Idaho, Montana, Utah, and Wyoming.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Consumption of marketable phosphate rock defined as the quantity sold or used plus imports minus exports, is shown in table 1. Table 1 also reports the quantity of phosphate rock sold or used.

The consumption pattern as reported by producers is shown in table 3.

The percent distribution by grade of marketable phosphate rock consumed in the United States and sold in the export market in 1980 is compared with the distribution patterns for prior years 1976-79 in the following tabulation. Trends in U.S. grade distribution pattern of phosphate rock are not discernible from these data because of the mix of furnace and wet process phosphoric acid-phosphate rock feed in the total distribution pattern.

Grade, percent BPL[1] content	Distribution (percent)				
	1976	1977	1978	1979	1980
Less than 60	7.8	5.7	6.2	5.4	5.3
60 to 66	14.6	11.6	13.3	14.2	15.7
66 to 70	53.8	57.3	54.3	56.3	56.7
70 to 72	9.4	12.2	13.3	13.6	12.7
72 to 74	8.3	7.4	8.6	6.6	6.0
Over 74	6.1	5.8	4.3	3.9	3.6

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Florida and North Carolina.—The quantity of phosphate rock sold or used is shown in table 4. Table 5 shows the distribution of phosphate rock sold or used in Florida and North Carolina by domestic and export tonnages.

The percent distribution by grade of the marketable rock sold or used from Florida and North Carolina, including exports, is tabulated for the years 1976-80.

Grade, percent BPL[1] content	Distribution (percent)				
	1976	1977	1978	1979	1980
Less than 60	0.2	0.1	0.1	0.2	0.1
60 to 66	13.4	10.5	11.9	12.6	15.3
66 to 70	60.2	62.7	60.8	62.4	62.2
70 to 72	11.2	14.1	15.7	12.7	11.2
72 to 74	7.7	5.9	6.5	7.6	7.0
Over 74	7.3	6.7	5.0	4.6	4.2

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Tennessee.—The quantity and value of marketable phosphate rock sold or used is shown in table 4. All of this rock was used in electric furnaces to produce elemental phosphorus and industrial chemicals. Most of the phosphorus was converted into intermediate phosphoric acid, the base for a large number of sodium, calcium, and potassium chemicals.

The percent distribution by grade of marketable rock sold or used in Tennessee for 1976-80 is shown in the following tabulation:

Grade, percent BPL[1] content	Distribution (percent)				
	1976	1977	1978	1979	1980
Less than 60	72.1	75.4	68.3	60.3	75.3
60 to 66	26.8	24.6	31.7	37.0	24.7
66 to 70	1.1	--	--	2.7	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Western States.—The quantity of marketable phosphate rock sold or used is shown in tables 4-5. In 1980, 78.6% was consumed in the United States and 21.4% was exported to Canada. The percent distribution by grade of marketable rock sold or used from the Western States for 1976-80 is shown in the following tabulation:

Grade, percent BPL[1] content	Distribution (percent)				
	1976	1977	1978	1979	1980
Less than 60	37.8	29.7	32.6	27.4	27.7
60 to 66	18.5	16.3	17.9	18.9	16.5
66 to 70	28.5	31.5	23.2	26.8	27.7
70 to 72	--	--	--	26.5	28.1
72 to 74	15.2	22.6	26.3	.4	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 5 shows the phosphate rock sold or used by producers by use, domestic (agriculture or industrial) and exports, and by State groupings.

The recent history of phosphate rock sold or used by producers by kind is shown in tables 6, 7, and 8 for Florida, Tennessee, and the Western States, respectively.

Table 3.—Phosphate rock sold or used by producers in the United States, by use

(Thousand metric tons)

Use	1979		1980	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Domestic:[1]				
Wet process phosphoric acid	r31,583	r9,722	33,884	10,444
Normal superphosphate	294	95	333	107
Triple superphosphate	1,662	533	1,348	436
Defluorinated rock	r334	r113	430	145
Direct applications	36	7	37	8
Elemental phosphorus	4,580	1,188	4,083	1,067
Ferrophosphorus	217	56	190	49
Total	38,706	11,714	40,305	12,256
Exports[2]	14,358	4,611	14,276	4,554
Grand total	[3]53,063	16,325	54,581	16,810

rRevised.
[1]Includes rock converted to products and exported.
[2]Exports reported to the Bureau of Mines by companies.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Phosphate rock sold or used by producers in the United States, by grade and State in 1980

(Thousand metric tons and thousand dollars)

Grade, percent BPL[1] content	Florida and North Carolina			Tennessee		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Below 60	32	6	668	1,254	318	9,401
60 to 66	7,195	2,084	179,096	410	114	3,929
66 to 70	29,351	9,086	618,823	--	--	--
70 to 72	5,324	1,720	143,061	--	--	--
72 to 74	3,309	1,108	103,788	--	--	--
Plus 74	1,992	691	64,223	--	--	--
Total[2]	47,203	14,696	1,109,659	1,665	432	13,330
	Western States			Total United States		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Below 60	1,582	398	14,021	2,868	722	24,090
60 to 66	940	262	13,501	8,546	2,460	196,526
66 to 70	1,583	495	42,142	30,934	9,581	660,965
70 to 72	1,608	527	50,644	6,932	2,248	193,706
72 to 74	--	--	--	3,309	1,108	103,788
Plus 74	--	--	--	1,992	691	64,223
Total[2]	5,713	1,681	120,309	54,581	16,810	1,243,297

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Phosphate rock sold or used by producers, by use and State

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee		Western States		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1979:								
Domestic:[1]								
Agricultural	31,902	9,835	--	--	2,006	635	33,909	10,470
Industrial	329	95	2,140	545	2,328	603	4,797	1,244
Total	32,231	9,930	2,140	545	4,334	1,238	38,706	11,714
Exports[2]	13,253	4,264	--	--	1,105	347	14,358	4,611
Total	45,484	14,194	2,140	545	5,439	1,585	[3]53,063	16,325
1980:								
Domestic:[1]								
Agricultural	33,877	10,452	--	--	2,155	687	36,032	11,140
Industrial	271	78	1,665	432	2,337	606	4,273	1,116
Total	34,148	10,530	1,665	432	[3]4,493	1,293	40,305	12,256
Exports[2]	13,055	4,166	--	--	1,221	388	14,276	4,554
Total	47,203	14,696	1,665	432	[3]5,713	1,681	54,581	16,810

[1]Includes rock converted to products and exported.
[2]Exports reported to the Bureau of Mines by companies.
[3]Data do not add to total shown because of independent rounding.

Table 6.—Florida phosphate rock sold or used by producers, by kind

(Thousand metric tons and thousand dollars)

Year	Land pebble[1]				Soft rock[e]				Total[2]			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1976	33,886	10,568	774,517	22.86	29	6	580	20.00	33,915	10,574	775,096	22.85
1977	40,970	12,838	726,950	17.74	25	5	504	20.16	40,994	12,843	727,454	17.75
1978	41,388	12,861	778,339	18.81	27	6	537	19.89	41,415	12,866	778,876	18.81
1979	45,459	14,189	935,127	20.57	26	5	545	20.96	45,484	14,194	935,672	20.57
1980	47,171	14,690	1,108,991	23.51	32	6	668	20.91	47,203	14,696	1,109,659	23.51

[e]Estimated.
[1]Includes North Carolina.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Tennessee phosphate rock sold or used by producers

(Thousand metric tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1976	1,731	448	15,326	8.85
1977	1,723	436	14,064	8.16
1978	1,688	434	13,833	8.19
1979	2,140	545	17,008	7.95
1980	1,665	432	13,330	8.01

Table 8.—Western States phosphate rock sold or used by producers

(Thousand metric tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1976	4,877	1,383	66,767	13.69
1977	4,719	1,382	87,566	18.56
1978	5,671	1,647	108,669	19.16
1979	5,439	1,585	110,837	20.38
1980	5,713	1,681	120,309	21.06

STOCKS

At the end of 1979, inventories of marketable phosphate rock had declined to 14.5 million metric tons. The gradual trend in the decline of U.S. phosphate rock stocks continued through 1980 and reached 13.7 million metric tons at the end of the year.

Stocks in Florida and North Carolina declined from 12.9 million metric tons at the beginning of the year to 12.2 million metric tons at yearend.

Stocks carried in Tennessee increased from 150,650 metric tons to 187,686 metric tons during the year.

Western State inventories were 1.4 million metric tons at the beginning of the year and 1.3 million metric tons at the end of the year.

PRICES

Negotiations between phosphate rock exporters and buyers at the end of 1979 and the beginning of 1980 developed the estimated price structure shown in table 9. The increase in U.S. export prices at the beginning of the year represented the first real increase in phosphate rock prices, neglecting price increases to account for inflation, since 1975. Increases ranging from $10 to $14 per metric ton negotiated by the Phosphate Rock Export Association, Tampa, Fla., corrected the fall of phosphate rock prices in real value that occurred after 1975.

The negotiated prices between buyer and seller in the domestic and international markets are not published. Published prices do not reflect the values realized from privately negotiated contracts.

In Florida, export prices include the f.o.b. mine price, the severance tax, estimated to be $1.54 per metric ton in 1980, but not finalized until later in 1981, and an average $3.94 per metric ton that includes rail freight, vessel loading, and weighing charges.

The Moroccan Office Cherifien des Phosphates also increased phosphate rock export prices at the beginning of 1980. Published prices were not available but estimates of price levels are shown in table 10. Because of rising freight rates from Tampa to Western Europe, Morocco was able to raise prices at the beginning of 1980 and still remain competitive in European markets with exports from Florida.

At the end of 1980, the Florida Phosphate Rock Export Association indicated that they would attempt to increase phosphate rock export prices by 15% for new business after January 1981 or an increase of the order of $5 to $7 per metric ton depending on grade. The price increase was prompted by indications of strong demand for P_2O_5 in the United States and gradually increasing prices for diammonium phosphate and triple superphosphate in world markets. Phosphate rock producers have absorbed higher costs for sulfur and general inflationary pressures during 1980, including increases in rail rates and an increase in taxes. An increase in the severance tax is forecast.

The Office Cherifien des Phosphates has not indicated what it plans for prices in 1981 but will probably attempt to maximize revenue from phosphate sales.

Table 9.—Phosphate rock estimated export prices per metric ton, unground, f.o.b. vessel Tampa Range or Jacksonville, Fla.

Grade, percent BPL[1] content	December 1978[2]	1979[3]	January 1980[4]
77	--	$38.00	--
75	$34.55	34.00	$44.00
72	32.55	30.00	40.00
70	30.55	26.00	36.00
68	28.55	25.00	34.00
66	26.55	25.00	34.00

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2]Estimated selling price including $0.55 severance tax.
[3]Estimated selling price including $1.15 severance tax.
[4]Estimated selling price including $1.54 severance tax.

Table 10.—Moroccan phosphate rock export prices, U.S. dollars per metric ton, f.a.s. Safi or Casablanca

Grade, percent BPL[1] content	1978	1979	1980[e]
Khouribga:			
76 to 77	41.00	43.00	55.00
75 to 76	37.00	42.00	54.00
72 to 73	32.00	40.00	52.00
70 to 71	--	43.00	47.00
Youssoufia:			
68 to 69	30.00	35.25	43.00
74 to 75	--	42.00	53.00

[e]Estimated.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 11.—Price or value of Florida and North Carolina phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade, percent BPL[1] content	1979			1980		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	12.12	--	12.12	20.91	--	20.91
60 to 66	22.90	21.06	22.68	24.98	24.53	24.89
66 to 70	17.65	23.48	18.73	19.63	27.83	21.08
70 to 72	20.37	23.62	22.35	22.11	30.61	26.87
72 to 74	22.76	26.40	25.54	25.72	33.83	31.36
Over 74	22.09	30.85	26.87	24.90	37.11	32.24
Average	18.91	24.60	20.57	21.01	30.03	23.51

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Table 12.—Price or value of Western States phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade, percent BPL[1] content	1979			1980		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	15.31	--	15.31	8.86	--	8.86
60 to 66	11.46	29.31	14.62	10.00	33.70	14.36
66 to 70	21.73	28.66	23.41	24.83	33.07	26.62
72 to 74	24.84	24.83	24.84	31.50	31.49	31.49
Average	18.56	27.52	20.38	18.02	32.25	21.06

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 13.—Price or value of Tennessee phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade, percent BPL[1] content	1979	1980
Less than 60	7.11	7.50
60 to 66	9.25	9.57
66 to 70	8.72	--
Average	7.95	8.01

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 14.—Price or value of United States phosphate rock

(Dollars per metric ton, f.o.b. mine)

Grade, percent BPL[1] content	1979			1980		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	11.51	--	11.51	8.26	--	8.26
60 to 66	19.82	22.79	20.16	22.44	25.57	23.00
66 to 70	17.82	23.80	18.94	19.88	28.16	21.37
70 to 72	22.17	23.98	23.19	24.73	30.78	27.94
72 to 74	22.79	26.39	25.54	25.72	33.83	31.36
Over 74	22.09	30.85	26.87	24.90	37.11	32.24
Average	18.27	24.83	20.04	20.14	30.22	22.78

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

FOREIGN TRADE

In 1980, producers reported that exports of phosphate rock from the United States were 14,276,000 metric tons.

Imports of phosphate rock decreased about 45% to 486 million metric tons. Most of this phosphate rock was imported from Morocco during the first three quarters of 1980. Imports ceased from Morocco and small tonnages imported from the Netherlands Antilles also terminated at the close of the year.

Tables 15-21 are included to show the quantities of phosphate rock, phosphate fertilizers, and phosphate intermediates exported from the United States in 1980.

Table 22 lists imports of phosphate fertilizers and chemicals during 1980.

Table 15.—U.S. exports of phosphate rock, by country

(Thousand metric tons and thousand dollars)

Destination	1979		1980	
	Quantity	Value[1]	Quantity	Value[1]
Australia	323	8,269	462	16,419
Austria	65	2,146	132	5,306
Belgium-Luxembourg	874	25,394	831	29,664
Brazil	389	13,259	113	4,901
Canada	3,396	89,837	3,825	122,879
Denmark	86	2,757	104	4,307
Finland	101	3,432	108	5,088
France	983	27,771	907	31,547
Germany, Federal Republic of	1,003	26,402	857	30,400
India	251	8,658	236	9,757
Italy	340	9,259	290	10,379
Japan	1,766	55,725	1,471	57,723
Korea, Republic of	1,727	56,505	1,751	60,915
Mexico	372	8,772	265	8,869
Netherlands	630	17,130	757	26,284
New Zealand	82	2,557	20	745
Norway	78	2,322	99	3,249
Philippines	116	4,430	99	4,701
Poland	742	21,382	900	31,672
Romania	646	21,824	382	17,275
Sweden	97	3,199	120	4,796
Taiwan	99	3,226	32	1,452
United Kingdom	411	10,655	391	12,415
Other	210	7,070	167	7,779
Total[2]	14,787	431,981	14,320	508,524

[1]All values f.a.s. (free alongside ship).
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 16.—U.S. exports of superphosphates more than 40% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1979		1980	
	Quantity	Value[1]	Quantity	Value[1]
Algeria	--	--	85	19,339
Argentina	46	5,864	4	562
Belgium-Luxembourg	113	13,890	107	19,320
Brazil	332	46,013	277	49,715
Bulgaria	--	--	58	9,943
Burma	--	--	27	6,107
Canada	108	13,946	61	9,395
Chile	125	16,448	86	15,220
China, mainland	86	13,705	153	29,545
Colombia	19	2,494	23	4,295
Costa Rica	9	1,192	14	2,889
Czechoslovakia	96	9,596	--	--
Dominican Republic	4	836	11	2,349
France	85	9,594	39	7,216
Germany, Federal Republic of	--	--	178	31,694
Hungary	117	12,256	--	--
Indonesia	44	6,089	105	20,149
Ireland	63	7,724	14	2,272
Italy	20	2,150	25	5,184
Japan	39	5,533	26	3,938
Kenya	--	--	11	1,821
Libya	--	--	11	3,433
Pakistan	--	--	29	4,746
Peru	12	1,377	15	2,768
Singapore	73	10,027	34	5,750
Turkey	--	--	79	13,263
Uruguay	23	2,987	15	2,645
Venezuela	7	1,300	32	7,190
Other	22	2,953	25	5,046
Total[2]	1,443	185,973	1,544	285,792

[1]All values f.a.s. (free alongside ship).
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 17.—U.S. exports of superphosphates, less than 40% P_2O_5, by country

Destination	1979 Quantity (metric tons)	1979 Value[1] (thousands)	1980 Quantity (metric tons)	1980 Value[1] (thousands)
Argentina	3,920	$600	--	--
Brazil	7,496	726	8,530	$751
Canada	1,198	50	18,899	413
Chile	--	--	5,371	399
Peru	2,205	220	--	--
Thailand	11,163	1,322	--	--
Other	169	7	68	12
Total	26,151	2,925	32,868	[2]1,574

[1]All values f.a.s. (free alongside ship).
[2]Data do not add to total shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 18.—U.S. exports of diammonium phosphates, by country

(Thousand metric tons and thousand dollars)

Destination	1979 Quantity	1979 Value[1]	1980 Quantity	1980 Value[1]
Algeria	--	--	11	3,913
Argentina	74	11,856	97	22,754
Australia	30	4,468	22	5,282
Bangladesh	31	6,492	11	2,568
Belgium-Luxembourg	324	51,920	242	55,349
Brazil	487	83,804	431	92,297
Canada	163	25,494	108	20,861
Chile	34	6,668	51	11,541
China, mainland	23	3,723	355	85,168
Colombia	38	6,587	37	8,234
Costa Rica	23	3,710	22	5,556
Dominican Republic	37	6,426	52	12,279
Ecuador	12	1,905	28	5,503
El Salvador	38	5,688	--	--
Ethiopia	115	27,219	64	18,344
Finland	--	--	43	8,865
France	191	29,414	168	40,339
Germany, Federal Republic of	21	3,519	73	9,603
Guatemala	27	3,758	9	2,400
India	558	96,659	841	171,872
Ireland	38	5,859	13	2,505
Italy	866	150,822	399	85,844
Japan	141	22,553	195	42,484
Libya	27	4,359	--	--
Mexico	140	16,486	245	44,763
Mozambique	--	--	80	21,596
Netherlands	37	5,378	1	283
New Zealand	27	4,042	10	2,617
Nicaragua	10	1,478	44	10,469
Pakistan	85	13,691	496	111,371
Spain	62	9,667	201	41,593
Thailand	55	9,389	87	16,361
Turkey	170	29,520	269	66,551
Uruguay	50	8,809	61	13,871
Yugoslavia	36	5,923	40	8,340
Other	54	8,910	192	44,566
Total[2]	4,026	676,194	4,995	1,095,944

[1]All values f.a.s. (free alongside ship).
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 19.—U.S. exports of phosphoric acid, less than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1979 Quantity	1979 Value[1]	1980 Quantity	1980 Value[1]
Argentina	--	--	10	1,321
Brazil	327	65,448	619	153,701
Canada	5	1,298	2	382
Colombia	26	4,069	26	5,728
Czechoslovakia	6	949	6	1,051
El Salvador	14	2,250	--	--
Germany, Federal Republic of	6	1,773	23	6,915
India	193	33,521	228	42,490
Indonesia	34	7,552	79	15,885
Mexico	--	--	32	5,415
Netherlands	18	4,519	22	4,307
Turkey	39	8,941	122	34,116
U.S.S.R	8	951	--	--
Venezuela	--	--	34	8,511
Other	(2)	52	8	1,524
Total[3]	677	131,324	1,212	281,348

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 20.—U.S. exports of phosphoric acid, more than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Destination	1979 Quantity	1979 Value[1]	1980 Quantity	1980 Value[1]
Brazil	2	370	5	997
Canada	6	1,553	83	3,246
Colombia	5	662	--	--
U.S.S.R	493	92,699	67	17,440
Other	(2)	4	(2)	2
Total[3]	505	95,289	156	21,686

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 21.—U.S. exports of elemental phosphorus, by country

Destination	1979 Quantity (metric tons)	1979 Value[1] (thousands)	1980 Quantity (metric tons)	1980 Value[1] (thousands)
Argentina	1,113	$1,400	2	$7
Australia	138	154	287	411
Brazil	8,348	10,118	6,476	9,800
Canada	1,204	1,354	1,010	1,514
Denmark	--	--	501	825
Japan	4,606	5,322	5,221	7,435
Korea, Republic of	--	--	475	442
Mexico	13,934	16,931	16,006	23,929
Taiwan	36	43	190	280
Other	225	353	275	987
Total	29,604	35,675	30,443	[2]45,631

[1]All values f.a.s. (free alongside ship).
[2]Data do not add to total shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 22.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand metric tons and thousand dollars)

Fertilizer	1979		1980	
	Quantity	Value[1]	Quantity	Value[1]
Phosphates, crude and apatite[2]	886	21,595	486	12,856
Phosphatic fertilizers and fertilizer materials	21	3,014	32	5,737
Ammonium phosphates, used as fertilizers	313	42,356	294	53,053
Bone ash, bone dust, bone meal, and bones ground, crude or steamed	5	1,152	3	1,143
Dicalcium phosphate	1	275	1	1,027
Basic slag	15	169	([3])	113
Manures including guano	([3])	10	([3])	1,111
Phosphorus	([3])	1,264	([3])	928
Phosphoric acid	([3])	125	([3])	337
Phosphoric acid, fertilizer grade	83	9,090	24	4,182
Normal superphosphate	15	1,992	24	3,949
Triple superphosphate	23	3,582	25	4,768

[1]Declared customs valuation.
[2]Limited to only imports from phosphate rock-producing countries in 1979 and 1980; Morocco and Netherlands Antilles in 1979, and Israel, Morocco, and Netherlands Antilles in 1980.
[3]Less than 1/2 unit.

Source: U.S. Bureau of the Census.

WORLD REVIEW

World phosphate rock production increased 5% over that of 1979 to a record estimated 135 million metric tons. The upward trend in production continued from production levels of 108, 117, 126, and 130 million tons in 1976, 1977, 1978, and 1979, respectively. Increases in production from the United States and Morocco were the principal reasons for the gain in world production in 1980. Phosphate rock was in good supply during the second half of the decade of the 1970's, and supplies are forecast to be more than adequate during the 1980's. World reserves appear to be adequate to supply world demand during the coming decade, but much higher new mine costs and logistic constraints will cause problems.

Traditionally, a major share of the world use of phosphates is based on imports. Phosphate imports can be phosphate rock, or intermediates such as phosphoric acid, monoammonium phosphate, diammonium phosphate, or triple superphosphate, or as finished fertilizer of varying concentrations of phosphorus. The phosphate industry developed in industrialized countries that were and are the principal consumers of phosphate fertilizers. In past years the phosphate industry in these countries was based on relatively cheap imported phosphate rock. Phosphate demands from less industrialized countries were met by imports of phosphate products from industrialized countries. With the development of high-grade intermediate products, economics now generally favor construction of intermediate producing complexes close to the phosphate rock source.

Fertilizer producers that are required to import phosphate rock find that their profit margins are restricted with high raw material costs and competition from cheaper finished products from raw-material-based operators. Resource-based operators can charge phosphate rock into their own plants at costs or a value less than market value. Imposition of regulations controlling the disposition of byproduct gypsum in industrialized countries is another deterrent to continuing phosphoric acid production in these countries. The environmental problems associated with gypsum piles are not as significant a manufacturing factor in less industrialized countries.

If indeed the bulk of new phosphoric acid plants are located near raw material sources, this will have a profound effect on phosphate supply patterns. It is probable that a major part of the supplies of phosphate rock will in the future be converted into intermediates in the phosphate rock supply countries. Trade in phosphate intermediates should increase at the expense of trade in phosphate rock.

For the longer term it appears that the phosphate processing industry will expand and develop in the phosphate rock producing areas.

Table 23.— Phosphate rock and guano: World production, by country[1]

(Thousand metric tons)

Commodity and country[2]	1976	1977	1978	1979[p]	1980[e]
Phosphate rock:					
Algeria	742	1,173	1,136	1,084	[3]1,025
Australia	276	450	285	7	4
Brazil	[r]490	650	1,023	1,589	2,200
China, mainland[e]	4,000	4,000	4,500	[r]5,500	5,500
Christmas Island (Indian Ocean)	1,033	1,186	1,400	1,362	[3]1,713
Colombia	14	8	5	7	7
Egypt	394	472	639	587	700
Finland	--	--	--	2	70
France	28	[r]25	25	11	10
Germany, Federal Republic of	86	80	--	--	--
India	682	740	789	665	590
Indonesia	7	4	6	[e]5	5
Israel	639	1,227	1,725	2,216	[3]2,610
Jordan	1,717	1,782	2,303	2,825	[3]4,243
Kiribati (Banaba Island, formerly Ocean Island)	417	446	465	420	--
Korea, North[e]	450	500	500	550	550
Mexico	224	285	322	171	300
Morocco	15,656	17,572	[4]19,713	[4]20,032	[4]18,824
Nauru	755	1,146	1,999	1,820	2,000
Netherlands Antilles (Curacao)	54	79	81	49	50
Philippines	12	10	1	2	3
Senegal	1,799	1,871	1,759	1,885	[3]1,292
South Africa, Republic of	1,731	2,403	2,699	3,221	[3]3,185
Sweden[5]	25	50	83	58	[3]88
Syria	511	425	800	1,272	[3]1,319
Thailand	7	3	3	5	5
Togo	2,008	2,857	2,827	2,920	[3]2,933
Tunisia	3,301	3,615	3,712	4,154	[3]4,582
Turkey	67	65	32	25	25
Uganda[e]	15	5	5	--	--
U.S.S.R.[e]	23,900	24,250	24,962	25,580	26,000
United States	44,671	47,256	50,037	51,611	[3]54,415
Venezuela	80	139	109	--	--
Vietnam[e]	1,500	1,500	1,800	400	500
Western Sahara	173	232	([4])	([4])	([4])
Zimbabwe	130	140	140	136	140
Total	[r]107,594	[r]116,646	125,885	130,171	134,888
Guano:					
Chile	16	7	([6])	--	--
Kenya	([6])	([6])	20	[e]20	20
Peru	2	--	--	--	--
Philippines	2	([6])	1	3	3
Seychelles Islands[7]	6	5	6	6	6
Total	[r]26	12	27	29	29

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 5, 1981.
[2]In addition to the countries listed, Belgium and Tanzania may have produced small quantities of phosphate rock, and the Territory of South-West Africa (Namibia) may have produced small quantities of guano, but output is not officially reported, and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Production from Western Sahara area (former Spanish Sahara) included with Morocco.
[5]As reported by the International Superphosphate Manufacturer's Association; official Swedish statistics show no production of phosphate rock; this material is byproduct apatite concentrate derived from iron ore.
[6]Less than 1/2 unit.
[7]Exports.

Historically, about half of the world phosphate rock production was exported. This trend was broken after the 1973-74 price increases; exports declined to about 40% of production in 1975 and have remained at this level. It is probable that this relationship will not change as long as a surplus of capacity exists for upgrading phosphate rock.

The two principal exporting countries, Morocco and the United States, furnished almost 60% of the world demand for phosphate rock. They are followed in relative importance by the U.S.S.R., Togo, Tunisia, Senegal, and Jordan.

Algeria.—Algerian phosphate rock production was an estimated 1,090,000 metric tons and although it was about the same as that produced in 1979, it was considerably less than the 1.5 million metric tons forecast by SONAREM, the Algerian Government phosphate mining organization. The capacity increases were to have come from the Djebel Onk Mine and the rebuilding of the Djebel Konif Mine. Reserves at Djebel Onk are estimated to be 200 million metric tons.

The Algerians plan to process more phosphate rock in Algeria instead of exporting phosphate rock. Contracts have been awarded to construct two phosphate fertilizer plants at a cost of $400 million. One of the plants at Annaba will produce 1,600 metric tons per day of sulfuric acid, 500 metric tons per day phosphoric acid, 231,000 metric tons per year diammonium phosphate, and 198,000 metric tons per year monoammonium phosphate. A plant at Tebessa will produce 280,000 metric tons of triple superphosphate and 5,000 metric tons per year of aluminum fluoride.

Australia.—The Queensland Phosphate Limited phosphate operation sustained continuous losses from the Duchess phosphate mine. The mine owned by Broken Hill South was closed to reduce the financial burden. In 1980, however, principally owing to the closing of the phosphate mine on Ocean Island and the uncertain supply from Christmas Island, there was renewed interest in reopening the Duchess Mine in Northwest Queensland.

Brazil.—Phosphate rock production was projected to reach almost 2 million metric tons in 1980 and grow to about 4 million metric tons by 1985. The increases will be supplied by Arafertil at Araxa, the Valep project at Topira, and the Quimbrazil project at Ipanema. In addition to these new mines, planned projects include Patos de Minas of Fertilizantes, the Catalão project of Metago, and the Mineração Catalão project at Catalão. The total estimated phosphate rock reserves (measured, indicated, and inferred) were recently set at 2.3 billion metric tons.

China, mainland.—There is little authoritative information about China's phosphate rock deposits. The resources have been estimated to be of the order of 30 billion metric tons of low-grade rock, and production is believed to be of the order of 4 million metric tons per year. Phosphate rock deposits are known to exist in north China in the Provinces of Shansi, Hanan, Anhwei, and Kiangsu; in western and central China deposits have been reported in the Provinces of Yunnan, Szechwan, Kweichow, Hupeh, and Hannan. The highest grade deposits known in China are in Kunyang Province, where the grade is reported to range from 28% to 38% P_2O_5. There is a possibility that phosphate deposits in Hunan and southern Kwantung Provinces are being worked.

Egypt.—The El Nasr Phosphate Co. operates the Mahamid and Oweiniya Mines near Sebaiya north of Aswan in the Nile Valley. The reserves in this region may be 300 million metric tons of rock in situ ranging from 45% to 65% BPL. On the coastline of the Red Sea near the southern end of the Gulf of Suez, the Red Sea Phosphate Co. operates several mines in the Kosseir-Safaga Region. Reserves in this area are of the order of 30 million metric tons. Large reserves of phosphate rock have been identified at Abu-Tartur in the Western Desert of Egypt. The total reserves are about 1 billion metric tons at a depth of from 170 to 280 meters from the surface. Large reserves of unknown quantity were recently discovered in the Qena Region of upper Egypt. Production from operating mines is of the order of 600,000 metric tons per year.

Finland.—The apatite mine at Siilinjarvi opened in 1980 with production projected to be over 200,000 metric tons per year. Domestic production will lessen Finland's dependency on supplies of phosphate rock from the U.S.S.R., Morocco, and Senegal.

Iran.—Geological explorations identified phosphate deposits in the region of the Sagros Mountains in southwest Iran and in the Elbruz Mountains, northeast of Tehran. The deposits have not been developed.

Israel.—Israel's phosphate deposits are located in the Negev Desert between the Red Sea, the Dead Sea, and Beersheba. The proven reserves and mines are in the Oron, Nahal Zin, Zefa, Machtesh, and Ein Yahev Fields. The reserve estimate is over 300 million tons recoverable from open pit mines. The railroad between Aron and Zin was expanded and a new jetty was constructed at Ashod Port to handle 50,000-ton ships.

Jordan.—Phosphate rock is mined at Ruseifa and El Hassa. The ore is mined from open pits at Ruseifa and only a small tonnage is recovered from room-and-pillar underground operations. Estimates of the reserves at Ruseifa are about 400 million tons. Mining is by open pit at El Hassa. Expansion plans now underway will increase the El Hassa Mine capacity by 4 million metric tons. Capacity from both mines will exceed 4 million metric tons in 1980.

Mexico.—In the State of Nuevo Leon, low-fluorine phosphate rock is mined and exported for animal feed supplements. The first of two new mines was started at San

Juan de La Costa. The mine will produce 230,000 metric tons per year of 30% P_2O_5 concentrates. In 1982, a second mine will be started at Santo Domingo to produce concentrates from 4% P_2O_5 beach sands. The mine will have a capacity of 1.5 million metric tons of concentrates grading 31% P_2O_5.

Morocco.—Phosphate rock is mined from vast reserves from the Oulad Abdoun Region, the Ganntour Plateau, and the Ben Guerir area. Although mining is not conducted, reserves have been identified in the Meskala Region. Total reserves have been estimated to be of the order of 40 billion tons of in situ rock phosphate. The recoverable reserve has not been published by the Moroccan Office Cherifien des Phosphates. Phosphate has been mined from the Oulad Abdoun Region since 1922, principally from open pit and a few underground mines near Khouribga. A new mine, Sidi Hajjaj, located about 50 kilometers west of Khouribga, is scheduled to start producing in 1983. The ore will be shipped to the new port of Jorf Lasfar, washed in seawater, rinsed with freshwater, and dried.

In the Ganntour Region, the deposits have been mined from a number of underground "Recettes" as well as surface workings on the contour of the outcrops. At Ben Guerir, east of the town of Youssoufia, the center of mining in the Ganntour Region, the new open pit mine will have an initial capacity of 2 million metric tons per year of product after washing at the new beneficiation plant at Safi.

Calcination of the black rock at Youssoufia has been successfully carried out at 750° C and the Office Cherifien des Phosphates plans to increase annual production from a current 0.4 million metric tons per year to 4 million metric tons per year by 1985.

By 1985, it is estimated that Moroccan phosphate mine capacities will be, in million tons per year, 20 at Khouribga, 10 at Youssoufia, 3 at Sidi Hajjaj, and 4 at Ben Guerir for a total capacity of 37 million metric tons.

The Moroccans have not announced any plans to reopen the Bu-Craa phosphate mine in the former Spanish Sahara. It is presumed that the mine will remain inactive until the political situation is resolved.

Senegal.—At Taiba, a high-grade concentrate is produced and at Pallo, aluminum phosphate is produced. After calcining at Pallo, the rock is sold as fertilizer under the name Phosphal. There are an estimated 50 million metric tons of calcium aluminum phosphate remaining to be produced at Pallo. The reserves at Taiba may be about 20 million metric tons and an additional 55 million metric tons have been identified at the nearby Tobene deposit. It is probable that the Tobene deposit will be mined after the Taiba deposit is depleted.

South Africa, Republic of.—The most important phosphate rock deposit in this country is the igneous complex at Phalaborwa. Another igneous deposit in the northwest Transvaal is mined and used exclusively to produce elemental phosphorus and thermal phosphoric acid. Phosphate rock is also produced from sedimentary deposits on the southwest coast at Langebaan at a rate of about 250,000 metric tons per year.

Palabora has increased its capacity to about 3 million metric tons per year. Foskorite, a titanium-rich magnetite and coarse granular apatite, pyroxenite, and tailings from the Palabora Mining Co., which extracts copper, are the minerals that are processed. Reserves are very large and are probably in excess of 1 billion metric tons.

Togo.—The principal deposits in the sedimentary ores that are mined are at Hahotoe and Kpagame. The combined capacity is 2.5 million metric tons per year, and there are plans to increase capacity to 3 million metric tons per year of product. The high-grade ore reserves are estimated to be 110 million metric tons.

Tunisia.—Phosphate ore is mined from the Kalaa Djerda Mine where production is of the order of 200,000 metric tons per year from a reserve base that will range from 10 to 40 million metric tons with variable costs. Most of the mines are located in the Gafsa area. The northern Gafsa mines include Moulares, M'Rata, Redeyef, and Kef Eschfair. The southern Gafsa mines include Metlaoui, M'Dilla, and the Sehib-Djellabia deposits. The total reserves have been estimated to approximate 1 billion metric tons of recoverable phosphate rock.

Tunisia has a new mine development plan. The primary goal will be to develop four new open pit mines.[2] Three of the mines will be in the Gafsa Region. The most important new mine will be the Djellabia-Mzinda, which is scheduled for startup in 1988. The reserves are of the order of 100 million metric tons and production will be 2.5 million metric tons per year. Kef Eddour will produce 1 million metric tons per year and will start in 1983. Oum el Khjer, a small mine, will open in the near future, and Sra Ouertane is scheduled to begin production in 1991-93. The site is in northwest Tunisia.

U.S.S.R.—Although the U.S.S.R. is one of the largest producers of phosphate rock in the world, only a limited amount of information is known about the detail of each mining operation. Eight apatite deposits have been identified in the Khibiny massif in the center of the Kola Peninsula. Four of these deposits, Kukisvumchor, Yukpor, Rasvumchor, and Koashvin, are being mined and have reserves of 1.2 billion metric tons. Production is at the rate of 15.3 million metric tons per year.

The Kara Tau phosphate rock deposits are located in southern Kazakhstan. There are five main deposits with a total estimated reserve of 1,700 million metric tons. The open pit mines are Chulak Tau, Dzhambul, Samarkand, Molodezhnaya, and Chardzhow. Production is scheduled to increase to about 9 million metric tons in 1990.

Phosphate rock is produced by the Maarder Chemical Combine from deposits along the Baltic coast. The capacity of the plant is 250,000 metric tons per year. A phosphate mine at Kingisepp produces about 1.7 million metric tons per year. Phosphate rock is mined in the Aktyubinsk area from a reserve of 800 million metric tons. Although several mines are operating, specific production is not known.

For the future, deposits discovered in eastern Siberia at Seligda with reported reserves of 3 billion tons could be exploited. Work is in progress to develop the Zabaikalsky apatite complex located near Ulan Ude on the Oshurkov phosphate deposit. Production from the first stage was 1.2 million metric tons per year.

TECHNOLOGY

Borehole mining, an experimental method that appears environmentally safe, was tested in St. Johns County, Fla. The tests were conducted by Flow Industries, Inc., on Agrico Chemical Co.'s property. They were conducted to determine the economic feasibility of using this mining technique and to assess any adverse environmental side-effects. Borehole mining is a method of extracting mineral through a borehole drilled from the surface into the ore. A high-pressure water jet is placed at the bottom of the borehole and is used to fragment the mineral and form a slurry. The slurry is pumped to the surface, the mineral is recovered, and the water is recycled.

In St. Johns County, the phosphate matrix is over 76 meters below the surface in water-bearing strata. These factors would make surface mining of these deposits difficult, costly, and certainly environmentally destructive. Three tests were made. In the first test, about 900 tons of matrix were extracted before the chamber flooded. In the second borehole test, the water and slurry in the chamber were pumped out and the roof of the chamber collapsed. In the third borehole test, a shroud of compressed air was used to encase the water jet, permitting the development of a slurry in the water-filled cavity. Another 900 metric tons of matrix were collected. The water jet was designed to operate in air. The effective slurry radius was reduced from 7.6 meters to 4.8 meters if the chamber floods. The compressed air shroud increased the slurry radius to 5.5 meters. The slurry will be concentrated by Agrico Chemical Co. to establish the characteristics of the concentrate. The development of this mining process for phosphate matrix will probably be long and costly. The disposition of waste slimes into the mineral cavities is planned, but the methodology has not been developed and proven. If successful, and if costs are acceptable and competitive with remaining mines in central Florida, the technology could convert identified deep phosphate deposits from resources to reserves.

Studies at the Bureau of Mines Albany Research Center, Albany, Oreg., developed a carbonate-silica flotation process for beneficiation of low-grade altered and unaltered western phosphate ores that contain high dolomite levels. The technology was transferred to industry with a demonstration project. Selective leaching of MgO from low-grade partially altered phosphatic shales from the Phosphoria Formation was studied. The process shows promise and may be applicable as a pretreatment prior to direct digestion with sulfuric acid for ores that are difficult to beneficiate by physical means.

The Bureau of Mines Tuscaloosa Research Center, Tuscaloosa, Ala., completed operation of the field test unit during which a variety of phosphate clay wastes were successfully dewatered. Consolidated phosphate clay wastes containing more than 20% solids were produced with a rotary screen using 0.69 pound of polyethylene oxide per ton of solids. The experimental program was conducted at Estech General Chemical Co.'s Silver City plant.

A study was initiated to determine the extent and nature of radiation problems associated with disposal and leaching of byproduct gypsum. The research showed that byproduct gypsum is produced at a rate of 30 million metric tons per year and there is an accumulation of 300 million metric tons in Florida. The average radium concentration for all byproduct gypsum stacks in Florida was 21 picocuries per gram of sample. The radium concentrations ranged from 9 to 42 picocuries per gram of sample from different gypsum stacks. X-ray diffraction analyses showed only gypsum and alpha-quartz in the byproduct gypsum.

A number of flotation techniques were tried to obtain a high-grade phosphate concentrate from dolomite-bearing phosphate matrix from south Florida. From tests designed to reduce the MgO content, concentrates assaying 33.4% P_2O_5 and 0.60% MgO were produced. P_2O_5 recovery was low, however, and represented only 45% of the P_2O_5 in the flotation feed. If the P_2O_5 recovery was raised under other flotation conditions, the concentrate grade declined. A generalized flowsheet was developed that consisted of primary desliming, grinding, secondary desliming, scrubbing and desliming, floating a rougher concentrate, and cleaning the rougher concentrate three times. The concentrate analyzed 29% to 30% P_2O_5, and 1.2% to 1.36% MgO. Phosphate recoveries ranged from 72.4% to 76.9% of the phosphate contained in the flotation feed. Evaluation of drill cores from the Hawthorn Formation in northeast Florida was completed. The average P_2O_5 content of the core samples was 2.6%. Although concentrates of acceptable P_2O_5 content were produced, the MgO content of these concentrates was 1.0% to 2.0%

[1]Physical scientist, Section of Nonmetallic Minerals.
[2]Engineering and Mining Journal, September 1980, pp. 39-40.

Platinum-Group Metals

By Christine M. Moore[1]

World production of platinum-group metals (PGM) in 1980 was estimated at 6.8 million troy ounces, 5% higher than production in 1979. The Republic of South Africa remained the leading producer of platinum and accounted for 45% of world production of PGM. The U.S.S.R. remained the leading producer of palladium and accounted for 48% of world production of PGM. Canadian production of PGM, a byproduct of nickel production, accounted for 6% of the total world production.

Domestic mine production in 1980, nearly all a byproduct of copper mining, decreased by more than 50% and was at the lowest level in nearly 50 years. Refinery output, produced almost entirely from secondary materials, increased for the third consecutive year. Sales of PGM in 1980 decreased 20% from the 1979 level, with the largest decrease (30%) noted in sales to the automobile industry.

Legislation and Government Programs.—U.S. Government inventories of platinum, palladium, and iridium were unchanged in 1980. The quantities, in troy ounces, held in the national stockpile and the goals (objectives) at yearend were as follows:

	Goal	Inventory
Platinum	1,310,000	452,640
Palladium	3,000,000	1,255,003
Iridium	98,000	16,991

The Environmental Protection Agency (EPA) waived several automotive models from requirements to meet pollution standards in the 1981 model year until the 1983 model year. The standards to be implemented in the 1983 model year allow emissions of 1.0 gram per mile of nitrogen oxides and 3.4 grams per mile of carbon monoxide.

Table 1.—Salient platinum-group metals[1] statistics

(Troy ounces)

	1976	1977	1978	1979	1980
United States:					
Mine production[2]	6,116	5,545	8,246	7,300	3,348
Value	$464,527	$396,649	$759,925	$1,288,155	$923,423
Refinery production:					
New metal	7,101	5,199	8,303	r8,392	2,300
Secondary metal	215,355	195,219	257,191	309,022	330,923
Toll-refined metal	869,664	1,005,023	1,023,314	r1,090,678	1,079,813
Total refined metal	1,092,120	1,205,441	1,288,808	1,408,092	1,413,036
Exports (except manufactured goods)	512,407	426,631	702,547	899,598	764,964
Imports for consumption	2,667,059	2,510,374	2,921,411	3,479,128	3,501,782
Stocks Dec. 31: Refiner, importer, dealer	1,085,703	1,012,812	861,411	761,282	973,261
Consumption (sales)	1,603,077	1,592,277	2,259,558	2,756,021	2,205,910
World: Production	r6,228,826	r6,510,632	r6,330,220	r6,486,270	6,830,093

rRevised.
[1]The platinum group comprises six metals: Platinum, palladium, iridium, osmium, rhodium, and ruthenium.
[2]Recovered from platinum placers and as byproducts of copper refining.

DOMESTIC PRODUCTION

In 1980, domestic mine production of PGM, largely a byproduct of copper mining, decreased sharply as a result of prolonged strikes in the copper industry. Total secondary recovery of PGM increased for the third consecutive year, primarily as a result of high prices in the early part of the year. Secondary recovery of platinum in 1980 was more than double the 1979 level.

Plans were announced to resume dredging operations at Goodnews Bay, Alaska, in spring 1981. Test samples were collected during 1980 by the Goodnews Bay Mining Co. Dredging of the placer deposit ceased in November 1975 because of the low PGM content.

The Anaconda Company continued exploration and test production of platinum and palladium at its deposit near Nye, Mont., within the Stillwater Complex. A final decision on the feasibility of the project was expected in 1981.

Stillwater PGM Resources, a joint venture of Johns-Manville Corp. and Chevron USA, Inc., continued exploration for PGM within the Stillwater Complex. The company expected to make a final decision on the project in 1983.

Environmental studies continued during the year to determine the effect of mining copper-nickel deposits in the Babbitt-Ely area of Minnesota. Minnamax, a subsidiary of AMAX Inc., continued development studies for producing copper, nickel, cobalt, and PGM from the deposit.

Platinum and palladium were recovered from copper ores by U.S. Metals Refining Co., a subsidiary of AMAX Copper Inc., ASARCO Incorporated, and Kennecott Copper Corp. Numerous refiners process PGM scrap on a toll and a nontoll basis. The largest processors in the United States are Engelhard Minerals & Chemicals Corp., Johnson Matthey Inc., and Simmons Refining Co.

Engelhard Minerals & Chemicals expanded its capacity to produce precious metal catalysts at its Newark, N.J., plant.

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1976	2,748	4,025	244	45	35	4	7,101
1977	831	4,300	52	9	6	1	5,199
1978	1,081	7,222	--	--	--	--	8,303
1979	1,980	6,412	--	--	--	--	8,392
1980	535	1,765	--	--	--	--	2,300
Toll-refined:							
1976	8,676	1,063	355	39	95	4	10,232
1977	466	610	4	--	3	--	1,083
1978	177	1,177	--	--	--	--	1,354
1979	56	420	--	--	--	--	476
1980	128	673	--	--	--	--	801
SECONDARY METAL							
Nontoll-refined:							
1976	64,901	134,747	3,921	10	8,058	3,718	215,355
1977	50,838	134,086	1,442	12	5,011	3,830	195,219
1978	75,585	166,371	1,565	3	8,266	5,401	257,191
1979	75,038	220,639	1,647	--	7,964	3,734	309,022
1980	154,075	162,408	3,186	13	10,106	1,135	330,923
Toll-refined:							
1976	494,069	311,000	6,507	1,429	34,035	12,392	859,432
1977	620,848	327,450	4,970	1,955	42,178	6,539	1,003,940
1978	630,961	344,022	6,599	667	35,914	3,797	1,021,960
1979	585,932	446,189	5,487	--	38,875	13,719	1,090,202
1980	533,101	498,905	4,933	1,371	33,362	7,340	1,079,012
1979 TOTALS							
Total primary refined	2,036	6,832	--	--	--	--	8,868
Total secondary refined	660,970	666,828	7,134	--	46,839	17,453	1,399,224
Grand total refined	663,006	673,660	7,134	--	46,839	17,453	1,408,092
1980 TOTALS							
Total primary refined	663	2,438	--	--	--	--	3,101
Total secondary refined	687,176	661,313	8,119	1,384	43,468	8,475	1,409,935
Grand total refined	687,839	663,751	8,119	1,384	43,468	8,475	1,413,036

CONSUMPTION AND USES

Reported sales of PGM in 1980 decreased 20% from the 1979 level, primarily as a result of decreased sales to the automotive industry. The automotive industry remained the largest purchaser of PGM, accounting for 33% of the sales in 1980, compared with 38% in 1979. Sales to other industries in 1980 were as follows: Electrical, 24%; chemical, 13%; dental and medical, 12%; petroleum, 8%; glass, 3%; jewelry and decorative, 3%; and miscellaneous, 4%. Sales of platinum accounted for 51% of total sales in 1980. Sales of palladium accounted for 41%, ruthenium for 4%, rhodium for 3%, iridium for 1%, and osmium for less than 1% of total sales. In addition to sales, more than 1 million ounces of PGM were recycled on a toll basis primarily for the chemical and petroleum industries.

The principal domestic uses of PGM in 1980 were as catalysts to control automobile exhaust emissions, reforming catalysts to upgrade the octane rating of gasolines, catalysts to produce acids and organic chemicals, electrical contacts and relays primarily for use in telephone systems, bushings for glass fiber manufacture, and dental alloys for orthodontic and prosthodontic uses.

Table 3.—Platinum-group metals[1] sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1976	851,105	657,062	10,117	797	40,875	43,121	1,603,077
1977	789,819	700,469	13,456	911	55,216	32,406	1,592,277
1978	1,196,341	917,928	16,839	817	69,640	57,993	2,259,558
1979:							
Automotive	803,229	222,156	--	--	26,136	--	1,051,521
Chemical	98,600	199,743	3,705	508	11,684	49,253	363,493
Dental and medical	27,053	243,627	570	466	45	274	272,035
Electrical	115,775	392,372	8,098	--	16,923	40,021	573,189
Glass	88,594	1,729	108	--	15,376	--	105,807
Jewelry and decorative	27,712	11,766	2,014	--	7,458	308	49,258
Petroleum	170,013	24,588	2,051	--	1,223	--	197,875
Miscellaneous	77,949	36,640	755	--	4,625	22,874	142,843
Total	1,408,925	1,132,621	17,301	974	83,470	112,730	2,756,021
1980:							
Automotive	517,143	176,518	--	--	37,012	674	731,347
Chemical	118,956	119,905	4,134	321	5,273	35,972	284,561
Dental and medical	25,831	244,279	495	498	45	508	271,656
Electrical	150,060	312,778	11,273	--	14,818	37,224	526,153
Glass	52,897	1,155	50	--	8,581	--	62,683
Jewelry and decorative	50,998	13,491	3,092	--	5,434	560	73,575
Petroleum	144,039	22,013	4,058	--	662	--	170,772
Miscellaneous	58,307	21,828	482	--	1,703	2,843	85,163
Total	1,118,231	911,967	23,584	819	73,528	77,781	2,205,910

[1]Comprises primary and nontoll-refined secondary metals.

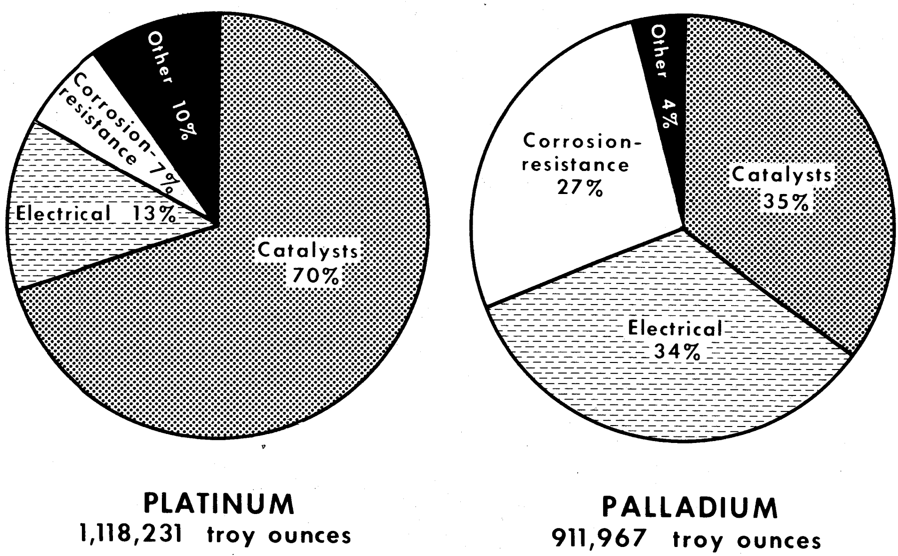

Figure 1.—Uses of platinum and palladium in 1980.

STOCKS

Stocks of platinum increased sharply during 1980 as a result of a substantial increase in inventories held by the New York Mercantile Exchange. Stocks of palladium held by refiners, importers, and dealers also increased during the year. However, stocks of iridium, osmium, rhodium, and ruthenium decreased during the year. Stock data in table 4 are partial stocks because the Bureau of Mines does not collect inventory data from end users of PGM, some of whom may hold sizable inventories. In addition, there were government inventories of platinum, palladium, and iridium.

Table 4.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31[1]

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1976	536,318	459,765	20,318	439	47,769	21,094	1,085,703
1977	438,045	475,358	15,689	420	48,392	34,908	1,012,812
1978	369,823	369,937	16,264	708	51,322	53,357	861,411
1979	305,605	323,865	18,303	1,487	49,678	62,344	761,282
1980	502,185	353,002	15,032	200	46,105	56,737	973,261

[1]Includes metal in depositories of the New York Mercantile Exchange; on Dec. 31, 1980, this comprised 279,800 troy ounces of platinum and 32,200 troy ounces of palladium.

PRICES

In response to continued strong investor demand, prices for platinum increased until March, at which time dealers' and futures exchange prices for the metal began a sharp decline. The platinum dealers' price began the year at $800 per troy ounce and peaked at $990 per troy ounce in early March. On March 5, the New York Mercantile Exchange price for platinum was a record high $1,040 per troy ounce. By yearend, the dealers' platinum price ranged from $586 to $596 per troy ounce. The producers' platinum price at the beginning of the year was $420 per troy ounce and was increased in August to $475 per troy ounce where it remained at yearend.

The palladium producers' price was increased from $150 per troy ounce to $175 per troy ounce at the end of January; at the end of February it was increased to $225 per troy ounce. However, in early December in response to falling demand, the producers' price was decreased to $200 per troy ounce.

Both producers' and dealers' prices for iridium were increased sharply during the year. However, producers' and dealers' prices for rhodium were decreased. Prices for ruthenium and osmium remained essentially unchanged during the year.

Table 5.—Monthly average producer and dealer prices[1] of platinum-group metals

(Dollars per troy ounce)

	Platinum		Palladium		Rhodium		Iridium		Ruthenium		Osmium	
	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer
1978: Average	237	261	71	63	510	524	300	240	56	33	150	130
1979:												
January	300	364	80	77	550	679	300	239	45	35	150	130
February	325	412	85	99	566	711	296	241	45	35	150	130
March	325	396	100	95	700	710	245	247	45	34	150	130
April	325	391	100	94	700	707	245	251	45	33	150	130
May	350	430	101	109	700	740	245	266	45	31	150	130
June	350	428	110	124	777	811	245	290	45	31	150	130
July	350	415	120	122	800	820	245	301	45	31	150	130
August	363	402	120	121	800	810	245	295	45	31	150	130
September	380	474	132	142	800	812	245	298	45	31	150	130
October	380	517	135	145	800	821	245	310	45	31	150	130
November	380	504	135	142	800	808	245	305	45	32	150	130
December	400	617	143	167	800	812	286	312	45	32	150	130
Average	352	445	113	120	733	770	257	280	45	32	150	130
1980:												
January	420	820	155	231	800	839	350	351	45	34	150	130
February	420	889	188	271	800	833	381	461	45	36	150	130
March	420	699	225	230	800	801	419	557	45	36	150	130
April	420	600	225	195	800	761	500	624	45	36	150	130
May	420	564	225	160	800	733	500	702	45	36	150	130
June	420	648	225	170	800	749	500	769	45	35	150	130
July	420	664	225	199	800	727	500	769	45	35	150	130
August	433	650	225	205	787	705	513	752	45	35	150	130
September	475	707	225	213	700	652	600	750	45	35	150	130
October	475	671	225	201	700	652	600	767	45	35	150	130
November	475	634	225	183	700	661	600	750	45	35	150	130
December	475	580	200	151	700	634	600	735	45	35	150	130
Average	439	677	214	201	766	729	505	666	45	35	150	130

[1]Average prices calculated at the low end of the ranges of weekly averages and rounded to the nearest dollar.

Source: Metals Week.

FOREIGN TRADE

Exports of PGM decreased 15% from the 1979 level. However, a sharp increase in the value of exports was noted, increasing to about $340 million in 1980 from slightly more than $200 million in 1979. Imports of PGM increased slightly in 1980 to 3.5 million troy ounces, valued at $1.2 billion. A large decrease in receipts from the U.S.S.R. was noted during the year.

Table 6.—U.S. exports of platinum-group metals, by country

Year and destination	Ores and concentrates (troy ounces)	Waste, scrap, and sweepings (troy ounces)	Metal not rolled (troy ounces)			Metal rolled		Total	
			Platinum	Palladium	Other platinum-group	Platinum	Other platinum-group	Troy ounces	Value (thousands)
1979:									
Argentina	--	--	61	25	554	--	--	640	$78
Australia	28	1	2,670	23	3,733	65	3,488	10,008	1,085
Belgium-Luxembourg	690	24,140	--	1,665	11,322	--	24	37,841	7,889
Brazil	64	112	1,711	1,192	703	16	3,018	6,816	951
Canada	693	10,528	7,515	12,816	25,522	1,533	3,789	62,396	15,199
Colombia	--	--	173	--	1,389	--	240	1,802	459
Finland	--	--	--	--	2,574	--	--	2,574	977
France	634	67	1,834	1,391	14,677	--	150	18,753	3,136
Germany, Federal Republic of	4,889	15,605	28,912	30,038	16,319	1,021	2,092	98,876	25,428
Greece	--	--	--	1,373	3,508	--	--	4,881	453
Hong Kong	--	--	--	897	579	11	--	1,487	192
Italy	--	--	899	187	7,358	8	322	8,774	1,053
Japan	5,223	1,315	120,950	140,054	41,967	15,076	4,304	328,889	80,358
Korea, Republic of	325	--	45	1,107	474	188	--	2,139	190
Mexico	302	42	488	831	51,337	161	1,843	55,004	2,662
Netherlands	--	450	3,640	2,177	1,216	--	3,127	10,610	2,485
Norway	--	148	--	--	3,032	--	--	3,180	1,280
Singapore	410	--	132	157	562	--	--	1,261	102
Spain	--	--	--	--	1,910	--	--	1,910	148
South Africa, Republic of	--	1,041	--	--	5,279	--	--	6,320	1,259
Sweden	--	236	11	--	17,492	--	--	17,739	4,706
Switzerland	--	127	13,767	2,724	32,092	--	--	48,710	9,684
Taiwan	--	--	49	458	634	20	--	1,161	118
United Kingdom	647	121,473	3,739	14,801	6,895	160	6,569	154,284	40,334
Venezuela	16	--	7	1,336	--	--	24	1,383	133
Other	--	12	1,582	1,306	7,699	1,388	173	12,160	1,798
Total	13,921	175,297	188,185	214,558	258,827	19,647	29,163	899,598	202,157
1980:									
Argentina	--	--	--	200	707	29	--	936	230
Australia	--	--	57	--	701	5	36	799	267
Belgium-Luxembourg	--	27,662	30	2,451	1,093	19	1,028	32,283	12,166
Brazil	--	--	53	2,214	--	774	1,593	4,634	915
Canada	344	27,781	6,187	20,060	17,047	307	673	72,399	27,796

Finland	--	--	--	20	4,664	--	--	4,684	2,908
France	--	358	2,065	4,634	4,149	614	18	11,838	3,878
Germany, Federal Republic of	1,472	14,001	43,264	26,873	23,184	732	1,649	111,175	57,596
Greece	--	--	--	2,304	511	--	--	2,815	279
Hong Kong	--	--	--	825	139	--	20	984	281
India	--	4	800	19	8	50	--	881	527
Ireland	--	--	--	581	--	--	--	581	52
Italy	15	12	1,667	983	2,805	844	67	6,393	2,514
Japan	289	--	97,949	83,073	23,715	29,655	3,282	237,963	108,493
Korea, Republic of	--	--	124	780	--	--	198	1,102	131
Mexico	--	6	253	323	5,044	497	21	6,144	2,126
Netherlands	--	--	(1)	9,347	1,115	1,106	218	11,786	2,934
Norway	--	--	--	3	3,929	--	35	3,967	2,293
Singapore	--	--	--	211	361	--	--	572	100
South Africa, Republic of	--	--	1,000	40	1,897	--	315	3,252	1,950
Sweden	17	69	--	1,286	2,551	--	326	4,249	1,835
Switzerland	80	4	48,649	8,032	10,367	13	49	67,194	38,862
United Kingdom	387	100,106	52,101	13,945	4,060	275	2,867	173,741	71,723
Venezuela	30	--	14	452	--	4	21	521	52
Other	163	253	282	1,030	1,464	35	844	4,071	1,296
Total	2,797	170,256	254,495	179,686	109,511	34,959	13,260	764,964	[2]341,206

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 7.—U.S. imports for consumption of platinum-group metals, by country

Year and country	Unwrought (troy ounces)										
	Platinum grains and nuggets	Platinum sponge	Palladium	Iridium	Osmium	Osmiridium	Rhodium	Ruthenium	Unspecified combinations	Platinum-group metals from precious metal ores	Sweepings, waste, and scrap
1979	8,232	1,352,054	1,435,808	33,166	300	7,125	104,337	124,887	85,115	11,100	156,674
1980:											
Argentina	--	--	--	--	--	--	--	--	--	--	162,933
Australia	--	--	--	--	--	--	--	--	13	--	10,383
Belgium-Luxembourg	--	12,184	51,053	--	--	--	54	--	254	--	38,695
Canada	482	31,025	24,474	--	--	--	230	1,500	500	19	33,960
Colombia	119	--	--	--	--	--	--	--	--	656	3,213
Costa Rica	--	490	--	--	--	--	--	--	--	--	3,828
Finland	--	--	--	--	--	--	2	--	--	--	2,643
France	--	225	200	545	--	--	--	--	4	--	4,761
Germany, Federal Republic of	112	15,270	32,885	1,300	--	--	--	--	161	--	2,066
Hong Kong	--	--	--	--	--	--	--	--	8,537	--	53,391
Italy	--	14,065	--	--	--	--	129	1,000	--	--	--
Japan	786	3,533	3,300	--	--	--	128	--	2,246	--	44
Mexico	--	--	--	--	--	--	--	--	--	--	41,332
Namibia	--	1,000	--	--	--	--	1,100	--	--	--	--
Netherlands	--	13,600	37,759	881	3	--	914	3,883	2,110	--	--
Norway	--	5,911	5,525	665	--	--	1,007	890	485	--	2,046
South Africa, Republic of	8,564	938,751	619,292	15,371	--	--	81,891	80,298	5,777	--	3,940
Sweden	--	--	--	--	--	--	64	--	--	--	8,672
Switzerland	1,574	--	1,046	--	--	--	50	1,000	2,218	--	1,494
U.S.S.R.	--	6,253	278,161	--	--	--	8,482	--	12,803	--	--
United Kingdom	3,390	146,853	146,043	7,264	437	10,388	15,347	9,917	73,604	--	685
Yugoslavia	--	643	2,604	--	--	--	--	--	--	--	--
Other	400	2,000	--	64	--	--	193	--	2,239	--	2,414
Total	15,427	1,191,803	1,202,342	26,090	440	10,388	109,591	98,488	110,951	675	376,500

	Semimanufactured (troy ounces)					Platinum-group metals in materials not elsewhere specified (troy ounces)	Total	
	Platinum	Palladium	Iridium	Rhodium	Unspecified combinations		Troy ounces	Value (thousands)
1979	73,925	68,626	650	4,681	134	12,314	3,479,128	$840,533
1980:								
Argentina	--	--	--	--	--	--	162,933	12,440
Australia	--	--	--	--	--	--	10,396	3,158
Belgium-Luxembourg	3	--	--	3	--	--	102,246	41,995
Canada	1,945	1,262	3	--	--	2,930	98,330	37,777
Colombia	--	--	--	--	--	--	3,988	2,117
Costa Rica	--	--	--	--	--	--	4,318	1,228
Finland	--	--	--	--	--	--	2,645	1,689
France	--	--	--	--	--	--	5,735	2,838
Germany, Federal Republic of	1,703	--	--	643	--	--	54,140	23,059
Hong Kong	(1)	--	--	--	--	--	61,928	3,157
Italy	--	--	--	--	--	--	15,194	6,073
Japan	11,102	1,249	--	--	--	--	22,388	15,051
Mexico	--	91	--	--	--	574	41,997	6,224
Namibia	500	995	--	--	--	--	3,595	2,178
Netherlands	154	--	--	--	--	--	59,304	16,481
Norway	700	400	--	--	--	--	17,629	7,982
South Africa, Republic of	112,197	29,695	--	--	--	8,389	1,904,165	677,418
Sweden	193	--	--	--	--	--	8,929	5,980
Switzerland	22,757	957	--	--	--	--	31,096	19,249
U.S.S.R.	9,639	61,409	--	--	--	--	376,747	89,622
United Kingdom	69,250	18,188	70	40	744	1,101	503,321	197,968
Yugoslavia	--	--	--	--	--	--	3,247	732
Other	201	--	--	--	--	--	7,511	2,333
Total	230,344	114,246	73	686	744	12,994	3,501,782	[2]1,176,747

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 8.—Imports of platinum-group metals in 1979-80, by source

(Percent of total imports)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total imports
1979:							
South Africa, Republic of	78	42	47	3	58	82	60
U.S.S.R.	3	38	--	--	15	--	20
United Kingdom	9	7	42	97	18	8	9
Other	10	13	11	--	9	10	11
1980:							
South Africa, Republic of	66	40	46	2	70	78	54
U.S.S.R.	1	21	--	--	7	--	11
United Kingdom	16	13	29	98	13	10	14
Other	17	26	25	--	10	12	21

WORLD REVIEW

World production of PGM in 1980 was estimated at 6.8 million troy ounces. The U.S.S.R. and the Republic of South Africa remained the leading producers. Byproduct production of PGM from nickel-copper ores in Canada, the third largest PGM producer, approached traditional levels following prolonged strikes in 1979.

World demand for platinum decreased for the second year, following a large drop in Japanese demand for platinum in jewelry uses, as well as a sharp decrease in consumption of platinum by the automobile industry in the United States.

Canada.—Inco Ltd. and Falconbridge Nickel Mines Ltd. decreased mine production levels in the second half of 1980 as nickel demand decreased. Total production of PGM in 1980 increased compared with the 1979 level when strikes stopped production for several months. Both companies recovered PGM as byproducts of nickel and copper production. Inco processed the concentrate at its refinery in Acton, England, and Falconbridge recovered PGM from nickel-copper matte at its refinery in Kristiansand, Norway.

Japan.—Imports of PGM by Japan decreased 10% from the 1979 level to 1.8 million troy ounces in 1980. The Republic of South Africa remained the primary supplier of platinum, and the U.S.S.R. remained the primary supplier of palladium and rhodium.

South Africa, Republic of.—Mine output of PGM in 1980 increased slightly from the 1979 level. The Republic of South Africa continued to be the world's largest producer of platinum, ruthenium, and possibly rhodium and osmium. Virtually all of the country's production was mined from the Merensky Reef of the Bushveld Complex in Transvaal by three companies. Osmiridium also was recovered as a byproduct of gold mining.

Rustenburg Platinum Mines, Ltd. (RPM), a subsidiary of Rustenburg Platinum Holdings Ltd. (RPH), continued to operate three major mines for the production of platinum-group metals from the Merensky Reef. ATOK Platinum Mines (Pty.) Ltd., a subsidiary of RPH, continued to operate a mine at the eastern end of the Merensky Reef.

During 1980, RPM completed the expansion of mining capacity at the Amandelbult section and the sinking of a new shaft at the Rustenburg section. A second smelter in the Union section was commissioned during the year.

RPM also continued exploration of the Potgietersrust area for possible future mining operations. Modifications of the Wadeville refinery, jointly owned by RPM and Johnson Matthey, were under way to increase the capacity, as well as to improve working conditions.

Impala Platinum Ltd. operated four mines in Bophuthatswana for the production of PGM. Three additional tube mills and flotation units were added at the Mineral Processes concentration facilities during 1980, and additional capacity at the Springs refinery was being installed to increase the company's PGM production to over 1.0 million troy ounces per year.

Western Platinum Ltd. announced plans to increase capacity for PGM production from 135,000 troy ounces per year to 245,000 troy ounces per year by 1983. The company also announced plans to begin a $33 million project to recover an estimated 50,000 troy ounces per year from the UG-2 Reef, which underlies the Merensky Reef. The company planned to use the recovery process developed by the Republic of South Africa's National Institute of Metallurgy. The process involved the separation of PGM from chromite by flotation, followed by smelting in hotter than normal furnaces to remove any remaining chromite.[2]

Table 9.—Platinum-group metals: World production, by country[1]

(Troy ounces)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Australia, metal recovered domestically from nickel ore:[3]					
Palladium, metal content, from nickel ore	7,950	9,581	7,395	6,880	7,200
Platinum, metal content, from nickel ore	3,158	3,697	2,958	2,765	2,500
Ruthenium	462	225	[e]300	[e]200	150
Canada: Platinum-group metals from nickel ore	416,821	465,371	346,213	197,943	[4]404,585
Colombia: Placer platinum	16,779	17,300	13,939	12,932	13,000
Ethiopia: Placer platinum	145	[e]100	123	108	120
Finland: Platinum-group metals from copper ore[e]	600	[r]670	[r]670	[r]590	590
Japan, metal recovered from nickel and copper ores:[5]					
Palladium	18,089	22,716	24,221	22,495	29,700
Platinum	8,706	9,737	10,176	12,142	12,900
South Africa, Republic of: Platinum-group metals from platinum ores[e] [6]	2,700,000	2,870,000	2,860,000	3,017,000	3,100,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel/copper ores[e]	[r]3,050,000	[r]3,100,000	3,050,000	3,200,000	3,250,000
United States: Placer platinum and platinum-group metals from gold and copper ores	6,116	5,545	8,246	7,300	[4]3,348
Yugoslavia:					
Palladium	NA	4,951	5,562	5,240	5,300
Platinum	NA	739	417	675	700
Total	[r]6,228,826	[r]6,510,632	6,330,220	6,486,270	6,830,093

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Table includes data available through May 4, 1981. Platinum-group metal production by the Federal Republic of Germany, Norway, and the United Kingdom is not included in this table as the production is derived wholly from imported metallurgical products and to include it would result in double counting.

[2]In addition to the countries listed, mainland China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan. (See footnote 5.)

[3]Partial figure; excludes platinum-group metals recovered in other countries from nickel ore of Australian origin; however, a part of this output may be credited to Japan. (See footnote 5.)

[4]Reported figure.

[5]Japanese figures do not refer to Japanese mine production, but rather represent Japanese smelter/refinery recovery from ores originating in a number of countries; this output cannot be credited to country of origin because of a lack of data. Countries producing and exporting such ores to Japan include (but are not necessarily limited to) Australia, Canada, Indonesia, Papua New Guinea, and the Philippines. Output from ores of Australian, Indonesian, Papua New Guinea, and Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

[6]Includes osmiridium produced in gold mines.

U.S.S.R.—The new nickel and copper production facilities at Norilsk reportedly underwent testing. The smelters have a rated capacity of 550,000 metric tons per year of nickel concentrate and 650,000 metric tons per year of copper concentrate. The new facilities were expected to increase the production level for PGM, especially palladium, upon completion of the expansion project.

Exports in 1980 of platinum, palladium, and rhodium to the United States and Japan decreased sharply, with direct exports to Japan at the lowest level since 1970.

United Kingdom.—Matthey Rustenburg Refiners (Pty.) Ltd. announced plans to build a $24 million PGM refinery at Royston. The facility, which would process both South African concentrate and secondary materials, would use solvent extraction and was scheduled for completion by yearend 1982.

Other countries.—Small quantities of PGM were produced by Rudarsko Topionicarski Basin (RTB) as byproducts of copper production in Yugoslavia and by Western Mining Corp. at Port Kembla as byproducts of nickel production in Australia. PGM concentrate was produced in Finland as a byproduct of copper smelting, and in the Philippines as a byproduct of nickel-cobalt production.

TECHNOLOGY

Research continued on methods to decrease the amount of platinum and rhodium used in automotive catalytic converters while continuing to meet air emission standards set by EPA. The research involved increasing the surface area per unit volume of catalyst support by reducing the diameter and lowering the density of pellets, or by increasing the number of cells per square inch in monolithic substrates.[3]

Development continued on a catalytic engine, an internal combustion engine where the heat release is brought about by a catalyst.[4] The advantages of a catalytic combustion system incorporating PGM include fuel economy comparable to a diesel engine over part of the load range, emissions of nitrogen oxides comparable to diesel engine emissions, emissions of hydrocarbons that are lower than hydrocarbon emissions from either the diesel engine or the gasoline engine, and the use of either methanol or gasoline as fuel.

Development of a catalytic converter to decompose ozone was reported.[5] The platinum catalyst was expected to be commercialized for use in airplanes that operate above 18,000 feet. The Federal Aviation Administration issued a final rule, effective February 21, 1981, that required that the ozone concentration inside the airplane cabin not exceed either 0.25 part per million by volume or 0.1 part per million by volume for each flight segment that exceeds 4 hours.

Corning Glass Works announced the development of a catalytic combustor that uses PGM for wood burning stoves. The combustor reduced the ignition point of combustion gases from 700° C to 260° C, which improved heating efficiency, decreased air pollution, and decreased the risk of creosote-based chimney fires.[6]

A review of research on ruthenium as an electrical contact was published.[7] The high prices of gold and rhodium have increased interest in ruthenium which exhibits properties of extremely high hardness and resistance to corrosion, as well as superior resistance to wear.

A study of PGM was published by the National Materials Advisory Board.[8] Included in the study were forecasts of use patterns, a discussion of recycling automobile catalytic converters, and a discussion of the national stockpile.

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[1]Mineral specialist, Section of Nonferrous Metals.
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[3]Chemical and Engineering News. Auto Emission Control Faces New Challenges. V. 58, No. 11, Mar. 17, 1980, p. 36.
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[7]Hydes, P. C. Electrodeposited Ruthenium as an Electrical Contact Material. Platinum Met. Rev., v. 24, No. 2, April 1980, pp. 50-55.
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Potash

By James P. Searls[1]

U.S. potash production rose slightly while apparent consumption fell by 7%. Prices rose strongly from 1979 to 1980, but were level in the latter half of 1980 as domestic demand, due to drought, leveled off. Production in the U.S.S.R. returned to close to pre-1979 levels. Worldwide potash supply and demand appeared to be nearly in balance at the prevailing price levels.

In the United States, average prices for muriate (standard, course, and granular) rose from $95 per metric ton K_2O equivalent[2] to $133 per ton, f.o.b. mine. The sulfate of potash price rose from $227 per ton in 1979 to $299 per ton, f.o.b. mine.

Potash Corp. of Saskatchewan (PCS) continued its strong capacity growth program, and three other Saskatchewan producers have announced plans for capacity increases. The Potash Co. of America has announced plans to build a mill at its New Brunswick mine site and to begin production by late 1982.

Legislation and Government Programs.—Final rulemaking on Fee, Rentals, and Royalties for potassium leases was issued on May 28, 1980, in the Federal Register 45 F.R. 36034 by the Bureau of Land Management (BLM). Minimum royalty is $2.00 per acre, adjusted annually by the Producer Prices and Price Indexes. The requirement that a lease must achieve production in commercial quantities before it can qualify for a reduction in the minimum royalty payment was deleted.

The Environmental Protection Agency (EPA) relaxed proposed standards in the final regulations for operators who inject hazardous materials into underground wells as part of mining operations. These were released in two parts: 45 F.R. 33290 and 45 F.R. 42472. These proposed standards outline minimum requirements that States must set for solution mining potash, among others.

EPA issued a guideline in July 1979 (EPA 440/T-76/059b) that prohibits the potash industry from discharging process-generated waste water pollutants to navigable waters, based on the application of the best practicable control technology currently available. The EPA does not consider this to be a burden to the potash industry because all present producers dispose of waste streams by using evaporation ponds in arid regions.

BLM held a Potassium Lease sealed bid auction May 1, 1980, containing 800 acres in the Carlsbad area. The site was about 3 miles east of Mississippi Chemical Corp.'s present mine.

Public Land Order 5774, November 12, 1980, issued by the Land Management Agency of BLM, reminded the general public that New Mexico (and other) lands had been open for potash (and other) exploration leasing since 1920, through the Leasing Act of 1920. The above-mentioned order was issued to clear up the status of the pre-1920 withdrawals. The order was not a new release of land for potash exploration leasing.

The U.S. International Trade Commission initiated an investigation to consider revoking the antidumping finding concerning muriate from Canada. There was an antidumping finding in November 1969; however, all Canadian producers but one have been excluded from that finding over the years.

The Waste Isolation Pilot Plant (WIPP) office issued the Final Environmental Impact Statement (45F.R.70539) October 24, 1980, on the proposed WIPP site near the potash mines. Congress passed a law (Public Law 96-164, Sec. 213) to keep the WIPP site strictly for defense waste. Transuranics will be stored at the site along with several high-level waste experiments.

Table 1.—Salient potash statistics[1]

(Thousand metric tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Production	4,016	4,241	4,326	4,271	4,315
K_2O equivalent	2,177	2,229	2,253	2,225	2,239
Sales by producers	4,184	4,241	4,358	4,549	4,265
K_2O equivalent	2,268	2,232	2,307	2,388	2,217
Value[2]	$210,800	$206,900	$226,500	$279,200	$353,900
Average value per ton product	$50.37	$48.78	$51.97	$61.38	$82.98
Average value per ton K_2O equivalent	$92.93	$92.68	$98.16	$116.92	$159.63
Exports[3]	1,514	1,497	1,431	1,119	1,289
K_2O equivalent	857	845	809	635	762
Value[4]	$91,900	$90,200	$88,600	$79,500	$153,100
Imports for consumption[3 5]	6,875	7,608	7,762	8,505	8,193
K_2O equivalent	4,168	4,605	4,707	5,165	4,972
Customs value	$344,000	$374,000	$399,000	$520,800	$648,000
Apparent consumption[6]	9,544	10,352	10,689	11,935	11,169
K_2O equivalent	5,578	5,992	6,205	6,918	6,427
Yearend producers' stocks, K_2O equivalent	471	467	414	251	273
World production, marketable K_2O equivalent	[r]24,281	[r]25,156	[r]26,173	[r]25,933	27,871

[r]Revised.
[1]Includes muriate and sulfate of potash, potassium magnesium sulfate, and some parent salts. Excludes other chemical compounds containing potassium.
[2]F.o.b. mine.
[3]Excludes potassium chemicals and mixed fertilizers.
[4]F.a.s. U.S. port.
[5]Includes nitrate of potash.
[6]Measured by sales plus imports minus exports.

DOMESTIC PRODUCTION

Domestic production has been essentially unchanged for the past 4 years. In 1980, 79% of all production was potassium chloride (standard, coarse, or granular), and 9% was potassium sulfate. The remaining production was made up of manure salts, potassium chloride (soluble and chemical), and potassium magnesium sulfate. The New Mexico potash producers accounted for 84% of the total domestic potash production. New Mexico mine production in 1980 was 18 million tons of 13.6% K_2O equivalent crude salts. This was down from 13.8% in 1979 and 14.2% in 1978. Production in other States is from brines or solution mining, so no comparable ore grade is available.

Seven companies produced potash in New Mexico in 1980 from underground, bedded deposits in the Carlsbad area. The companies were AMAX Chemical Corp. of AMAX Inc., Duval Corp. of Pennzoil Co. Inc., Kerr-McGee Chemical Corp. of Kerr-McGee Corp., Mississippi Chemical Corp., National Potash Co. of Freeport Minerals Co., and Potash Co. of America of Ideal Basic Industries, Inc. AMAX Chemical Corp. has started a 15% refinery capacity increase which should be completed by 1983. About 70% of the mining in New Mexico was by undercutting, drilling, blasting, and loading, and the remainder was by continuous mining methods. Sylvinite ores were mined to produce muriate of potash (potassium chloride) with table salt (sodium chloride) and clay as waste. Langbeinite ore was also mined to produce sulfate of potash (potassium sulfate) and potassium magnesium sulfate. Sulfate of potash is also produced by reacting muriate of potash with sulfuric acid. Three plants in Texas use this process.

There were three potash producers in Utah in 1980. Great Salt Lake Minerals & Chemicals Corp. of Gulf Resources and Chemical Corp. produced potassium sulfate as a coproduct from the Great Salt Lake brines. Kaiser Aluminum & Chemical Corp. of Kaiser Industries Corp. produced muriate of potash from natural near-surface brines at the west end of the Bonneville Salt Flats near Wendover, Utah. Texasgulf, Inc., produced muriate of potash from underground mines near Moab, Utah, using solution mining techniques.

In California in 1980, Kerr-McGee Chemical Corp. produced both muriate and sulfate of potash from underground brines at Searles Lake.

Table 2.—Production, sales, and inventory of U.S. produced potash

(Thousand metric tons and thousand dollars)

	Production				Sold or used						Stocks, end of 6-month period			
	Gross weight		K_2O equivalent		Gross weight		K_2O equivalent		Value[1]		Gross weight		K_2O equivalent	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	673	701	408	426	751	702	456	427	37,100	51,400	207	169	125	102
Coarse	311	281	190	172	379	274	232	168	22,400	22,500	55	58	33	35
Granular	439	468	266	283	526	463	319	281	30,900	37,200	58	68	35	41
Chemical	42	30	26	19	41	30	26	19	W	W	1	4	1	3
Potassium sulfate	212	222	109	114	[r]199	202	103	104	22,500	29,700	52	62	27	32
Other potassium salts[2]	515	528	124	132	504	523	121	127	W	W	264	243	59	58
Total[3]	2,192	2,230	1,123	1,145	2,400	2,194	1,257	1,125	139,600	172,600	637	603	280	271
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	674	729	410	443	711	731	432	445	40,500	59,500	170	167	103	101
Coarse	308	271	188	166	312	262	191	160	20,300	23,100	51	67	31	41
Granular	472	447	287	271	466	441	283	267	30,500	38,700	64	74	39	45
Chemical	41	32	26	20	38	35	24	22	W	W	4	1	2	1
Potassium sulfate	186	175	96	90	196	190	101	97	23,700	30,400	42	47	22	24
Other potassium salts[2]	399	431	95	105	425	412	100	101	W	W	237	262	54	61
Total[3]	2,080	2,086	1,102	1,094	2,149	2,071	1,132	1,092	139,600	181,300	568	618	251	273
Grand total[3]	4,271	4,315	2,225	2,239	4,549	4,265	2,388	2,217	279,200	353,900	XX	XX	XX	XX

[r]Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]F.o.b. mine.
[2]Includes soluble muriate, manure salts, and potassium magnesium sulfate.
[3]Data may not add to totals shown because of independent rounding.

Table 3.—Production and sales of potash in New Mexico

(Thousand metric tons and thousand dollars)

Period	Crude salts[1] (mine production)		Marketable potassium salts				
			Production		Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value[2]
1979:							
January-June	8,660	1,190	1,852	931	2,047	1,055	114,700
July-December	8,693	1,208	1,783	934	1,826	950	114,100
Total	17,353	2,398	3,635	1,865	3,873	2,005	228,800
1980:							
January-June	8,985	1,232	1,872	945	1,889	952	143,600
July-December	9,046	1,222	1,788	926	1,756	916	145,400
Total	18,031	2,454	3,660	1,871	3,645	[3]1,869	289,000

[1]Sylvinite and langbeinite.
[2]F.o.b. mine.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Salient sulfate of potash statistics[1]

(Thousand metric tons of K_2O and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Production	211	221	205	205	203
Sales by producers	214	221	222	204	201
Value[2]	$47,100	$42,400	$45,300	$46,230	$60,080
Exports[3]	84	84	83	81	113
Imports	21	34	29	10	22
Value[4]	$4,500	$6,800	$6,230	$2,710	$7,111
Apparent consumption[5]	151	171	169	133	110
Yearend producers' stocks	38	38	21	22	24

[1]Excluding potassium magnesium sulfate.
[2]F.o.b. mine.
[3]Export data supplied by Potash & Phosphate Institute.
[4]C.i.f. to U.S. port.
[5]Sales plus imports minus exports. independent rounding.

CONSUMPTION AND USES

Apparent domestic consumption of all forms of potash was down in 1980 because of adverse weather conditions for the farmers and higher prices for the three fertilizers. The decline in apparent domestic potash consumption was made up of a 7% decline in sales by domestic producers and a 4% decline in imports.

According to the Potash & Phosphate Institute, the consumption of muriate of potash declined as follows: Standard grade fell 11% to less than 1 million tons, coarse grade fell 9% to 2.2 million tons, and granular fell 14% to 1.7 million tons. Sulfates, both potassium sulfate and potassium magnesium sulfate, rose 38% to 250,000 tons.

The Potash & Phosphate Institute reported that U.S. domestic agricultural sales of potash from Canadian and U.S. producers were 40% coarse muriate, 30% granular muriate, 17% standard muriate, 8% soluble, and 4% sulfates. Of these fractions, potash from mines in the United States was 42% of the standard sales, 9% of the coarse sales, 20% of the granular sales, 4% of the soluble sales, and 100% of the sulfate sales.

In addition, the Potash & Phosphate Institute reported that 355,000 metric tons of potash were sold for chemical uses. Standard muriate was 68% of the nonagricultural sales, soluble muriate was 30%, and the rest were sulfates. Nonagricultural use of potash is primarily for caustic potash-chlorine plants.

Caustic potash was used as the major pathway to the other potassium chemicals, as well as for other uses. Some muriate also was used in petroleum well drilling muds for shale stabilization and petroleum well stimulation by massive fracturing to stabilize clay particles.

According to the Potash & Phosphate Institute, the top six States for agricultural consumption of potash were Illinois, Iowa, Ohio, Indiana, Minnesota, and Wisconsin. These six States consumed 55% of the agricultural potash from U.S. and Canadian producers. The top six States for agricultural consumption using domestically produced potash were Mississippi, Texas, Florida, Missouri, Georgia, and California. These six States consumed 55% of the agricultural potash from U.S. producers.

Table 5.—Sales of North American potash, by State of destination

(Metric tons of K_2O equivalent)

Destination	Agricultural potash		Nonagricultural potash	
	1979	1980	1979	1980
Alabama	121,914	112,613	66,424	54,893
Alaska	--	--	--	88
Arizona	1,595	1,266	2,236	2,746
Arkansas	62,642	54,526	367	486
California	67,848	62,078	9,325	10,955
Colorado	23,116	29,332	220	291
Connecticut	4,632	5,713	142	1
Delaware	31,623	30,596	29,170	28,275
Florida	162,561	183,035	745	944
Georgia	230,437	202,651	594	181
Hawaii	21,555	22,697	--	--
Idaho	14,801	13,236	--	19
Illinois	898,657	843,752	41,607	29,782
Indiana	522,627	448,642	5,645	5,620
Iowa	627,806	528,721	227	443
Kansas	54,806	40,593	2,500	3,543
Kentucky	158,811	143,689	16,113	15,131
Louisiana	54,638	47,111	4,404	3,830
Maine	9,949	9,570	--	68
Maryland	48,442	33,770	1,444	1,468
Massachusetts	3,342	4,198	816	631
Michigan	202,314	197,546	2,916	2,645
Minnesota	484,547	415,802	59	57
Mississippi	234,288	248,918	9,294	6,808
Missouri	313,801	272,853	4,209	3,885
Montana	9,393	7,196	66	13
Nebraska	55,086	52,522	151	211
Nevada	68	--	797	629
New Hampshire	293	435	--	--
New Jersey	11,936	8,532	965	608
New Mexico	2,445	5,600	6,886	12,558
New York	74,587	53,319	49,664	44,269
North Carolina	127,173	126,006	258	634
North Dakota	21,567	15,556	79	78
Ohio	453,957	482,688	49,002	46,524
Oklahoma	28,266	26,583	5,310	12,266
Oregon	23,414	20,477	1,451	1,774
Pennsylvania	67,531	54,437	4,073	3,835
Rhode Island	2,131	2,209	133	161
South Carolina	85,003	80,653	214	318
South Dakota	15,752	10,470	23	--
Tennessee	157,325	125,948	31	79
Texas	199,218	117,123	36,372	52,209
Utah	6,659	1,142	661	1,288
Vermont	6,970	5,566	--	--
Virginia	65,458	59,083	778	1,087
Washington	38,978	29,210	2,899	2,937
West Virginia	8,577	4,720	28	--
Wisconsin	355,596	308,973	267	166
Wyoming	3,328	4,060	1,066	931
Total	6,177,463	5,555,416	359,631	355,365

Source: Potash & Phosphate Institute.

Table 6.—Sales of North American muriate of potash to U.S. customers, by grade

(Thousand metric tons of K_2O)

	1977	1978	1979	1980
Agricultural:				
Standard	1,042	954	1,067	948
Coarse	1,978	2,305	2,459	2,228
Granular	1,641	1,747	1,952	1,687
Soluble	380	387	522	447
Total	5,041	5,393	6,000	5,310
Nonagricultural:				
Soluble	102	103	118	108
Other	193	191	237	242
Total	295	294	355	350
Grand total	5,336	5,687	6,355	5,660

Source: Potash & Phosphate Institute.

STOCKS

Yearend 1980 producers' stocks of potash rose slightly to 1.5 months of average 1980 production. All types of potash products stocks increased from yearend 1979 to yearend 1980, except for a small decrease in standard muriate.

TRANSPORTATION

The Fertilizer Institute has estimated that in 1978 85% of potash tonnage moved by rail, 11% of potash tonnage moved by truck (not including movements from warehouse to retailer or from retailer to farmer), and 3% of potash tonnage moved by railroad/water combinations. Deregulation of railroad and truck rates and service started in 1980.

PCS added a third warehouse in Springfield, Ill., to the number of facilities (Seneca, Ill., and Waterloo, Iowa) that receive unit train shipments of potash from Saskatchewan. PCS started construction of a fourth facility at Danville, Ill.

Potash shipping declined so that there was an excess of about 500 to 700 cars per day available in the fall of 1980.

PRICES

The average value, f.o.b. mine, of U.S. potash production of all types and grades in 1980 was $160 per ton. The average value, f.o.b. mine, of the first half of the year was $153 per ton, and the average value for the second half of the year was $166 per ton. The average value per ton for the three major muriate grades was $133 for the year. The individual average year prices were standard, $127; coarse, $139; and granular, $139. The average value per ton for sulfate of potash for 1980 was $299.

Table 7.—Prices[1] of U.S. potash, by type and grade

(Dollars per metric ton K_2O)

	1978		1979		1980	
	January-June	July-December	January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:						
Standard	$66.45	$69.46	$81.33	$93.70	$120.30	$133.82
Coarse	81.36	82.26	96.63	106.26	134.28	144.69
Granular	82.97	84.38	96.79	107.53	132.48	145.10
All muriate[2]	75.04	76.88	89.75	100.66	126.88	139.27
Sulfate, 50% K_2O minimum	205.44	194.08	218.87	234.61	285.75	313.06

[1]Average prices, f.o.b. mine, based on sales.
[2]Excluding soluble and chemical muriates.

FOREIGN TRADE

Total U.S. exports of potash in 1980 increased 20% from 1979 but had not returned to the 1977-78 levels. The potassium sulfates exports declined 50% below that of 1979 and accounted from only 6% of exports. Muriate exports increased 32% from 1979.

Total U.S. imports of potash decreased 4% in 1980, with muriate and potassium sodium nitrate mixtures decreasing and potassium sulfate and potassium nitrate increasing. Potassium sulfate imports increased by more than 100%. However, potassium sulfate imports are less than 0.5% of the total imports. Muriate from Canada declined 5% but was still 95% of muriate imports and 94% (by K_2O equivalents) of all imports. Israel was the second largest shipper with 4% of muriate imports and 4% of all imports because it ships both muriate and potassium nitrate.

Table 8.—U.S. exports of potash

	Approximate average K_2O content (percent)	1979			1980		
		Quantity (metric tons)		Value[1] (thousands)	Quantity (metric tons)		Value[1] (thousands)
		Product	K_2O equivalent[e]		Product	K_2O equivalent[e]	
Potassium chloride, all grades	61	891,200	543,600	$66,050	1,175,000	717,000	$134,140
Potassium sulfates, all grades[2]	40	227,800	91,100	13,410	113,900	45,600	18,970
Total[3]	--	1,119,000	634,700	79,500	1,289,000	762,000	153,100

[e]Estimated.
[1]Export values are f.a.s., American port.
[2]This includes potassium magnesium sulfate, so the combined K_2O equivalent is estimated at 40%.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 9.—U.S. exports of potash, by country

	Metric tons product						Total value[2 3] (thousands)	
	Chloride		Potassium sulfate, all grades[1]		Total[2]			
	1979	1980	1979	1980	1979	1980	1979	1980
Latin America:								
Argentina	1,700	1,200	3,800	7	5,500	1,200	$420	$170
Belize	360	630	9	--	370	630	45	120
Brazil	436,700	509,300	15,300	2,600	452,000	511,900	36,700	65,100
Chile	--	40	7,400	16,400	7,400	16,500	1,100	2,800
Colombia	19,700	43,800	3,000	36	22,600	43,900	1,670	4,580
Costa Rica	24,900	14,800	3,700	5,050	28,600	19,800	1,960	2,560
Dominican Republic	37,000	52,300	1,500	440	38,500	52,700	3,300	6,990
Ecuador	12,700	17,100	--	80	12,700	17,200	870	2,200
El Salvador	50	--	3,900	--	3,950	--	380	--
Guatemala	9,900	10,900	--	18	9,900	10,900	920	1,420
Guyana	750	2,730	--	--	750	2,730	140	510
Honduras	920	15	230	--	1,150	15	190	1
Jamaica	5,100	5,800	20	--	5,120	5,800	405	690
Mexico	33,500	63,200	54,100	9,800	87,600	73,000	2,700	7,050
Nicaragua	--	6,500	--	--	--	6,500	--	880
Panama	400	1,720	--	--	400	1,720	90	240
Paraguay	250	--	--	--	250	--	23	--
Peru	7,300	13,750	--	2,500	7,300	16,300	700	2,150
Trinidad	30	15	--	--	30	15	1	1
Uruguay	1,800	6,420	700	--	2,500	6,420	170	800
Venezuela	--	14,100	20	3,400	20	17,500	2	2,400
Other	--	--	60	--	60	--	2	--
Total[2]	593,000	764,300	93,700	40,400	686,700	805,000	51,800	100,600

See footnotes at end of table.

Table 9.—U.S. exports of potash, by country —Continued

	Metric tons product							
	Chloride		Potassium sulfate, all grades[1]		Total[2]		Total value[2 3] (thousands)	
	1979	1980	1979	1980	1979	1980	1979	1980
Oceania:								
Australia	6,100	28,300	2,400	1,320	8,500	29,700	$780	$3,980
Canada	1,400	33,600	94,400	40,400	95,800	74,100	4,730	10,700
New Zealand	165,000	141,600	780	380	165,800	142,000	10,400	12,800
Total[2]	172,500	203,600	97,600	42,100	270,000	245,700	15,900	27,500
Asia:								
Japan	55,300	91,500	35,800	29,900	91,100	121,300	7,700	13,000
Indonesia	400	21,000	--	--	400	21,000	16	2,740
Korea, Republic of	970	160	9	17	980	175	35	15
Malaysia	10,400	--	700	--	11,100	--	890	--
Philippines	--	7,180	--	1,500	--	8,700	--	1,120
Saudi Arabia	740	70	--	--	740	70	36	13
Singapore	--	10,500	--	--	--	10,500	--	1,270
Taiwan	--	30,300	50	--	50	30,300	4	3,160
Other	540	60	13	--	550	60	21	10
Total[2]	68,400	160,700	36,600	31,400	105,000	192,100	8,700	21,300
Europe:								
Belgium-Luxembourg	3,500	--	--	--	3,500	--	270	--
Denmark	26,900	44,800	--	--	26,900	44,800	1,460	3,460
France	10,000	--	--	--	10,000	--	200	--
Ireland	4,300	--	--	--	4,300	--	320	--
Italy	12,000	--	--	--	12,000	--	790	--
Sweden	--	870	--	--	--	870	--	170
Other	--	--	--	18	--	18	--	3
Total[2]	56,700	45,700	--	18	56,700	45,700	3,040	3,630
Africa:								
Benin	230	--	--	--	230	--	31	--
Gambia	--	--	65	--	65	--	2	--
Libya	180	--	--	--	180	--	4	--
Other	210	220	--	--	210	220	30	48
Total[2]	620	220	65	--	685	220	70	48
Grand total[2]	891,200	1,175,000	227,800	113,900	[r]1,119,000	1,289,000	79,500	153,100

[r]Revised.
[1]This includes potassium magnesium sulfate.
[2]Data may not add to totals shown because of independent rounding.
[3]F.a.s. U.S. port.

Source: U.S. Bureau of the Census.

Table 10.—U.S. imports of potash

	Approximate average K_2O content (percent)	Quantity (metric tons)		Value (thousands)	
		Product	K_2O equivalent[e]	Customs	C.i.f.
1979					
Potassium chloride	61	8,428,000	5,141,000	$510,800	$654,300
Potassium sulfate	50	20,200	10,100	2,370	2,710
Potassium nitrate	45	19,100	8,600	3,640	3,990
Potassium sodium nitrate mixtures	14	37,700	5,300	4,000	4,660
Total[1]	--	8,505,000	5,165,000	520,800	665,600
1980					
Potassium chloride	61	8,080,000	4,929,000	628,700	753,800
Potassium sulfate	50	44,800	22,400	6,550	7,110
Potassium nitrate	45	35,600	16,000	8,620	9,600
Potassium sodium nitrate mixtures	14	32,500	4,550	4,050	4,880
Total[1]	--	8,193,000	4,972,000	648,000	775,300

[e]Estimated.
[1]Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

Table 11.—U.S. imports of potash, by country

Country	Metric tons product: Chloride 1979	Chloride 1980	Sulfate 1979	Sulfate 1980	Nitrate 1979	Nitrate 1980	Potassium sodium nitrate 1979	Potassium sodium nitrate 1980	Total 1979	Total 1980	Total value (thousands): Customs 1979	Customs 1980	C.i.f. 1979	C.i.f. 1980
Belgium-Luxembourg	--	--	7,500	14,800	--	--	--	--	7,500	14,800	$840	$2,040	$980	$2,250
Canada	8,026,500	7,642,200	240	--	230	--	1,420	--	8,028,400	7,642,200	482,100	587,600	622,300	706,700
Chile	--	5,900	--	--	--	--	36,200	32,400	36,200	38,300	3,720	4,430	4,330	5,280
El Salvador	22	--	--	--	--	--	--	--	22	--	1	--	2	--
France	--	--	3,200	--	--	--	--	--	3,200	--	400	--	460	--
German Democratic Republic	68,000	57,300	--	--	--	--	--	--	68,800	57,300	3,880	4,410	4,500	6,500
Germany, Federal Republic of	12,400	10,030	9,200	29,970	--	--	--	--	21,600	40,000	2,010	5,450	2,440	6,200
Israel	285,100	312,100	--	--	18,900	35,600	--	--	304,000	347,700	25,640	40,260	28,110	43,600
Japan	--	--	--	--	--	--	110	130	110	130	22	26	31	40
Mexico	91	--	--	--	--	--	--	--	91	--	6	--	8	--
Netherlands	--	3,150	--	--	--	--	--	--	--	3,150	--	330	--	420
Spain	20,500	11,000	--	--	--	--	--	--	20,500	11,000	1,420	920	1,540	1,040
U.S.S.R	12,100	38,400	--	--	--	--	--	--	12,100	38,400	605	2,400	830	3,350
Yemen Arab Republic	2,300	--	--	--	--	--	--	--	2,300	--	140	--	180	--
Total[1]	8,428,000	8,080,000	r20,200	44,800	19,100	35,600	37,700	32,500	8,505,000	8,193,000	520,800	648,000	665,700	775,300

r Revised.

1 Data may not add to totals shown because of independent rounding.

Source: U.S. Bureau of the Census.

WORLD REVIEW

For 1980, the total world potash production was estimated at 27.9 million tons, up 7% from 1979. Of this, the U.S.S.R. and the German Democratic Republic produced 11.4 million tons or 41% of the total. North America produced 9.8 million tons or 35% of the world total. Western Europe produced 5.8 million tons or 21% of the world total.

Brazil.—Petroquisa, a State-owned company, awarded a contract for mine and mill construction at the Sergipe State site to the French potash producer Enterprise Miniere et Chemique (EMC) and a French engineering firm.

Canada.—The damaged railroad bridge across Vancouver Harbor was repaired by March 5, and potash offshore exports from Canada returned to normal.

PCS, a crown corporation, continued its expansion program at the Rocanville, Lanigan, Cory, and Allan Mines. PCS had also started the Environmental Impact Assessment study for a 2-million-ton potash plant at Bredenbury. PCS also took operational control over the Allan Mine, which is 40% owned by Texasgulf, Inc., of the United States. Cominco, Ltd., Potash Corp. of America, and Kalium Chemicals, Ltd., announced expansion plans of roughly one-third of present capacity for each. PCS started a study of the production of potassium sulfate from reacting potassium chloride with sodium sulfate. The sodium sulfate is mined near the Saskatchewan potash mines.

The Potash Corp. of America decided to go ahead with the development of the mill at the Sussex, New Brunswick site. Nearby at Salt Springs, New Brunswick, Denison Mines sold 40% interest in the site to Potash Co. of Canada (Potacan), the former owners of the Alwinsal (Lanigan) Mine in Saskatchewan. Dension Mines will operate the mine, and Potacan will market the product. Potacan is jointly owned by EMC of France and Kali und Salz Aktiengesellschaft of the Federal Republic of Germany. EMC, the State-owned potash monopoly in France, controls the Mines de Potasse d'Alsace and is affiliated with the Belgium companies that convert muriate of potash to sulfate of potash. Kali und Salz is controlled by BASF Winthershall Group of the Federal Republic of Germany, and is the largest potash producer in that country.

BP Exploration Canada Ltd. won the rights to explore and develop the third New Brunswick site called Millstream. BP Exploration was one of five bidders and offered to the Province a percentage of profits beyond a specified company return on investment.

International Minerals & Chemicals Corp. (Canada) has started an exploration and evaluation program at a site southwest of St. Lazare, Manitoba. The Province of Manitoba has an option to take up to 25% participation.

Table 12.—Salient statistics on Canadian potash

(Thousand metric tons of K_2O equivalent)

	1977	1978	1979	1980
Production[1]	6,089	6,124	6,715	7,300
Domestic sales by domestic producers[1]	249	370	379	378
Exports:				
United States[1]	4,198	4,498	4,931	4,563
Overseas[1]	1,232	1,596	1,846	2,170
Imports for consumption[2]	31	39	29	33
Domestic consumption[3]	[r]280	409	408	411
Yearend producers' stocks[1]	1,183	832	378	564

[r]Revised.
[1]Data supplied by the Potash & Phosphate Institute.
[2]From U.S. Bureau of the Census export data, assumed 30% K_2O equivalent for the mixture of potassium sulfate and potassium-magnesium sulfate and 61% K_2O equivalent for potassium chloride, according to the estimated relative tonnages to Canada.
[3]Domestic sales by domestic producers plus imports.

China, Mainland.—In 1980, China released official potash production figures for the first time in 20 years. Actual production is nearly an order of magnitude smaller than past estimated figures. The world production table has been revised to include these official numbers. Canpotex Ltd. of Canada signed an agreement to export to China at least 650,000 tons per year for 3 years. Kali-Export, GmbH, representing Kali und Salz Ag, EMC, and Cleveland Potash Ltd. (U.K.) signed an agreement to export 100,000 tons per year to China for 3 years.

France.—French production is restricted to under 2 million tons per year because of the Rhine River pollution problem. The French discarded most of their waste sodium chloride into the Rhine River, and downstream water users vigorously protested the level of pollution.

Peru.—A technical service agreement was signed to study the possible extraction of potash from the saline brines of a large phosphate deposit in Peru.

Spain.—The Potasas de Navarra's Pamplona Mine has been suffering losses over the past several years, and the owners, INI, a State holding company, were considering closing the mine. Strikes, high production costs, and declining ore grade have made the mine unprofitable.

Union Explosivos Rio Tinto S.A. was granted a development lease for potash reserves in the Catalan area.

U.S.S.R.—Potash production in 1979 was less than formerly estimated, being only 6,635,000 tons. Part of the problem seemed to be transportation bottlenecks, but Berezniki No. 2 mine was not operated for 127 days, and Solikamsk No. 2 was not operated for 104 days. There were rumors of flooded mines at the time, but there has never been an official confirmation. An unknown amount of capacity was added by Soligorsk No. 4 mine during 1980. The U.S.S.R. production for 1980 was estimated as near 1978 levels. The new shiploading operation at Ventspils in Latvia was put into operation in late 1980. Designed capacity has been put at 2 million tons of potash per year.

In November, the mineral fertilizer ministry was separated from the rest of the chemical ministry to improve the mineral fertilizer industry's production results and expansion planning.

United Kingdom.—The Cleveland Potash production target was reduced to 220,000 tons, and the work force was reduced to about 850 persons. The cost of production has been high, and with the high exchange rate of the pound sterling, offshore sources of potash have been available at lower prices to the United Kingdom consumers.

Table 13.—Marketable potash: World production by country[1]

(Thousand metric tons of K_2O equivalent)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Canada (sales)[3]	[r]5,215	[r]5,764	6,340	7,074	[4]7,532
Chile[5]	[r]17	[r]11	15	21	21
China, mainland[6]	[r]12	[r]18	[r]21	[r]16	12
Congo	254	[r]136	--	--	--
France	1,603	[r]1,580	1,795	1,920	[4]1,939
German Democratic Republic	3,161	3,229	3,323	3,395	[4]3,422
Germany, Federal Republic of	2,036	2,341	2,470	2,690	[4]2,674
Israel	680	[r]707	695	730	[4]797
Italy	[r]140	[r]151	196	182	185
Spain	630	[r]562	722	781	770
U.S.S.R	8,310	8,347	8,193	6,635	8,000
United Kingdom	[r]46	81	150	264	280
United States	2,177	2,229	2,253	2,225	[4]2,239
Total	[r]24,281	[r]25,156	26,173	25,933	27,871

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Apr. 27, 1981.

[2]In addition to the countries listed, Australia apparently produced small quantities of marketable potash during 1976-80, but output was not reported quantitatively, and general information was inadequate for the formulation of reliable estimates of output levels.

[3]Official Government figures. Potash & Phosphate Institute production data are given in table 12.

[4]Reported figure.

[5]Series revised; new data represent offically reported output of potassium nitrate product (gross weight basis) converted assuming 14% K_2O equivalent.

[6]Series revised to reflect officially reported Chinese data on production of potassic fertilizers in terms of nutrient content; small additional quantities may be produced and used by the nonfertilizer chemical industry.

TECHNOLOGY

The Bureau of Mines Salt Lake City Research Center continued with studies on recovery of potash from low-grade resources. The project is divided into two parts: Potash recovery from carnallite, and potash recovery from plant process and waste brines by solar evaporation.

The Bureau of Mines Denver Research Center continued an investigation of longwall mining in evaporite (trona and salt) deposits for maximum resource recovery. Investigators have been installing pressure cells in trona and salt ore bodies, then mining past the cells. Previously formulated finite element analysis was compared to pressure cell results to "calibrate" the finite elements model.

The Bureau of Mines Tuscaloosa Research Center published a report concerning the dewatering of clay wastes.[3] Potash-clay brine slurry was consolidated from 3.8% to 35% solids by using high-molecular-weight nonionic polyethylene oxide polymer.

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[1]Physical scientist, Section of Nonmetallic Minerals.

[2]All quantities in this report are in metric tons, K_2O equivalent, unless otherwise noted.

[3]Smelley, A. G., B. J. Scheiner, and J. R. Zatko. Dewatering of Industrial Clay Wastes. BuMines RI 8498, 1980, 13 pp.

Pumice and Volcanic Cinder

By Arthur C. Meisinger[1]

Production of pumice, pumicite, volcanic cinder, and scoria in 1980, by U.S. producers, declined 15% in the quantity sold or used to 3.8 million tons valued at $15.5 million, compared with 4.4 million tons valued at $15.5 million in 1979. The 1980 output came from 319 operations in 12 States, compared with 327 operations in 12 States in the previous year. Four States, Arizona, California, New Mexico, and Oregon, accounted for 82% (3.1 million tons) of total domestic output, an increase of 12% over that in 1979.

U.S. consumption (excluding imports) of pumice and pumicite was 543,000 tons, a significant decrease from the 1979 total of nearly 1.2 million tons. The 54% decline in quantity was attributed primarily to the inactivity of a major pumicite producer during the year. The quantity of volcanic cinder and scoria sold or used in 1980 was 3.2 million tons, of which 44% was produced by U.S. Forest Service operations, primarily for road construction and maintenance.

The weighted average value of pumice and related volcanic materials in 1980 increased 17% from $3.52 per ton (revised) in 1979 to $4.12 per ton. The higher cost for processing pumice during the year contributed greatly to this increase.

Pumice imports totaled 194,318 tons in 1980. This was a sharp increase over the 61,713 tons imported in 1979, owing to more normal resumption of shipments from Greece.

Table 1.—Salient pumice and volcanic cinder statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States: Sold and used by producers:					
Pumice and pumicite	906	1,178	1,208	r1,172	543
Value[1]	$3,830	$4,625	$4,836	r$4,864	$4,267
Average value per ton	$4.23	$3.93	$4.00	r$4.24	$7.86
Volcanic cinder and scoria	3,228	2,831	3,549	r3,239	3,212
Value[1]	$6,636	$7,340	$9,619	r$10,645	$11,217
Average value per ton	$2.06	$2.59	$2.71	r$3.29	$3.49
Exports	1	2	e2	e2	e1
Imports for consumption	81	253	216	62	194
World: Production, pumice and related volcanic materials	r17,576	r17,994	19,179	p18,004	e17,712

eEstimated. pPreliminary. rRevised.
[1]Values f.o.b. mine and/or mill.

DOMESTIC PRODUCTION

Production of pumice, pumicite, volcanic cinder, and scoria by U.S. producers in 1980 declined nearly 15% in quantity to 3.8 million tons, compared with 4.4 million tons in 1979. Value of output remained at $15.5 million. Domestic output came from 76 individuals, firms, and governmental agencies producing from 319 operations in 12

Table 2.—Pumice, pumicite, volcanic cinder, and scoria sold and used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Arizona	940	2,367	990	3,228
California	r794	r3,478	568	3,159
Hawaii	359	1,240	314	1,200
New Mexico	r603	3,550	448	3,028
Oklahoma	1	W	1	W
Oregon	r722	r1,555	1,090	2,734
Utah	28	280	35	347
Washington	63	202	23	W
Other States[1]	901	r2,837	286	1,788
Total	r4,411	r15,509	3,755	15,484
American Samoa	2	15	3	32

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other States."
[1]Colorado, Idaho, Kansas, Nevada, Oklahoma (value only), Washington (value only, 1980).

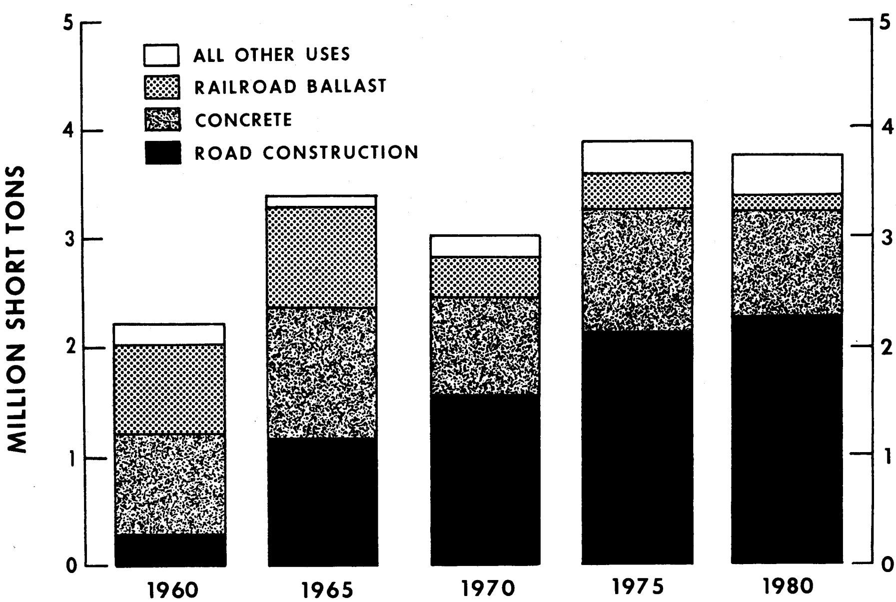

Figure 1.—Pumice and related volcanic materials sold and used by producers in the United States, by use.

States, compared with 75 producers and 327 operations in 12 States (revised) in 1979. California led all producing States in 1980 with 121 active operations, followed by Oregon with 86, and Arizona with 40. The combined quantity of pumice and related volcanic materials produced in Arizona, California, New Mexico, and Oregon was 3.1 million tons, or 82% of the national total, compared with 69% the previous year.

Production of volcanic cinder and scoria in 1980 declined less than 1% in quantity, but increased 5% in value compared with that in 1979. Of the 3.2 million tons produced in 1980, 1.4 million tons (44%) came from U.S. Forest Service operations in Arizona, California, Oregon, and Washington, compared with 926,000 tons (21%) from U.S. Forest Service operations in 1979. Output of pumice and pumicite in 1980 declined significantly in quantity (54%) and much less (12%) in value, compared with that in 1979. The nearly 629,000-ton decrease to 543,000 tons was attributed primarily to the inactivity of a major pumicite producer.

Of the 12 States with reported production in 1980, pumice and pumicite (volcanic ash) was produced in 8 States, and volcanic cinder (including scoria) was produced in 10 States and American Samoa.

CONSUMPTION AND USES

Apparent domestic consumption (sold or used, plus imports, minus exports) of pumice and related volcanic materials in 1980 was approximately 3.9 million tons, a decrease of 12% from that of 1979.

Consumption of domestic pumice and pumicite in concrete admixture and aggregate (the major end use, table 3) was 58% lower than that in 1979. Nearly all of the 635,000-ton decrease in 1980 was attributed to the loss in supply of pumicite for concrete admixture by an idle major producer. Pumice used as landscaping material declined in quantity, but increased in value compared with that in 1979.

Other uses of domestic pumice and pumicite, including abrasives, totaled 65,000 tons valued at $1.5 million, an increase of 23% in quantity and 7% in value over that reported in 1979.

Total consumption of domestic volcanic cinder and scoria was only 1% lower than the quantity (revised, table 4) reported in 1979. The amount consumed in road construction, the principal end use, increased 23% in quantity and 20% in value compared with consumption in 1979. The amount used as landscaping material also increased in quantity and value, but volcanic cinder and scoria used in concrete aggregate and other applications showed significant declines in quantity and value compared with that used in 1979.

Table 3.—Pumice and pumicite sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	r26	r520	27	568
Concrete admixture and concrete aggregate	1,094	r3,266	459	2,515
Landscaping	25	196	19	249
Other uses[1]	r27	r882	38	935
Total	r1,172	r4,864	543	4,267

rRevised.
[1]Includes absorbents (1979), asphalt mix (1979), decorative building block, heat-or-cold insulating medium, pesticide carriers, road construction material, roofing granules, and miscellaneous uses.

Table 4.—Volcanic cinder and scoria sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Concrete admixture and aggregate[1]	744	3,066	514	3,316
Landscaping	r191	r2,244	209	2,513
Railroad ballast	193	400	140	377
Road construction and maintenance	r1,839	r3,817	2,267	4,585
Other uses[2]	272	1,118	82	426
Total	r3,239	r10,645	3,212	11,217

rRevised.
[1]Includes cinder block (1980).
[2]Includes asphalt mix (1980), horticultural uses, roofing granules, and miscellaneous uses.

PRICES

Price quotations in the American Paint and Coatings Journal in 1980 remained unchanged for pumice and pumicite for the 11th consecutive year. Prices quoted in Chemical and Marketing Reporter for pumice from domestic and foreign sources were unchanged from 1979, and were as follows at yearend 1980: Domestic grades, bagged in 1-ton lots, $205 per ton for fine (4F-0); $225 per ton for medium (0-1/2-1-1/2); and $205 per ton for coarse (2-extra coarse). Yearend quoted prices on imported (Italian) pumice, f.o.b. east coast, bagged in 1-ton lots, were $200 per ton for fine, $280 per ton for medium, and $250 per ton for coarse.

The average value, f.o.b. mine and/or mill, for pumice and pumicite sold or used by producers in 1980 was $7.86 per ton, an increase of 85% over the 1979 value. The average value for volcanic cinder and scoria sold or used increased slightly (6%) over the 1979 value. The average value for pumice and related volcanic materials, based on processed and unprocessed production, sold or used in 1980, increased 17% over the revised 1979 value to $4.12 per ton. Average values per ton for material in the major end uses were higher in 1980, with the exceptions of volcanic cinder used in road construction and pumice used for "Other uses."

FOREIGN TRADE

The total quantity of pumice imported for domestic consumption in 1980 was 194,318 tons—up sharply from the 61,713 tons reported in 1979, but still lower than the 1977-78 average of 234,800 tons. Pumice imported for use in the manufacture of concrete masonry construction products, primarily from Greece and Italy, totaled nearly 189,400 tons, an increase of 132,100 tons over the 1979 figure. Of the total quantity imported in 1980, Greece supplied nearly 90%, and Italy supplied the remainder. U.S. exports of pumice were estimated to be 1,000 tons in 1980.

[1]Industry economist, Section of Nonmetallic Minerals.

Table 5.—U.S. imports of pumice for consumption, by class and country

Country	Crude or unmanufactured		Wholly or partly manufactured		For use in the manufacture of concrete masonry products		Manufactured, n.s.p.f.
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)
1979:							
France	--	--	2	(1)	--	--	$1
Germany, Federal Republic of	--	--	(1)	$1	--	--	9
Greece	11	$5	--	--	25,288	$112	--
Italy	3,557	158	867	82	31,943	162	62
Japan	--	--	--	--	45	1	4
Other[2]	--	--	--	--	--	--	47
Total	3,568	163	869	83	57,276	275	123
1980:							
Greece	2,345	27	--	--	171,630	953	--
Italy	2,273	106	323	37	17,747	95	27
Other[3]	--	--	--	--	--	--	65
Total	4,618	133	323	37	189,377	1,048	92

[1]Less than 1/2 unit.
[2]Austria, Canada, mainland China, Hong Kong, Mexico, Taiwan, and the United Kingdom.
[3]Austria, Belgium, Canada, mainland China, Federal Republic of Germany, Japan, Mexico, Taiwan, and the United Kingdom.

Table 6.—Pumice and related volcanic materials: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Argentina[3]	63	72	24	27	28
Austria: Pozzolan	13	10	10	9	8
Cape Verde Islands: Pozzolan[e]	17	17	NA	NA	NA
Chile: Pozzolan	109	175	201	242	275
Costa Rica[e]	1	1	2	2	2
Dominica: Pumice and volcanic ash[e]	120	120	120	120	120
Egypt[e]	(4)	(4)	(4)	(4)	(4)
France: Pozzolan and lapilli	703	774	648	[e]650	660
Germany, Federal Republic of:					
Pumice (marketable)	2,422	1,928	2,294	1,579	1,440
Pozzolan	110	131	192	215	220
Greece:					
Pumice	441	626	827	692	695
Pozzolan	1,081	1,385	1,565	1,235	1,650
Guadeloupe: Pozzolan	220	209	220	220	220
Guatemala:					
Pumice	NA	NA	21	[r e]20	20
Volcanic ash	26	29	39	41	40
Iceland	2	8	9	27	26
Italy:					
Pumice and pumiceous lapilli[e]	[r]949	[r e]825	[e]860	[r e]940	880
Pozzolan[e]	[r]6,600	6,300	6,400	6,500	6,600
Martinique: Pumice	[r e]330	316	183	172	165
New Zealand	55	31	44	[e]44	45
Spain[5]	133	1,027	759	854	860
United States (sold or used by producers):					
Pumice and pumicite	906	1,178	1,208	[r]1,172	[6]543
Volcanic cinder (including scoria)[7]	3,275	2,832	3,553	3,243	[6]3,215
Total	[r]17,576	[r]17,994	19,179	[r]18,004	17,712

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 5, 1981.
[2]Pumice and related volcanic materials are also produced in a number of other countries, including (but not limited to) Iran, Japan, Mexico, Turkey, and the U.S.S.R., but output is not reported quantitatively and available information is inadequate for the formulation of reliable estimates of output levels.
[3]Unspecified volcanic materials produced mainly for use in construction products.
[4]Less than 1/2 unit.
[5]Includes Canary Islands.
[6]Reported figure.
[7]Includes American Samoa.

Rare-Earth Minerals and Metals

By James B. Hedrick[1]

Domestic mine production of rare-earth oxide (REO) contained in bastnäsite and monazite decreased slightly in 1980. Molycorp, Inc., and Associated Minerals Ltd., Inc., were the only domestic producers. During 1980, Molycorp, Inc., and W. R. Grace & Co. remained the principal processors of rare earths in the United States. Major end uses were in petroleum catalysis and metallurgical applications.

Legislation and Government Programs.—Shipments of previously sold rare earths from the U.S. General Services Administration stockpile totaled 1,386 short tons REO in 1980. A total of 431 short tons REO contained in sodium sulfate and 3,106 short tons REO contained in bastnäsite were sold in fiscal year 1979. Government stocks of REO contained in bastnäsite were sold out in fiscal year 1979. No stocks of rare earths were sold in 1980. Remaining stocks of rare earths at yearend 1980 were 488 (dry) short tons REO in sodium sulfate. The stockpile of yttrium oxide remained unchanged throughout 1980 at 237 pounds.

Lower tariffs for imported rare earths, resulting from the 1979 Tokyo Round of Negotiations, began for nations having "most-favored-nation" (MFN) status. The tariffs for these countries will decline annually through January 1, 1987. The new rare-earth schedule is shown in table 1.

DOMESTIC PRODUCTION

Concentrate.—Domestic mine production of REO in bastnäsite and monazite decreased 6% from the 1979 level. The major domestic source of rare earths continued to be bastnäsite. Less than 5% was produced from monazite.

Molycorp, Inc., was the only domestic producer of bastnäsite. Total production was from its Mountain Pass, Calif., mine. According to the annual report of the Union Oil Co. of California, the parent firm of Molycorp, production of REO contained in bastnäsite was 17,622 short tons.

In May 1980, Titanium Enterprises properties at Green Cove Springs, Fla., were acquired for $11.7 million by Associated Minerals Consolidated Ltd. (AMC) of Sydney, New South Wales, Australia. The properties were mined thereafter by Associated Minerals Ltd., Inc., a subsidiary of the Australian firm AMC. According to AMC, an additional $6 million will be invested for working capital and improvements. Mineral reserves at Green Cove Springs were reported to be sufficient for 16 years. Titanium Enterprises and Associated Minerals Ltd., Inc., were the sole domestic producers of monazite in 1980.

Rhône-Poulenc Inc. awarded Davy McKee Houston a contract for the construction of a rare-earth separation facility in Freeport, Tex. A production capacity of 4,000 metric tons per year of rare-earth oxides was planned. Completion was scheduled for August 1981. Rare-earth products from the plant will reportedly be available in the last quarter of 1981.

W. R. Grace & Co., Davison Chemical Div., opened a new plant at Lake Charles, La., to produce "Super D" fluid cracking catalysts containing rare earths. The denser and harder catalyst will reportedly reduce oil refinery stack emissions.

Compounds and Metals.—Molycorp completed construction of a samarium metal production plant in Washington, Pa., at the

Table 1.—U.S. import duties

TSUS Number	Article	Most Favored Nation (MFN)			Non-MFN	
		Jan. 1, 1980	Jan. 1, 1981	Jan. 1, 1987	Jan. 1, 1980	Jan. 1, 1981
601.12, 601.45	Ore and concentrate	Free	Free	Free	Free	Free.
418.40, 418.42, 418.44	Cerium chloride, oxide, compounds	14% ad valorem	13.1% ad valorem	7.2% ad valorem	35% ad valorem	35% ad valorem.
423.003	Rare-earth oxides except cerium oxide	4.8% ad valorem	4.7% ad valorem	3.7% ad valorem	25% ad valorem	25% ad valorem.
632.38	Rare-earth metals (including scandium and yttrium).[1]	do	do	do	do	Do.
632.78	Alloys wholly or almost wholly of rare-earth metals (mischmetal).	47 cents per pound.	45 cents per pound.	32 cents per pound.	$2 per pound	$2 per pound.
632.79	Other alloys wholly or almost wholly of rare-earth metals.	46 cents per pound plus 5.6% ad valorem.	42 cents per pound plus 5.1% ad valorem.	20 cents per pound plus 2.4% ad valorem.	$2 per pound plus 25% ad valorem.	$2 per pound plus 25% ad valorem.
755.35	Ferrocerium and other pyrophoric alloys.	do	43 cents per pound plus 5.1% ad valorem.	22 cents per pound plus 2.6% ad valorem.	do	Do.

[1]Duty on waste and scrap temporarily suspended.

end of 1980. Production was scheduled to begin in the first half of 1981. The plant has an annual capacity of 40 short tons. Several new solvent extraction circuits to separate samarium and gadolinium were being installed at Mountain Pass, Calif. The new circuits, scheduled for completion in the second half of 1981, were designed to have the capacity to produce 100 short tons of samarium oxide per year. Molycorp also announced plans to increase yttrium and rare-earth chloride production. Plant expansions at the company's Louviers, Colo. (yttrium), and York, Pa. (rare-earth chloride), facilities were planned.

Molycorp and W. R. Grace were the largest producers of rare-earth compounds. Production of mixed rare-earth compounds decreased slightly while output of purified compounds increased. The largest increases were reported in the production of samarium and europium oxides. Production of high-purity metals was 16% lower than that of 1979.

Producers of high-purity oxides and compounds during 1980 were Molycorp, W. R. Grace, Research Chemicals, a division of NUCOR Corp., Reactive Metals and Alloys Corp. (REMACOR), and Transelco Div. of Ferro Corp.

In response to strong demand in metallurgical application, rare-earth metal alloy production increased 22%. Mischmetal was produced by REMACOR and Ronson Metals Corp. Other rare-earth metal alloys were produced by Foote Mineral Co.

Production of rare-earth silicide also increased in 1980 in response to higher metallurgical demand. Producers were Foote Mineral Co., Globe Div. of Interlake Inc., and American Metallurgical Products Co., Inc. (AMMET).

Molycorp and Research Chemicals were the major processors of yttrium concentrate during the year. Research Chemicals also produced high-purity rare-earth and yttrium metals.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 20,900 short tons of REO contained in raw materials in 1980, reflecting a 7% increase from the 19,500 short tons consumed in 1979. Bastnäsite consumption increased 6% and monazite consumption increased 11%. Shipments of rare-earth and yttrium products from primary processing plants to domestic end-use consumers were about 11,600 short tons contained REO, compared with 12,100 short tons shipped in 1979.

The approximate distribution of rare earths by end use, based on information supplied by primary processors and certain consumers, was as follows: Petroleum cracking catalysts, 40%; metallurgical uses (including nodular iron and steel, other alloys, and mischmetal), 37%; ceramics and glass, 20%; and miscellaneous (including nuclear, electrical, arc carbons, and research), 3%.

Consumption of mixed rare-earth compounds increased during 1980, owing primarily to increased chloride use in catalyst and metallurgical applications. Consumption of mixed compounds, including oxides, chlorides, fluorides and other compounds, increased 24%.

Consumption of purified rare-earth compounds decreased about 3%. In the glass industry high-purity oxides and compounds were used as colorants and decolorizers, dopants in lasers, polishing agents, color stabilizers, absorbers of ultraviolet light, additives to increase refractive indices and decrease dispersion, and color correctors in incandescent and fluorescent lighting.

Activated phosphors containing rare earths were used in color television tubes, X-ray intensifying screens, low- (fluorescent) and high-pressure mercury vapor lamps, and trichromatic fluorescent lamps.

Gadolinium was used in nuclear reactor control rods as a burnable neutron absorber. Other uses were in nuclear fuel processing, phosphors, high refractive index glass, and GGG (gadolinium-gallium-garnet) substrates for magnetic bubble memory systems in computers.

The ceramic industry used purified rare earths in pigments, heating elements, dielectric and conductive ceramics, and as principal constituents and stabilizers in high-temperature ceramics and glazes. Purified rare-earth compounds were also used in gas mantles, electronic components, and synthetic gem stones.

The production of mischmetal, rare-earth silicide, and other alloys containing rare earths consumed 361 short tons of contained REO, a 26% increase over that of 1979. Mischmetal was in demand for use in high-strength, low-alloy steels and ductile iron.

Consumption of high-purity metals decreased in 1980, although shipments to consumers during the year were above the 1979 level. The use of lanthanum metal in hydrogen storage alloys continued to grow. Domestic consumption of samarium decreased an estimated 50% owing to the cost and availability of cobalt, its principal alloying agent in permanent magnets. Samarium-cobalt permanent magnets were used in alternators and generators, various electric motors, line printers, disk-drive actuators, proton linear accelerators, speakers and microphones, earrings and necklace clasps, medical and dental applications, traveling wave tubes, and aerospace applications.

Metallurgical applications of rare earths included alloys and additives in high-strength low-alloy steels, gray and ductile iron, stainless and carbon steels, high-temperature and corrosion-resistant metals, hydrogen storage alloys, lighter flints, permanent magnets, and welding materials.

STOCKS

Stocks of rare earths in all forms held by 14 producing, processing, and consuming companies decreased 9.5% during 1980.

Bastnäsite concentrate stocks held by the principal producer and three other processors increased about 14%. Yearend inventories of monazite and other rare-earth concentrates decreased markedly.

Stocks of mixed rare-earth compounds increased from 1,658 short tons of contained REO at yearend 1979 to 2,091 short tons at yearend 1980. Inventories of purified rare-earth compounds also increased from 312 short tons REO in 1979 to 374 short tons REO in 1980. Yearend stocks of mischmetal and alloys containing rare earths increased 26%. High-purity rare-earth metal inventories were 34% higher.

PRICES

The average declared value of imported monazite increased during 1980 to $326 per short ton, an increase of $84 per short ton over the 1979 value. The 1980 price of Australian monazite (minimum 60% REO including thoria, f.o.b./f.i.d.), as quoted in Metal Bulletin (London), remained at the yearend 1979 price of $367 to $417 (A$318 to A$363) per short ton. Industrial Minerals quoted prices for Malaysian xenotime (25% Y_2O_3, c.i.f.) at $2 to $3 per pound.

Prices of unleached, leached, and calcined bastnäsite containing 60%, 70%, and 85% REO remained at $0.85, $0.90, and $1.05 per pound of contained REO, respectively, throughout 1980. The price of cerium concentrate quoted by American Metal Market remained at the yearend 1978 level of $1.15 per pound during 1979 and 1980. Lanthanum concentrate remained at the yearend 1979 price of 90 cents per pound throughout 1980. Mischmetal (99.8%, 50- to 100-pound lots, f.o.b. Newark, N.J.) prices, quoted in American Metal Market, increased from $4.20 per pound at yearend 1979 to $5.60 per pound at yearend 1980.

Rhône-Poulenc Inc. quoted REO prices, per kilogram, net 30 days f.o.b. New Brunswick, N.J., or duty paid at point of entry, effective January 1, 1980, as follows:

Product (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Gadolinium	99.99	50	$118.00
Lanthanum	99.9	50	12.50
Neodymium	95	50	6.60
Praseodymium	96	50	37.30
Samarium	96	50	46.80
Terbium	99.9	50	1,075.00
Yttrium	99.9	50	74.70

Nominal prices for various rare-earth materials were also quoted by Research Chemicals, net 30 days f.o.b. Phoenix, Ariz., effective January 7, 1980:

Element	Oxide[1] price per kilogram	Metal[2] price per kilogram
Cerium	$20.00	$115.00
Dysprosium	110.00	300.00
Erbium	160.00	530.00
Europium	1,900.00	7,000.00
Gadolinium	125.00	440.00
Holmium	575.00	1,400.00
Lanthanum	19.00	115.00
Lutetium	4,800.00	12,900.00
Neodymium	70.00	260.00
Praseodymium	120.00	310.00
Samarium	120.00	300.00
Terbium	1,050.00	2,300.00
Thulium	3,000.00	6,900.00
Ytterbium	200.00	825.00
Yttrium	84.00	390.00

[1]Minimum 99.9% purity, 1- to 20-kilogram quantities.
[2]Ingot form, 1 to 5 kilograms, from 99.9% grade oxides.

Molycorp, Inc., quoted prices for rare-earth oxides, net 30 days, f.o.b. from Louviers, Colo., Mountain Pass, Calif., or York, Pa., effective April 1, 1980:

Product (oxide)	Percent purity	Quantity (pounds)	Price per pound
Cerium	99.9	1-199	$8.75
Europium	99.99	1-24	900.00
Gadolinium	99.99	1-69	60.00
Lanthanum	99.99	1-299	7.00
Neodymium	99.99	1-49	60.00
Praseodymium	95.0	1-249	16.50
Terbium	99.99	1-49	575.00
Yttrium	99.99	1-49	42.00

Prices for rare-earth metals were also quoted by Molycorp, Inc., net 30 days, f.o.b. Washington, Pa., effective January 15, 1980:

Product (metal)	Percent purity	Quantity (pounds)	Price per pound
Cerium	99	10-100	$25
Gadolinium	99	>10	210
Lanthanum	99	10-100	29
Neodymium	99	>10	100
Praseodymium	99	10-100	65
Samarium	99	10-100	70
Yttrium	99	10-100	165

FOREIGN TRADE

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 34,241 pounds in 1980, a 59% decrease from the total in 1979. Major destinations were Mexico (41%), Bahrain (25%), and Hong Kong (8%). Monazite exports were resumed in 1980 after an absence of exports in 1979. France received all of 1980's reported total of 6,898 pounds, valued at $17,226.

Imports for consumption of rare earths, shown in table 3, showed an overall increase in 1980. Substantial increases in receipts came from Brazil. The newest entry into the U.S. rare-earth market was mainland China. Trade with China was expected to increase in 1981. Monazite imports decreased in 1980, with Australia continuing to be the leading supplier. Approximately one-third of Australia's 1980 monazite production was imported by the United States.

Table 2.—U.S. imports for consumption of monazite

Country	1976		1977		1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	--	--	3,149	$491	5,532	$1,154	6,268	$1,501	5,438	$1,749
Malaysia	2,103	$431	2,331	409	1,276	255	618	161	236	101
South Africa, Republic of	--	--	--	--	--	--	3	2	--	--
Thailand	--	--	--	--	846	193	42	13	--	--
Total	2,103	431	5,480	900	7,654	1,602	6,931	1,677	5,674	1,850
REO content[e]	1,157	XX	3,014	XX	4,210	XX	3,812	XX	3,121	XX

[e]Estimated. XX Not applicable.

Table 3.—U.S. imports for consumption of rare earths, by country

	1978		1979		1980	
	Quantity (pounds)	Value (dollars)	Quantity (pounds)	Value (dollars)	Quantity (pounds)	Value (dollars)
Cerium oxide:						
Austria	--	--	220	1,002	--	--
Belgium	--	--	2,205	14,150	--	--
France	6,920	40,068	5,840	40,519	4,805	26,896
Germany, Federal Republic of	--	--	10	1,624	9	1,975
Japan	150	309	--	--	--	--
Switzerland	--	--	98	4,769	23	1,095
United Kingdom	--	--	5,295	53,788	8,015	71,524
Total	7,070	40,377	13,668	115,852	12,852	101,490
Rare-earth oxide, excluding cerium oxide:						
Austria	--	--	--	--	110	1,372
Belgium	--	--	2,205	49,492	--	--
Brazil	--	--	110	880	453,045	3,890,000
Canada	37,991	287	--	--	75,380	6,123
China, mainland	--	--	--	--	4	1,229
France	193,996	2,095,182	535,230	7,660,675	542,228	11,199,793
Germany, Federal Republic of	64,310	887,775	136,729	3,276,152	2,132	126,314
Italy	--	--	--	--	1,576	34,540
Japan	--	--	44,028	1,298,004	370	125,002
Malaysia	--	--	35,274	152,232	--	--
Norway	2,428	75,909	8,479	282,976	4,557	166,609
Switzerland	663	102,000	--	--	--	--
U.S.S.R.	73,672	3,329,576	85,696	2,417,062	73,778	2,256,545
United Kingdom	365	15,235	330	15,996	2,272	147,480
Total	373,425	6,505,964	848,081	15,153,469	1,155,452	17,955,007
Rare-earth metals (alloys):						
Austria	66,339	213,287	--	--	--	--
Brazil	312,646	805,030	44,092	159,070	692,326	2,747,765
France	110	346	1,212	14,331	8,819	113,428
Germany, Federal Republic of	102,694	392,091	352	2,728	110	826
Italy	200,868	620,160	--	--	--	--
Japan	92,593	242,746	22,046	63,626	--	--
U.S.S.R.	--	--	--	--	--	--
United Kingdom	45,294	116,005	77,162	337,407	507	55,597
Total	820,544	2,389,665	144,864	577,162	701,762	2,917,616
Rare-earth metals, including scandium and yttrium:						
France	3,045	41,061	4,079	52,129	--	--
U.S.S.R.	9,470	192,413	4,412	104,592	8,191	252,225
United Kingdom	114	26,958	483	29,277	278	54,459
Total	12,629	260,432	8,974	185,998	8,469	306,684
Other rare-earth metals:						
Brazil	--	--	--	--	17,637	71,616
Germany, Federal Republic of	70	4,137	1	261	25	900
United Kingdom	--	--	--	--	5	454
Total	70	4,137	1	261	17,667	72,970
Ferrocerium and other pyrophoric alloys:						
Austria	613	4,868	414	3,821	--	--
Belgium	220	2,500	--	--	458	1,400
Brazil	5,040	16,934	417	750	--	--
France	73,060	380,803	92,123	518,935	95,424	633,108
Germany, Federal Republic of	--	--	74	1,663	--	--
Hong Kong	1,681	1,653	--	--	--	--
Italy	7,518	39,954	--	--	--	--
Japan	41,047	186,769	29,000	143,810	47,000	255,248
Switzerland	8	648	4	352	--	--
United Kingdom	895	7,255	1,186	10,281	1,117	12,054
Total	130,082	641,384	123,218	679,612	143,999	901,810

WORLD REVIEW

World production of monazite decreased slightly, reflecting a decline in the monazite content of Australia's mineral sands. Production of bastnäsite also decreased slightly.

Australia.—Allied Eneabba Ltd. recorded its first profit since the company was formed in 1972, reportedly because of higher product prices. A new wet monazite circuit installed at Narngulu, Western Australia, increased the company's processing capacity to 10,000 metric tons per year. Allied reported monazite production for 1980 at 8,095 metric tons.

Mineral Deposits Ltd. suspended mineral sand mining operations in March at Middle Head, New South Wales, because of protests based on environmental concerns.

AMC acquired the properties of Titanium Enterprises at Green Cove Springs, Fla., in May. A dredge, wet and dry separation plant, operating spare parts, and administrative facilities were purchased for $11.7 million. AMC planned to invest an additional $6 million for working capital and improvements.

Westralian Sands Ltd. announced plans to sell its interest in certain mineral leases at Eneabba, Western Australia, to Allied Eneabba Ltd. In consideration of the sale, Westralian Sands will reportedly receive an undisclosed amount of zircon and an option to buy ilmenite. Monazite production by Westralian Sands was about 1,900 metric tons in 1980.

Brazil.—The State of Espirito Santo continued to be the principal area of mineral sand mining and monazite production. Brazilian rare-earth production in kilograms was as follows:

Year	Carbonate	Chloride	Oxide
1975	5,320	2,001,000	NA
1976	3,351	2,036,000	3,320
1977	7,210	2,527,455	16,926
1978	7,000	2,799,000	21,000
1979	14,000	2,725,000	16,000

NA Not available.

China, Mainland.—Rare earths associated with iron mineralization were reported in the Bayan Obo mining district, 95 miles north of the city of Baotou.[2] The total proven iron ore resources of the district were given as 1 billion tons. Reserves reportedly contain 1% to 6% rare earths, with high-grade areas assaying 10%. Rare-earth recovery to date has been minor.

An export catalog from the Chinese Rare Earth Co., Baotou, Inner Mongolia, listed bastnäsite concentrate, a chloride, a fluoride, and several individual oxides as products.

China's National Minerals and Metals Import and Export Corp. decentralized the trading of several commodities, including rare earths. Trade once handled only by the Beijing office has been given to local offices on a trial basis.

India.—Indian Rare Earths Ltd. (IREL) reported a decrease in monazite production for 1979-80. Technological changes at the Manavalakurichi, Tamil Nadu, separation plant and lower concentrations in the mineral sands were cited as the cause. An Australian preconcentrator installed at Manavalakurichi in January 1980 was to provide higher feed grades and production capabilities.

Steel and cement shortages as well as financial problems delayed construction of IREL's Orissa Sands complex. Completion was rescheduled for mid-1982.

Japan.—Japanese imports of rare earths were reported in the Japan Metal Journal. Shipments in 1979 from the United States were as follows:

Product	Quantity (kilograms)
Cerium fluoride	747
Cerium oxide	728
Lanthanum oxide	181
Yttrium oxide	10
Rare-earth metals including yttrium and scandium.	3,850
Crude rare-earth chloride, for manufacturing metallic compounds.	284,692
Compounds of rare-earth metals including yttrium and scandium.	1,473,211

Malaysia.—Mitsubishi Chemical Industries was reportedly planning to construct a rare-earth processing plant at Ipoh. Scheduled for completion in 1981, the facility will process Malaysian monazite for rare-earth oxides and chlorides. Mitsubishi planned to establish a 35%-owned subsidary, Asian Rare Earths, to operate the plant.

Norway.—Surface exploration by the Union Oil Co. subsidiary, Union Mineral Norway, and the Norwegian company Fenco indicated a large deposit of rare earths in the Ulefloss area, Telemark, southern Norway. Drilling was planned for summer 1981.

Table 4.—Monazite concentrates: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Australia	5,853	[r]10,339	16,526	17,864	16,200
Brazil	1,775	2,691	2,801	2,555	2,900
India[3]	3,300	3,014	3,465	3,086	3,200
Korea, Republic of	(4)	(4)	(4)	(4)	--
Malaysia[5]	2,071	2,179	1,392	737	900
Nigeria[e]	20	20	20	20	20
Sri Lanka	1	[e]5	[e]220	[e]280	280
Thailand	--	--	(6)	13	10
United States	W	W	W	W	W
Zaire	265	[r]107	85	85	85
Total	[r]13,285	[r]18,355	24,509	24,640	23,595

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through Apr. 27, 1981.
[2]In addition to the countries listed, mainland China, Indonesia, and North Korea may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.
[3]Data are for years begining Apr. 1 of that stated.
[4]Revised to zero.
[5]Exports.
[6]Revised to zero; figure previously reported (845 short tons) was the 1978 export and apparently was possible because production in 1975 and before that had not been shipped when mined. Exports were not permitted in 1976 and 1977.

TECHNOLOGY

Researchers at Union Carbide Corp. produced a high-temperature solar absorbing coating using plasma sprayed yttrium hexaboride and erbium dodecaboride. When used in solar energy systems the powdered borides showed good heat transference, solar porosity, and high-temperature (500° to 2,000° C) stability.[3] Borides were also used in the form of a high-purity single crystal of lanthanum hexboride. Incorporated into a multimode analytical electron-microscope gun, the microscope's triple lens system and lanthanum boride gun provides a wide variety of illumination.[4]

Experiments were conducted on zone refining high-purity cerium and gadolinium metals. Impurities were moved by zone melting and consolidating the samples in a vacuum. Although not as pure as metals prepared by solid-state electrotransport, the metals were produced faster by zone refining. Future refinements of the process may provide lower cost ultra-high-purity metals.[5] Optimum conditions providing a 99.8% conversion of Gd_2O_3 to $GdCl_3$ were determined. Data for the oxide chlorination process were plotted to obtain the best time, temperature, airflow rate, and reagent mixture ratio. The anhydrous chlorides are widely used in the preparation of rare-earth metals by electrolytic and metallothermic methods.[6] A study was also made of electrowinning gadolinium metal from gadolinium oxide at temperatures below 1,000° C. Using a platinum anode, a tantalum cathode, and an electrolyte with a low oxide concentration, gadolinium metal was prepared containing less than 200 parts per million by weight of each element, oxygen and carbon.[7]

An aqueous pH sensor that operates at high temperatures and pressures was developed at the General Electric Co. The sensor uses an oxygen-permeable ceramic membrane made of yttria-stabilized zirconia. Possible applications include direct pH measurements of primary water systems in nuclear reactors, geothermal brines, and other high-temperature aqueous solutions.[8] Yttria was also used by NASA's Lewis Research Center and INCO Ltd.'s Research and Development Center in developing a nickel-base superalloy. Yttrium oxide as an additive was used in a powder metallurgy process. The new alloy withstands high-temperature and high-pressure environments. Initial use of the superalloy will be as uncooled gas turbine blades.[9]

Researchers at General Telephone and Electronic Corp. (GTE) laboratory in Danvers, Mass., studied an improved mercury lamp for low-color temperature applications. Blending cerium-activated yttrium aluminum garnet (YAG) phosphor with europium-activated yttrium vanadate phosphor resulted in a 400-watt warm mercury lamp that provided 25,500 lumens, a 3,350 K color temperature, and a color rendering index of 48. The blended phosphors reportedly showed good stability and efficacies equal to or greater than popular deluxe mercury lamps.[10]

A direct-writing recorder using an array of light gates was developed by Bell & Howell Co. The device is based on a PLZT (lead-lanthanum-zirconium-titanate) ceramic material. Using polarizing filters to block or permit light through to sensitized paper, the PLZT rotates the filters when an electric current is applied.[11]

Laser research at Battelle Development Corp., Columbus Laboratories, developed a neodymium-doped laser to obtain X-ray data of atoms having a molecular weight less than 40.[12] Research at the U.S. Naval Research Laboratory separated cerium from light-water fission reactor wastes using noble-gas halide lasers. Separation was accomplished by altering the oxidation states of the rare earths using ultraviolet laser energy. Future applications will reportedly include isolating radioactive lanthanides from the environment.[13]

Samarium-cobalt permanent magnets were used to economically focus charged particles. New England Nuclear Corp. developed the permanent magnet quadrupoles to achieve the high-quality, high-strength field gradients needed to focus protons in a linear accelerator. Advantages over electromagnets include compact size, no power consumption, and no cooling requirements.[14]

The Bureau of Mines continued research on improving the beneficiation of bastnäsite. Specific objectives were lower energy consumption and the recovery of barite from flotation tailings. Research was conducted on a samarium-free, mischmetal-cobalt-copper-magnesium magnet developed by the Bureau. By varying the rare-earth content of mischmetal, improved magnetic properties may be obtained. The intrinsic coercivity of the mischmetal-cobalt-copper-magnesium magnet exceeded that of samarium-cobalt magnets.

The Bureau of Mines published a report on using ferrosilicon-aluminum reduction of rare-earth oxides to prepare an alloy with a high rare-earth content and recovery.[15] A report was also made on the effects various oxides (yttrium, cerium, gadolinium) have on sintering silicon nitride-alumina compositions.[16]

The proceedings of rare-earth related conferences that were published in 1980 included those of the 14th Rare Earth Research Conference,[17] the Indo-U.S. Conference on Science and Technology of Rare Earth Materials,[18] the International Conference on Crystalline Electric Field and Structural Effects in f-Electron Systems,[19] the 178th American Chemical Society Meeting,[20] the International Conference on Magnetism,[21] and the 1st United Kingdom Conference of Permanent Magnets.[22]

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Rhenium

By Ivette E. Torres[1]

Rhenium was produced by four domestic firms in 1980. Consumption of rhenium in 1980 decreased about 23% from that of 1979, to an estimated 7,300 pounds. Imports of rhenium in ammonium perrhenate decreased from 8,299 pounds in 1979 to 4,991 pounds in 1980. Prices increased during the first 4 months of the year, reaching $2,500 per pound by May, and thereafter declined to a range of $800 to $1,000 per pound by yearend. Bimetallic platinum-rhenium reforming catalysts continued to be the major use for rhenium domestically and worldwide.

Table 1.—Salient rhenium statistics

(Pounds of contained rhenium)

	1976	1977	1978	1979	1980
Mine production[e]	1,500	--	W	W	W
Consumption[e]	8,300	7,300	12,500	9,500	7,300
Imports (metal)	82	148	449	927	513
Imports (ammonium perrhenate)	4,047	6,111	[1]12,042	8,299	4,991
Stocks, Dec. 31	18,300	17,300	W	W	W

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1] Includes 850 pounds of perrhenic acid.

DOMESTIC PRODUCTION

Kennecott Corp., near Salt Lake City, Utah, M&R Refractory Metals Inc., in Winslow, N.J., and Molycorp Inc., in Washington, Pa., recovered rhenium from domestic porphyry copper ores in 1980. This was as a byproduct from roasting the molybdenite (MoS_2) concentrates obtained from southwestern porphyry copper ores. Shattuck Chemical Co., a subsidiary of Engelhard Minerals & Chemicals Corp., recovered rhenium from Canadian molybdenite concentrates on a toll-conversion basis, returning the rhenium to its owner for subsequent sale.

CONSUMPTION AND USES

Domestic consumption of rhenium fell an estimated 23% below that of 1979 to 7,300 pounds. The decrease in usage was attributed to the plentiful supply of refined gasoline, which lessened demand for reforming catalysts, and to efforts by the petroleum industry to intensify recycling. The recycling of rhenium catalysts was especially encouraged by the high prices that prevailed during the first few months of the year.

As in previous years, probably greater than 90% of rhenium consumption was in catalytic applications. The use of rhenium in bimetallic reforming catalysts to produce high-octane, low-lead gasoline accounts for the major portion of rhenium demand. In this application, bimetallic, platinum-rhenium catalysts compete with other bimetallic catalysts and with the conventional monometallic catalyst (platinum). In 1980, total reforming capacity at domestic refineries increased approximately 3% to 4,051,419 barrels per stream day. Of this total, 74%, or 3,017,250 barrels per stream day, represented bimetallic reforming capacity.[2]

Of the three basic types of bimetallic reforming catalysts, the semiregenerative type accounted for about 58% of total reforming capacity. Cyclic bimetallic reforming catalysts and other types (nonregenerative, continuous, and moving-bed systems) accounted for 11% and 5%, respectively, of domestic reforming capacity. An estimated 85% of the total bimetallic reforming capacity employed platinum-rhenium catalysts. These bimetallic catalysts contain about 0.3% rhenium and 0.3% platinum, by weight, although newer forms may contain 0.6% or more rhenium.

The trend towards increased use of the platinum-rhenium reforming catalysts, compared with the other kinds, has been due primarily to conversion of monometallic reformers to bimetallic reformers and to capacity additions at existing bimetallic reformers. The advantages of the platinum-rhenium catalysts include their generally lower cost and greater carbon tolerance than monometallic catalysts. In addition, about 93% of the rhenium and 98% to 99% of the platinum can be recovered from spent bimetallic catalysts. The regeneration of these catalysts effectively reduces the annual demand for output of first-generation catalytic feedstock.

Other applications of reforming platinum-rhenium catalysts included the production of benzene, toluene, and xylenes.

Less than 10% of the total rhenium consumption was accounted for by use in thermocouples, temperature controls, ionization gages, electron tubes and targets, electrical contacts, X-ray tubes and targets, metallic coatings, semiconductors, heating elements, and high-temperature nickel-based alloys.

PRICES

In 1979, the price of rhenium increased dramatically, reaching $2,000 per pound by yearend. During the first 4 months of 1980, rhenium prices continued the upward trend that characterized 1979, increasing to about $2,500 per pound by May. Thereafter the price began to decrease, and by the third quarter it was about $1,800 per pound. By yearend, it was in the range of $800 to $1,000 per pound. The softening of the market price was attributed to an oversupply of refined gasoline and decreased purchases of rhenium by the petroleum industry, the predominant users of rhenium-containing catalysts.

FOREIGN TRADE

Imports for consumption of rhenium in ammonium perrhenate totaled 4,991 pounds in 1980, a 40% decrease from those of 1979. The value of these imports was $7.9 million. Imports of rhenium metal totaled 513 pounds and were valued at $0.7 million. The major sources of rhenium continued to be the Federal Republic of Germany and Chile, which together supplied over 96% of the ammonium perrhenate and over 94% of total imports.

The import duty on ammonium perrhenate from most-favored-nations was 3.9% ad valorem; the statutory rate of duty, applicable to the U.S.S.R. and certain other specified countries with central economies, was 25% ad valorem. The duty on rhenium metal from most-favored-nations was 4.8% ad valorem for unwrought metal and 8.6% ad valorem for wrought metal. The statutory rate of duty on rhenium metal from countries with central economies was 25% ad valorem for unwrought metal and 45% ad valorem for wrought metal. The duty on waste and scrap has been suspended indefinitely.

Table 2.—U.S. imports for consumption of ammonium perrhenate, by country[1]

(Rhenium content)

Country	1976		1977		1978		1979		1980	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Chile	1,280	$606	4,187	$1,087	5,855	$889	4,335	$1,380	2,049	$2,775
Germany, Federal Republic of	2,767	801	1,924	533	[2]6,187	1,512	3,898	1,854	2,721	4,720
Poland	--	--	--	--	--	--	66	25	--	--
U.S.S.R	--	--	--	--	--	--	--	--	135	229
Yugoslavia	--	--	--	--	--	--	--	--	86	165
Total	4,047	1,407	6,111	1,620	12,042	2,401	8,299	3,259	4,991	7,889

[1]Adjusted by Bureau of Mines.
[2]Includes 850 pounds of perrhenic acid.

Table 3.—U.S. imports for consumption of rhenium metal, by country

(Gross weight)

Country	1976		1977		1978		1979		1980	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Belgium-Luxembourg	17	$8,687	18	$4,120	15	$6,075	--	--	--	--
France	--	--	--	--	--	--	238	$97,836	100	$43,587
Germany, Federal Republic of	65	29,060	130	51,734	434	161,920	468	426,735	390	539,985
U.S.S.R	--	--	--	--	--	--	220	82,594	--	--
United Kingdom	--	--	--	--	--	--	--	--	23	84,135
Other[1]	--	--	--	--	--	--	1	478	--	--
Total	82	37,747	148	55,854	449	167,995	927	607,643	513	667,707

[1]Includes Austria and Switzerland.

WORLD REVIEW

World production of rhenium in 1980 was estimated to be 21,000 to 24,000 pounds. The major worldwide sources of rhenium were the porphyry copper deposits in Canada, Chile, Peru, the U.S.S.R., and the United States. Outside the United States rhenium was known to have been recovered in Chile, the Federal Republic of Germany, France, Sweden, the United Kingdom, and the U.S.S.R.

Argentina.—The Compañía Minera Aguilar S.A., a subsidiary of St. Joe Minerals Corp., was studying the possibility of a partnership with two other companies to develop the El Pachón copper deposit. The property, which is located in the southwest of the Province of San Juan, has estimated reserves of 800 million metric tons of ore with 0.56% copper and 0.016% molybdenum. Assuming 200 parts per million (ppm) rhenium in MoS_2, rhenium content would total almost 95,000 pounds.

Canada.—Utah International Inc. was the sole producer of rhenium in Canada during 1980. Production of rhenium was estimated at 4,000 pounds, the same as that of 1979. Molybdenite concentrates were recovered at the Island Copper Mine on Vancouver Island, British Columbia, and shipped to the United States and the Federal Republic of Germany, where ammonium perrhenate and perrhenic acid were recovered and returned to Utah International for subsequent sale.

Chile.—Production of rhenium in Chile was estimated at 8,500 pounds. The Corporación Nacional del Cobre de Chile (CODELCO) was negotiating with some of its tolling agents to formulate contractual clauses that include credits for the rhenium contained in its molybdenum concentrates. Since 1979, CODELCO has had a tolling contract with Molibdenos y Metales S.A. (MOLYMET), which provides for the recovery of rhenium. Under this agreement, both MOLYMET and CODELCO obtain 50% of the recoverable rhenium in concentrates containing more than 350 ppm of rhenium. CODELCO was also studying the possibility of adding rhenium recovery equipment to the molybdenite roaster under construction at its Chuquicamata property. The roaster was scheduled for completion during 1982.

Panama.—Rio Tinto-Zinc Ltd. acquired a 49% interest in the company that owns and is evaluating the Cerro Colorado copper deposit. The remaining 51% will be held by the Panamanian State agency, Corporación de Desarrollo Minero de Cerro Colorado (CODEMIN). The deposit, which was discovered in the 1930's and is located about 200 miles west of Panama City, was originally owned by the Panamanian Government (80%) and Texasgulf Inc. (20%). The decision whether to develop the project will be made after an 8-month feasibility study. Texasgulf has the option to acquire a 15% interest if the project is undertaken. Studies in 1971 indicated potential ore reserves of 1.3 billion metric tons with an average 0.78% copper and 0.015% molybdenum. The deposit has recoverable quantities of rhenium.

Papua New Guinea.—In early 1980 the Government of Papua New Guinea gave its preliminary approval for the development of the OK Tedi copper, gold, and molybdenum deposit. Discovered in 1968 by Kennecott Corp., the deposit is located on Mount Fabilan, along the southern slopes of the Star Mountains. The development of the deposit will be undertaken by an international consortium that includes Broken Hill Pty. (30%), Amoco Minerals Co. (30%), a group of West German companies (20%), and the Government of Papua New Guinea (20%). Early in 1981, authorization for the project was announced. The project was to be developed in three stages over the next 9 years. For the initial 2 or 3 years of operation, only gold will be recovered, after which copper concentrates will also be produced. Within 5 or 6 years, copper and probable byproduct molybdenum concentrates were expected to be the major materials produced. Reserves are estimated at 300 million metric tons of ore with 0.85% copper and 0.012% molybdenum. Assuming 300 ppm rhenium in MoS_2, rhenium content would total almost 40,000 pounds.

TECHNOLOGY

Phelps Dodge Corp. developed a modification of the solvent extraction method to determine quantitatively the rhenium contained in molybdenum concentrates.[3] The method is reportedly simple, selective, and accurate. Separation of rhenium by extraction with tetraoctylammonium chloride and tetrabutylammonium chloride proved to be the most efficient of the solvents used. Analysis after extraction was performed using a double-beam spectrophotometer. The method was compared with other methods previously used, such as inductively coupled plasma emission spectrometry, isotopic dilution mass spectrometry, and thermal neutron activation. The modified solvent extraction method produced results that were in reasonable agreement with those of other analytical methods.

Russian scientists conducted research on the electrodeposition of rhenium coatings on various metals from fluorine-containing electrolytes.[4] Rhenium coatings have the advantages that they do not form nitrites or carbides, are more resistant than tungsten and molybdenum to oxygen, and are more resistant to water vapor than tungsten. Electrolytes investigated were formulated from perrhenic acid, potassium perrhenate, and ammonium perrhenate. After it was established that the nature of the cation did not influence the process, subsequent investigations were performed with ammonium perrhenate, the most soluble salt. It was determined that the coating quality was governed by the current density and the temperature of the electrolyte. Rhenium concentration had little influence on the deposition rate and current yield. Rhenium coatings, 10 to 15 micrometers thick, on molybdenum, tungsten, and stainless steel did not crack and were practically nonporous. These studies showed that deposition of rhenium from electrolytic solutions containing fluoride ion was economically more attractive and faster then other techniques for coating rhenium.

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[1]Physical scientist, Section of Ferrous Metals.
[2]Oil and Gas Journal. Annual Refining Survey. V. 79, No. 13, Mar. 30, 1981, pp. 110-153.
[3]Budesinsky, B. W. Determination of Rhenium in Molybdenum Concentrates. Analyst, v. 105, No. 1248, March 1980, pp. 278-281.
[4]Ivanova, N. D., N. I. Taranenko, and A. V. Gorodyskii. Electrodeposition of Rhenium From Fluorine-Containing Electrolytes. Protection of Metals, v. 15, No. 4, July-August 1979, pp. 385-386.

Salt

By Dennis S. Kostick[1]

The total production of salt in the United States in 1980 decreased to 41.5 million short tons, the lowest production recorded since 1968. This was attributed to a decrease in rock salt usage for deicing purposes because the winter weather, particularly in the Northeast, was milder than anticipated. Production of salt in brine was also down owing to the reduction of chlorine production. The demand for polyvinyl chloride (PVC) in 1980 decreased because of the slowdown in construction starts.

Legislation and Government Programs.—The responsibility of inspecting 27 salt facilities that use brine wells, solar, or vacuum pan processes has been transferred from the Mine Safety and Health Administration (MSHA) to the Occupational Safety and Health Administration (OSHA). Underground salt mines associated with a complex containing either of the three processes will remain under the jurisdiction of MSHA.

The Select Committee on Generally Recognized as Safe Substances (GRAS) of the Federation of American Societies for Experimental Biology concluded its study on food additives and recommended that the use of salt as a food ingredient should be tightly restricted or even prohibited from use in foods. The reduction could benefit between 10% to 30% of the population that have genetic tendencies to high blood pressure.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Production[1]	43,801	42,922	42,878	46,317	41,483
Sold or used by producers[1]	44,191	43,412	42,869	45,793	40,352
Value	$430,959	$451,579	$499,345	$538,352	$656,164
Exports	1,007	1,008	776	697	831
Value	$10,326	$10,881	$9,795	r$9,025	$12,829
Imports for consumption	4,352	4,529	5,380	5,275	5,263
Value	$23,476	$26,694	$34,247	$40,860	$44,071
Consumption, apparent	47,536	46,933	47,473	50,371	44,784
World: Production	r177,105	r177,349	r184,007	r189,436	181,608

rRevised.
[1]Excluding Puerto Rico: Estimated 27,000 short tons per year (1975-80).

DOMESTIC PRODUCTION

The total quantity of domestic salt sold or used by producers in 1980 decreased to 40.4 million short tons. Solar salt was the only type of salt sold or used that showed an increase, mainly because it is a cheaper substitute for the more expensive vacuum pan and open pan salt.

In 1980, 47 companies operated 89 salt-producing plants in 17 States. Eleven of the companies sold or used over 1 million tons each, accounting for 82% of the U.S. total.

The five leading States in the amount of salt sold or used follow:

State	Percent of total	
	1979	1980
Louisiana	31	31
Texas	25	25
New York	14	14
Ohio	9	8
Michigan	7	6
Total	86	84

The percentage of salt sold or used by domestic producers in 1980 by type follows:

	Percent	
	1979	1980
Salt in brine	54	55
Mined rock salt	32	30
Vacuum pan salt and grainer or open pan salt	9	9
Solar-evaporated salt	5	6
Total	100	100

In November, the Jefferson Island, La., rock salt mine owned by Diamond Crystal Salt Co. was destroyed by a drilling accident. Texaco Inc. was exploring for oil and gas on nearby Lake Peigneur when the drill accidentally penetrated the top of the 1,200-foot-deep cavern of the 60-year-old mine. The resulting whirlpool created a 40-acre opening and swept underground all of the lake water, including a tugboat, 11 barges, several homes, and the $5 million drill rig.

Within 3 days, the lake refilled and the barges resurfaced; however, concern developed over the possibility that the island would collapse because of the dissolution by the lake water of the subterranean salt pillars that support the top of the salt dome.[2]

The U.S. Department of Energy had planned to purchase the Cote Blanche rock salt mine in Louisiana from Domtar, Inc., as a Strategic Petroleum Reserve site. Owing to oil shortages and economic conditions, the plans were abandoned. Domtar hopes to increase annual production from 1 million tons to 1.4 million tons by 1982. The proposed increase will help offset the loss of production from Diamond Crystal's Jefferson Island Mine.[3]

CONSUMPTION AND USES

In 1980 the apparent consumption of salt in the United States fell to 44.8 million short tons; the lowest level since 1975. Consumption of salt in every major end use declined except for salt used in the oil industry as an ingredient in drilling, workover, and completion fluids.

The demand for deicing salt decreased 21% over that of the previous year as a result of the milder than anticipated winter weather. Imports of salt for highway use in 1980 dropped 55% compared with those of 1979.

The production of chlorine and sodium hydroxide declined in 1980, which was reflected by the decrease in salt consumption in the chloralkali industry. The output of metallic sodium also fell because of the decline in usage of leaded fuel additives.

Production of chlorine gas, caustic soda, and metallic sodium, in thousand short tons, in 1979 and 1980 as reported by the U.S. Department of Commerce, was as follows:

	1979	1980	Percent change
Chlorine gas (100%)	12,102	11,195	-7.5
Sodium hydroxide, liquid (100%)	12,428	11,309	-9.0
Metallic sodium	151	112	-25.8

STOCKS

Total yearend salt stocks as reported by producers amounted to 3.2 million tons in 1980. Most was in the form of rock and solar salt.

Table 2.—Salt sold or used by producers in the United States,[1] by method of recovery

(Thousand short tons and thousand dollars)

Recovery method	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Evaporated:				
Bulk:				
Open pan or grainer and vacuum pan	3,726	229,662	3,587	274,188
Solar	2,104	25,575	2,334	36,516
Pressed blocks	391	19,727	393	24,412
Total[2]	6,221	274,965	6,314	335,117
Rock:				
Bulk	14,827	148,205	11,742	172,039
Pressed blocks	64	3,987	65	4,502
Total[2]	14,891	152,192	11,806	176,541
Salt in brine (sold or used as such)	24,681	111,195	22,231	144,507
Grand total[2]	45,793	538,352	40,352	656,164

[1]Excludes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Kansas[1]	1,900	61,184	1,572	64,276
Louisiana	14,207	113,167	12,662	132,182
Michigan	3,080	82,540	2,406	104,842
New York	6,387	77,751	5,509	99,395
Ohio	4,135	79,598	3,228	87,371
Texas	11,283	67,602	9,978	93,414
Utah	1,204	14,723	1,157	19,373
West Virginia	1,078	W	953	W
Other[2]	2,520	41,787	2,887	55,311
Total	[3]45,793	538,352	40,352	656,164
Puerto Rico[e]	27	639	27	642

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Quantity and value of brine included with "Other."
[2]Includes Alabama, Arizona, California, Colorado, Hawaii, Kansas (brine only), Nevada, New Mexico, North Dakota, Oklahoma, and items indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Evaporated salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Kansas	976	51,780	901	56,555
Louisiana	318	22,545	280	20,487
Michigan	1,116	64,003	1,133	90,916
New York	709	44,951	638	50,579
Utah	1,128	14,371	1,091	19,005
Other[1]	1,973	77,316	2,271	97,575
Total[2]	6,221	274,965	6,314	335,117
Puerto Rico[e]	27	639	27	642

[e]Estimated.
[1]Includes Arizona, California, Hawaii, New Mexico, North Dakota, Ohio, Oklahoma, and Texas.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1976	15,668	125,682
1977	14,958	136,437
1978	14,688	150,794
1979	14,891	152,192
1980	11,806	176,541

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1976	412	18,401	76	3,807	[1]487	22,208
1977	388	19,307	65	3,281	453	22,588
1978	381	20,625	58	3,041	439	23,666
1979	391	19,727	64	3,987	455	23,714
1980	393	24,412	65	4,502	458	28,914

[1]Data do not add to total shown because of independent rounding.

Table 7.—Distribution of salt sold or used by producers in the United States, by use

(Thousand short tons)

Consumer or use	1979				1980			
	Evaporated	Rock	Brine	Total[1]	Evaporated	Rock	Brine	Total[1]
Chlorine, caustic soda, soda ash	557	1,819	23,824	26,200	682	2,103	21,156	23,941
All other chemicals	446	625	150	1,222	396	505	119	1,020
Textile and dyeing	134	53	--	188	124	53	--	177
Meatpackers, tanners, casing manufacturers	259	287	--	546	278	268	--	546
Dairy	78	7	--	85	79	5	--	84
Canning	181	99	([2])	280	182	104	([2])	287
Baking	109	10	--	119	105	8	--	113
Flour processors (including cereal)	70	25	([2])	95	68	24	([2])	92
Other food processing	204	56	([2])	261	197	40	14	251
Feed dealers	688	506	--	1,194	732	440	--	1,172
Feed mixers	364	359	--	723	337	326	--	662
Metals	70	286	([2])	356	56	215	([2])	272
Rubber	W	9	W	99	W	5	W	95
Oil	228	103	218	550	345	100	264	709
Paper and pulp	W	134	W	194	W	135	W	230
Water softener manufacturers and service companies	464	345	([2])	810	443	234	8	686
Grocery stores	887	253	([2])	1,140	825	168	([2])	995
Highway use	308	8,433	([2])	8,742	252	6,137	([2])	6,389
U.S. Government	20	58	([2])	78	39	82	([2])	121
Distributors (brokers, wholesalers, etc.)	588	W	W	1,249	529	W	W	989
Miscellaneous and undistributed[3]	603	1,430	491	[4]1,714	637	1,320	501	[4]1,810
Total[1]	[5]6,260	[5]14,901	[5]24,684	[6]45,844	[5]6,306	[5]12,272	[5]22,063	[6]40,641

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 5 units; included with "Miscellaneous and undistributed."
[3]Includes withheld figures and some exports and consumption in overseas areas administered by the United States.
[4]Incomplete totals; withheld totals are included with total for each specific use.
[5]Differs from totals shown in tables 2, 4, and 5 because of changes in inventory.
[6]Differs from totals shown in tables 1, 2, and 3 because of changes in inventory.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1979				1980			
	Evaporated		Rock		Evaporated		Rock	
	Domestic	Imported	Domestic	Imported	Domestic	Imported	Domestic	Imported
Alabama	56	--	402	--	47	--	504	--
Alaska	W	--	--	--	16	--	--	--
Arizona	63	--	3	--	61	--	15	--
Arkansas	30	--	87	--	29	--	68	--
California	774	--	1	--	934	--	1	--
Colorado	131	--	47	--	130	W	50	--
Connecticut	25	W	W	--	24	W	83	--
Delaware	5	W	W	--	47	W	272	--
District of Columbia	W	W	W	--	W	W	W	--
Florida	67	W	115	--	67	W	86	--
Georgia	66	W	129	--	93	W	90	--
Hawaii	W	--	--	--	W	--	--	--
Idaho	72	--	W	--	66	--	W	--
Illinois	408	W	1,051	W	360	W	804	270
Indiana	174	W	638	W	150	W	468	170
Iowa	204	(1)	323	(1)	205	W	289	W
Kansas	101	--	200	--	97	--	222	--
Kentucky	39	(1)	728	(1)	35	(1)	589	W
Louisiana	56	(1)	436	--	53	--	464	--
Maine	8	(1)	W	W	7	(1)	89	W
Maryland	51	W	W	(1)	39	W	139	W
Massachusetts	44	W	W	W	37	W	194	W
Michigan	202	W	W	W	170	W	520	624
Minnesota	194	--	334	W	182	(1)	315	W
Mississippi	25	(1)	100	--	23	--	116	--
Missouri	109	W	507	--	106	--	353	--
Montana	56	--	2	--	69	(1)	2	--
Nebraska	127	--	118	--	125	(1)	101	--
Nevada	W	--	W	--	W	(1)	W	--
New Hampshire	5	W	W	W	3	W	W	W
New Jersey	213	W	W	W	194	W	360	W
New Mexico	62	--	23	--	70	--	27	--
New York	330	31	1,680	W	299	25	1,335	73
North Carolina	122	W	165	(1)	102	W	152	--
North Dakota	W	--	1	--	W	--	1	--
Ohio	367	10	1,718	W	347	56	1,399	W
Oklahoma	54	--	90	--	63	--	87	--
Oregon	58	W	(1)	--	158	W	--	--
Pennsylvania	204	W	1,140	W	159	W	969	W
Rhode Island	8	W	W	W	13	W	W	W
South Carolina	40	W	16	--	31	W	17	W
South Dakota	47	--	35	--	46	(1)	41	--
Tennessee	95	--	595	W	88	--	498	W
Texas	235	--	265	--	233	--	243	--
Utah	301	--	W	--	241	(1)	W	--
Vermont	5	(1)	W	W	5	(1)	104	W
Virginia	117	W	W	(1)	103	W	252	--
Washington	153	511	(1)	--	131	423	W	--
West Virginia	23	W	365	(1)	63	W	210	W
Wisconsin	207	W	481	W	186	W	350	415
Wyoming	30	--	W	--	32	--	W	--
Other[2]	498	1,018	3,107	2,126	609	800	400	183
Total[3]	[4]6,261	[5]1,570	[4]14,902	[5]2,126	[4]6,348	[5]1,304	[4]12,279	[5]1,735

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and shipments to States indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.
[4]Differs from totals in tables 2, 4, and 5 because of changes in inventory.
[5]Differs from totals in tables 1, 11, 12, and 13 because of incomplete data on the distribution of imported salt.

PRICES

The average values of different classes of salt, f.o.b. works, as reported by producers follow:

	Per ton	
	1979	1980
Evaporated:		
Open pan or grainer, and vacuum pan	$61.64	$76.44
Solar	12.16	15.65
Pressed blocks, all sources	52.12	63.20
Rock salt, bulk	10.00	14.65
Salt in brine	4.51	6.50

The following salt prices were quoted at yearend 1980 in Chemical Marketing Reporter:[4]

Salt, evaporated, common, 80-pound bags, carlots or truckloads, North, works, 80 pounds	$2.46
Salt, chemical-grade, same basis, 80 pounds	2.67
Salt, rock, medium coarse, same basis, 100 pounds	1.55
Salt, rock, extra coarse, same basis, 100 pounds	1.63

FOREIGN TRADE

Exports of salt from the United States increased to 831,000 short tons in 1980. The majority of the salt was shipped to Canada with minor amounts being exported to Saudia Arabia, Iraq, and Mexico.

U.S. imports of salt decreased slightly to 5.3 million short tons in 1980 as a result of reduced consumption of salt in the United States. Canada and Mexico remained the largest sources of foreign salt.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Puerto Rico	20,944	$3,908	22,315	$4,281
Virgin Islands	293	16	173	15

Table 10.—U.S. exports of salt, by country

(Thousand short tons and thousand dollars)

Destination	1979		1980	
	Quantity	Value	Quantity	Value
Angola	1	78	--	--
Bahamas	1	121	1	169
Bermuda	1	3	(1)	2
Canada	681	r6,753	800	8,224
Costa Rica	1	53	1	157
Denmark	(1)	33	(1)	42
Germany, Federal Republic of	(1)	6	(1)	15
Hong Kong	1	53	(1)	30
Iraq	--	--	7	301
Mexico	3	287	3	326
Netherlands Antilles	1	60	(1)	68
Saudi Arabia	3	835	12	2,348
South Africa, Republic of	(1)	6	(1)	5
Sweden	1	21	(1)	7
Trinidad and Tobago	2	119	2	186
United Arab Emirates	1	72	(1)	97
United Kingdom	1	78	(1)	93
Venezuela	1	7	(1)	29
Other	3	440	5	730
Total	2697	r9,025	831	12,829

rRevised.
1Less than 1/2 unit.
2Data do not add to total shown because of independent rounding.

Table 11.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1979		1980	
	Quantity	Value	Quantity	Value
Bahamas	528	3,985	531	5,573
Brazil	197	1,625	62	608
Canada	[1]2,057	[1]15,580	[2]2,089	[2]16,515
Chile	244	1,699	341	2,689
Colombia	41	480	273	2,280
Italy	42	1,205	([3])	([3])
Mexico	1,649	11,282	1,457	10,216
Nepal	--	--	22	161
Netherlands	57	960	104	2,034
Netherlands Antilles	175	1,597	193	2,031
Spain	252	1,745	99	831
Tunisia	33	250	60	530
Yemen Arab Republic	--	--	31	163
Other	[5]([4])	[5]452	[6]([4])	[6]439
Total[7]	5,275	40,860	5,263	44,071

[1]Includes salt brine through Detroit customs district, 239 short tons ($5,370).
[2]Includes salt brine through Detroit customs district, 11,490 short tons ($39,205) and Ogdensburg customs district, 20 short tons ($1,406).
[3]Includes 405 pounds ($6,989) salt in bags, sacks, and barrels.
[4]Less than 1/2 unit.
[5]Includes salt brine from Denmark through Cleveland customs district, 6 short tons ($43,410); from Finland through New York customs district, less than 1 short ton ($949); from Sweden through New York customs district, less than 1 short ton ($637).
[6]Includes salt brine from Austria through New York customs district, 50 short tons ($500); from Sweden through New York customs district, 36 short tons ($727). Salt in bags, sacks, and barrels from Denmark through Boston and Cleveland customs district, 66 short tons ($28,577); from Japan through Norfolk, Los Angeles, and Anchorage customs districts, 19 short tons ($268,695).
[7]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. imports for consumption of salt, by class

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Quantity	Value	Quantity	Value
1978	1	1,209	[1]5,380	[1]33,037
1979	1	1,760	[2]5,275	[2]39,099
1980	1	1,478	[3]5,263	[3]42,593

[1]Includes salt brine from Canada through St. Albans customs district, 24 short tons ($259), and through Buffalo customs district, 2 short tons ($330); from Chile through Philadelphia customs district, 1 short ton ($280); from the Netherlands through San Juan customs district, 53 short tons ($1,104); from Denmark through Chicago customs district, less than 1 short ton ($1,355), and through Cleveland customs district, 8 short tons ($69,902).
[2]Includes salt brine from Canada through Detroit customs district, 239 short tons ($5,370); from the United Kingdom through Washington customs district, less than 1 short ton ($344); from Denmark through Cleveland customs district, 6 short tons ($43,410); from Finland through New York customs district, less than 1 short ton ($949); from Sweden through New York customs district, less than 1 short ton ($637).
[3]Includes salt brine from Canada through Ogdensburg customs district, 20 short tons ($1,406) and Detroit district, 11,490 short tons ($39,205); from Sweden through New York customs district, 36 short tons ($727); from Denmark through Cleveland customs district, 2 short tons ($20,498); from Federal Republic of Germany through Boston customs district, 2 short tons ($1,774); from Austria through New York customs district, 50 short tons ($500); from Poland through Cleveland customs district, less than 1 short ton ($300).

Table 13.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1979		1980	
	Quantity	Value	Quantity	Value
Anchorage, Alaska	1	350	([1])	278
Baltimore, Md	498	4,550	472	3,497
Boston, Mass	34	270	33	319
Buffalo, N.Y	23	258	64	434
Chicago, Ill	519	3,629	554	3,810
Cleveland, Ohio	16	157	34	600
Detroit, Mich	697	5,390	599	4,715
Duluth, Minn	182	1,625	179	1,434
Los Angeles, Calif	150	683	190	1,700
Milwaukee, Wis	520	3,162	442	2,959
New Orleans, La	132	1,122	66	463
New York, N.Y	253	2,449	397	5,401
Norfolk, Va	109	1,051	86	751
Ogdensburg, N.Y	18	189	58	530
Philadelphia, Pa	36	290	47	469
Portland, Maine	485	4,182	397	3,640
Portland, Oreg	436	2,309	513	3,158
Providence, R.I	109	922	--	--
St. Albans, Vt	25	390	39	590
San Juan, P.R	41	341	6	70
Savannah, Ga	318	2,197	273	2,178
Seattle, Wash	500	3,416	576	3,843
Tampa, Fla	16	136	51	394
Wilmington, N.C	158	1,755	184	2,692
Other	1	39	3	146
Total[2]	5,275	40,860	5,263	44,071

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 14.—U.S. imports for consumption of salt, by use as reported by salt producers

(Thousand short tons)

Use	1979	1980
Government (highway use)	2,396	1,087
Chemical industry	762	803
Water-conditioning service companies	148	179
Other	388	260
Total[1 2]	3,695	2,330

[1]Disagreement with totals in tables 1, 11, 12, and 13 is because of incomplete data on the uses of imported salt.
[2]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

	Million tons	
	1979	1980
Europe	80.0	73.6
North America	60.8	56.2
Asia	33.3	36.5
South America	5.7	6.0
Oceania	6.5	5.9
Africa	2.9	3.3

Canada.—A $37 million expansion of Domtar Chemical Groups' rock salt mine at Goderich, Ontario, was announced in October 1980. The project is scheduled for completion by February 1983 and will increase the annual capacity of the mine from 2.25 million tons to 3.5 million tons.[5]

China, Mainland.—A recent survey estimated the salt reserves of the salt lakes in Qaidam basin in the Quinghai Province to be about 60 million tons.[6] A salt industry is under development in the Inner Mongolia region of China from seven major salt lakes. The region presently produces about 1 million tons of salt per year.[7]

Germany, Federal Republic of.—Saline Lüneburg Chemische Fabrik GmbH announced the closure of its salt facility in Lüneburg due to the high cost of heating oil used to heat the salt pans. Production of salt at this site has occurred for the last 1,000 years.[8]

Poland.—The Klodawa Mine in Konin Province, the country's largest rock salt mine, is scheduled to expand production by about 165,000 short tons. No date has been announced for completion of the project.[9]

Spain.—A research project to compare energy costs associated with the production of rock salt, vacuum pan salt, and solar salt was initiated by Andaluz de Sal; a joint venture between Akzo Zout Chemie Nederland B.V. in the Netherlands and two unnamed Spanish concerns.[10]

U.S.S.R.—The Khodzhaikan rock salt mine began with limited production in Uzbekistan. Full operating capacity of 550,000 tons per year is scheduled by 1983.[11]

Yemen Arab Republic.—Salt and gypsum are the only minerals commercially developed in Yemen. Recent exploration for oil in North Yemen has resulted in the discovery of new rock salt deposits. The salt is mined by the Salif Salt Mining Co., which is supervised by the State-owned Yemen Oil and Mineral Corp.[12]

Yugoslavia.—A rock salt deposit was discovered at Tetina Village in the Mount Majevica-Mount Kozara region. The salt bed is between 60 feet to 600 feet thick, at a depth of about 2,400 feet. The discovery of this deposit is important because the salt deposits near Tuzla in Bosnia Province are expected to be depleted by 1995.[13]

Table 15.—Salt: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Bahamas	1,491	1,841	[e]1,800	485	[3]754
Canada	6,607	6,657	7,112	7,585	[3]7,748
Costa Rica	22	30	38	51	44
Dominican Republic	[r]40	[r]38	42	42	42
El Salvador[e]	25	30	30	30	30
Guatemala	12	12	12	16	[3]11
Honduras	35	[e]35	[e]35	[e]35	35
Leeward and Windward Islands[e]	55	55	55	55	55
Mexico	5,061	[r]5,400	6,212	[e]6,200	6,600
Netherlands Antilles[e]	530	440	440	440	440
Nicaragua	16	[e]18	[e]20	[e]20	22
Panama	14	23	17	21	21
United States, including Puerto Rico:					
Rock salt	15,668	14,958	14,688	14,891	11,807
Other salt:					
United States	28,523	28,454	28,181	30,902	28,545
Puerto Rico[e]	27	27	27	27	27
South America:					
Argentina:					
Rock salt	2	2	1	1	[3]1
Other salt	727	1,263	771	619	[3]690
Brazil	2,726	[r]2,735	3,006	3,087	3,300
Chile	472	467	434	650	550
Colombia:					
Rock salt	205	199	196	194	190
Other salt	1,020	817	632	505	490
Peru	335	342	542	496	550
Venezuela	[e]330	266	174	[e]170	[3]268
Europe:					
Albania[e]	55	55	55	70	75
Austria:					
Rock salt	1	1	1	1	[3]1
Evaporated salt	366	356	354	419	[3]452
Salt in brine	270	[r]160	172	229	220
Bulgaria	83	96	96	95	[3]134
Czechoslovakia	269	280	284	299	300
Denmark	385	346	358	419	420
France:					
Rock salt	[r]304	316	505	631	[3]331
Brine salt	[r]1,116	1,120	1,215	1,310	[3]1,227
Marine salt	[r]1,458	[r]1,087	952	1,986	[3]1,405
Salt in solution	[r]3,613	[r]3,844	4,254	4,955	[3]4,867

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Europe—Continued					
German Democratic Republic:					
Rock salt	2,765	2,855	2,963	3,304	3,400
Marine salt	57	58	58	60	62
Germany, Federal Republic of:					
Marketable:					
Rock salt	7,027	7,860	7,546	9,876	7,600
Marine salt and other salt	5,448	5,723	6,407	6,757	6,700
Greece	154	209	147	170	170
Iceland	[e](4)	[e](4)	[e](4)	[e](4)	[3](4)
Italy:					
Rock salt and brine salt	3,759	3,969	4,102	4,949	[3]4,406
Marine salt	664	1,576	1,334	1,300	1,400
Malta	(4)	1	1	[e]1	1
Netherlands	3,336	3,429	3,240	4,355	[3]3,818
Poland:					
Rock salt	1,821	1,722	1,582	1,607	1,200
Other salt	2,388	3,081	3,261	3,275	2,500
Portugal:					
Rock salt	338	387	360	449	450
Marine salt	180	164	165	[e]155	140
Romania:					
Rock salt	4,641 (rock salt and other salt)	5,000 (rock salt and other salt)	1,827	1,819	1,820
Other salt			3,397	3,384	3,380
Spain:					
Rock salt	2,204	[r]1,360	1,560	1,562	1,600
Marine salt and other evaporated salt[5]	1,277	[r]1,323	1,408	1,389	1,490
Switzerland	343	403	431	431	[3]406
U.S.S.R.[e]	15,650	15,760	15,980	[r]15,760	15,980
United Kingdom:					
Rock salt	674	998	1,445	1,752	1,760
Brine salt[6]	2,114	2,062	1,940	2,111	2,200
Other salt[6]	6,037	5,981	4,673	4,756	3,300
Yugoslavia:					
Rock salt	101	94	94	151	[3]416 (rock salt, marine salt and salt from brine)
Marine salt	14	23	23	23	
Salt from brine	204	207	212	212	
Africa:					
Algeria	150	162	189	182	190
Angola[e]	55	55	55	55	55
Benin	(4)	(4)	[e](4)	[e](4)	(4)
Egypt	530	658	832	679	770
Ethiopia:[7]					
Rock salt[e]	11	6	11	[r]17	17
Marine salt	97	[e]85	[e]55	102	100
Ghana[e]	[r]57	55	55	55	55
Kenya:					
Crude	55	44	22	[e]22	22
Refined	16	14	[e]13	[e]13	13
Libya[e]	11	11	17	11	11
Madagascar	30	29	33	[e]33	33
Mali[e]	[r]5	5	5	5	5
Mauritania[e]	1	1	1	1	1
Mauritius	6	7	7	7	7
Morocco	24	14	38	112	115
Mozambique[e]	31	31	31	31	31
Namibia (marine salt)[e]	240	250	250	250	250
Niger[e]	1	1	1	[r]3	3
Senegal	156	154	154	[e]154	154
Sierra Leone[e]	200	200	200	200	200
Somalia	[r] [e]30	[r] [e]30	[r] [e]30	33	[3]33
South Africa, Republic of	247	267	540	594	[3]625
Sudan	77	101	79	90	90
Tanzania	51	31	22	41	40
Togo	[e](4)	--	1	[e]1	1
Tunisia	529	446	469	440	[3]481
Uganda[e]	1	1	1	1	1
Asia:					
Afghanistan	77	86	89	22	6
Bangladesh[7]	606	381	866	743	770
Burma	139	254	336	284	[3]296

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Asia —Continued					
China:					
Mainland	22,046	18,850	21,528	16,281	[3]19,048
Taiwan	548	547	375	404	[3]796
Cyprus	4	--	--	7	[3]8
India:					
Rock salt	4	4	5	5	[3]5
Marine salt	5,066	5,873	7,381	7,751	8,000
Indonesia	[r]620	[r]867	259	779	720
Iran[e,8]	[r]770	[r]770	[r]770	[r]770	660
Iraq[e]	[r]70	90	90	[r]110	100
Israel	95	[e]110	134	118	121
Japan[9]	1,125	1,164	1,183	1,202	1,200
Jordan	22	33	33	28	33
Kampuchea[e]	33	33	13	[r]29	33
Korea, North[e]	600	600	600	600	630
Korea, Republic of	[r]765	[r]875	717	551	[3]502
Kuwait	17	18	21	21	22
Laos[e]	11	11	17	20	22
Lebanon[e]	[r]39	[r]39	13	[r]11	13
Mongolia[e]	12	17	17	17	17
Pakistan:					
Rock salt[7]	413	424	455	564	550
Other salt	159	126	250	212	220
Philippines	[r]224	[r]221	249	373	390
Sri Lanka	155	57	165	134	140
Syria	60	[r]117	[r,e]120	83	90
Thailand:					
Rock salt	6	14	13	12	13
Other salt[e]	180	180	180	180	180
Turkey	638	857	1,024	1,246	1,200
Vietnam[e]	[r]640	[r]640	[r]585	[r]580	570
Yemen Arab Republic	110	80	30	70	72
Yemen, People's Democratic Republic of[e]	83	83	83	83	88
Oceania:					
Australia (marine salt and brine salt)	6,051	5,197	6,356	6,393	[3]5,859
New Zealand	47	58	72	77	80
Total	[r]177,105	[r]177,349	[r]184,007	189,436	181,608

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 17, 1981.
[2]Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Includes production in the Canary Islands (Spain's provinces of Las Palmes and Santa Cruz de Tenerife) totaling 17,434 short tons in 1977, 15,766 short tons in 1978, and 8,685 short tons in 1979 (1976 and 1980 not available).
[6]Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brines; that captioned "Other salt" are the salt content of brines used for purposes other than production of salt by evaporation.
[7]Year ending June 30 of that stated.
[8]Year beginning Mar. 21 of that stated.
[9]Includes Ryukyu Islands.

TECHNOLOGY

A 150-kilowatt electrical generator at Ein Bokek in Israel has been running almost continuously since its startup in December 1979. The power is supplied by a salt-gradient solar pond in conjunction with a low-temperature turbogenerator. This new power system is based on the principle that the salinity and temperature in the pond increase with depth, resulting in a dense saline bottom layer that restricts convection. The heat from the brine (about 195° F) runs the turbine to generate the electricity.

Near the Salton Sea in California, a 5-megawatt electrical generator plant is scheduled for construction with similar projects under consideration in other parts of the world.[14]

A ring dike composed of compacted reef shells and sand was constructed in a marshy delta area near New Orleans. The purpose was to develop a reservoir to contain 25 million barrels of salt brine that will be used to displace oil temporarily stored in the Clovelly salt dome at the Lousiana Offshore Oil Port. The facility is owned by LOOP, Inc., a joint venture of five major oil companies. The walls of the 220-acre reservoir were constructed to be impervious to any brine seepage that could contaminate surrounding ground water.[15]

The Bureau of Mines in 1980 continued to conduct pressure and deflection measurements on remnant pillars at the Cayuga salt mine in New York. The objectives of the study are to design favorable mine entries for long-term stability of longwall mining operations and to improve the ore extraction ratios for mining evaporate minerals.

Another Bureau of Mines project was concerned with methane gas emissions in salt domes. Investigations into the geologic character of salt bodies and the composition and content of contained gases were initiated after the Belle Isle salt mine explosion in June 1979.[16]

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[1]Physical scientist, Section of Nonmetallic Minerals.

[2]The Washington Post. Louisiana Salt Mine Collapse. Nov. 21, 1980, No. 352, p. A15.

[3]Industrial Minerals. Salt Mine To Remain. V. 149, February 1980, p. 18.

[4]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 218, No. 26, Dec. 29, 1980, p. 34.

[5]————. Domtar Chemicals Begins Salt Mine Expansion Work. V. 218, No. 17, Oct. 27, 1980, p. 3.

[6]Industrial Minerals. V. 157, October 1980, p. 71.

[7]————. V. 158, November 1980, p. 65.

[8]Work cited in footnote 6.

[9]Mining Journal. Salt Mine Expansion. V. 294, No. 7537, Feb. 1, 1980, p. 82.

[10]Chemical Age. Spanish Salt Study. Nov. 14, 1980, p. 3.

[11]Industrial Minerals. V. 156, September 1980, p. 67.

[12]The Wall Street Journal. North Yemen's Rock Salt Finds a Growing Market. V. 195, No. 90, May 7, 1980, p. 20.

[13]Engineering and Mining Journal. V. 181, No. 4, April 1980, p. 175.

[14]Popular Science. Power From the Dead Sea Via Solar Ponds. V. 218, No. 4, April 1981, pp. 84-86.

[15]Engineering News Record. Slurry Wall Seals Brine Reservoir. V. 204, No. 2, July 10, 1980, p. 27.

[16]————.Bureau of Mines Research in 1980. Methane in Salt Mine. Pittsburgh Research Center. 1981.

Sand and Gravel

By Valentin V. Tepordei[1]

A total of 794 million tons of sand and gravel was reported produced in the United States in 1980 with a value of $2.3 billion, f.o.b. plant. This tonnage is the second lowest production reported in the last 18 years, 20% below the record high production of 1978. Of the 1980 total, 96% was construction sand and gravel and 4% was industrial sand and gravel.

Production of construction sand and gravel decreased 19% in 1980 and that of industrial sand and gravel decreased 9%, reflecting the impact of the recession on the construction industry. Exports of sand and gravel in 1980 increased 18% to 2.5 million tons and imports increased 28% to 541,000 tons. Domestic apparent consumption of total sand and gravel (construction and industrial) was 795 million tons.

Table 1.—Salient sand and gravel statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Sold or used:					
Construction:					
Sand:					
Quantity	418,495	439,400	489,800	455,000	374,000
Value	$654,389	$848,200	$989,200	$974,100	$926,000
Gravel:					
Quantity	436,747	458,400	473,500	490,500	390,000
Value	$949,405	$968,700	$1,064,000	$1,170,000	$1,072,000
Total construction:[2]					
Quantity	855,242	897,900	963,300	945,500	764,000
Value	$1,603,974	$1,817,000	$2,053,000	$2,144,000	$1,998,000
Industrial:					
Sand:					
Quantity	29,669	29,610	31,810	32,120	29,610
Value	$169,127	$201,900	r$243,200	$275,200	$297,800
Gravel:					
Quantity	245	1,745	1,041	1,391	865
Value	$1,109	$8,704	$5,554	$8,574	$6,458
Total industrial:[2]					
Quantity	29,914	31,360	32,850	33,510	30,480
Value	$170,236	$210,600	$248,800	$283,800	$304,300
Grand total:[2]					
Quantity	885,156	929,200	996,200	979,000	794,400
Value	$1,774,030	$2,028,000	$2,302,000	$2,427,000	$2,302,000
Exports:					
Quantity	3,692	3,689	4,260	2,076	2,451
Value	$19,516	$21,515	$29,270	$32,440	$40,660
Imports:					
Quantity	353	386	625	423	541
Value	$909	$1,278	$2,084	r$2,321	$2,718

[r]Revised.
[1]Puerto Rico excluded from all sand and gravel statistics.
[2]Data may not add to totals shown because of independent rounding.

Legislation and Government Programs.—In October 1980, the National Materials and Minerals Policy Research and Development Act became Public Law 96-479. This law seeks to provide for the formulation of a national minerals policy to promote an adequate and stable supply of materials and minerals necessary to maintain national security, economic well-being, and industrial production. The law provides explicit authority for the Bureau of Mines to collect from the industry and Federal and State agencies data concerning mineral occurrences, production, and uses and to evaluate and analyze this information and to protect against disclosure of company proprietary data sought under the Freedom of Information Act.

In March 1980, the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) published plans to review its safety and health standards for open pit mines, including sand and gravel and crushed stone operations. This review was initiated by MSHA to update its existing standards by simplifying, consolidating, or eliminating some of the present provisions. MSHA encouraged all segments of the mining industry to provide their input into the revision process. The revised MSHA standards were expected to be published during 1981.

Following the publication in November 1979 of the final report of its Committee on Surface Mining and Reclamation (COSMAR) regarding the applicability of the Federal Surface Mining Control and Reclamation Act of 1977 to the surface mining of noncoal minerals, the Council of Environmental Quality (CEQ) held extensive hearings on this matter. Based on the COSMAR report's conclusions and recommendations as well as the hearings, CEQ recommended that Congress should not enact any new legislation regulating noncoal minerals mining and reclamation on public or private lands.

Under a minerals research contract with the Bureau of Mines and with the technical assistance of the Interstate Mining Compact Commission, Hittman Associates, Inc., of Lexington, Ky., completed the final draft of a reclamation planning guide for small sand and gravel operations. The report explains the importance of public involvement in planning such operations and gives detailed information on pollution control and reclamation procedures for small sand and gravel pits. The report also includes an index of Federal agencies that may have some control over sand and gravel mining and a list of States with laws controlling this type of operation. The guide should help small operations comply with the increasing public pressures and regulatory restrictions affecting their businesses. The final form of the report entitled "Reclamation and Pollution Control: Planning for Small Sand and Gravel Mines" has been published.

DOMESTIC PRODUCTION

Beginning with the 1980 data year, a new procedure for the annual survey of sand and gravel producers was implemented by the Bureau of Mines. The new system provided a continuation of the annual survey of large operations that produce most of the sand and gravel. Producers that report a smaller and/or less diversified production, but represent a relatively large number of operations were to be surveyed by rotation, one-third of them each year. Production of the other two-thirds of these operations was to be estimated each year based on prior reporting. Bureau of Mines statistical studies indicated that the new sampling plan would reduce the number of operations canvassed each year by approximately 40%, without affecting significantly the quality of the data.

In 1980, the Pacific region led the Nation in the production of construction sand and gravel with 194 million tons or 25% of the U.S. total. Next was the East North Central region with 138 million tons or 18% of the total, followed by the Mountain region with 93 million tons or 12% of the total. In industrial sand and gravel, the East North Central region led the Nation with 11.3 million tons or 37% of the national total, followed by the South Atlantic region with 4.3 million tons or 14% and the West South Central region with 4.1 million tons or 13%.

If the four major geographic regions are compared (table 2), the West led the Nation in the production of construction sand and gravel with 38% of the total. North Central was next with 28% and the South was third with 24% of the national total. In industrial sand and gravel, the North Central region produced 42% of the national total followed by the South with 30% and the West, a distant third, with 15%.

A comparison of 1979 and 1980 production data by region indicates the following: Production of construction sand and gravel in the Northeast, North Central, and South (except West South Central) decreased in 1980 between 21% and 26%, more than the national average of 19%; at the same time, production in the western regions, including the West South Central, decreased only between 10% and 12%. Production of industrial sand and gravel in the North Central and South decreased between 14% and 20%, more than the national average of 9%, while in the Northeast production increased 4% and in the West, 43%. The largest increase in production of industrial sand in the West was reported in California.

Based on the 1980 census data on population, the U.S. per capita sand and gravel production was 3.5 tons. At the regional level, per capita production was 6.7 tons in the West, followed by North Central with 3.7 tons, the South with 2.4 tons, and Northeast with 1.7 tons.

The five leading States in the production of construction sand and gravel, in order of volume, were California, Alaska, Texas, Ohio, and Michigan. The combined production of these five States represented 35% of the national total. In industrial sand and gravel, four States produced 50% of the national total with Illinois first, followed by Michigan, California, and New Jersey.

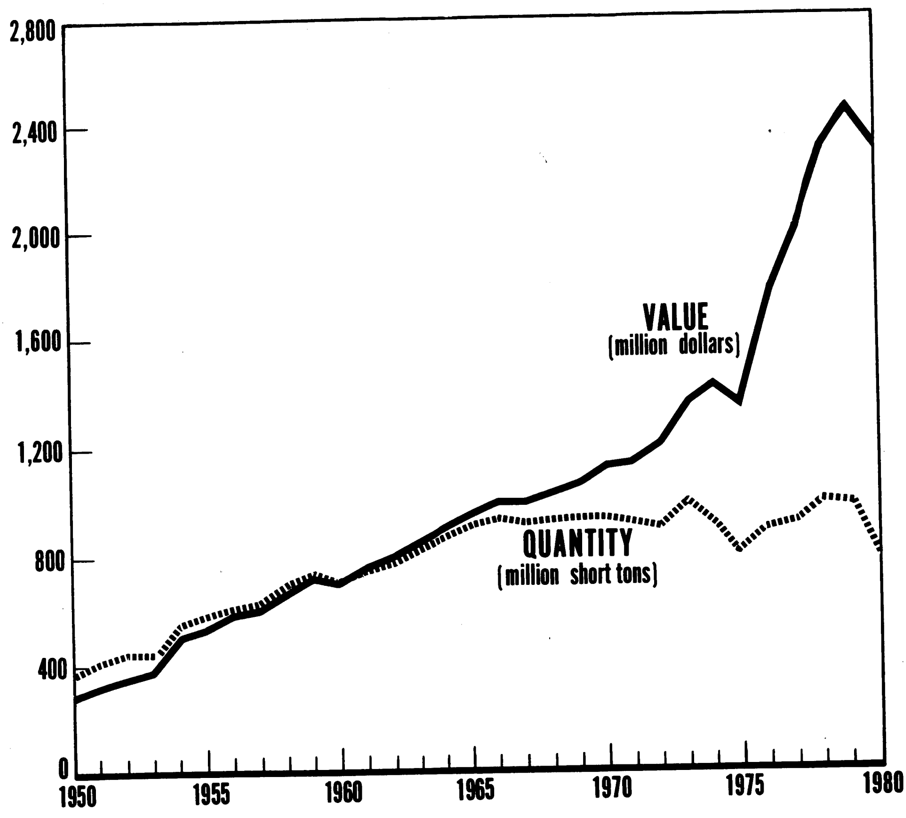

Figure 1.—Production and value of sand and gravel in the United States for 1950-80.

For the combined production of construction and industrial sand and gravel, the five leading States in order of volume were California, Texas, Alaska, Ohio, and Michigan with 35% of the U.S. total.

Compared with that of 1979, the 1980 production of construction sand and gravel decreased significantly in some major producing States such as Illinois and Wisconsin (32%), Florida (30%), and Michigan (27%). In Alaska, California, and Texas, the decrease was only between 11% and 12%, significantly less than the national average. The production of industrial sand in 1980 decreased in Michigan (27%) and Illinois (14%), but increased in Texas (5%), New Jersey (10%), and especially in California (71%).

The top 10 producers of construction sand and gravel in 1980 were, in descending order of tonnage: Lone Star Industries, Inc.; Conrock Co., Inc.; American Aggregates Corp.; Tanner Companies; Gifford-Hill & Co., Inc.; Kaiser Sand and Gravel Corp.; Owl Rock Products Co.; Livingston-Graham (Brown Co.); Dravo Corp.; and A. Teichert & Son, Inc. Combined production from the 123 operations of the top 10 producers represented 11% of the national total.

The five leading producers of industrial sand and gravel, in order of tonnage, were Pennsylvania Glass Sand Corp., Ottawa Silica Co., Martin Marietta Aggregates, Owens-Illinois Inc., and Manley Brothers of Indiana, Inc. Their combined production from 32 operations represented 52% of the U.S. total.

Mostly because of the drop in the demand for sand and gravel, the trend toward larger operations slowed down somewhat during the year, while a significant number of small operations ceased production either temporarily or permanently (table 4).

In 1980, a total of 4,559 producers of sand and gravel with 6,177 operations were canvassed by the Bureau of Mines. Construction sand and gravel was produced by 4,512 companies with 6,057 operations and industrial sand and gravel by 100 companies with 151 operations. Some companies produced both construction and industrial sand and gravel from the same operations. Most of the construction sand and gravel came from operations that produced more than 200,000 tons per year; 980 operations, representing 16% of the total, produced 65% of the total tonnage. The total number of active sand and gravel operations in each State and geographic region, as well as the number of processing plants on land or associated with dredging operations, whether stationary or portable, etc., is shown in tables 5 and 6.

As a result of the introduction of the sampling plan for the annual survey as well as the fact that some companies did not respond to the Bureau of Mines canvass, the production from 3,573 operations, representing 58% of the total number of operations, was estimated in 1980. Their total estimated production was 264 million tons or 33% of the U.S. total.

The sand and gravel production reported by producers to the Bureau of Mines is actually material that is "sold or used" by the companies and is defined as such. Stockpiled production is not reported until it is consumed. Therefore, the sold or used tonnage represents the amount produced for consumption (or export) in a given year.

In 1980, Martin Marietta Aggregates became the third largest U.S. producer of industrial sand following its acquisition in 1979 of Wedron Silica Co. The company now owns 12 industrial sand operations in 10 States, but as a result of an agreement with the U.S. Department of Justice, it will sell 2 of its Illinois plants within a year.

As a result of a very low demand for aggregates in 1980, especially in the northern States, a significant number of sand and gravel operations were at least temporarily closed. A total of 2,134 operations were reported idle during 1980. Only a few companies announced new sand and gravel operations in 1980; these were Lone Star in Virginia, Vulcan in Texas, and Unimin in New Jersey.

Production and productivity were two major topics presented in several articles published about the sand and gravel industry in 1980.[2]

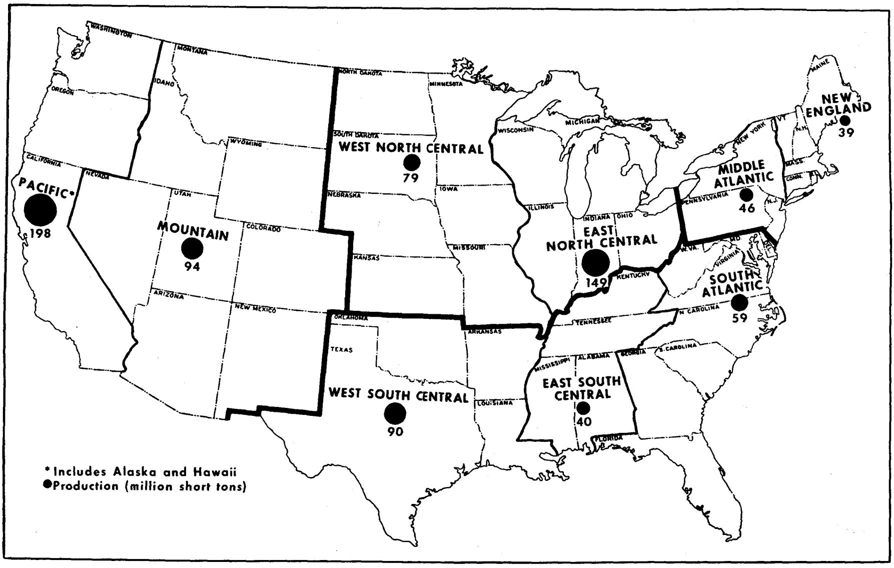

Figure 2.—Production of sand and gravel by geographic region in the United States in 1980.

CONSUMPTION AND USES

In 1980, U.S. consumption of construction sand and gravel was about 764 million tons or 96% of the total, valued at $2.0 billion. About 38% of this tonnage was used as concrete aggregate for residential and nonresidential buildings and for highways, dams, and airports; 5% was used for concrete products such as blocks, bricks, concrete pipes, and plaster and gunite sands; 14% was used as asphaltic concrete aggregates and other bituminous mixtures; nearly 24% was consumed in road base and coverings; 16% as construction fill; and the remaining 3% for railroad ballast, snow and ice control, and other unspecified uses.

Tables 8 and 9 show the consumption of sand and gravel by end use, and by geographic region and State. The data in table 8 indicate that most of the sand and gravel used in concrete aggregate and concrete products was in the South (33%) and the West (31%), regions with high levels of construction activity. The same table indicates that most of the sand and gravel for asphaltic concrete aggregate and roadbase and road surfacing was used in the West (39%) and the North Central (33%).

Total consumption of industrial sand and gravel was 30.5 million tons, 1.2 million tons of which were exported. Table 11 shows the industrial sand and gravel sold or used in 1980 by end uses in the four major geographic regions. The main uses were 44% for glassmaking and 28% for foundry. Most of the glass sand was used in the South (33%) and North Central (28%), and most of the foundry sand was consumed in the North Central (78%).

PRICES

For purposes of this chapter, price means f.o.b. plant value per ton of sand and gravel, which usually is the first point of sale or self-use. This value does not reflect any needed transportation from the plant, yard, or deposit to the consumer. It does, however, reflect those transportation costs needed to bring sand and gravel to the first point of sale or self-use.

Based on the 1980 canvass, the average

national value per ton of construction sand was $2.48; gravel, $2.75; and sand and gravel, $2.61. For industrial sand, the average value per ton was $10.06; for gravel, $7.47; and for industrial sand and gravel, $9.99. For all sand and gravel, construction and industrial, the national average value per ton was $2.90. National average values per ton for major construction sand and gravel end uses are given in table 7, and for each State in table 10. Nationally, plaster and gunite sands had the highest value per ton at $3.35, followed by sand and gravel for concrete aggregates at $2.95.

The average values per ton for industrial sand and gravel were, as usual, much higher. Table 11 contains, in addition to the national values, the average values per ton and end uses for the four major geographic regions. Nationally, industrial sand used as filler had the highest value per ton at $31.54, followed by ceramics with $27.95, and hydraulic fracturing sand with $20.42.

FOREIGN TRADE

Construction sand and gravel and industrial sand were exported in 1980 from the United States as follows: 587,000 tons of construction sand valued at $6.7 million; 687,000 tons of gravel valued at $1.5 million; and 1.2 million tons of industrial sand valued at $32.5 million. Ninety-two percent of the construction sand and gravel exported went to Canada and the remainder was shipped to 57 different countries. Sixty-two percent of the industrial sand exported went to Canada, 29% to Mexico, and the remainder to 65 other countries.

Of the 502,000 tons of construction sand and gravel imported, 99.9% came from Canada and the rest from seven other countries. Of the 39,000 tons of industrial sand imported, 87% came from Australia, and the remainder from nine other countries.

TECHNOLOGY

Between January 27th and 31st, the 1980 International Concrete and Aggregates Show sponsored jointly by the National Sand and Gravel Association, the National Crushed Stone Association, and National Ready Mixed Concrete Association was held in Houston, Tex. Over 16,000 registrants attended the show, with about 1,700 representing 50 foreign countries. About 225 exhibitors from the United States and abroad presented their latest products, goods, and services.

The show was held in conjunction with the annual conventions of the three associations. A large spectrum of technical and business problems of concern to the industry were discussed at the convention's workshops or joint meetings.[3]

Between May 27th and 30th, the Fourth Industrial Minerals International Congress was held in Atlanta, Ga., with a record participation of over 700 delegates from 40 countries. Twenty-seven technical papers were presented at the Congress, two of them on sand and gravel.[4]

A study regarding the availability of sand and gravel resources in different counties of the State near major metropolitan areas was undertaken by the Maryland Geological Survey. By indicating the limitations imposed by housing developments, zoning regulations, and environmental restrictions on sand and gravel resources, the study underlined the need for a coordinated effort to establish an official minerals policy, especially for the mining of construction aggregates.[5]

During 1980, Rock Products magazine continued the publication of a series of articles entitled "Aggregate Plant Design: The Planned Approach," which discussed different technical, environmental, and financial factors important in planning a new or expanded facility.

The operation's efficiency and productivity as well as the cost of compliance with environmental regulations and land reclamation remained the major areas of concern for the sand and gravel industry. Several articles on these subjects were published in 1980.[6]

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[1]Physical scientist, Section of Nonmetallic Minerals.

[2]Engineering News Record. Conveyor Pacing Dam to Possible Early Finish. Oct. 25, 1979, pp. 34-35.

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—. Two Dredges Extract Raw Material for 1,000-tph Sand and Gravel Plant. Rock Prod., September 1980, pp. 62-66.

[3]Grancher, R. A. The 1980 Con/Agg Show. Rock Prod., May 1980, pp. 66-71.

[4]Industrial Minerals. Fourth Industrial Minerals: International Congress: Abst., May 1980, pp. 27-43.

[5]Stearn, E. W. Study Reveals Rapidly Dwindling Resources Availability. Rock Prod., August 1980, pp. 60-61.

[6]Caley, J. D. Your Own Small Computer? Pit & Quarry, April 1980, pp. 73-79.

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Szaj, A. P. Preplanning Maintenance Prevents Plant Equipment Failures. Rock Prod., March 1980, pp. 55-60.

Table 2.—Sand and gravel sold or used in the United States, by geographic region

(Thousand short tons and thousand dollars)

Geographic region	Construction				Industrial				Total			
	Quantity	Percent of total	Value	Percent of total	Quantity	Percent of total	Value	Percent of total	Quantity	Percent of total	Value	Percent of total
1979												
Northeast:												
New England	52,000	5	109,600	5	178	1	2,173	1	52,180	5	111,800	5
Middle Atlantic	53,480	6	137,400	6	3,685	11	35,370	12	57,170	6	172,800	7
North Central:												
East North Central	186,800	20	385,200	18	14,200	42	102,400	36	201,000	21	487,600	20
West North Central	102,900	11	200,500	9	1,651	5	13,320	5	104,500	11	213,800	9
South:												
South Atlantic	74,230	8	172,900	8	5,371	16	49,700	18	79,600	8	222,600	9
East South Central	52,900	6	116,800	5	776	2	5,511	2	53,670	5	122,300	5
West South Central	97,800	10	248,000	12	4,351	13	43,130	15	102,200	10	291,100	12
West:												
Mountain	104,000	11	233,900	11	978	3	8,659	3	105,000	11	242,600	10
Pacific	221,400	23	539,400	25	2,325	7	23,470	8	223,700	23	562,900	23
Total[1]	945,500	100	2,144,000	100	33,510	100	283,800	100	979,000	100	2,427,000	100
1980												
Northeast:												
New England	38,750	5	93,540	5	159	1	2,134	1	38,910	5	95,670	4
Middle Atlantic	42,300	6	127,700	6	3,868	13	39,900	13	46,170	6	167,600	7
North Central:												
East North Central	138,000	18	339,800	17	11,330	37	95,700	32	149,300	19	435,500	19
West North Central	77,990	10	170,500	8	1,360	4	13,120	4	79,350	10	183,600	8
South:												
South Atlantic	54,700	7	151,900	8	4,326	14	40,180	13	59,020	7	192,000	8
East South Central	38,960	5	96,010	5	645	2	4,375	1	39,600	5	100,400	5
West South Central	86,040	11	256,900	13	4,069	13	49,920	16	90,110	11	306,800	13
West:												
Mountain	93,450	12	242,300	12	877	3	12,240	4	94,330	12	254,600	11
Pacific	193,800	25	518,900	26	3,840	13	46,740	15	197,600	25	565,700	25
Total[1]	764,000	100	1,998,000	100	30,480	100	304,300	100	794,400	100	2,302,000	100

[1]Data may not add to totals shown because of independent rounding.

Table 3.—Sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1979						1980					
	Construction		Industrial		Total[1]		Construction		Industrial		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	13,451	29,944	297	1,375	13,747	31,319	10,803	23,942	361	1,821	11,165	25,763
Alaska	50,900	104,905	--	--	50,900	104,905	44,911	85,214	--	--	44,911	85,214
Arizona	30,520	74,716	W	W	W	W	24,229	71,838	170	1,936	24,399	73,773
Arkansas	15,964	32,594	501	2,605	16,465	35,200	12,943	31,024	74	627	13,017	31,651
California	127,226	326,109	2,122	21,276	129,348	247,385	112,795	336,817	3,631	44,189	116,426	381,005
Colorado	25,512	56,263	169	W	25,680	W	27,433	74,452	W	W	W	W
Connecticut	9,990	23,612	W	W	W	W	7,103	18,692	W	W	W	W
Delaware	1,674	3,281	--	--	1,674	3,281	1,075	2,398	--	--	1,075	2,398
Florida	20,642	31,145	1,066	8,375	21,708	39,520	14,464	28,831	W	W	W	W
Georgia	5,014	10,792	W	W	W	W	4,858	11,898	W	W	W	W
Hawaii	1,081	3,063	--	--	1,081	3,063	1,035	2,855	--	--	1,035	2,855
Idaho	7,719	18,149	W	W	W	W	5,299	14,203	W	W	W	W
Illinois	40,033	87,016	5,416	47,174	45,448	134,190	27,094	78,510	4,631	43,822	31,725	122,332
Indiana	27,050	55,842	W	W	W	W	21,772	51,738	259	1,201	22,031	52,939
Iowa	17,297	37,867	198	1,819	17,495	39,686	12,683	32,722	W	W	W	W
Kansas	14,084	24,780	196	1,710	14,280	26,490	12,124	23,817	W	W	W	W
Kentucky	11,726	23,721	W	W	W	W	7,767	17,637	W	W	W	W
Louisiana	20,446	54,081	W	W	W	W	18,152	62,568	353	3,845	18,505	66,413
Maine	11,022	20,534	--	--	11,022	20,534	6,978	15,434	--	--	6,978	15,434
Maryland	13,988	39,033	--	--	13,988	39,033	10,732	33,625	--	--	10,732	33,625
Massachusetts	16,705	37,164	W	W	W	W	13,925	34,459	W	W	W	W
Michigan	44,596	86,635	5,572	29,962	50,169	116,597	32,536	73,166	4,062	25,188	36,597	98,354
Minnesota	30,939	55,427	W	W	W	W	25,110	49,180	W	W	W	W
Mississippi	16,940	37,797	W	W	W	W	11,710	31,606	W	W	W	W
Missouri	11,699	24,201	859	7,109	12,558	31,310	8,178	19,255	722	7,498	8,900	26,753
Montana	7,012	15,106	--	--	7,012	15,106	6,639	16,057	W	W	W	W
Nebraska	16,197	33,001	--	--	16,197	33,001	10,514	22,798	24	183	10,538	22,981
Nevada	10,498	21,387	W	W	W	W	8,439	18,360	W	W	W	W
New Hampshire	7,086	15,301	--	--	7,086	15,301	6,334	15,837	--	--	6,334	15,837
New Jersey	8,277	21,590	2,504	23,092	10,781	44,682	5,829	18,578	2,766	26,957	8,596	45,535
New Mexico	7,141	18,245	--	--	7,141	18,245	7,050	17,676	--	--	7,050	17,676
New York	26,242	55,889	W	W	W	W	21,918	53,276	W	W	W	W
North Carolina	9,634	21,618	1,569	8,115	11,203	29,733	7,837	20,910	1,472	7,825	9,309	28,735
North Dakota	6,648	15,128	--	--	6,648	15,128	5,173	14,457	--	--	5,173	14,457

See footnotes at end of table.

Table 3.—Sand and gravel sold or used in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1979						1980					
	Construction		Industrial		Total[1]		Construction		Industrial		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Ohio	44,218	104,888	1,726	16,160	45,944	121,048	35,462	97,690	1,510	16,601	36,972	114,291
Oklahoma	10,496	20,372	1,605	12,129	12,101	32,502	10,294	23,395	1,587	13,767	11,881	37,162
Oregon	17,874	45,829	--	--	17,874	45,829	16,005	47,300	--	--	16,005	47,300
Pennsylvania	19,047	60,031	1,102	11,709	20,150	71,740	14,554	55,883	1,049	12,374	15,603	68,257
Rhode Island	3,537	6,737	--	--	3,537	6,737	2,506	4,945	--	--	2,506	4,945
South Carolina	7,332	16,273	989	10,392	8,321	26,665	4,737	13,227	819	9,628	5,556	22,855
South Dakota	6,001	10,119	--	--	6,001	10,119	4,209	8,243	--	--	4,209	8,243
Tennessee	10,778	25,300	431	3,755	11,210	29,056	8,676	22,824	244	2,106	8,921	24,930
Texas	50,893	140,955	1,953	26,121	52,846	167,076	44,651	139,892	2,054	31,684	46,704	171,576
Utah	10,363	18,621	W	W	W	W	8,906	17,234	W	W	W	W
Vermont	3,660	6,240	--	--	3,660	6,240	1,900	4,171	--	--	1,900	4,171
Virginia	11,803	32,268	W	W	W	W	8,264	29,508	W	W	W	W
Washington	24,258	59,382	W	W	W	W	19,019	46,731	W	W	W	W
West Virginia	4,138	18,501	W	W	W	W	2,728	11,454	W	W	W	W
Wisconsin	30,879	50,824	1,166	7,752	32,046	58,576	21,143	38,678	872	8,887	22,014	47,565
Wyoming	5,265	11,419	W	W	W	W	5,454	12,523	W	W	W	W
Total U.S.[1]	945,500	2,144,000	33,510	283,800	979,000	2,427,000	764,000	1,998,000	30,480	304,300	794,400	2,302,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Data may not add to totals shown because of independent rounding.

Table 4.—Sand and gravel production in the United States, by size of operation [1]

Sales and use level	Construction: Number of operations	Construction: Percent of total	Construction: Thousand short tons	Construction: Percent of total	Industrial: Number of operations	Industrial: Percent of total	Industrial: Thousand short tons	Industrial: Percent of total
1979								
Less than 25,000	2,132	31.9	20,860	2.2	31	19.4	280	0.8
25,000 to 49,999	1,009	15.1	36,440	3.9	28	17.5	1,060	3.2
50,000 to 99,999	1,229	18.4	86,660	9.2	25	15.6	1,788	5.3
100,000 to 199,999	1,077	16.1	149,800	15.8	22	r13.8	3,149	9.4
200,000 to 299,999	450	6.7	108,300	11.5	12	7.5	2,912	8.7
300,000 to 399,999	258	3.9	87,930	9.0	17	10.6	6,039	18.0
400,000 to 499,999	152	2.3	67,190	7.1	7	r4.4	3,107	9.3
500,000 to 599,999	103	1.5	55,760	r5.9	4	2.5	2,196	6.6
600,000 to 699,999	53	.9	34,290	3.6	4	2.5	2,603	7.8
700,000 to 799,999	54	.8	40,060	r4.2	4	2.5	2,959	8.8
800,000 to 899,999	33	.5	27,630	2.9	--	--	--	--
900,000 to 999,999	21	.3	19,780	2.1	1	.6	995	3.0
1,000,000 to 1,499,999	66	1.1	79,130	8.4	4	2.5	4,711	14.0
1,500,000 to 1,999,999	19	.3	31,450	3.3	1	.6	1,714	5.1
2,000,000 to 2,499,999	10	.1	22,370	2.4	--	--	--	--
2,500,000 and over	10	.1	77,850	8.2	--	--	--	--
Total[2]	6,676	100.0	945,500	100.0	160	100.0	33,510	100.0
1980								
Less than 25,000	2,080	34.3	21,430	2.8	34	22.5	415	1.4
25,000 to 49,999	961	15.9	35,020	4.6	22	14.6	838	2.7
50,000 to 99,999	1,141	18.8	81,830	10.7	22	14.6	1,588	5.2
100,000 to 199,999	895	14.8	127,100	16.6	22	14.6	3,071	10.1
200,000 to 299,999	373	6.2	90,030	11.8	16	10.6	3,954	13.0
300,000 to 399,999	226	3.7	77,640	10.2	12	7.9	4,114	13.5
400,000 to 499,999	116	1.9	51,150	6.7	10	6.6	4,251	13.9
500,000 to 599,999	71	1.2	38,560	5.0	3	2.0	1,631	5.3
600,000 to 699,999	54	.9	35,260	4.6	3	2.0	1,962	6.4
700,000 to 799,999	31	.5	23,080	3.0	--	--	--	--
800,000 to 899,999	22	.4	18,560	2.4	1	.7	876	2.9
900,000 to 999,999	21	.3	20,020	2.6	1	.7	993	3.3
1,000,000 to 1,499,999	44	.7	51,890	6.8	3	2.0	3,333	10.9
1,500,000 to 1,999,999	9	.1	15,510	2.0	2	1.3	3,450	11.3
2,000,000 to 2,499,999	3	(3)	6,533	.9	--	--	--	--
2,500,000 and over	10	.2	70,390	9.2	--	--	--	--
Total[2]	6,057	100.0	764,000	100.0	151	100.0	30,480	100.0

rRevised.
[1]An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 5.—Number of sand and gravel active operations and processing plants in the United States, by geographic region[1]

Geographic region	Total number of active operations		Total number of active operations with plants[2]		Active operations with processing plants										Total number of active operations without plants[2]	
					Associated with extraction areas on land						Associated with dredging operations					
					Plants at site: Stationary		Plants at site: Portable		Plants not at site (stationary or portable)		Plants on board		Plants on land			
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
Northeast:																
New England	597	542	476	325	166	125	254	151	25	20	r8	3	22	26	84	74
Middle Atlantic	608	556	512	403	212	207	245	156	15	11	10	7	30	22	91	79
North Central:																
East North Central	1,341	1,193	1,080	800	409	340	485	304	16	16	33	19	137	121	125	90
West North Central	1,270	1,123	1,061	785	308	244	536	340	6	4	42	24	169	173	111	95
South:																
South Atlantic	478	422	334	209	136	102	96	47	26	13	20	10	56	37	74	81
East South Central	325	276	248	153	83	60	74	27	7	9	33	22	51	35	49	38
West South Central	657	594	481	327	172	141	162	89	19	20	41	21	87	56	100	76
West:																
Mountain	819	751	662	528	198	171	370	290	34	30	5	2	55	35	78	54
Pacific	705	638	555	448	233	251	228	148	17	16	10	4	67	29	82	61
Total	6,800	6,095	5,409	3,978	1,917	1,641	2,450	1,552	165	139	r202	112	674	534	794	648

r Revised.
[1] An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.
[2] Based on reports submitted by individual companies.

Table 6.—Number of sand and gravel active operations and processing plants in the United States, by State[1]

State	Total number of active operations		Total number of active operations with plants[2]		Active operations with processing plants										Total number of active operations without plants[2]	
					Associated with extraction areas on land						Associated with dredging operations					
					Plants at site				Plants not at site (stationary or portable)		Plants on board		Plants on land			
					Stationary		Portable									
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
Alabama	100	86	73	45	26	17	15	4	1	1	7	5	24	18	20	12
Alaska	51	47	30	26	4	5	23	18	2	--	1	1	--	2	17	13
Arizona	158	145	132	101	47	34	64	49	11	7	1	--	9	11	14	11
Arkansas	205	187	114	97	40	34	45	38	7	6	9	5	13	14	71	38
California	375	347	307	261	145	169	97	68	9	7	2	--	54	17	44	25
Colorado	200	199	160	151	31	37	101	97	6	6	--	--	22	11	22	9
Connecticut	136	125	106	76	40	36	57	33	4	3	--	--	5	4	26	17
Delaware	9	7	8	7	3	5	4	1	--	--	--	--	1	1	1	--
Florida	51	45	39	22	7	3	9	6	--	--	5	1	18	12	7	2
Georgia	48	54	40	19	17	10	4	1	1	1	--	--	18	7	4	4
Hawaii	6	5	5	2	3	1	2	1	--	--	--	--	--	--	--	--
Idaho	87	71	73	46	27	13	40	29	5	3	1	1	--	--	8	6
Illinois	217	204	174	131	46	41	76	48	2	3	13	10	37	29	36	21
Indiana	182	165	143	93	52	38	48	22	--	--	6	2	37	31	29	17
Iowa	207	200	175	149	62	48	77	57	--	--	3	4	33	40	23	19
Kansas	160	146	127	103	38	24	54	33	3	3	6	2	26	41	24	22
Kentucky	37	35	35	28	13	9	4	2	3	3	12	11	3	3	1	3
Louisiana	118	102	109	72	18	17	42	20	--	--	18	13	31	22	2	2
Maine	154	149	115	75	23	17	77	49	7	3	2	--	6	6	28	33
Maryland	52	50	32	18	16	6	5	2	4	4	1	--	6	6	9	8
Massachusetts	187	162	153	106	59	40	73	43	9	8	4	2	8	13	22	20
Michigan	322	293	234	178	79	64	118	77	3	2	8	3	26	32	25	21
Minnesota	348	278	276	177	75	53	180	100	--	--	1	2	20	22	37	26
Mississippi	101	84	82	41	29	18	31	12	1	3	8	2	13	6	15	12
Missouri	101	97	94	68	28	22	32	14	2	1	9	9	23	22	5	5
Montana	89	91	71	63	23	18	41	37	3	4	--	--	4	4	5	4
Nebraska	237	209	224	162	74	67	90	65	1	--	17	7	42	23	14	11
Nevada	82	61	62	43	22	18	34	20	2	2	--	--	4	3	18	13
New Hampshire	50	48	49	32	30	20	14	9	2	1	1	1	1	1	1	1
New Jersey	60	62	51	50	25	32	16	9	2	2	--	--	8	7	8	8

See footnotes at end of table.

Table 6.—Number of sand and gravel active operations and processing plants in the United States, by State[1] —Continued

State	Total number of active operations		Total number of active operations with plants[2]		Active operations with processing plants										Total number of active operations without plants[2]	
					Associated with extraction areas on land						Associated with dredging operations					
					Plants at site				Plants not at site (stationary or portable)		Plants on board		Plants on land			
					Stationary		Portable									
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
New Mexico	77	70	74	59	27	29	39	23	5	6	2	--	1	1	3	4
New York	399	358	332	251	127	116	180	115	8	5	8	7	9	8	66	55
North Carolina	151	135	112	79	52	46	47	24	6	1	4	3	3	5	34	45
North Dakota	85	85	80	77	23	24	46	38	--	--	1	--	10	15	3	3
Ohio	298	291	267	235	181	160	65	53	5	7	2	2	14	13	27	25
Oklahoma	121	122	100	80	41	42	35	22	4	5	2	--	18	11	17	20
Oregon	110	102	99	86	50	44	39	29	3	5	1	1	6	7	10	9
Pennsylvania	149	136	129	102	60	59	49	32	5	4	2	--	13	7	18	16
Rhode Island	25	22	22	19	9	8	12	8	--	2	--	--	1	1	4	2
South Carolina	69	53	49	30	22	17	15	7	4	1	2	2	6	3	7	9
South Dakota	132	108	85	49	8	6	57	33	--	--	5	--	15	10	5	9
Tennessee	87	71	58	39	15	16	24	9	2	2	6	4	11	8	12	11
Texas	213	183	158	78	73	48	40	9	8	9	12	3	25	9	10	16
Utah	70	66	52	38	12	15	32	22	1	1	--	--	7	--	5	5
Vermont	45	36	31	17	5	4	21	9	3	3	1	--	1	1	3	1
Virginia	90	70	51	28	17	10	12	5	10	6	8	4	4	3	12	13
Washington	163	137	114	73	31	32	67	32	3	4	6	2	7	3	11	14
West Virginia	8	8	3	6	2	5	--	1	1	--	--	--	--	--	--	--
Wisconsin	322	240	262	163	51	37	178	104	6	4	4	2	23	16	8	6
Wyoming	56	48	38	27	9	7	19	13	1	1	1	1	8	5	3	2
Total	6,800	6,095	5,409	3,978	1,917	1,641	2,450	1,552	165	139	r202	112	674	534	794	648

rRevised.
[1]An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.
[2]Based on reports submitted by individual companies.

Table 7.—Construction sand and gravel sold or used in the United States, by major use

Use	1979			1980		
	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregate (including concrete sand)	357,100	$923,000	$2.58	287,600	$847,100	$2.95
Plaster and gunite sands	10,950	30,400	2.78	8,408	28,140	3.35
Concrete products (blocks, bricks, pipe, decorative, etc.)	32,780	86,940	2.65	30,970	87,130	2.81
Asphaltic concrete aggregate and other bituminous mixtures	142,000	343,000	2.42	111,800	321,800	2.88
Road base and coverings	222,400	458,800	2.06	181,100	436,100	2.41
Fill	155,550	240,500	1.55	122,000	217,100	1.78
Snow and ice control	8,207	16,670	2.03	6,621	14,500	2.19
Railroad ballast	1,190	2,849	2.39	946	2,499	2.64
Other	15,430	41,500	2.69	14,390	43,150	3.00
Total[1] or average	945,500	2,144,000	2.27	764,000	1,998,000	2.62

[1]Data may not add to totals shown because of independent rounding.

Table 8.—Construction sand and gravel sold or used in the

(Thousand short tons

Geographic region	Concrete aggregate (including concrete sand)		Plaster and gunite sands		Concrete products (blocks, bricks, pipe, decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1979								
Northeast:								
New England	14,680	38,460	174	478	1,486	3,584	8,771	20,700
Middle Atlantic	16,750	51,790	946	3,124	2,472	8,153	7,453	19,990
North Central:								
East North Central	69,130	156,900	1,234	2,715	6,643	16,160	31,420	65,940
West North Central	35,460	80,080	783	2,276	4,779	10,760	16,150	30,160
South:								
South Atlantic	37,220	90,870	991	3,009	5,294	15,430	9,646	26,730
East South Central	23,140	55,480	1,097	2,456	1,798	4,858	9,130	22,090
West South Central	55,080	157,600	882	2,440	3,561	9,668	11,750	30,110
West:								
Mountain	31,270	85,720	1,245	3,483	2,042	5,732	16,460	39,150
Pacific	74,330	206,100	3,599	10,410	4,708	12,600	31,230	88,130
Total[1]	357,100	923,000	10,950	30,400	32,780	86,940	142,000	343,000
1980								
Northeast:								
New England	11,330	32,530	182	636	1,748	4,002	5,474	14,970
Middle Atlantic	13,070	47,820	753	2,799	1,925	6,579	6,828	25,410
North Central:								
East North Central	47,210	123,400	716	2,133	7,340	21,210	25,860	67,400
West North Central	26,730	67,380	667	2,062	4,139	9,939	11,400	24,410
South:								
South Atlantic	29,290	84,030	948	2,819	5,219	14,600	6,984	22,300
East South Central	17,890	45,380	260	1,198	2,569	7,382	7,545	21,150
West South Central	48,610	162,000	426	1,296	3,243	9,807	7,345	25,770
West:								
Mountain	31,860	98,770	951	3,266	1,660	4,565	12,930	34,080
Pacific	61,650	185,800	3,504	11,930	3,127	9,050	27,480	86,300
Total[1]	287,600	847,100	8,408	28,140	30,970	87,130	111,800	321,800

[1]Data may not add to totals shown because of independent rounding.

United States, by geographic region and major use

and thousand dollars)

Road base and coverings		Fill		Snow and ice control		Railroad ballast		Other uses		Total[1]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
13,300	23,480	9,180	13,290	2,355	4,286	68	238	1,988	5,067	52,000	109,600
14,620	33,200	7,666	11,210	1,889	4,654	56	142	1,717	5,255	53,480	137,400
47,950	93,400	25,360	38,340	1,922	3,362	47	105	3,070	8,237	186,800	385,200
29,000	53,030	13,960	18,620	767	1,653	402	756	1,560	3,189	102,900	200,500
8,522	18,920	10,870	13,220	144	319	27	32	1,506	4,373	74,230	172,900
11,740	22,700	5,537	7,726	79	188	11	22	365	1,241	52,900	116,800
14,460	30,050	11,310	15,500	51	241	74	186	625	2,167	97,800	248,000
38,740	75,910	11,890	18,260	713	1,274	234	588	1,437	3,791	104,000	233,900
44,050	108,100	59,710	104,300	286	694	271	780	3,158	8,179	221,300	539,400
222,400	458,800	155,500	240,500	8,207	16,670	1,190	2,849	15,430	41,500	945,500	2,144,000
11,380	24,620	5,498	9,046	1,811	3,375	58	229	1,266	4,135	38,750	93,540
10,950	26,860	5,790	9,804	1,615	3,874	60	172	1,312	4,428	42,300	127,700
35,770	82,930	17,270	32,680	1,337	2,760	76	258	2,429	7,038	138,000	339,800
23,270	45,780	9,114	14,470	703	1,504	253	412	1,713	4,531	77,990	170,500
4,977	14,420	6,262	10,640	144	394	23	31	847	2,615	54,700	151,900
6,735	13,410	2,996	4,234	34	84	1	2	924	3,171	38,960	96,010
14,320	37,560	11,290	17,460	26	123	54	159	730	2,700	86,040	256,900
35,440	80,040	8,358	15,580	779	1,739	89	212	1,386	4,084	93,450	242,300
38,280	110,500	55,450	103,200	173	650	332	1,025	3,781	10,450	193,800	518,900
181,100	436,100	122,000	217,100	6,621	14,500	946	2,499	14,390	43,150	764,000	1,998,000

Table 9.—Construction sand and gravel sold or used in the

(Thousand short tons

State	Concrete aggregates (including concrete sand)		Plaster and gunite sands		Concrete products (blocks, bricks, pipe, decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	5,267	12,732	--	--	1,084	2,896	1,613	4,062
Alaska	1,903	9,408	W	W	W	W	850	1,799
Arizona	6,710	24,416	638	1,911	507	1,879	3,853	12,061
Arkansas	5,662	16,447	176	440	471	1,150	1,467	3,810
California	49,603	146,932	3,307	11,199	2,141	6,157	20,560	66,030
Colorado	9,392	34,032	97	560	243	586	3,660	8,137
Connecticut	2,407	7,534	12	60	183	499	825	2,113
Delaware	338	914	W	W	W	W	W	W
Florida	7,927	16,713	W	W	2,424	4,998	619	1,855
Georgia	3,047	7,038	235	490	599	1,492	236	956
Hawaii	39	168	--	--	--	--	324	1,329
Idaho	2,194	6,543	16	71	359	807	419	1,375
Illinois	11,237	31,720	92	324	1,236	3,554	4,079	12,644
Indiana	9,749	24,712	45	122	844	2,100	3,730	9,019
Iowa	5,101	14,836	146	490	497	1,529	1,014	2,674
Kansas	3,662	7,829	102	247	1,064	2,207	2,191	4,637
Kentucky	4,582	10,413	119	415	486	1,102	1,150	2,936
Louisiana	9,318	32,681	W	W	W	W	2,874	12,343
Maine	735	2,073	--	--	88	202	1,225	3,248
Maryland	6,376	20,058	W	W	394	1,190	1,568	4,816
Massachusetts	4,983	14,439	62	222	1,032	2,342	1,635	4,268
Michigan	9,735	25,853	241	694	1,809	5,305	5,704	12,801
Minnesota	7,758	18,327	211	571	1,981	4,539	3,892	7,202
Mississippi	4,898	12,867	8	W	713	2,443	3,280	10,269
Missouri	4,715	11,603	4	20	175	443	1,434	3,553
Montana	1,297	4,039	7	37	265	593	1,495	4,187
Nebraska	3,480	7,304	95	185	263	578	1,567	3,721
Nevada	4,330	9,438	24	91	W	W	1,025	2,441
New Hampshire	2,030	5,683	44	110	228	588	1,231	3,535
New Jersey	2,551	9,306	177	735	390	1,226	577	1,810
New Mexico	3,067	8,804	128	475	101	278	496	1,548
New York	4,737	15,081	153	585	839	2,310	3,377	10,420
North Carolina	3,876	11,033	110	301	223	625	1,559	4,362
North Dakota	976	4,028	103	527	142	603	867	1,863
Ohio	9,966	27,038	260	736	2,783	8,579	9,569	28,117
Oklahoma	5,779	14,841	85	175	574	1,366	623	1,993
Oregon	3,016	9,227	156	552	179	916	3,440	10,515
Pennsylvania	5,785	23,433	423	1,479	696	3,042	2,873	13,177
Rhode Island	428	986	W	W	W	W	357	1,286
South Carolina	2,151	6,270	W	W	403	1,337	1,410	4,479
South Dakota	1,040	3,449	5	22	18	40	439	755
Tennessee	3,145	9,370	133	765	287	941	1,503	3,879
Texas	27,851	98,040	135	456	1,753	5,588	2,381	7,628
Utah	3,578	7,242	25	56	W	W	1,161	2,277
Vermont	750	1,812	9	26	93	155	202	518
Virginia	3,811	14,278	132	554	1,030	4,248	875	3,387
Washington	7,084	20,095	37	158	803	1,955	2,304	6,622
West Virginia	1,767	7,726	W	W	W	W	W	W
Wisconsin	6,520	14,057	79	255	667	1,667	2,777	4,814
Wyoming	1,289	4,258	15	65	W	W	818	2,055
Total[1]	287,600	847,100	8,408	28,140	30,970	87,130	111,800	321,800

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.

United States in 1980, by State and major use

and thousand dollars)

Road base and coverings		Fill		Snow and ice control		Railroad ballast		Other uses		Total[1]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1,891	2,968	860	1,008	W	W	--	--	W	W	10,803	23,942
848	1,957	41,243	71,811	16	69	--	--	42	124	44,911	85,214
9,459	24,799	2,804	5,925	29	33	W	W	W	W	24,229	71,838
4,102	6,910	727	1,255	W	W	--	--	W	W	12,943	31,024
26,251	78,238	8,429	21,344	78	364	139	505	2,286	6,048	112,795	336,817
11,067	24,954	1,705	3,061	538	1,161	75	156	656	1,804	27,433	74,452
2,322	5,608	965	1,788	250	545	--	--	139	546	7,103	18,692
398	786	186	242	--	--	--	--	--	--	1,075	2,398
680	1,907	2,432	2,310	--	--	--	--	W	W	14,464	28,831
299	1,205	W	W	W	W	--	--	--	--	4,858	11,898
352	877	320	482	--	--	--	--	--	--	1,035	2,855
1,963	4,602	301	706	29	37	--	--	19	61	5,299	14,203
6,741	20,246	3,452	8,873	60	204	--	--	197	944	27,094	78,510
4,286	9,162	2,556	5,336	289	626	12	120	261	540	21,772	51,738
3,897	8,482	1,756	3,820	111	301	4	13	156	576	12,683	32,722
2,599	4,914	1,978	2,839	109	363	W	W	W	W	12,124	23,817
359	996	954	1,433	12	35	W	W	W	W	7,767	17,637
3,850	12,836	1,635	2,781	--	--	--	--	--	--	18,152	62,568
2,934	6,124	948	1,515	648	979	45	194	356	1,101	6,978	15,434
1,286	3,823	929	3,066	2	5	--	--	W	W	10,732	33,625
3,346	7,015	1,821	3,143	634	1,411	--	--	412	1,618	13,925	34,459
10,673	22,020	3,242	4,109	448	673	56	118	628	1,593	32,536	73,166
7,294	12,284	2,601	3,197	307	434	37	99	1,031	2,528	25,110	49,180
2,289	5,057	449	738	1	1	--	--	73	W	11,710	31,606
1,032	2,161	613	1,018	66	157	--	--	140	300	8,178	19,255
2,980	5,846	500	1,028	74	236	W	W	W	W	6,639	16,057
3,981	9,234	1,052	1,544	34	60	W	W	W	W	10,514	22,798
1,870	3,732	870	1,743	52	153	--	--	W	W	8,439	18,360
1,889	4,132	566	1,016	187	280	--	--	158	492	6,334	15,837
669	2,353	1,314	2,323	82	336	--	--	68	489	5,829	18,578
2,931	6,002	300	458	--	--	--	--	27	111	7,050	17,676
7,344	14,907	3,417	4,972	1,375	2,952	15	48	661	1,999	21,918	53,276
1,221	3,067	631	922	12	40	W	W	W	W	7,837	20,910
2,352	5,534	599	1,397	W	W	3	21	W	W	5,173	14,457
6,478	19,130	4,960	9,627	387	995	W	W	W	W	35,462	97,690
699	1,517	2,473	3,124	6	18	W	W	W	W	10,294	23,395
6,026	18,845	1,881	3,255	48	162	1	6	1,258	3,822	16,005	47,300
2,932	9,595	1,059	2,508	158	586	W	W	W	W	14,554	55,883
572	1,080	963	1,133	W	W	--	--	--	--	2,506	4,945
60	106	606	866	3	6	W	W	W	W	4,737	13,227
2,115	3,167	514	652	63	132	--	--	15	27	4,209	8,243
2,195	4,389	734	1,055	10	37	--	--	669	2,388	8,676	22,824
5,668	16,295	6,451	10,296	3	5	W	W	W	W	44,651	139,892
2,506	5,140	1,317	1,824	58	119	--	--	W	W	8,906	17,234
314	663	236	452	83	134	W	W	W	W	1,900	4,171
871	2,963	1,074	2,546	69	186	--	--	401	1,345	8,264	29,508
4,802	10,558	3,571	6,317	31	55	191	515	195	458	19,019	46,731
161	564	W	W	--	--	--	--	W	W	2,728	11,454
7,591	12,372	3,064	4,737	152	262	5	W	287	W	21,143	38,678
2,667	4,968	561	834	--	--	--	--	W	W	5,454	12,523
181,100	436,100	122,000	217,100	6,621	14,500	946	2,499	14,390	43,150	764,000	1,998,000

Table 10.—Average value per ton for construction sand and gravel sold or used in the United States in 1980, by State and major use

State	Concrete aggregate (including concrete sand)	Plaster and gunite sands	Concrete products (blocks, bricks, pipe, decorative, etc.)	Asphaltic concrete aggregates and other bituminous mixtures	Road base and coverings	Fill	Snow and ice control	Railroad ballast	Other uses	Total
Alabama	$2.42	--	$2.67	$2.52	$1.57	$1.17	$1.00	--	$3.41	$2.22
Alaska	4.94	$5.35	5.00	2.12	2.31	1.74	4.28	--	2.99	1.90
Arizona	3.64	3.00	3.70	3.13	2.62	2.11	1.17	$3.12	3.53	2.96
Arkansas	2.90	2.49	2.44	2.60	1.68	1.73	5.54	--	2.86	2.40
California	2.96	3.39	2.88	3.21	2.98	2.53	4.66	3.62	2.65	2.99
Colorado	3.62	5.76	2.41	2.22	2.25	1.80	2.16	2.09	2.75	2.71
Connecticut	3.13	4.91	2.72	2.56	2.42	1.85	2.18	--	3.93	2.63
Delaware	2.71	3.84	2.75	2.75	1.98	1.30	--	--	--	2.23
Florida	2.11	2.99	2.06	2.99	2.80	.95	--	--	1.37	1.99
Georgia	2.31	2.08	2.49	4.05	4.02	1.46	2.70	--	--	2.45
Hawaii	4.27	--	--	4.10	2.49	1.51	--	--	--	2.76
Idaho	2.98	4.48	2.25	3.28	2.34	2.35	1.28	--	3.27	2.68
Illinois	2.82	3.53	2.88	3.10	3.00	2.57	3.40	--	4.79	2.90
Indiana	2.53	2.74	2.49	2.42	2.14	2.09	2.16	9.74	2.07	2.38
Iowa	2.91	3.36	3.08	2.64	2.18	2.17	2.70	3.05	3.68	2.58
Kansas	2.14	2.43	2.07	2.12	1.89	1.43	3.33	1.00	2.63	1.96
Kentucky	2.27	3.48	2.27	2.55	2.78	1.50	2.91	1.28	2.92	2.27
Louisiana	3.51	7.50	3.83	4.29	3.33	1.70	--	--	--	3.45
Maine	2.82	--	2.30	2.65	2.09	1.60	1.51	4.29	3.10	2.21
Maryland	3.15	5.85	3.02	3.07	2.97	3.30	2.23	--	3.58	3.13
Massachusetts	2.90	3.59	2.27	2.61	2.10	1.73	2.22	--	3.93	2.47
Michigan	2.66	2.89	2.93	2.24	2.06	1.27	1.50	2.11	2.54	2.25
Minnesota	2.36	2.71	2.29	1.85	1.68	1.23	1.41	2.66	2.45	1.96
Mississippi	2.63	2.20	3.43	3.13	2.21	1.65	1.19	--	2.92	2.70
Missouri	2.46	5.02	2.54	2.48	2.09	1.66	2.38	--	2.15	2.35
Montana	3.11	5.13	2.24	2.80	1.96	2.05	3.20	4.19	4.50	2.42
Nebraska	2.10	1.93	2.20	2.37	2.32	1.47	1.78	7.86	2.85	2.17
Nevada	2.18	3.71	2.32	2.38	2.00	2.00	2.93	--	2.98	2.18
New Hampshire	2.80	2.50	2.57	2.87	2.19	1.79	1.50	--	3.11	2.50
New Jersey	3.65	4.14	3.15	3.13	3.51	1.77	4.09	--	7.16	3.19
New Mexico	2.87	3.71	2.75	3.12	2.05	1.53	--	--	4.17	2.51
New York	3.18	3.83	2.75	3.09	2.03	1.46	2.15	3.22	3.02	2.43
North Carolina	2.85	2.73	2.80	2.80	2.51	1.46	3.20	4.51	2.72	2.67
North Dakota	4.13	5.10	4.25	2.15	2.35	2.33	4.38	8.00	3.61	2.79
Ohio	2.71	2.84	3.08	2.94	2.95	1.94	2.57	2.00	3.28	2.75
Oklahoma	2.57	2.07	2.38	3.20	2.17	1.26	3.17	5.00	6.53	2.27

Oregon	3.06	3.53	5.12	3.06	3.13	1.73	3.38	4.00	3.04	2.96
Pennsylvania	4.05	3.49	4.37	4.59	3.27	2.37	3.70	2.76	3.33	3.84
Rhode Island	2.31	3.96	1.75	3.61	1.89	1.18	2.88	--	--	1.97
South Carolina	2.92	1.63	3.31	3.18	1.76	1.43	2.50	1.21	1.73	2.79
South Dakota	3.32	4.06	2.22	1.72	1.50	1.27	2.09	--	1.75	1.96
Tennessee	2.98	5.74	3.28	2.58	2.00	1.44	3.65	--	3.57	2.63
Texas	3.52	3.38	3.19	3.20	2.88	1.60	1.99	2.92	4.02	3.13
Utah	2.02	2.20	2.29	1.96	2.05	1.39	2.06	--	2.14	1.94
Vermont	2.42	3.00	1.67	2.57	2.11	1.92	1.61	2.84	1.87	2.20
Virginia	3.75	4.21	4.12	3.87	3.40	2.37	2.71	--	3.35	3.57
Washington	2.84	4.27	2.44	2.87	2.20	1.77	1.79	2.69	2.34	2.46
West Virginia	4.37	5.81	5.79	3.50	3.50	5.64	--	--	4.60	4.20
Wisconsin	2.16	3.23	2.50	1.73	1.63	1.55	1.72	2.89	1.75	1.83
Wyoming	3.30	4.26	2.23	2.51	1.86	1.49	--	--	3.43	2.30
Total	2.95	3.35	2.81	2.88	2.41	1.78	2.19	2.64	3.00	2.61

Table 11.—Industrial sand and gravel sold or used by U.S. producers, by geographic region and major use

Geographic region	North East			North Central			South			West			United States		
	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton
1979															
Sand:															
Glassmaking:															
Containers	2,630	$23,820	$9.06	2,202	$13,330	$6.05	2,670	$20,530	$7.69	r1,531	r$14,560	r$9.51	r9,032	r$72,240	r$8.00
Flat (plate and window)	83	792	r9.54	517	3,588	6.94	1,023	8,162	r7.98	210	1,916	9.12	1,833	14,460	r7.89
Specialty	142	1,423	r10.02	128	860	r6.77	656	4,412	r6.73	r139	r1,401	r10.08	r1,065	r8,096	r7.60
Fiberglass (unground)	--	--	--	910	6,807	7.48	r91	r1,075	r11.81	156	1,252	r8.03	r1,157	r9,134	7.89
Fiberglass (ground)	7	172	r24.57	177	2,542	r14.36	r367	r5,225	r14.24	--	--	--	r551	r7,939	r14.41
Foundry:															
Molding and core	549	4,964	9.04	7,308	42,710	5.84	1,400	8,937	6.38	r219	r1,623	r7.41	r9,477	r58,240	6.15
Molding and core facing (ground)	60	480	8.00	17	149	r8.76	--	--	--	r3	r38	r12.67	r80	r667	8.34
Refractory	32	559	r17.47	218	2,725	12.50	31	428	r13.81	10	107	r10.70	290	3,819	r13.17
Metallurgical:															
Silicon carbide	1	14	r14.00	332	2,076	r6.25	4	35	r8.75	r14	r123	r8.79	351	r2,248	6.40
Flux for metal smelting	--	--	--	--	--	--	--	--	--	160	1,156	r7.23	160	1,156	r7.23
Abrasives:															
Blasting	21	205	r9.76	236	3,249	r13.77	1,662	18,520	11.14	143	1,423	r9.95	2,063	23,400	11.34
Scouring cleansers (ground)	1	35	r35.00	120	2,074	r17.28	75	1,293	r17.24	7	46	r6.57	204	3,448	16.90
Sawing and sanding	13	93	r7.15	61	387	r6.34	78	594	r7.62	--	--	--	152	1,075	r7.07
Chemicals (ground and unground)	r94	903	r9.61	354	3,216	r9.08	r148	1,749	r11.82	r55	r542	r9.85	r651	6,410	r9.85
Fillers (ground):															
Rubber, paints, putty, etc	19	1,118	r58.84	45	1,025	r22.78	113	3,467	r30.68	1	21	r21.00	179	5,631	r31.46
Ceramic (ground):															
Pottery, brick, tile, etc	15	319	r21.27	103	2,085	20.24	58	1,192	r20.55	11	209	r19.00	186	3,805	r20.46
Filtration	2	16	r8.00	69	551	r7.99	87	657	7.55	31	111	r3.58	190	1,335	r7.03
Traction (engine)	23	199	r8.65	123	873	r7.10	192	1,240	6.46	72	522	r7.25	409	2,835	6.93
Coal washing	8	79	r9.88	11	96	r8.73	39	295	r7.56	--	--	--	58	470	r8.10
Roofing granules and fillers	24	311	r12.96	87	1,321	r15.18	99	1,727	r17.44	50	316	r6.32	259	3,674	14.19
Hydraulic fracturing	2	21	r10.50	278	3,882	13.96	546	10,310	18.89	107	1,897	r17.73	933	16,110	17.27
Other	136	2,024	r14.88	2,210	20,120	9.10	222	2,799	r12.61	273	4,065	r14.89	2,842	29,000	10.21
Total[1]	3,863	37,550	9.72	15,510	113,700	7.33	9,561	92,650	9.69	3,192	31,320	9.81	32,120	275,200	8.57

Gravel:															
Metallurgical:															
Silicon, ferrosilicon	--	--	--	190	1,378	7.25	824	5,345	6.49	--	--	--	1,014	6,723	6.63
Filtration	--	--	--	11	100	r9.09	10	29	r2.90	1	3	3.00	21	132	r6.29
Other	--	--	--	142	602	4.24	104	312	3.00	110	805	7.32	356	1,720	4.83
Total[1]	--	--	--	342	2,080	6.08	937	5,686	6.07	111	809	7.29	1,391	8,574	6.16
Grand total[1]	3,863	37,550	9.72	15,850	115,700	7.30	10,500	98,340	9.37	3,303	32,130	9.73	33,510	283,800	8.47
1980															
Sand:															
Glassmaking:															
Containers	2,142	20,690	9.66	2,330	17,590	7.55	2,698	22,080	8.18	2,389	29,140	12.20	9,559	89,490	9.36
Flat (plate and window)	88	968	11.00	492	3,629	7.38	865	6,393	7.39	182	2,025	11.13	1,627	13,000	8.00
Specialty	144	1,634	11.35	243	3,194	13.14	595	4,532	7.62	146	1,656	11.34	1,128	11,000	9.77
Fiberglass (unground)	73	601	8.23	542	4,129	7.62	7	53	7.57	124	1,392	11.23	747	6,175	8.27
Fiberglass (ground)	83	762	9.18	118	1,987	16.84	268	5,138	19.17	3	51	17.00	473	7,938	16.78
Foundry:															
Molding and core	657	7,860	11.96	6,373	45,330	7.11	894	6,860	7.67	204	2,746	13.46	8,128	62,800	7.73
Molding and core facing (ground)	67	632	9.43	57	255	4.47	26	229	8.81	4	40	10.00	153	1,156	7.56
Refractory	45	750	16.67	302	2,783	9.22	49	551	11.24	--	--	--	395	4,083	10.34
Metallurgical:															
Silicon carbide	1	15	15.00	144	1,470	10.21	2	19	9.50	9	98	10.89	156	1,603	10.28
Flux for metal smelting	--	--	--	10	29	2.90	--	--	--	1,106	13,820	12.49	1,116	13,800	12.41
Abrasives:															
Blasting	142	1,760	12.39	161	2,484	15.43	1,065	14,250	13.38	128	1,406	10.98	1,496	19,900	13.30
Scouring cleansers (ground)	(2)	14	--	88	1,663	18.90	75	1,374	18.32	--	--	--	163	3,051	18.72
Sawing and sanding	20	149	7.45	60	379	6.32	82	735	8.96	--	--	--	162	1,262	7.79
Chemicals (ground and unground)	73	802	10.99	211	1,802	8.54	132	1,688	12.79	40	447	11.18	456	4,739	10.39
Fillers (ground):															
Rubber, paints, putty, etc	39	1,060	27.18	82	2,693	32.84	95	3,077	32.39	1	14	14.00	217	6,844	31.54
Ceramic (ground):															
Pottery, brick, tile, etc	11	267	24.27	88	2,853	32.42	46	963	20.93	4	53	13.25	148	4,136	27.95
Filtration	71	1,087	15.31	63	720	11.43	89	816	9.17	11	154	14.00	233	2,776	11.91
Traction (engine)	17	178	10.47	188	1,354	7.20	140	935	6.68	46	357	7.76	391	2,825	7.23
Coal washing	2	18	9.00	10	111	11.10	31	275	8.87	--	--	--	43	404	9.40
Roofing granules and fillers	17	266	15.65	22	201	9.14	107	1,475	13.79	44	448	10.18	189	2,390	12.65
Hydraulic fracturing	1	11	11.00	379	6,968	18.39	688	14,560	21.16	108	2,481	22.97	1,176	24,000	20.42

See footnotes at end of table.

Table 11.—Industrial sand and gravel sold or used by U.S. producers, by geographic region and major use —Continued

Geographic region	North East			North Central			South			West			United States		
	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton
1980 —Continued															
Sand —Continued															
Other	333	$2,504	$7.52	648	$6,446	$9.95	370	$3,530	$9.54	103	$1,906	$18.50	1,453	$14,390	$9.90
Total[1]	4,027	42,030	10.44	12,600	108,070	8.58	8,324	89,520	10.75	4,653	58,220	12.51	29,610	297,800	10.06
Gravel:															
Metallurgical:															
Silicon, ferrosilicon	--	--	--	75	562	7.49	605	4,465	7.38	--	--	--	680	5,027	7.39
Filtration	--	--	--	8	160	20.00	10	39	3.90	1	9	9.00	19	209	11.00
Other	--	--	--	2	23	11.50	101	452	4.48	63	747	11.86	166	1,222	7.36
Total[1]	--	--	--	85	745	8.76	716	4,957	6.92	64	756	11.81	865	6,458	7.47
Grand total[1]	4,027	42,030	10.44	12,690	108,800	8.58	9,040	94,480	10.45	4,717	58,980	12.50	30,480	304,300	9.99

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 12.—Transportation of sand and gravel in the United States to site of first sale or use

Method	1979		1980	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	848,300	87	714,300	90
Rail	25,520	3	15,060	2
Waterway	26,350	3	11,550	1
Not shipped, used at site	77,090	8	50,090	6
Unspecified	1,761	(1)	3,410	(1)
Total[2]	979,000	100	794,400	100

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 13.—U.S. exports of construction sand, gravel, and industrial sand

(Thousand short tons and thousand dollars)

Year and country	Construction sand		Gravel		Industrial sand	
	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]
1979						
Argentina	2	183	530	1,029	2	116
Bahamas	6	66	--	--	45	271
Canada	267	1,609	--	--	687	12,576
Costa Rica	--	--	--	--	19	206
France	6	145	--	--	2	266
Mexico	7	476	28	54	386	6,500
Panama	--	--	--	--	5	205
Peru	--	--	--	--	11	1,026
United Kingdom	25	151	--	--	3	508
Yugoslavia	--	--	--	--	6	426
Other	11	1,123	8	88	20	5,417
Total	324	3,753	566	1,171	1,186	27,517
1980						
Bahamas	6	46	--	--	31	115
Canada	504	2,535	663	1,284	729	14,896
Costa Rica	--	--	--	--	13	194
Mexico	49	1,056	20	39	341	7,168
Panama	--	--	--	--	9	236
Peru	--	--	--	--	13	1,316
Yugoslavia	--	--	--	--	9	209
Other	28	3,024	4	157	32	8,385
Total	587	6,661	687	1,480	1,177	32,519

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

Table 14.—U.S. imports for consumption of sand and gravel

(Thousand short tons and thousand dollars)

Year and country	Construction sand and gravel		Industrial sand	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
1979				
Australia	(2)	3	68	1,392
Canada	352	668	3	82
Philippines	(2)	21	--	--
South Africa, Republic of	--	--	(2)	48
Other	(2)	29	(2)	78
Total	352	721	71	1,600
1980				
Australia	(2)	41	34	903
Canada	502	1,027	(2)	120
Germany, Federal Republic of	(2)	3	(2)	196
Japan	(2)	21	(2)	55
South Africa, Republic of	--	--	(2)	16
Other	--	51	5	285
Total	502	1,143	39	1,575

[1]Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[2]Less than 1/2 unit.

Silicon

By Peter H. Kuck[1]

Demand for silicon metal and alloys in the United States decreased significantly in 1980 because of substantial cutbacks in automotive, machinery, and construction industries. Imports of ferrosilicon and silicon metal declined 38% and 21%, respectively, in terms of gross weight. Because of rising power costs overseas, exports of both materials continued to increase in spite of weakened demand in foreign markets.

DOMESTIC PRODUCTION

Shipments of silicon metal and alloys decreased significantly in 1980 as a result of cutbacks in automotive, machinery, and construction industries. The decrease was evenly distributed between all four classes of alloys and metal. Estimated value of production (excluding electronic-grade silicon) was $510 million. Magnesium ferrosilicon constituted about three-fourths of production classified as miscellaneous alloys, the remainder in this class being calcium-silicon, silicon-manganese-zirconium, and proprietary inoculants.

More than one-fifth of the nation's silicon metal and alloy plants changed or were in the process of changing ownership during 1980. Union Carbide Corp. signed an agreement-in-principle in June for the sale of more than half of its ferroalloys business to a group composed of Elkem A/S, Shieldings Investments Ltd. of Canada, and certain Norwegian investors. The Elkem-led group was to acquire the silicon metal and alloy plants at Alloy, W. Va.; Ashtabula, Ohio; Beauharnois, Quebec; Chicoutimi, Quebec; and Trondelag, Norway, as part of the agreement. Union Carbide said it would retain and expand its specialty silicon chemical operations.

Also in June, Union Carbide sold its ferrosilicon plant at Sheffield, Ala. to Reynolds Metals Co. Reynolds has integrated the plant site into its adjacent Listerhill aluminum reduction and fabrications complex but has discontinued production of ferrosilicon. The 40-year-old facility needed substantial modernization.

Cabot Corp. sold its National Metallurgical Div. in September to Dow Corning Corp. for $13 million. National Metallurgical has been a producer of metallurgical-grade silicon metal for the aluminum and silicones industries at its plant in Springfield, Oreg. The plant has a single 18-megawatt (MW) furnace with a capacity of 12,000 tons per year and was to provide Dow Corning with raw materials for its silicone and electronic-grade polysilicon operations in Michigan.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1980

(Short tons, gross weight except as noted)

Alloy	Silicon content (percent) Range	Silicon content (percent) Typical	Producers' stocks as of Dec. 31, 1979	Production	Shipments	Producers' stocks as of Dec. 31, 1980
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (includes briquets)	25-55	48	r67,120	452,123	385,510	70,345
Do	56-95	76	r20,780	120,444	109,350	24,152
Silicon metal (excluding semiconductor grades)	96-99	98	8,620	129,629	124,534	11,081
Miscellaneous silicon alloys (excluding silicomanganese)	32-65	--	15,533	72,848	62,026	15,217

rRevised. W Withheld to avoid disclosing company proprietary data.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1980

Producer	Plant location	Product
Alabama Alloy Co., Inc	Bessemer, Ala	FeSi.
Aluminum Co. of America, Northwest Alloys, Inc	Addy, Wash	FeSi, Si.
Dow Corning Corp.[1]	Springfield, Oreg	Si.
Chromasco, Ltd., Chromium Mining & Smelting Corp. Div	Woodstock, Tenn	FeSi.
Foote Mineral Co., Ferroalloys Div	Graham, W.Va	Do.
Do	Keokuk, Iowa	Silvery pig iron.
Hanna Mining Co.:		
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Silicon Div	Wenatchee, Wash	FeSi, Si.
Interlake, Inc., Globe Metallurgical Div	Beverly, Ohio	Do.
Do	Selma, Ala	Si.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div	Bridgeport, Ala	FeSi.
Do	Kimball, Tenn	Do.
Ohio Ferro-Alloys Div	Montgomery, Ala	FeSi, Si.
Do	Philo, Ohio	FeSi.
Do	Powhatan Point, Ohio	Si.
Reynolds Metals Co	Sheffield, Ala	Do.
Satralloy, Inc	Steubenville, Ohio	FeSi.
SKW Alloys, Inc	Calvert City, Ky	Do.
Do	Niagara Falls, N.Y	Do.
South African Manganese Amcor, Ltd., Roane Electric Furnace Co	Rockwood, Tenn	Do.
Union Carbide Corp., Metals Div	Alloy, W. Va	FeSi, Si.
Do	Ashtabula, Ohio	FeSi.
Do	Portland, Oreg	Do.
Do.[2]	Sheffield, Ala	Do.

[1]Cabot Corp., Kawecki Berylco Industries, Inc., until October 1980.
[2]Sold to Reynolds Metals Co. in June 1980.

CONSUMPTION AND USES

Reported consumption of silicon metal and alloys totaled 413,000 short tons of contained silicon in 1980, a decrease of 19% from the previous year. This reversal of the demand growth rate was due largely to lower demand for ferrosilicon both by iron foundries and steel plants. Iron foundries were especially hard hit by production declines in the automobile industry. Cast iron shipments (exclusive of ingot molds), as reported by the Bureau of the Census, fell 30% from 12.7 million net tons in 1979 to 8.9 million tons in 1980. Several secondary aluminum smelters were forced to trim production and reduced their purchases of metallurgical-grade silicon metal by 30% to 50%. Even consumption of silicon metal in silicones decreased 9%, ending a 5-year period of growth by the silicones industry.

Several producers of silicon chemicals announced plans to construct new plants or to increase capacity at existing facilities. Union Carbide Corp. was to build a $150 million silicones plant at South Charleston, W. Va. The new facility was scheduled to come onstream in 1983 for conversion of metallurgical-grade metal into methylchlorosilanes and thence into several hundred different silicone products, including oils, resins, lubricants, surfactants, elastomers, and antifoaming agents. Dow Chemical U.S.A. was to construct a fumed silica plant with a capacity of 10 million pounds per year at Midland, Mich. This represented Dow Chemical's entry into a field presently shared by Cabot Corp. and Degussa Alabama, Inc.

Synthesis of several novel families of silicon chemicals opened new markets for the metal. Olin Corp. has begun marketing nontoxic silicate esters as specialty lubricants, high-performance hydraulic fluids, coolants, defoamers, and additive solubilizers. The new silicate esters have silicon, carbon, hydrogen, and oxygen atoms arranged in a novel cluster structure that protects the molecule from hydrolysis and gives a mixture of properties characteristic of both inorganic and organic compounds.

A relatively small tonnage of metallurgical-grade metal was used in 1980 to produce electronic-grade polycrystalline silicon. Domestic polysilicon production was estimated to be 1,200 metric tons. Polysilicon facilities were currently being expanded at Hemlock Semiconductor Corp. (Hemlock, Mich.) and Great Western Silicon Corp. (Chandler, Ariz.). Solarex Corp. also announced that it will build a $20 million facility at Frederick, Md., to produce silicon material for photovoltaic devices. In December, Applied Materials Inc. and Fairchild Camera & Instrument Corp. agreed to sell Great Western Silicon Corp. to the General Electric Co. for slightly less than $8 million. Present capacity of the Chandler plant is 120 metric tons of polysilicon per year.

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1980

(Short tons, gross weight except as noted)

End use	Silvery pig iron	Ferrosilicon[1]				Silicon metal	Miscellaneous silicon alloys[2]	Silicon carbide[3]
Silicon content (percent): Range	5-24	25-55	56-70	71-80	81-95	96-99		63-70
Typical	18	48	65	76	85	98	49	64
Steel:								
Carbon	537	89,552	([4])	24,114	([4])	16	2,684	181
Stainless and heat-resisting	--	29,192	([4])	17,843	71	233	118	([4])
Full alloy	1,063	34,439	([4])	12,256	([4])	1,601	1,072	([4])
High-strength low-alloy	([4])	7,114	--	2,097	--	2	622	--
Electric	--	([4])	([4])	([4])	--	--	--	--
Tool	--	1,621	--	1,247	--	59	([4])	--
Unspecified	68	13,325	4,725	22,413	574	--	26	31
Total steel	1,668	175,243	4,725	79,970	645	1,911	4,522	212
Cast irons	45,867	126,820	3,243	26,654	589	171	32,976	32,383
Superalloys	7	261	--	94	34	31	3	--
Alloys (excluding alloy steels and superalloys)	130	6,684	--	95	33	64,953	46	5
Silicones and silanes	--	--	--	--	--	46,464	--	--
Miscellaneous and unspecified	42	18,847	--	99	16	[5]9,300	271	--
Total	47,714	327,855	7,968	106,912	1,317	122,830	37,818	32,600
Percent of 1979	77	83	100	74	86	96	70	65
Total silicon content[6]	8,588	157,370	5,179	81,253	1,119	120,373	18,531	20,864
Consumers' stocks, Dec. 31, 1980	4,171	22,015	724	9,340	193	6,811	3,932	2,529

[1]Includes briquets.
[2]Primarily magnesium-ferrosilicon but also includes other silicon alloys. Average silicon content estimated as 49%, based on 1980 production survey.
[3]Does not include silicon carbide for abrasive or refractory uses.
[4]Included with "Steel: Unspecified."
[5]Includes an estimated 9,000 tons consumed for unspecified chemicals.
[6]Estimated based on typical percent content.

PRICES

Prices for both domestic and imported metallurgical-grade silicon metal increased in January in response to inflation and higher energy costs. Attempts by domestic producers to increase prices for ferrosilicon failed because of declining demand on the part of the ferrous castings industry. Importers of ferrosilicon and silicon metal lowered prices during the fourth quarter in order to remain competitive.

The price of domestic, lump silicon metal with 1% maximum iron and 0.07% maximum calcium was raised at the beginning of 1980 from 56.5 cents per pound to 59.5 cents per pound of contained silicon, and then remained steady through December. In October, quoted prices for imported silicon metal declined from 59.25 to 58.00-59.00 cents per pound.

The price of domestic, regular 50% ferrosilicon remained at 42.0 cents per pound of contained silicon throughout the year. The price of regular 75% ferrosilicon was also unchanged at 46.25 cents per pound. The f.o.b. warehouse price of imported 75% ferrosilicon, as quoted in Metals Week, gradually declined from 42.0-45.0 to 37.5-39.0 cents per pound. In October, three domestic producers increased prices of various grades of magnesium ferrosilicon by about 5%. The price increases were attributed to rising costs of power and pure magnesium. Price of the 5% magnesium grade with no cerium was raised from 46.5 cents to 49.0 cents per pound of alloy, while the 9% grade went from 62.0 cents to 66.0 cents per pound of alloy.

FOREIGN TRADE

Exports of ferrosilicon-based alloys increased 23% in terms of gross weight, with 44% of shipments going to Canada. Principal other buyers in 1980 were Australia (21%), Mexico (17%), Japan (7%), and Angola (4%). Exports of silicon metal increased 188% in terms of gross weight at a record value of $65.5 million. Slightly more than 75% of silicon metal exports went to Japan. The remainder was divided among 41 countries, none of which received over 4% of the total.

Imports of ferrosilicon and silicon metal decreased 38% and 21%, respectively, because of cutbacks in the automotive and construction industries. Imports of ferrosilicon were at their lowest level in 5 years.

In 1978 the Treasury Department received a petition from the Ferroalloys Association alleging that the Government of Spain had subsidized exports of ferrosilicon and several other ferroalloys. Since then, no silicon alloys have been imported from Spain. In December 1979, the Treasury Department ruled the Government of Spain had indeed subsidized exports of 75% ferrosilicon and other ferroalloys to the United States with tax incentives and credit preferences. A countervailing duty of 3.36% ad valorem in addition to the regular duty was levied by the U.S. Customs Service at the beginning of 1980.

In March 1980, the Ferroalloys Association withdrew its petition for countervailing duties on imports of 75% ferrosilicon and three other ferroalloys from Brazil. The association stated that its main objective had been achieved after the Government of Brazil took action to eliminate more than 90% of its ferroalloy subsidy programs.

Effective May 5, 1980, in response to the Soviet invasion of Afghanistan, the U.S. Department of Commerce established interim controls on exports to the U.S.S.R. of electronic-grade polycrystalline silicon and on wafers and boules of monocrystalline silicon.

Table 4.—U.S. exports of ferrosilicon and silicon metal

Year	Quantity (short tons)	Value (thousands)
FERROSILICON		
1978	11,900	$7,871
1979	22,357	14,740
1980	27,488	18,572
SILICON METAL		
1978	2,404	21,974
1979	4,987	45,752
1980	14,372	65,478

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1979 Quantity (short tons) Gross weight	1979 Quantity (short tons) Silicon content	1979 Value (thousands)	1980 Quantity (short tons) Gross weight	1980 Quantity (short tons) Silicon content	1980 Value (thousands)
Ferrosilicon:						
Over 8% but not over 30% silicon:						
Brazil	794	137	$302	--	--	--
Canada	3,698	529	272	1,106	170	$85
Germany, Federal Republic of	--	--	--	82	14	42
Total[1]	4,491	666	575	1,188	184	127
Over 30% but not over 60% silicon, with over 2% magnesium:						
Brazil	1,773	825	1,385	2,733	1,308	1,992
Canada	2,906	1,374	1,320	527	289	1,054
France	2,302	1,139	1,875	1,316	651	1,287
Germany, Federal Republic of	451	250	748	393	203	530
Italy	443	204	269	307	140	204
Japan	210	95	166	--	--	--
Norway	885	396	615	246	114	226
Venezuela	3,159	1,485	791	--	--	--
Total[1]	12,127	5,768	7,169	5,523	2,706	5,293
Over 30% but not over 60% silicon, not elsewhere classified:						
Belgium-Luxembourg	73	44	71	--	--	--
Brazil	91	55	90	154	91	180
Canada	6,478	3,098	2,000	6,099	2,996	1,610
France	2,613	1,486	2,615	2,569	1,485	3,187
Germany, Federal Republic of	867	477	1,012	586	328	758
Italy	--	--	--	37	19	34
Norway	2,756	1,622	707	1,765	1,004	582
South Africa, Republic of	1,472	519	641	2,898	1,047	1,272
Total[1]	14,350	7,298	7,137	14,107	6,971	7,621
Over 60% but not over 80% silicon, with over 3% calcium:						
Brazil	(2)	(2)	(2)	2,702	2,013	1,741
Canada				1,133	880	678
France				2,272	1,475	2,128
Germany, Federal Republic of				438	267	579
Italy				121	77	139
South Africa, Republic of				1,706	1,308	953
Total[1]	(2)	(2)	(2)	8,373	6,020	6,217
Over 60% but not over 80% silicon, not elsewhere classified:[2]						
Argentina	551	408	269	--	--	--
Australia	1,101	782	273	--	--	--
Brazil	15,011	11,032	8,080	9,233	6,962	4,779
Canada	12,507	9,328	6,522	7,513	5,532	4,326
Chile	533	401	212	1,547	1,171	645
France	2,744	1,899	2,079	1,572	1,115	1,239
Germany, Federal Republic of	1,398	910	2,358	447	315	1,040
Iceland	--	--	--	4,163	3,161	2,228
Norway	29,050	21,405	13,078	10,417	7,603	4,916
Peru	220	166	105	--	--	--
South Africa, Republic of	4,124	3,155	1,693	661	502	372
Venezuela	11,481	8,454	6,059	6,176	4,632	3,726
Yugoslavia	3,400	2,412	1,811	--	--	--
Total[1]	82,122	60,352	42,540	41,729	30,993	23,271
Over 80% but not over 90% silicon:						
Canada	406	341	172	42	35	34
Chile	--	--	--	55	45	21
Venezuela	57	48	28	--	--	--
Total	463	389	200	97	80	55
Over 90% but not over 96% silicon:						
Canada	--	--	--	16	14	5
Chile	--	--	--	119	110	51
Total	--	--	--	135	124	56
Grand total[1]	113,553	74,473	57,621	71,152	47,078	42,640

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country —Continued

Grade and country	1979 Quantity (short tons) Gross weight	1979 Quantity (short tons) Silicon content	1979 Value (thousands)	1980 Quantity (short tons) Gross weight	1980 Quantity (short tons) Silicon content	1980 Value (thousands)
Silicon metal:						
Over 96% but not over 99% silicon:						
Argentina	332	NA	$222	--	--	--
Australia	--	--	--	1	NA	(3)
Belgium	--	--	--	5	NA	$39
Canada	9,538	NA	8,827	7,927	NA	8,147
Finland	10	NA	10	--	--	--
France	359	NA	294	68	NA	64
Germany, Federal Republic of	22	NA	8	57	NA	46
Japan	131	NA	81	(4)	NA	10
Norway	321	NA	235	888	NA	790
South Africa, Republic of	4,407	NA	3,512	4,661	NA	4,511
Switzerland	(4)	NA	33	--	--	--
United Kingdom	131	NA	90	(4)	NA	8
Yugoslavia	4,685	NA	3,519	2,281	NA	2,002
Total[1]	19,936	NA	16,831	15,887	NA	15,617
Over 99% but not over 99.7% silicon:						
Brazil	--	--	--	(4)	(4)	1
Canada	2,750	2,724	2,809	3,888	3,852	4,257
Norway	2,538	2,518	2,318	827	820	830
South Africa, Republic of	1,761	1,745	1,519	543	538	574
United Kingdom	--	--	--	(4)	(4)	1
Yugoslavia	--	--	--	112	111	97
Total[1]	7,050	6,987	6,646	5,370	5,322	5,760
Over 99.7% silicon:						
Belgium-Luxembourg	6	NA	53	11		88
Canada	214	NA	200	(4)		2
China:						
Mainland	--	--	--	(4)		1
Taiwan	--	--	--	1		40
Denmark	21		3,468	9		2,157
France	20		284	19	NA	235
Germany, Federal Republic of	289	NA	14,826	429		21,538
Italy	95		4,776	104		5,737
Japan	11		604	4		459
Sweden	--	--	--	1		5
Switzerland	--	--	--	5		1,477
United Kingdom	(4)	NA	16	(4)		1
Total[1]	656	NA	24,225	582	NA	31,740
Grand total	27,642	NA	47,702	21,839	NA	53,117

NA Not available.
[1]Data may not add to totals shown because of independent rounding.
[2]Prior to 1980, no distinction was made between high-calcium ferrosilicon and regular ferrosilicon with 60% to 80% silicon.
[3]Less than $500.
[4]Less than 1/2 unit.

WORLD REVIEW

Australia.—Kaiser Aluminum and Chemical Corp. (Australia) Ltd. announced plans to build Australia's first silicon metal smelter at Geelong in the State of Victoria. The plant will have an initial capacity of 33,000 short tons of metal per year and is expected to begin production in 1983.[2]

Brazil.—The Brazilian ferroalloy industry continued to expand production of silicon alloys and metal. Ferrosilicon production totaled 120,000 short tons in 1980, an increase of approximately 64% over that of the previous year. Silicon metal production rose to 13,000 tons, an increase of over 110%.[3] Four ferrosilicon furnaces and one silicon metal furnace were brought on line during the year by various companies.[4]

China, mainland.—China National Metals and Minerals Import and Export Corp. has agreed to supply two Japanese trading companies, Kyokuei Industry and Meikai Boeki, with 5,500 short tons of metallurgical-grade silicon metal in fiscal 1981, 11,000 tons in 1982, and 16,000 tons in

1983.[5] These negotiations suggested that China's 1980 production of silicon metal was about 12,000 tons and that capacity of its ferroalloy plants was being rapidly expanded. The Chinese exported 618 tons of ferrosilicon and 200 tons of silicon metal to Japan in calendar year 1980.[6]

Germany, Federal Republic of.—Wacker-Chemie GmbH, the world's largest producer of semiconductor-grade polysilicon, was increasing capacity of its Burghausen plant in southeastern Bavaria from 1,200 to 1,800 metric tons per year. The $13 million expansion will allow the company to meet customer demand until new production facilities being built at Portland, Oreg., can be brought onstream in 1983.[7]

Iceland.—The second of two 30-MW furnaces was brought onstream in September 1980 at the new ferrosilicon plant of Icelandic Alloys, Ltd. The plant, located at Grundartangi, now has an annual production capacity of 61,000 short tons of 75% ferrosilicon.[8] Icelandic Alloys was considering shutting down one of the furnaces because of the poor international market for ferrosilicon and silicon metal.

India.—Ferrosilicon production improved considerably during the third quarter of 1980 after full power was restored to plants in Orissa, Karnataka, and Andhra Pradesh. Indian ferroalloy producers, dependent on hydroelectric power, were seriously hurt by droughts in 1978, 1979, and part of 1980. As a result, only 56,400 short tons of ferrosilicon were produced in 1979, although production capacity was 105,000 tons.[9] Preliminary reports indicated that ferrosilicon production decreased in 1980 to about 47,000 tons.

Italy.—The ferroalloys and engineering portion of the Montedison S.p.A. chemical group was reorganized into an independent company, Società Ferroleghe S.p.A.[10] The new company will continue to operate two 12-megavolt ampere (MVA) three-phase furnaces and two 3.6-MVA two-phase furnaces at Domodossola, with a total combined capacity of 26,000 tons of 75% and 45% ferrosilicon.

Montedison also sold Materiali Iperpuriper Elettronica S.p.A. (SMIEL) to Dynamit Nobel A.G. for $40 million. SMIEL has been a major supplier of polycrystalline silicon and semiconductor-grade wafers to the U.S. electronics industry. Dynamit, a German producer of silanes, was to expand the capacity of SMIEL's plant at Merano in the Province of Trentino-Alto Adige.[11]

Japan.—Power cost hikes of 60% to 90% hurt several small Japanese ferrosilicon producers who lack their own power generating facilities.[12] Unable to compete against a surge of cheap imports, Japan Metals and Chemicals Co., Ltd., shut down four ferrosilicon furnaces with a total annual capacity of 18,500 short tons. The company was to continue to produce ferrosilicon at its Date plant in Fukushima Prefecture and its Wakagawa plant in Iwate Prefecture.[13] Ube Denka Kogyo KK idled one of its 48-MVA furnaces at Mine, while Joetsu Denko Kogyo Co., Ltd., ceased ferrosilicon production entirely.[14] Production of polycrystalline silicon for the Japanese semiconductor industry reached a record high of 470 metric tons, up 42% from 330 tons in 1979.[15]

Norway.—Elkem A/S shut down the largest of four silicon metal furnaces at Fiskaa Verk and decreased output from the other three in response to the depressed international market for ferroalloys.[16] The company has also been forced to delay plans to build a fourth ferrosilicon furnace at Salten Verk because of uncertainty about power prices and allocations created by the Government Energy White Paper (No. 54). The White Paper plan, approved by Parliament in October 1980, called for steep price increases for hydroelectric power. The new base price for metallurgical industries is expected to be 22 mills (U.S.) per kilowatthour (including all taxes) by 1985, an increase of 130% from 9.5 mills in 1979.[17]

Philippines.—Exports of ferrosilicon to Japan rose from 8,735 short tons in 1979 to 15,243 tons in 1980.[18] Ferrosilicon was produced by three companies: Maria Cristina Chemical Industries, Inc. (MCCI), Electro Alloys Corp., and Ferro-Chemicals, Inc. MCCI was in the process of developing a silica mine at Barangay Maaslum in Ayungon, Negros Oriental, from a deposit with estimated quartz reserves of 550 million tons. The silica was to be shipped by boat to the company's smelter at Iligan City on Mindanao.[19]

South Africa, Republic of.—Transalloys (Pty.) Ltd., a subsidiary of Highveld Steel and Vanadium Corp. Ltd., converted one of its two silicomanganese furnaces at Witbank to ferrosilicon because of weakened demand for manganese ferroalloys. The converted furnace was recommissioned in May 1980. Another ferrosilicon furnace rated at 22-MVA was under construction and was to be commissioned before the end of 1981. The company has been producing ferrosilicon from a single 15-MVA Elkem furnace.[20]

Spain.—Silicio de Sabon has been forced to cut back production of silicon metal because of weakened demand worldwide and serious economic problems facing the Spanish ferroalloy industry. During 1979 the company produced 23,125 short tons of the metal at its Arteijo plant in La Coruna Province.[21]

Sweden.—Vargön Alloys AB, now jointly owned by Macmetal Corp. and Satra Corp., converted a 48-MVA ferrochromium furnace to ferrosilicon.

Yugoslavia.—Opalit Proizvodstveno Industriski Kombinat opened a 65,000-ton-per-year quartz mine near Stip in eastern Macedonia. Reserves were in excess of 6 million tons of high-quality quartz suitable for silicon alloy smelting.[22] A ferrosilicon and silicon metal plant was being planned for Kosovska Kamenica in Kosovo, consisting of four 27-MVA furnaces with a total capacity of 36,000 tons per year of 75% ferrosilicon and 28,000 tons per year of silicon metal.[23]

TECHNOLOGY

In November 1980, Mobil Tyco Solar Energy Corp. opened a 13,000-square-foot plant at Waltham, Mass., for manufacturing silicon photovoltaic cells. The Mobil plant utilizes a production process based on edge-defined, film-fed growth technology that avoids the conventional steps of wafer sawing and polishing. Long, thin ribbons of monocrystalline silicon are pulled from the melt, cut into squares, and then fabricated into 50-square-centimeter solar cells with conversion efficiencies of up to 14.2%.[24] Arthur D. Little, Inc. (A.D.L.), also announced development of a continuous ribbon process for large-scale production of photovoltaic cells. The A.D.L. "edge-stabilized ribbon" process produces monocrystalline silicon 25 millimeters wide and as much as 4.3 meters long. Thickness of the ribbon can be varied from 4 to 300 micrometers. The Advanced Energy Systems Div. of Westinghouse Electric Corp. was evaluating a third crystal-growing process. The Westinghouse "dendritic web" technique produces a 0.15-millimeter-thick, mirror-smooth ribbon that requires no polishing. The monocrystalline "web" is formed by solidification of a liquid silicon film supported by surface tension between two silicon filaments, called dendrites.

High-performance silicon-base ceramics were being increasingly accepted as a substitute for superalloys and other metals in high-temperature or highly corrosive situations. Most development work to date has focused on silicon nitride, silicon carbide, and sialons. Brittleness and difficult machinability of silicon ceramics have been the biggest drawbacks. However, these drawbacks are often offset by lower cost, lower density, better resistance to thermal shock, higher melting point, and better corrosion resistance of the ceramic. Simple one-for-one substitution is difficult, substantial design modifications usually being required.[25]

Major domestic producers of silicon-based ceramics include Norton Co., The Carborundum Co., Dresser Industries, Inc., Coors Porcelain Co., Kawecki Berylco Industries, and Kyocera International, Inc. Kyocera International is a subsidiary of Kyoto Ceramic Co., Ltd., Kyoto, Japan. Lucas Industries, Ltd., of Birmingham, United Kingdom, announced that it will market cutting tools with sialon components and will continue to develop sialon parts for gas-turbines and automobile engines. Many research and development programs involving high-temperature ceramics were in progress worldwide. In the United States, work was being done at more than 25 facilities, including the U.S. Army Materials and Mechanics Research Center, Battelle Columbus Laboratories, GTE Sylvania, Inc., General Electric Co., AiResearch Manufacturing Co., and Ford Motor Co.[26] In Japan, Shin-Etsu Chemical Co. has begun a feasibility study on commercial production of silicon nitride.

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[1]Physical scientist, Section of Ferrous Metals.

[2]Australia Bulletin. No. 101, Nov. 6, 1980, p. 3.

[3]Instituto Brasileiro de Siderurgia Revista. No. 40, January-February 1981, p. 25.

[4]Associação Brasileira dos Produtores de Ferro-Ligas. Anuário da Indústria Brasileira de Ferro-Ligas-1980. Rio de Janeiro, p. 14.

[5]Metals Week. V. 51, No. 48, Dec. 1, 1980, p. 6.

[6]Japan Tariff Association. Japan Exports and Imports. V. 12, 1980, pp. 122, 321.

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Silver

By Harold J. Drake[1]

U.S. mine production of silver declined 18%, and U.S. consumption decreased 21% in 1980. The declines were attributed to strikes at production facilities and the high price of silver, respectively. The United States was a net exporter of silver in 1980, the first time since 1969, as exports exceeded imports by 2.1 million ounces.[2]

The annual average price of silver was sharply higher than the comparable price for the preceding year, notwithstanding the declining daily price trend during 1980. The decrease in price was attributed to waning speculative interest in silver and the decline in demand.

Table 1.—Salient silver statistics

	1976	1977	1978	1979	1980
United States:					
Mine production ---------- thousand troy ounces--	34,328	38,166	39,385	r38,087	31,327
Value -------------------- thousands--	$149,328	$176,325	$212,681	r$422,386	$646,585
Ore (dry and siliceous) produced:					
Gold ore ------------ thousand short tons--	1,993	3,478	3,499	r4,202	5,511
Gold-silver ore ------------------ do----	1,027	481	738	756	872
Silver ore ------------------ do----	794	976	1,102	1,066	1,069
Percentage derived from:					
Dry and siliceous ores ------------------	32	43	55	51	51
Base metal ores ------------------	68	57	45	49	49
Refinery production[1] ------ thousand troy ounces--	34,359	36,729	44,018	38,982	36,171
Exports[2] ------------------------ do----	14,596	22,394	22,400	35,563	80,851
Imports for consumption[2] -------------- do----	72,700	79,147	75,641	92,381	78,795
Stocks Dec. 31:					
Treasury[3] ------------ million troy ounces--	40	39	39	39	39
Industry[4] ---------- thousand troy ounces--	146,423	165,343	146,902	r149,131	140,298
Consumption:					
Industry and the arts -------------- do----	170,559	153,613	160,165	157,258	124,694
Coinage ------------------ do----	1,315	91	45	168	72
Price[5] -------------------- per troy ounce--	$4.354	$4.623	$5.401	$11.109	$20.632
World:					
Production ------------ thousand troy ounces--	r316,384	r340,262	r344,438	r345,958	341,370
Consumption:[6]					
Industry and the arts -------------- do----	r437,500	r433,600	r442,600	r419,800	340,200
Coinage ---------------------- do----	29,700	r23,400	r36,300	r27,800	15,700

rRevised.
[1]From domestic ores.
[2]Excludes coinage.
[3]Excludes silver in silver dollars.
[4]Includes silver in COMEX warehouses and silver registered in Chicago Board of Trade.
[5]Average New York price. Source: Handy & Harman.
[6]Market economies only. Source: Handy & Harman.

The decline in consumption was led by products containing large quantities of silver per item, such as sterlingware, photography, contacts and conductors, solders, and catalysts. Uses showing increased consumption included jewelry, batteries, bearings, coins, medallions, commemorative objects, and others. Coinage use was well below use of 1979.

Refinery output rose slightly in 1980 as production from ores and concentrates dropped, whereas production from old scrap rose 34% mainly as a result of high bullion prices, which led to sharply increased recovery from demonetized coin and high-silver-content scrap.

Trading of silver futures on the New York Commodity Exchange (COMEX) and the Chicago Board of Trade (CBT) fell from 34.1 billion ounces in 1979 to 6.8 billion ounces in 1980, reflecting the sharply decreased speculative interest in silver. Stocks on the exchanges fell to 120.8 million ounces. Industrial stocks were moderately lower, whereas Treasury bullion stocks were only slightly below the 1979 level. The national stockpile contained 139.5 million ounces at yearend 1980.

Legislation and Government Programs.—The General Services Administration sold 350,008 ounces of silver reclaimed by the Veterans Administration. The silver was recovered by the U.S. Assay Office of the Department of the Treasury from scrap materials.

DOMESTIC PRODUCTION

Mine production declined to 31.3 million ounces, valued at $646.6 million in 1980, mainly as a result of strikes at copper mines producing byproduct silver and mines producing silver ore. The value of the silver produced was, however, 53% higher than value of 1979.

The 25 largest silver producers contributed 85% of the total output. Seven of these, 1st, 2d, 3d, 7th, 12th, 14th, and 15th, mined silver ores; two, 6th and 24th, mined gold-silver ore, and the others mined base-metal ores and produced byproduct silver. Ten of the mines produced over 1 million ounces of silver each, which in the aggregate equaled 59% of total production. Domestic mine production was equivalent to 25% of consumption in 1980.

The Galena Mine in Idaho's Coeur d'Alene silver district continued to be the largest silver producer in the United States. The Sunshine Mine of Sunshine Mining Co., in the same district, underwent a prolonged strike in 1980 and dropped from 2d to 12th place in output.

ASARCO Incorporated reported production of silver at 3.4 million ounces from the Galena Mine and 2.5 million ounces from the Coeur Mine.[3] The company proceeded with the development of the Troy copper-silver deposit in western Montana, with production expected before the end of 1981. The mine is expected to produce 4.2 million ounces of silver per year for about 16 years. Asarco's silver refinery in Amarillo, Tex., produced 27.1 million ounces of silver in 1980, compared with 36.1 million ounces in 1979.

Hecla Mining Co., Wallace, Idaho, reported production of 3.5 million ounces of silver in 1980.[4] Hecla's Lucky Friday Mine produced 3.0 million ounces, and its shares of the Sunshine Mine and the Star-Morning Mine totaled 261,771 and 206,157 ounces, respectively. The grade of ore milled at the Lucky Friday Mine in 1980 averaged 16.0 ounces per ton. Reserves at yearend 1980 totaled 636,000 tons compared with 585,000 tons at the end of 1979. Ground was broken for the new Silver Shaft at the Lucky Friday Mine, which is expected to increase mine capacity by 35% and to accelerate exploration of geologically favorable areas surrounding the mine. Hecla headed a joint venture to lease the mining properties of the Consolidated Silver Corp. near Osborn, Idaho. The main shaft on the property was rehabilitated and production commenced in October. Known ore reserves of about 1.3 million ounces in upper levels of the property will be mined concurrently with the exploration program.

Homestake Mining Co. reported production of 1.5 million ounces of silver from its Bulldog silver mine near Creede, Colo.[5] This level of production was slightly higher than the 1979 level, which reflected partly the processing of higher grade ore and partly an increase in the tonnage milled. Ore reserves in the Bulldog Mine at yearend 1980 totaled 446,000 tons, averaging 16.0 ounces of silver per ton.

Earth Resources Co. (ERC) produced 1.6 million ounces of silver at its DeLamar silver-gold mine near DeLamar, Idaho.[6] ERC estimated that its silver reserves totaled more than 34 million ounces, and ongoing drilling continued to add to their reserve. Increasing silver prices also added substantially to the reserves by lowering the cutoff grade.

Day Mines, Inc. (DMI), Wallace, Idaho, reported silver ore production from its Leadville Unit (Sherman Tunnel) in Colorado totaled 116,353 tons averaging 8.41 ounces per ton in 1980.[7] Production from DMI's Republic, Wash., gold-silver mine in 1980 totaled 62,718 tons, averaging 0.27 ounce of gold and 1.51 ounces of silver per ton. DMI also shared in the production of the Coeur and Galena silver mines in Idaho and reopened the Victoria copper-silver mine in Elko County, Nev., which DMI acquired in 1979. Other silver properties in the Coeur d'Alene district that DMI has interests in include Hunter Ranch, the Caladay, Hornsilver, DIA, and Abot North Projects.

Phelps Dodge Corp. reported 2.3 million ounces of byproduct silver was produced during the company's domestic copper-mining operations.[8] Production of silver at

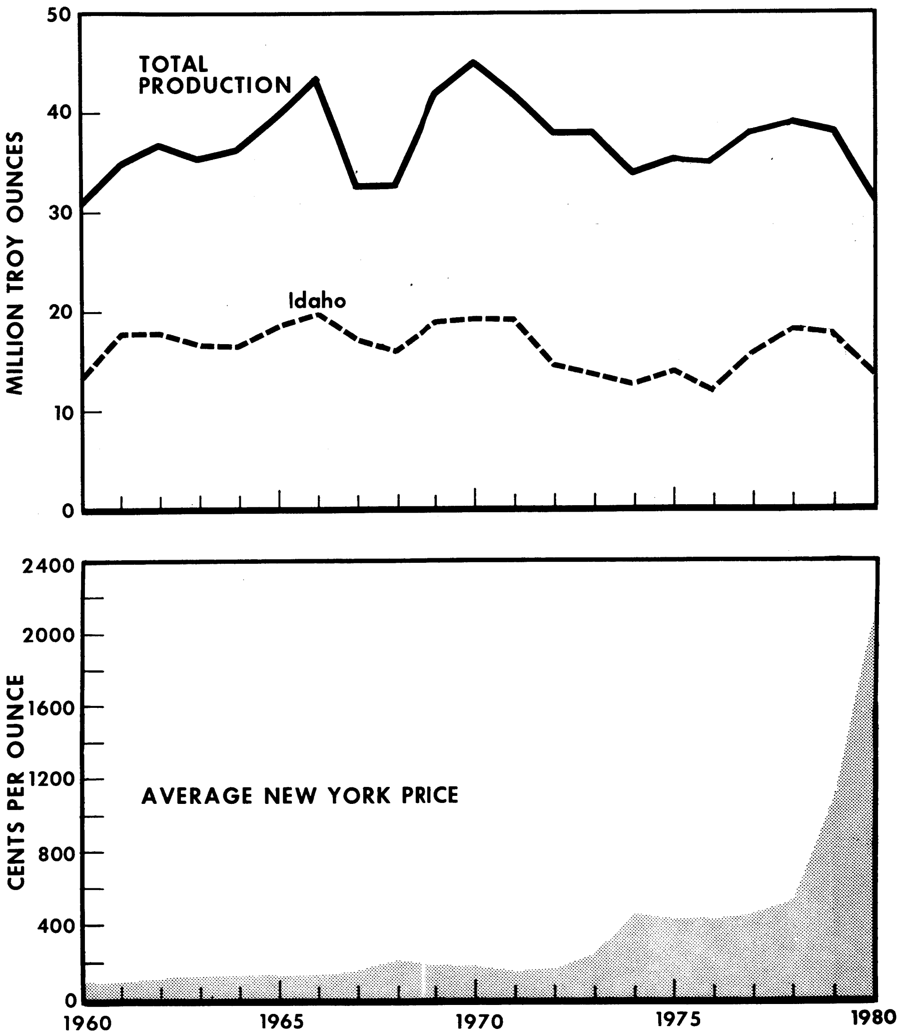

Figure 1.—Silver production in the United States and price per ounce.

Inspiration Consolidated Copper Co.'s Black Pine silver mine at Philipsburg, Mont., totaled 421,000 ounces, which came from a 1.8-million-ton ore body, averaging 5.9 ounces of silver per ton.[9]

Ag-Met Inc., a secondary refiner of precious and other metals, changed its name to Refinemet International Co.[10] In addition to secondary silver, the company produces gold, platinum, palladium, tantalum, selenium, and steel, and began processing concentrates from mining operations in 1980.

CONSUMPTION AND USES

Industrial consumption of silver declined 21% in 1980 primarily as a result of high silver prices and declining business activity. The weakness in silver demand continued throughout most of the year, notwithstanding a sharp declining trend in silver prices that was prevalent during the year. Of the major uses, electroplated ware, sterlingware, photographic materials, brazing alloys and solders, and contacts and conductors were most noticeably affected as demand for silver in their manufacture fell anywhere from 17% to 46%. In the aggregate, these uses accounted for 80% of total consumption in 1980 compared with 84% in 1979. Use of silver in catalysts dropped 46%. Most other uses showed gains in consumption during 1980.

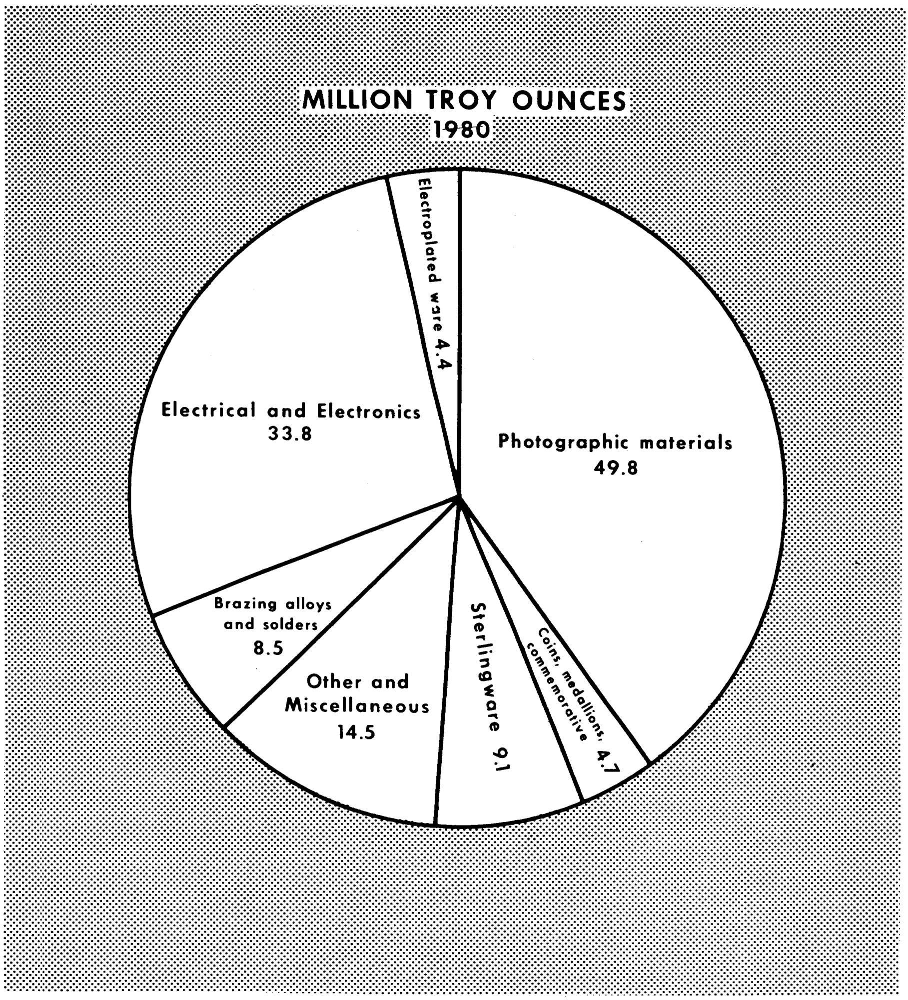

Figure 2.—Silver consumption in the United States in 1980.

STOCKS

Total accountable stocks at yearend 1980 were 323.2 million ounces, a level 10.2 million ounces below that of 1979. Refiner, fabricator, and dealer stocks rose slightly, while silver stocks in registered vaults of COMEX recorded a 16% gain. Silver bullion held by the CBT fell 41% and bullion of the U.S. Department of Defense fell 20%. The strategic stockpile contained 139.5 million ounces, all of which has been declared surplus to national defense needs. Although a number of bills have been introduced in the Congress to dispose of all or part of this silver, none had been passed at yearend 1980.

PRICES

The price of silver fell sharply in 1980 as speculative interest in silver metal declined. The average daily price per ounce of silver, as quoted by Handy & Harman, New York, began the year at $37.75, rose to the high of $48.00 on January 21, and then fell sharply to the low of $10.80 on May 22. The price fluctuated after that, but finished the year on a downward trend.

The average daily price was $20.63 compared with $11.09 in 1979. The average monthly price, which was $38.26 for January, declined to $12.53 for May, then rose to $20.18 in October before falling to $16.39 in December. The year ended with no abatement in the downward pressure on the price.

Prices on the London Metal Exchange ranged from a high of $49.48 on January 18 to a low of $10.89 on May 22. The average for 1980 was $20.87.

Trading volume on the COMEX was 5.2 billion ounces during 1980, a decrease of 15.2 billion ounces from that of 1979. The CBT trading volume was 1.6 billion ounces, a decline of 12.1 billion ounces from volume of 1979.

FOREIGN TRADE

Exports of silver totaled 80.9 million ounces in 1980, a 127% increase over the comparable figure for 1979. Refined bullion, which accounted for 71% of total exports, totaled 57.2 million ounces, a level 250% over that of 1979. Exports of waste, scrap, and sweepings increased to 21.1 million ounces, which was equivalent to 26% of total exports. Most of the increased exports of waste, scrap, and sweepings occurred in the first half of 1980 as a result of falling prices and the lack of domestic refining capacity to process the extra-large volume of silver scrap generated by higher prices beginning in 1979. Exports of doré and precipitates rose slightly. The remainder of the exports consisted of very minor quantities of silver ore and concentrates. The principal foreign markets for bullion were the United Kingdom and Switzerland; and for waste, scrap, and sweepings, Belgium-Luxembourg, the United Kingdom, and Canada.

Imports for consumption of silver decreased mainly because of reduced shipments of refined bullion from Canada, Mexico, and Peru. Refined bullion, which accounted for 82% of the imports, decreased 17%, while imports of ore and concentrates, and doré and precipitates decreased slightly. Imports of waste and sweepings were slightly higher in 1980. The principal sources for imported silver in 1980 were Canada, Peru, and Mexico, which, in the aggregate, supplied 81% of total imports and 83% of bullion imports. The United Kingdom, the other major source of bullion, accounted for 6% of total imports.

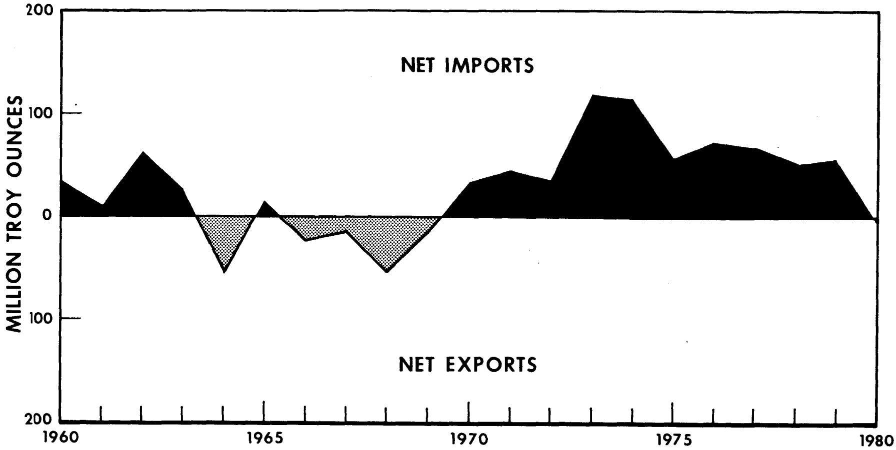

Figure 3.—Net exports or imports of silver, 1960-80.

WORLD REVIEW

World mine production of silver in 1980, including centrally planned economy countries, decreased slightly. Canada, Mexico, Peru, and the United States, accounted for 47% of world output; the U.S.S.R., 13%; Australia, 7%; and Poland, 7%. The remainder came from numerous other countries. Strikes at mining facilities in some countries, notably Canada, Peru, and the United States, held world output below the level expected from recent expansions in capacity.

World consumption of silver in 1980 for industrial and coinage uses, exclusive of centrally planned economy countries, totaled 355.9 million ounces compared with 447.6 million ounces in 1979.[11] A 19% decrease in industrial use, which accounted for 96% of total use in 1980, was accompanied by a 44% decrease in the use of silver in coinage. Total consumption by market economy countries exceeded newly mined supply by 101 million ounces, according to Handy & Harman estimates. Secondary production totaled 121.5 million ounces; outflow from Indian stocks, 41.7 million ounces; demonetized coin, 55.0 million ounces; and U.S. and foreign Government stock withdrawals, 5.3 million ounces. Privately held bullion stocks increased by 122.6 million ounces, according to Handy & Harman.

Australia.—The Woodlawn Mine in New South Wales commenced operating late in 1979, but resolution of metallurgical problems was not expected to be achieved until sometime in 1981. The open pit mine is expected to produce about 0.9 million ounces of silver per year, in addition to large tonnages of copper, lead, and zinc, for about 10 years. The mine is operated as a joint venture between Phelps Dodge Corp. and subsidiaries of St. Joe Minerals Corp. and Conzinc Riotinto of Australia, Ltd., with each having an equal interest. M.I.M. Holdings Ltd., reported silver production from the Mount Isa Mine for the fiscal year ending June 30, 1980, at 14.7 million ounces.[12] Silver reserves at the Elura lead-zinc-silver deposit of EZ Industries, Ltd., totaled 27 million tons, averaging 4.5 ounces of silver per ton.[13] Construction of the mine commenced in June 1980, and it is expected to be operational at the end of 1982, with annual production to exceed 4.5 million ounces of silver per year.

Canada.—Mine production of silver decreased because of strikes at mines. Production of silver at the Kidd Creek Mine of Texasgulf Canada Ltd. totaled about 8.6 million ounces in concentrate, about 23% above the total of 1979.[14] At yearend, the mine contained a 205-million-ounce silver reserve above the 5,000 foot level; ore reserves below the 5,000 foot level had not been delineated. Exploration continued to find ore, so that the ultimate depth or lateral extension of the deposit had not been determined at yearend.

Mine production of silver in 1980 by United Keno Hill Mines, Ltd., fell 33% to 1.7 million ounces as a result of a strike during the fourth quarter of the year.[15] Ore reserves of the Elsa Mining Div. increased from 330,636 tons, averaging 29.1 ounces of silver per ton, to 480,394 tons, averaging 24.7 ounces per ton. The company made plans to construct a precious-metal refinery to process precipitates from the cyanide plant. Silver production at the Sturgeon Lake Mine of Corp. Falconbridge Copper, was 1.3 million ounces, a 22% decrease from production of 1979.[16] Mining operations at the mine were terminated at the end of 1980.

Noranda Mines Ltd. reported silver production from the No. 12 and No. 6 Mines of Brunswick Mining & Smelting Corp., Ltd., totaled 3.5 million ounces in 1980 compared with 5.3 million ounces in 1979.[17] Proven reserves at both mines at yearend totaled about 67 million tons, containing 186 million ounces of silver. Noranda Mines Ltd. has a 64.1% interest in Brunswick Mining. Noranda's Geco Div. reported production of 1.7 million ounces of silver in 1980 from an ore reserve which contained 30.5 million ounces at the end of the year. Production of silver by Mattabi Mines Ltd. totaled 1.9 million ounces in 1980. Ore reserves of the mine totaled 13.1 million ounces at yearend. Noranda Mines Ltd. has an operating interest in this mine.

Placer Development, Ltd., with a 70% interest in Equity Mining Corp.'s Sam Goosley silver-gold-copper property located at Houston, British Columbia, completed construction of the mine, except for the leach plant, in 1980.[18] The property was estimated to contain 27 million tons of ore containing 3.4 ounces of silver per ton. Production was planned at 5.7 million ounces of silver per year. Placer Development is responsible for financing, constructing, and operating the mining and processing facilities.

Chile.—St. Joe Minerals Corp. began developing the El Indio gold-silver-copper deposit in northeastern Chile, which has a proven reserve of 2.2 million tons of ore averaging 4.4 ounces of silver per ton.[19] The mine is expected to begin operating in the third quarter of 1981 and reportedly will produce 1.5 million ounces of silver per year.

Honduras.—Production of silver in 1980 at the El Mochito Mine of Rosario Resources Corp., a subsidiary of AMAX Inc., totaled 1.7 million ounces.[20] Ore reserves at yearend totaled 7.9 million tons, containing 31.6 million ounces of silver in addition to gold, lead, zinc, and copper. Rate of ore production is being increased from 1,100 to 2,500 tons per day by 1983.

Mexico.—Mine production of silver was well below production expected to result from the extensive expansion of silver mines and plants of recent years. Production had been expected to increase to about 60 million ounces by the end of 1979.

Silver and other mining operations in Mexico were covered extensively in trade publications in 1980.[21] Minera Real de Angeles S.A. de C.V. began construction of a silver-lead-zinc open pit mine early in 1980, with completion scheduled early in 1982. Silver production is expected to total 7 million ounces per year from an ore reserve containing 141 million ounces of silver. Industrial Minera Mexico S.A. de C.V. (IMMSA) began expanding capacity at its San Martin Mine to about 7,500 tons per day, which will increase its production of silver to over 7 million ounces per year. The expansion program will be completed early in 1982. IMMSA also began increasing the silver production capacity at its Santa Barbara Unit to about 6.5 million ounces by the middle of 1981 and to approximately 9 million ounces at some later date. Reserves at the mine totaled about 122 million ounces at yearend 1980. Cia. Minera Fresnillo S.A.'s program to raise capacity at its Naica Mine to 3,300 tons per day will be completed in 1983. Reserves at the mine totaled more than 5 million tons, averaging about 5 ounces of silver per ton, and the expansion program will bring annual silver production up to 3.5 million ounces. Industrias Peñoles S.A. de C.V. began modernizing its precious-metal and base-metal refinery-smelter complex at Torreon, Coahuila. In addition to processing ore and concentrates from Peñoles subsidiaries, the metallurgical complex processes similar material from over 300 shippers. Annual production of silver in recent years at the complex has averaged about 33.5 million ounces.

Peru.—Southern Peru Copper Corp. reported that silver production from its Toquepala and Cuajone copper mines totaled 2.4 million ounces in 1980.[22] Cia. Minera del Madrigal continued to explore promising areas around its Madrigal Mine, a silver base-metal producer north of Arequipa in the Western Andes Cordillera.[23] The mine produces 1,300 tons per day of ore averaging 2.2 ounces of silver per ton.

South Africa, Republic of.—Black Mountain Mineral Development Co., Ltd., continued to develop the Black Mountain Mine ore body, one of the three large contiguous lead, zinc, copper, and silver deposits located near Aggeneys, northwestern Cape Province.[24] In the aggregate, the three deposits contain about 600 million ounces of silver. The property came onstream early in 1980 and produced 4.4 million ounces of silver during the year. Gold Fields of South Africa, Ltd., the manager of the project, owns a 51% interest, and Phelps Dodge Corp. of the United States owns 49%.

TECHNOLOGY

Research scientists at the Bureau of Mines, Avondale (Md.) Research Center, conducted studies to recover silver from aircraft scrap.[25] Silver-brazed honeycomb panels located on the surface of obsolete B-58 bombers were detached, shredded, and subjected to electrolytic treatment in a specially designed cell. Silver recovery averaged 95% in a single refining step that produced silver of 99.3% purity. A report was published on an optical ore-sorting system tested at the Black Pine Mine, Philipsburg, Mont.[26] The system processed 500 tons of silver ore per day, with a 93% overall silver recovery. Attempts to lower or eliminate silver in photography continued in 1980.[27] The main emphasis of the research was on graphic art film, X-ray film, microfilm, and amateur film.

An industry report stated that silver-silicon photovoltaic cells were used to capture the sun's rays to operate water pumps, two-way radios, and other electrical devices in remote areas.[28] The report is published monthly and covers a wide range of applications both decorative and utilitarian.

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[2]Ounce as used throughout this chapter refers to the troy ounce.
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[5]Homestake Mining Co. 1980 Annual Report. 32 pp.
[6]Earth Resources Co. 1980 Annual Report. 29 pp.
[7]Day Mines Inc. 1980 Annual Report. 21 pp.
[8]Phelps Dodge Corp. 1980 Annual Report. 40 pp.
[9]Inspiration Consolidated Copper Co. 1980 Annual Report. 28 pp.
[10]Refinement International Co. 1980 Annual Report. 32 pp.
[11]Handy & Harman. The Silver Market, 1980. 65th Annual Report. 32 pp.
[12]M.I.M. Holdings Ltd. 1980 Annual Report. 48 pp.
[13]EZ Industries, Ltd. 1980 Annual Report. 32 pp.
[14]Texasgulf Inc. 1980 Annual Report. 57 pp.
[15]United Keno Hill Mines, Ltd. 1980 Annual Report. 24 pp.
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[22]Work cited in footnote 8.
[23]Work cited in footnote 21.
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[27]Chemical Week. They're Taking Silver Out of the Picture. V. 126, No. 8, Feb. 20, 1980, p. 50.
[28]The Silver Institute. Silver Helps Bring Solar Energy to Remote Areas of the World. V. 10, No. 7, July-August 1980, 4 pp.

Table 2.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1979	1980
January	3,268	3,170
February	3,070	3,261
March	3,327	3,178
April	3,244	3,232
May	3,358	2,913
June	3,256	3,065
July	3,214	1,931
August	r3,500	1,687
September	r2,912	1,721
October	r3,072	2,010
November	r2,903	2,077
December	r2,963	3,082
Total	r38,087	31,327

rRevised.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1980, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Galena	Shoshone, Idaho	ASARCO Incorporated	Silver ore.
2	Lucky Friday	do	Hecla Mining Co	Do.
3	Coeur	do	ASARCO Incorporated	Do.
4	Utah Copper	Salt Lake, Utah	Kennecott Corp	Copper ore.
5	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
6	DeLamar	Owyhee, Idaho	Earth Resources Co	Gold-silver ore.
7	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
8	Sierrita	Pima, Ariz	Duval Corp	Copper ore.
9	Buick	Iron, Mo	Amax Lead Co. of Missouri	Lead ore.
10	Twin Buttes	Pima, Ariz	Anamax Mining Co	Copper ore.
11	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
12	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
13	Bunker Hill	do	The Bunker Hill Co	Lead-zinc ore.
14	Sherman Tunnel	Lake, Colo	Day Mines, Inc	Silver ore.
15	Crescent	Shoshone, Idaho	The Bunker Hill Co	Do.
16	Star Unit	do	Helca Mining Co	Lead-zinc ore.
17	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
18	Bagdad	Yavapai, Ariz	Cyprus Bagdad Copper Co	Do.
19	Gooseberry	Storey, Nev	West Coast Oil & Gas Corp	Gold ore.
20	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
21	San Manuel	do	do	Do.
22	Eisenhower	Pima, Ariz	Eisenhower Mining Co	Do.
23	Leadville Unit	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
24	Trixie	Utah, Utah	Kennecott Corp	Gold-silver ore.
25	Magmont	Iron, Mo	Cominco American, Inc	Lead ore.

Table 4.—Silver produced in the United States in 1980, by State, type of mine, and class of ore yielding silver, in terms of recoverable metal

State	Placer (troy ounces of silver)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	374	1,912	156	23	756	--	--
Arizona	--	50,000	500	--	--	W	W
California	93	6,849	9,811	1,789	14,464	--	--
Colorado	--	W	W	20	199	226,039	2,440,142
Idaho	--	24	35	W	W	770,721	10,538,445
Missouri	--	--	--	--	--	--	--
Montana	--	W	W	W	W	55,430	295,490
Nevada	--	3,085,793	562,721	--	--	11,575	13,282
New York	--	--	--	--	--	--	--
Oregon	--	941	841	--	--	--	--
South Dakota	--	1,786,521	51,257	--	--	--	--
Other[1]	--	578,705	124,464	870,187	1,938,455	5,726	26,398
Total	467	5,510,745	749,785	872,019	1,953,874	1,069,491	13,313,757
Percent of total silver	([2])	XX	2	XX	6	XX	42

State	Lode					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	--	--	187	7,068	--	--
Arizona	150,269,129	5,640,703	1,944	1,485	--	--
California	--	--	W	W	--	--
Colorado	--	--	43,892	97,071	--	--
Idaho	W	W	1,810	21,243	407	254
Missouri	--	--	10,021,725	2,357,236	--	--
Montana	9,058,125	1,612,034	10,075	13,977	--	--
Nevada	W	W	W	W	--	--
New York	--	--	--	--	370,295	20,702
Oregon	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Other[1]	60,285,774	3,265,811	1,353	36,748	--	--
Total	219,613,028	10,518,548	10,080,986	2,534,828	370,702	20,956
Percent of total silver	XX	34	XX	8	XX	([2])

See footnotes at end of table.

Table 4.—Silver produced in the United States in 1980, by State, type of mine, and class of ore yielding silver, in terms of recoverable metal-Continued

State	Lode					
	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total[3]	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	--	--	--	--	2,122	8,354
Arizona	--	--	W	W	150,338,948	5,667,815
California	--	--	W	W	8,655	49,257
Colorado	W	W	5,414	18,023	603,932	2,987,058
Idaho	W	W	--	--	2,423,492	13,694,902
Missouri	--	--	--	--	10,021,725	2,357,236
Montana	--	--	--	--	9,648,374	2,023,893
Nevada	--	--	19,800	5,409	3,256,539	670,635
New York	--	--	--	--	370,295	20,702
Oregon	--	--	--	--	941	841
South Dakota	--	--	--	--	1,786,521	51,257
Other[1]	3,256,562	2,112,419	42,409	[4]98,731	62,379,612	3,794,847
Total	3,256,562	2,112,419	67,623	122,163	240,841,156	31,326,797
Percent of total silver	XX	7	XX	([2])	XX	100

W Withheld to avoid disclosing company proprietary data; included in "Other." XX Not applicable.
[1]Includes Illinois, Michigan, New Mexico, Tennessee, Utah, Washington, and States indicated by symbol W.
[2]Less than 1/2 unit.
[3]Data may not add to State totals because of items withheld to avoid disclosing company proprietary data.
[4]Includes byproduct silver recovered from tungsten ore in California and fluorspar in Illinois.

Table 5.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1976	1977	1978	1979	1980
Alaska	3,265	1,725	2,052	W	8,354
Arizona	7,615,112	6,828,145	6,637,838	7,478,942	5,667,815
California	57,265	57,891	58,014	64,185	49,257
Colorado	4,083,171	4,663,496	4,217,181	2,808,934	2,987,058
Idaho	11,561,421	15,291,964	18,379,417	17,144,209	13,694,902
Michigan	310,837	335,479	W	W	W
Missouri	2,277,013	2,362,752	2,056,053	2,201,112	2,357,236
Montana	3,278,629	3,367,442	2,918,317	3,301,928	2,023,893
Nevada	783,892	738,402	803,887	[r]560,435	670,635
New Mexico	891,932	918,155	894,833	W	W
New York	49,199	56,353	20,911	10,538	20,702
Oregon	--	7,134	1,714	1,572	841
South Dakota	58,117	68,717	53,099	57,973	51,257
Tennessee	77,890	60,246	W	W	W
Utah	3,134,021	3,283,323	2,885,065	2,454,136	2,087,351
Washington	W	120,582	W	W	W
Other	146,466	3,897	456,989	[r]2,003,102	1,707,496
Total	34,328,230	38,165,703	39,385,370	[r]38,087,066	31,326,797

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1980, by State and method of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc. treated[1 2] (thousand short tons)	Ore and old tailings to mills: Thousand short tons[1 2]	Recoverable in bullion: Amalgamation (troy ounces)	Recoverable in bullion: Cyanidation (troy ounces)	Concentrates smelted and recoverable metal: Concentrates (short tons)	Concentrates smelted and recoverable metal: Troy ounces	Crude ore, old tailings, etc., to smelters[1]: Thousand short tons	Crude ore, old tailings, etc., to smelters[1]: Troy ounces
Alaska	2	2	70	70	--	--	(3)	7,840
Arizona	[4]170,081	[4]169,618	--	500	2,759,846	5,636,733	463	30,582
California	9	9	163	--	2,153	48,692	(3)	309
Colorado	605	591	1,269	161,644	51,905	2,591,003	15	233,142
Idaho	2,423	2,421	--	1,547,146	132,284	12,121,844	2	25,912
Missouri	10,022	10,022	--	--	907,885	2,357,236	--	--
Montana	[4]9,657	[4]9,597	--	39,556	160,880	1,643,058	59	341,279
Nevada	[4 5]7,257	[4 5]7,257	--	568,274	8,980	102,260	(3)	101
New York	435	435	--	--	69,015	20,702	--	--
Oregon	1	--	--	--	--	--	1	841
South Dakota	1,787	1,787	--	51,257	--	--	--	--
Utah	32,360	32,222	--	--	640,315	1,718,051	137	369,300
Other[6]	35,640	35,573	--	--	1,319,335	1,670,986	67	36,510
Total	270,279	269,534	1,502	2,368,447	6,052,598	27,910,565	[7]745	1,045,816

[1]Includes some non-silver-bearing ore not separable.
[2]Excludes tonnages of fluorspar and tungsten ores from which silver was recovered as a byproduct.
[3]Less than 1/2 unit.
[4]Includes ore from which silver was recovered by heap leaching.
[5]Includes ore from which silver was recovered by vat leaching.
[6]Includes Illinois, Michigan, New Mexico, Tennessee, and Washington.
[7]Data do not add to total shown because of independent rounding.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces): Amalgamation	Bullion and precipitates recoverable (troy ounces): Cyanidation	Silver recoverable from all sources (percent): Amalgamation	Cyanidation	Smelting[1]	Placers
1976	1,862	407,375	(2)	1.19	98.80	0.01
1977	16,720	1,308,209	0.04	3.43	96.52	.01
1978	654	2,600,357	(2)	6.60	93.39	.01
1979	170	[r]2,374,767	(2)	[r]6.24	[r]93.76	(2)
1980	1,502	2,368,447	.01	7.56	92.43	(2)

[r]Revised.
[1]Crude ores and concentrates.
[2]Less than 0.005%.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

Source	1979	1980
Concentrates and ores:		
Domestic	38,982	36,171
Foreign	11,779	3,182
Total	50,761	39,353
Old scrap:		
Coins	3,909	12,089
Other	[r]35,820	41,043
Total[1]	[r]39,729	53,131
Total net production	[r]90,490	92,484
New scrap	[r]36,714	65,642
Grand total[1]	[r]127,204	158,127

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

Final use[1]	1979	1980
Electroplated ware	8,065	4,350
Sterlingware	13,088	9,082
Jewelry	5,358	5,893
Photographic materials	65,978	49,825
Dental and medical supplies	2,295	2,212
Mirrors	1,850	672
Brazing alloys and solders	10,912	8,508
Electrical and electronic products:		
Batteries	4,583	5,976
Contacts and conductors	33,506	27,796
Bearings	332	649
Catalysts	5,637	3,035
Coins, medallions, commemorative objects	4,676	4,693
Miscellaneous[2]	978	2,005
Total net industrial consumption	157,258	[3]124,694
Coinage	168	72
Total consumption	157,426	[3]124,766

[1]End use as reported by converters of refined silver.
[2]Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paints, etc.
[3]Data do not add to total shown because of independent rounding.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1978	119,125	389,016
1979	471,162	961,761
1980	1,909,733	1,606,010

Table 11.—U.S. exports of silver in 1980, by country

Destination	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion		Total[1]	
	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)
Argentina	--	--	--	--	--	--	116	$1,624	116	$1,624
Belgium-Luxembourg	6	$192	7,553	$187,979	1,604	$35,279	41	1,427	9,204	224,877
Canada	178	3,084	3,148	64,284	260	4,432	5,022	83,598	8,608	155,398
France	([2])	6	1,075	24,300	--	--	609	19,618	1,684	43,923
Germany, Federal Republic of	4	96	2,127	72,357	90	2,180	3,361	81,854	5,583	156,487
Italy	--	--	76	2,336	--	--	236	4,708	311	7,044
Japan	41	361	147	2,419	169	4,628	4,209	82,570	4,566	89,979
Netherlands	--	--	42	1,232	--	--	2,432	40,100	2,474	41,332
Panama	--	--	66	2,874	--	--	1	21	67	2,895
Spain	--	--	1,688	37,866	--	--	--	--	1,688	37,866
Sweden	--	--	81	1,422	--	--	--	--	81	1,422
Switzerland	7	177	747	22,486	3	100	15,086	514,329	15,843	537,092
United Kingdom	66	1,986	4,317	106,826	124	3,399	26,026	495,824	30,533	608,035
Uruguay	--	--	--	--	--	--	31	500	31	500
Other	4	23	8	195	13	334	36	707	61	1,258
Total[1]	307	5,925	21,074	526,577	2,264	50,353	57,206	1,326,878	80,851	1,909,733

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 12.—U.S. imports for consumption of silver in 1980, by country

Country	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion		Total[1]	
	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)	Thousand troy ounces	Value (thousands)
Argentina	47	$941	(2)	$2	--	--	171	$3,225	218	$4,168
Australia	97	3,651	1	8	(2)	$2	1	52	98	3,713
Belgium-Luxembourg	--	--	--	--	29	476	799	22,289	829	22,765
Brazil	74	1,775	--	--	--	--	53	937	126	2,711
Canada	511	8,394	1,360	24,823	199	5,234	29,012	621,544	31,083	659,996
Chile	170	2,938	64	1,032	598	9,633	585	9,305	1,418	22,908
Colombia	29	608	--	--	(2)	2	34	805	64	1,415
Dominican Republic	--	--	1	12	118	5,326	165	2,968	284	8,306
France	--	--	49	518	1	8	1,273	21,405	1,323	21,931
Germany, Federal Republic of	--	--	(2)	9	101	1,725	48	751	149	2,485
Honduras	659	16,283	--	--	--	--	--	--	659	16,283
Hong Kong	(2)	3	128	3,282	270	3,742	208	3,223	606	10,250
Italy	--	--	17	539	--	--	39	865	56	1,405
Japan	28	401	--	--	53	1,646	810	21,784	892	23,830
Korea, Republic of	--	--	--	--	243	4,488	375	5,827	618	10,315
Mexico	581	13,245	55	887	223	3,838	13,789	263,583	14,648	281,553
Netherlands	--	--	--	--	--	--	573	8,906	573	8,906
Panama	--	--	43	1,791	15	505	143	2,074	201	4,370
Paraguay	--	--	6	103	3	68	74	2,570	82	2,741
Peru	6,646	121,242	7	157	373	11,803	11,092	221,068	18,119	354,270
Poland	--	--	--	--	--	--	209	5,000	209	5,000
Singapore	--	--	68	837	(2)	6	8	144	76	986
Switzerland	--	--	1	16	5	67	384	10,465	390	10,547
United Kingdom	788	16,289	61	1,573	20	426	3,669	67,658	4,538	85,946
Yugoslavia	--	--	--	--	10	166	1,224	33,085	1,234	33,251
Other	70	1,250	94	1,978	17	385	122	2,344	303	5,957
Total[1]	9,700	187,019	1,956	37,567	2,281	49,547	64,859	1,331,877	78,795	1,606,010

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 13.—Silver: World production,[1] by country

(Thousand troy ounces)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada	41,199	42,236	40,733	36,874	[3]33,340
Costa Rica[e]	2	1	2	[e]2	2
Dominican Republic	[r]891	[r]1,852	1,848	1,248	1,600
El Salvador	166	112	185	152	155
Guatemala	NA	NA	10	10	10
Honduras	3,184	2,819	2,788	2,434	2,700
Mexico	42,640	47,030	50,779	49,310	[3]49,408
Nicaragua	208	[r]167	482	318	[3]164
United States	34,328	38,166	39,385	38,087	[3]31,327
South America:					
Argentina	2,250	2,451	2,042	2,193	2,200
Bolivia	[r]5,340	[r]5,813	6,285	5,742	[3]6,099
Brazil[4]	[r,e]264	372	506	[e]580	640
Chile	7,342	8,461	8,210	8,740	8,500
Colombia[5]	107	91	83	99	150
Ecuador	47	57	29	[e]44	45
Peru	35,579	39,088	37,045	43,415	47,900
Europe:					
Bulgaria[e]	900	840	900	920	930
Czechoslovakia[e]	1,190	1,192	1,300	1,300	1,300
Finland	773	813	1,133	1,028	1,000
France	2,806	3,004	2,754	2,429	2,500
German Democratic Republic[e]	1,600	1,600	1,600	1,550	1,600
Germany, Federal Republic of	1,026	1,061	799	1,042	1,000
Greece	1,845	1,070	1,360	1,752	1,800
Greenland	479	521	559	765	[3]547
Hungary[e]	32	39	39	[r]32	32
Ireland	925	936	631	1,054	1,200
Italy[5] [6]	1,593	1,222	890	1,065	[3]1,366
Poland[e]	17,800	20,708	21,900	22,600	23,100
Portugal	28	26	23	31	32
Romania[e]	1,220	1,125	1,030	[r]965	1,000
Spain	3,222	3,215	3,092	3,168	3,200
Sweden	4,617	5,438	5,144	5,649	5,000
U.S.S.R.[e] [5]	44,000	45,000	46,000	46,000	46,000
Yugoslavia[5]	4,631	4,679	5,123	5,214	4,790
Africa:					
Algeria[e]	80	40	75	100	80
Ghana	[e]20	[e]20	19	[e]20	20
Kenya	(7)	--	--	--	--
Mauritania	32	[e]26	19	--	--
Morocco	2,054	2,244	2,315	2,418	2,300
Namibia	1,400	1,684	1,399	1,606	1,610
South Africa, Republic of	2,821	3,130	3,104	3,236	5,500
Tanzania	(7)	--	--	--	--
Tunisia	257	236	281	231	[3]236
Zaire	2,472	2,730	4,391	3,892	4,000
Zambia	1,065	[e]1,450	1,069	914	[3]764
Zimbabwe	200	207	1,109	977	[3]949
Asia:					
Burma	211	355	377	340	425
China:					
Mainland[e]	1,000	1,000	1,500	2,000	2,500
Taiwan	100	68	75	85	[3]95
India[5]	102	425	388	370	[3]366
Indonesia	1,072	790	826	662	680
Japan	9,299	[r]9,604	9,664	8,680	8,930
Korea, North[e]	1,600	1,600	1,600	1,550	1,550
Korea, Republic of	[r]1,858	[r]2,106	1,385	2,278	[3]2,292
Malaysia (Sabah)	[e]300	[e]430	482	[e]450	400
Philippines	1,481	1,621	1,637	1,830	1,930
Turkey	[e]220	[e]220	219	250	200
Oceania:					
Australia	25,034	27,525	26,123	26,816	[3]24,714
Fiji	20	15	10	11	10
New Zealand	1	8	2	2	2
Papua New Guinea	1,451	[r]1,523	1,680	1,428	1,180
Total	[r]316,384	[r]340,262	344,438	345,958	341,370

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Recoverable content of ores and concentrates produced unless otherwise noted. Table includes data available through June 3, 1981.

[2]In addition to the countries listed, Austria and Thailand may produce silver, but information is inadequate to make reliable estimates of output levels.

[3]Reported figure.

[4]Officially reported output, including that obtained from treatment of gold as follows in troy ounces: 1976—20,126; 1977—14,339; 1978—21,348; 1979—14,725; 1980—not available; and that recovered from treatment of lead as follows in troy ounces: 1976—243,381; 1977—358,002; 1978—484,157; 1978—565,000 (estimated); 1980—not available.

[5]Smelter and/or refinery production.

[6]Includes production from imported ores.

[7]Less than 1/2 unit.

Slag—Iron and Steel

By Richard H. Singleton[1]

Combined sales and use of iron and steel slag in 1980 decreased 30% to 25.2 million tons[2] and decreased 16% in value to $92.5 million. The decrease in consumption was greater than that for crushed stone, its major competition, and the decrease was caused primarily by a decrease in supply created by the depressed condition of the steel industry. Pennsylvania, Ohio, Indiana, and Michigan, in order of tonnage, supplied 62% of the total U.S. slag. Approximately three-quarters of the Nation's iron slag and more than 90% of its steel slag was used in road and railroad construction and in fill. About 15% of iron slag production was used as aggregate in cement concrete and concrete products. Iron slags comprised 76% of total U.S. slag tonnage and comprised 82% of total value. Of this iron slag, expanded slag comprised 6% of the tonnage and 11% of the value, and granulated slag comprised 4% of both tonnage and value. Average unit values for iron and steel slags increased by 20% and 18% to $4.01 per ton and $2.64 per ton, respectively. Average unit values for expanded and granulated iron slag increased by 6% and 7% to $6.94 per ton and $3.81 per ton, respectively. Interest increased in the use of iron slag as an admixture to portland cement, and construction of a slag cement plant in Maryland was scheduled for completion in 1982.

DOMESTIC PRODUCTION

Iron slags sold or used in 1980 decreased 31% in tonnage to 19.0 million tons and decreased 17% in value to $76.3 million. The principal cause of this decline was the depressed condition of the steel industry. Iron slag was processed at 49 U.S. locations. Of the total iron slag, 90% was air cooled, or essentially unprocessed, 6% was expanded, and the remainder was granulated. Pennsylvania, Ohio, and Indiana, in that order, were the leading States, producing 55% of total U.S. air-cooled iron slag.

The only iron slag banks waiting to be tapped were in Pittsburgh, Pa., and Youngstown, Ohio. Slag continued to be in short supply due to reduced steel mill operations and closure of additional blast furnaces, although some new or enlarged capacities went onstream or were under construction. Water-granulated slag was imported from Japan to the west coast for sale to local cement producers.

Steel slags sold or used in 1980 decreased 25% in tonnage to 6.2 million tons and decreased 12% in value to $16.3 million. Steel slag was processed at 39 operations. Ohio, Michigan, Pennsylvania, and California, in that order, were the leading States producing 71% of the U.S. total.

An undetermined tonnage of steel slag banks exists. Before it can be utilized, some steel slag requires a natural aging process to minimize expansion during end use, caused by the hydration of free lime contained in the slag.

The major method of transportation continued to be by truck (83%), followed by rail (12%), and water (3%).

CONSUMPTION AND USES

The major uses for domestic slags continued to be in the construction industry, especially in roadbuilding and also as aggregate for cement concrete. Domestic slag was competitive with crushed stone, chiefly, and sand and gravel. Approximately three-quarters of domestic iron slag and more than 90% of steel slag was used in road and railroad construction and fill. Approximately 15% of iron slag production was used as aggregate in cement concrete and concrete products.

End uses for air-cooled iron slag in 1980 were 78% in road and railroad construction and fill, 11% as aggregate in concrete and concrete products, and 4% in mineral wool production. Consumption was down in all end-use categories.

Domestic sales of expanded iron slag decreased 30% to 1.16 million tons, valued at $8.0 million in 1980. The major end use (78%) was aggregate in cement concrete, less than one-half of which was the lightweight type. Production of lightweight aggregate for concrete decreased by 60%.

Domestic sales of granulated iron slag decreased by 10% to 772,000 tons, valued at $2.9 million. Of this, 83% was used as roadbase material. Granulated slag has natural cementing qualities imparting to it the ability, on damp compaction, to slowly set into a hard, dense mass which minimizes settlement of pavements.

Atlantic Cement Co., Inc., scheduled construction of a slag cement plant at Bethlehem Steel Corp's. complex at Sparrows Point, Md. The plant was expected to consume annually about 800,000 tons of water-granulated blast-furnace iron slag. The process was claimed to use six times less energy than the process required to manufacture portland cement. Although the comminuted product has good bonding characteristics, it was to be blended with portland cement in its end use. Plant construction was scheduled to begin in August 1981, and end at midyear 1982. Use of slag in this application appears to be more profitable than its use as aggregate.

Sales of steel slags decreased in every end-use category, except that use for railroad ballast increased 22% to 640,000 tons, valued at $2.0 million.

Table 1.—Iron and steel slags sold or used in the United States, by type[1]

(Thousand short tons and thousand dollars)

Year	Iron blast-furnace slag								Steel slag		Total slag[2]	
	Air-cooled		Granulated		Expanded		Total iron slag[2]					
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1971	21,444	42,352	1,787	2,445	1,581	4,887	24,812	49,684	8,488	9,719	33,300	59,403
1972	21,878	44,787	1,657	3,059	1,518	5,529	25,053	53,375	10,162	11,023	35,215	64,398
1973	24,971	52,249	1,999	3,667	1,852	6,936	28,822	62,852	9,739	10,765	38,561	73,617
1974	26,226	57,227	2,081	4,442	1,573	6,461	29,880	68,130	8,862	11,195	38,742	79,325
1975	22,242	53,386	1,780	4,335	1,302	5,934	25,324	63,655	7,302	8,965	32,626	72,620
1976	22,899	59,813	1,618	3,529	1,492	6,610	26,009	69,952	6,588	9,728	32,597	79,680
1977	22,753	61,270	1,488	3,579	1,475	6,414	25,716	71,262	6,668	10,850	32,384	82,112
1978	25,119	73,148	1,372	3,608	1,914	9,641	28,404	86,398	8,457	14,510	36,861	100,908
1979	25,009	78,415	855	3,037	1,648	10,794	27,512	92,246	8,252	18,476	35,764	110,722
1980	17,113	65,313	772	2,938	1,156	8,028	19,041	76,279	6,158	16,270	25,199	92,549

[1]Value based on selling price at plant.
[2]Data may not add to totals shown because of independent rounding.

Source: National Slag Association (1971-76).

Table 2.—Iron blast-furnace slags sold or used in the United States, by region and State[1]

(Thousand short tons and thousand dollars)

Region and State	1979				1980			
	Air-cooled, screened and unscreened		Total all types		Air-cooled, screened and unscreened		Total all types	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North Central:								
Illinois, Indiana, Michigan	7,278	16,152	W	W	3,519	10,245	W	W
Ohio	4,448	17,580	W	W	3,210	14,740	W	W
Total	11,726	33,732	13,239	41,567	6,729	24,985	7,590	29,678
Middle Atlantic:								
Pennsylvania	5,518	20,424	W	W	4,299	17,885	W	W
Maryland, New York, West Virginia	2,746	7,599	W	W	1,603	4,996	W	W
Total	8,264	28,023	9,243	34,000	5,902	22,881	6,968	29,154
West:								
Colorado, Texas, Utah	2,494	7,369	W	W	2,446	8,751	2,446	8,751
South:								
Alabama and Kentucky	1,861	7,809	W	W	1,509	7,298	1,509	7,298
Pacific:								
California	663	1,482	663	1,482	528	1,398	528	1,398
U.S. total[2]	25,009	78,415	27,512	92,246	17,113	65,313	19,041	76,279

W Withheld to avoid disclosing company proprietary data; included in U.S. total.
[1]Value based on selling price at plant.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Locations and processing methods of iron slag and sources of steel slag

State and City	Company	Processing method of iron slag: Air-cooled	Processing method of iron slag: Expanded	Processing method of iron slag: Granulated	Steel slag	Sources of steel slag: Open hearth	Sources of steel slag: Basic oxygen process	Sources of steel slag: Electric
Alabama:								
Alabama City	Vulcan Materials Co	1	--	--	1	--	1	--
Ensley	do	1	--	--	--	--	--	--
Fairfield	do	1	--	--	1	--	1	--
Birmingham	U.S. Pipe and Foundry Co	1	--	--	--	--	--	--
Total		4	--	--	2	--	2	--
California: Fontana	Heckett Co	1	--	--	1	--	1	--
Colorado: Pueblo	Fountain Sand and Gravel Co	1	--	--	1	--	1	1
Delaware: Claymont	International Mill Service	--	--	--	1	--	--	1
Georgia: Atlanta	do	--	--	--	1	--	--	1
Illinois:								
Altona	do	--	--	--	1	--	--	1
Chicago	Illinois Slag & Ballast Co	1	--	--	1	--	1	--
Granite City	International Mill Service	--	--	--	1	--	1	--
Do	St. Louis Slag Products, Co., Inc	1	--	--	--	--	--	--
Peoria	International Mill Service	--	--	--	1	--	--	1
Total		2	--	--	4	--	2	2
Indiana:								
Burns Harbor	The Levy Co	1	1	--	1	--	1	--
Gary	United States Steel Corp	1	1	--	--	--	--	--
East Chicago	Vulcan Materials Co	1	--	--	--	--	--	--
Total		3	2	--	1	--	1	--
Kentucky: Ashland	Standard Slag Co	1	--	--	--	--	--	--
Maryland: Baltimore	Maryland Slag Co	1	1	--	--	--	--	--
Michigan: Detroit	E. C. Levy Co	1	1	1	1	--	1	1

Table 3.—Locations and processing methods of iron slag and sources of steel slag —Continued

State and City	Company	Processing method of iron slag			Steel slag	Sources of steel slag		
		Air-cooled	Expanded	Granu-lated		Open hearth	Basic oxygen process	Electric
Michigan —Continued								
Ecorse	E. C. Levy Co	--	--	--	1	--	1	1
Trenton	do	1	--	--	1	--	1	--
Total		2	1	1	3	--	3	2
Minnesota: Newport	International Mill Service	--	--	--	1	--	--	1
New York: Buffalo	Buffalo Slag Co	1	1	--	--	--	--	--
Ohio:								
Canton	Heckett Co	--	--	--	1	--	--	1
Cleveland	Stein, Inc	--	--	--	1	--	1	1
Do	Standard Slag Co	1	--	--	1	1	--	--
Do	do	1	--	--	--	--	--	--
Hamilton	American Materials Corp	1	--	--	--	--	--	--
Lorain	Spang and Co	--	--	--	1	--	1	--
Do	United States Steel Corp	1	--	--	1	--	1	--
Lordstown	Standard Slag Co	--	--	1	--	--	--	--
Mansfield	International Mill Service	--	--	--	1	1	--	--
McDonald	United States Steel Corp	1	--	--	1	1	--	--
Middletown	American Materials Corp	1	--	--	--	--	--	--
Do	McGraw Construction Co	--	--	--	1	1	1	--
Mingo Junction	International Mill Service	--	--	--	1	1	--	--
Do	Standard Slag Co	1	--	--	--	--	--	--
New Boston	do	1	--	--	--	--	--	--
Warren	Heckett Co	--	--	--	1	--	--	1
Do	Standard Slag Co	1	--	--	--	--	--	--
Youngstown	do	1	--	--	--	--	--	--
Total		10	1	1	10	5	4	3
Oklahoma: Sand Springs	International Mill Service	--	--	--	1	--	--	1
Pennsylvania:								
Belle Vernon	Duquesne Slag Products Co	1	--	--	--	--	--	--

Bethlehem	Bethlehem Mines Corp	1	--	--	--	--	--	--
Do	Sheridan Slag Co	--	1	--	--	--	--	--
Birdsboro	Birdsboro Slag Products	1	--	--	--	--	--	--
Burgettstown	Duquesne Slag Products Co	--	--	1	--	--	--	--
Butler	Spang and Co	--	--	--	1	--	--	1
Coatesville	International Mill Service	--	--	--	1	--	--	1
Dunbar	Vanderbilt Slag Co	--	--	1	--	--	--	--
Lebanon	Sheridan Slag Corp	1	--	--	--	--	--	--
McKees Rocks	Phillips Contracting	--	--	1	--	--	--	--
Midland	International Mill Service	1	--	--	1	1	--	1
Morrisville	Warner Co	1	1	--	--	--	--	--
Park Hill	Standard Slag Co	1	--	--	--	--	--	--
Penn Hills	United States Steel Corp	--	--	--	1	1	--	--
Phoenixville	International Mill Service	--	--	--	1	1	--	--
Pittsburgh	Duquesne Slag Products Co	1	--	--	--	--	--	--
Pricedale	do	--	--	1	--	--	--	--
Riddlesburg	New Enterprise Stone & Lime Co., Inc	1	--	--	--	--	--	--
Steelton	Hempt Bros	1	--	--	--	--	--	--
West Aliquippa	Duquesne Slag Products Co	1	--	--	--	--	--	--
West Mifflin	do	1	--	--	1	1	1	--
Wheatland	Dunbar Slag Co	1	--	--	1	--	1	--
Total		13	2	4	7	4	2	3
South Carolina:								
Darlington	R. B. Ponds Construction Co	--	--	--	1	--	--	1
Texas:								
Beaumont	International Mill Service	--	--	--	1	--	--	1
Houston	Houston Slag Materials Co	1	--	--	1	--	--	1
Lone Star	Gifford-Hill Co	1	--	--	--	--	--	--
Midlothian	International Mill Service	--	--	--	1	--	--	1
Total		2	--	--	4	--	--	4
Utah: Provo	United States Steel Corp	1	--	--	1	1	--	--
West Virginia:								
Weirton	International Mill Service	--	--	--	1	1	--	--
Do	Standard Slag Co	1	--	--	--	--	--	--
Total		1	--	--	2	2	--	--
Grand total		43	7	6	39	11	16	19

Table 4.—Shipments of iron and steel slag in the United States in 1980, by method of transportation

Method of transportation	Quantity (thousand short tons)	Percent of total
Truck	20,797	83
Rail	3,086	12
Waterway	682	3
Not transported (used at plant site)	634	2
Total	25,199	100

Table 5.—Air-cooled iron blast-furnace slag sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Concrete aggregate	2,367	8,199	1,516	6,743
Concrete products	421	1,676	390	1,601
Cement manufacture	W	W	1	5
Asphaltic concrete aggregate	3,421	12,365	2,928	12,587
Roadbase	8,452	25,435	5,881	22,582
Fill	3,861	9,512	2,362	6,813
Railroad ballast	2,505	6,591	2,151	7,415
Mineral wool	826	3,374	680	3,354
Roofing, built-up and shingles	247	1,324	234	1,311
Sewage treatment	W	W	59	180
Glass manufacture	21	W	W	W
Other[2]	2,889	9,939	911	2,724
Total[3]	25,009	78,415	17,113	65,313

W Withheld to avoid disclosing company proprietary data.
[1]Value based on selling price at plant.
[2]Includes airport runway base, drainage, ice control, soil conditioning, miscellaneous, and uses indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

Table 6.—Granulated and expanded iron blast-furnace slags sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1979				1980			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Lightweight concrete aggregate	83	W	931	6,388	--	--	369	3,420
Concrete products	--	--	607	3,865	--	--	527	3,203
Roadbase	637	W	--	--	644	2,149	--	--
Soil conditioning	25	W	--	--	--	--	--	--
Other[2]	109	3,037	110	541	128	789	260	1,405
Total	[3]855	3,037	1,648	10,794	772	2,938	1,156	8,028

W Withheld to avoid disclosing company proprietary data.
[1]Value based on selling price at plant.
[2]Includes airport runway base, drainage, fill, ice control, cement manufacture, miscellaneous, and uses indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 7.—Steel slag sold or used in the United States, by use[1 2]

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Asphaltic concrete aggregate	822	2,481	662	2,259
Roadbase	4,237	8,818	3,231	7,499
Fill	1,882	4,305	1,251	3,552
Railroad ballast	530	1,243	644	1,990
Fire protection	8	W	--	--
Other[3]	773	1,629	371	970
Total	8,252	18,476	[4]6,158	16,270

W Withheld to avoid disclosing company proprietary data.
[1]Excludes tonnage returned to furnace for charge material.
[2]Value based on selling price at plant.
[3]Includes ice control, miscellaneous, and uses indicated by symbol W.
[4]Data do not add to total shown because of independent rounding.

Table 8.—Value per ton at the plant for iron and steel slags sold or used in the United States, by type

Year	Iron blast-furnace slag: Air cooled	Granulated	Expanded	Total iron slag	Steel slag	Total slag
1971	$1.98	$1.37	$3.09	$2.00	$1.15	$1.78
1972	2.05	1.85	3.64	2.13	1.08	1.83
1973	2.09	1.83	3.75	2.18	1.11	1.91
1974	2.18	2.13	4.11	2.28	1.26	2.05
1975	2.40	2.44	4.56	2.51	1.23	2.23
1976	2.61	2.18	4.43	2.69	1.48	2.44
1977	2.69	2.41	4.35	2.77	1.63	2.54
1978	2.91	2.63	5.04	3.04	1.72	2.74
1979	3.14	3.55	6.55	3.35	2.24	3.10
1980	3.82	3.81	6.94	4.01	2.64	3.67

PRICES

Average 1980 unit values f.o.b. plant, based on actual sales, indicated a 22% increase to $3.82 per ton for air-cooled iron slag and a 6% and 7% increase for expanded and granulated iron slag to $6.94 per ton and $3.81 per ton, respectively. Similar prices for steel slags indicate an 18% increase to $2.64 per ton.

The high prices in table 9 for certain use categories were caused by specifications that require more than normal processing.

Table 9.—Average selling price and range of selling prices at the plant for iron and steel slags in the United States in 1980, by use

(Dollars per short ton)

Use	Iron blast-furnace slag						Steel slag	
	Air-cooled		Granulated		Expanded			
	Average	Range	Average	Range	Average	Range	Average	Range
Concrete aggregate	4.45	0.82-5.33	--	--	--	--	--	--
Lightweight concrete aggregate	--	--	--	--	9.27	0.20-6.49	--	--
Concrete products	4.11	1.14-4.77	--	--	6.08	4.93-8.10	--	--
Cement manufacture	4.36	4.36-4.36	7.49	7.49-7.49	6.11	3.50-5.20	--	--
Asphaltic concrete aggregate	4.30	2.28-6.00	--	--	--	--	3.41	1.70-8.25
Roadbase	3.84	1.48-5.74	3.34	3.13-3.40	--	--	2.32	.88-6.35
Fill	2.88	.23-7.10	6.13	2.10-7.70	5.04	2.75-6.24	2.84	.30-7.00
Railroad ballast	3.45	2.27-7.51	--	--	--	--	3.09	1.00-5.50
Mineral wool	4.93	2.27-9.56	--	--	--	--	--	--
Roofing, built-up and shingles	5.60	2.64-7.50	--	--	--	--	--	--
Sewage treatment	3.05	2.65-4.11	--	--	--	--	--	--
Glass manufacture	W	W	--	--	W	W	--	--
Other	2.99	1.57-7.61	--	--	--	--	2.61	1.78-7.75

W Withheld to avoid disclosing company proprietary data; included with "Other."

WORLD REVIEW

Data for production of slag in other countries were not available. Data pertaining to stockpiled resources also were not available. However, resources and consumption are known to be significant in developed countries such as Japan, the Federal Republic of Germany, France, and the United Kingdom where there is a large iron and steel industry. In particular, these countries used significant quantities of ground iron slag in admixtures with portland cement.

TECHNOLOGY

Engineering testing, mostly overseas, has indicated that ground water-granulated slag or ground pelletized slag can be blended in amounts 25% to 65% with portland cement to produce a Type IS cement with dependable concrete performance. The energy requirement to produce the slag component of this cement is 10% to 20% of that required to produce the portland cement component.

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[1]Supervisory physical scientist, Section of Nonmetallic Minerals.

[2]Short tons are used throughout, unless otherwise stated.

Sodium Compounds

By Dennis S. Kostick[1]

Production of natural and synthetic soda ash increased slightly in 1980, with the entire soda ash industry working at 86% of total nameplate capacity. Domestic apparent consumption was down slightly compared with that of the previous year, but exports reached a record high of over 1 million short tons. Natural sodium sulfate production increased 9% in 1980, and production of sodium sulfate from synthetic sources increased about 4%. The rise in demand for sodium sulfate, the largest increase since 1976, caused an increase in imports.

	Production (thousand short tons)		Value (thousand dollars)	
	1979	1980	1979	1980
Soda ash[1]	8,253	8,275	543,812	768,168
Natural sodium sulfate	533	583	29,689	33,389

[1]Natural and synthetic combined to avoid disclosure of company proprietary data.

DOMESTIC PRODUCTION

The total domestic production of soda ash in 1980 was 8,275,230 short tons. Beginning in 1979, production data from the one remaining Solvay plant were combined with natural soda ash statistics to avoid revealing company proprietary data.

Several soda ash companies announced plans for major or incremental expansions of nameplate capacity during 1980. Texasgulf Chemicals Co. intends to double existing capacity by bringing onstream an additional 1 million tons starting in April 1984, with full production slated for 1987. The $63 million expansion is pending until differences with the Wyoming Industrial Siting Council are resolved concerning the socioeconomic impact of the expansion on local communities and the effect on waterfowl of caustic solutions in the proposed new tailing pond.[2]

Stauffer Chemical Co. of Wyoming added an additional 300,000 tons of annual capacity in October 1980 by installing a new ventilation and production shaft and expanding the evaporator section in its soda ash refinery.[3]

By 1981-82, FMC Corp. plans to increase its existing soda ash capacity by 300,000 tons through debottlenecking. FMC obtained permits in 1980 to conduct solution mining tests on State-leased property from the Wyoming State Department of Environmental Quality.[4] The first injection and production wells will be drilled during the summer of 1981, with hydrofracking and solution recovery to occur soon after. If the tests are successful, FMC will bring onstream by the mid-1980's 1 million tons of additional nameplate capacity through the use of this method.

Vulcan Materials Co. also received permits to begin a solution mining pilot project in the same region. If the project is successful, Vulcan may construct a 1-million-ton-per-year soda ash processing plant.

In addition to FMC and Vulcan, Allied Chemical Corp. plans to solution mine trona on some recently acquired property in the southern part of the Green River Basin. No date has been announced for startup of the project.

Construction progressed on schedule of

Tenneco Oil Co.'s soda ash facility in Wyoming. The 1-million-ton-per-year plant is slated to begin production in the spring of 1982.

Kerr-McGee Chemical Corp. opened a soda ash terminal at Port Newark, N.J., during the third quarter of 1980. The terminal has a 50,000-ton storage capacity that is designed to provide a steady, dependable supply of soda ash to consumers located within a 200-mile radius of Port Newark, particularly during the winter when adverse weather and railcar shortages reportedly have hampered some shipments from Wyoming.[5]

Domestic production of sodium sulfate in 1980 was 1,258,809 short tons. Natural production accounted for 582,950 tons from five plants operated by three companies. The balance of production was from 19 plants recovering byproduct sodium sulfate.

Avtex Fibers, Inc., terminated production at the beginning of the year of its rayon staple plant at Nitro, W. Va. The plant closed because of the uncertain future of the export market and the increased level of imports of less expensive rayon. The facility had an annual sodium sulfate capacity of about 60,000 tons.[6]

In April, Church & Dwight Co. opened its new 70,000-ton-per-year-capacity sodium bicarbonate production facility at Old Fort, Ohio. As a result, the company allowed its contract with Allied at Syracuse, N.Y., to expire on June 30. Allied had been providing Church & Dwight with 96,000 tons of sodium bicarbonate annually. About the same time, BASF Wyandotte Corp. discontinued production of sodium bicarbonate, chlorine, and caustic soda at its Wyandotte, Mich., complex. Arrangements were made with Allied to assume the sales obligations of BASF. The loss of BASF's 71,000 tons of sodium bicarbonate capacity was offset in April when Stauffer Chemical Co. emerged with its 90,000-ton-per-year facility at Chicago Heights, Ill.[7]

Product and company	Plant location	Source of sodium
Soda ash:		
Kerr-McGee Chemical Corp	Trona, Calif	Dry lake brine.
Do	Argus, Calif	Do.
Do	Westend, Calif	Do.
Allied Chemical Corp	Green River, Wyo	Underground trona.
FMC Corp	do	Do.
Stauffer Chemical Co. of Wyoming	do	Do.
Texasgulf Chemicals Co	Granger, Wyo	Do.
Sodium sulfate:		
Kerr-McGee Chemical Corp	Trona, Calif	Dry lake brine.
Do	Westend, Calif	Do.
Ozark-Mahoning Co	Brownfield, Tex	Subterranean brine.
Do	Seagraves, Tex	Do.
Great Salt Lake Minerals & Chemical Corp	Ogden, Utah	Salt lake brine.

Table 1.—Manufactured and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process)[1 2] Quantity	Natural sodium carbonates[3] Quantity	Natural sodium carbonates[3] Value	Total quantity
1975	2,802	4,328	182,620	7,130
1976	2,344	5,216	259,253	7,560
1977	1,812	6,228	337,516	8,040
1978	[e]1,500	6,790	370,147	8,290
1979	W	W	[4]543,812	8,253
1980	W	W	[4]768,168	8,275

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

[1]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census. Bureau of Mines responsible for data compilation after January 1979.

[2]Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.

[3]Soda ash and trona (sesquicarbonate).

[4]Includes value for synthetic soda ash.

Table 2.—Source of U.S. soda ash by process

(Thousand short tons)

Year	Solvay Production	Solvay Percent of total	Natural Production	Natural Percent of total
1969	4,540	64.5	2,495	35.5
1970	4,393	62.1	2,678	37.9
1971	4,298	60.0	2,865	40.0
1972	4,305	57.2	3,218	42.8
1973	3,813	50.6	3,722	49.4
1974	3,507	46.4	4,059	53.6
1975	2,802	39.3	4,328	60.7
1976	2,344	31.0	5,216	69.0
1977	1,812	22.5	6,228	77.5
1978	[e]1,500	18.1	6,790	81.9
1979	W	W	W	W
1980	W	W	W	W

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

Table 3.—Manufactured and natural sodium sulfate produced in the United States[1]

(Thousand short tons and thousand dollars)

Year	Manufactured and natural[2]			Natural only	
	Lower purity[3] (99% or less)	High purity	Total[4]	Quantity	Value
1975	431	796	1,227	667	27,667
1976	466	766	1,232	663	32,655
1977	458	741	1,199	636	29,313
1978	606	630	1,235	605	27,865
1979	667	508	1,175	533	29,689
1980	739	519	1,259	583	33,389

[1]All quantities converted to 100% Na_2SO_4 basis.
[2]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census.
[3]Includes Glauber's salt.
[4]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

The demand for soda ash decreased about 2.3% in 1980 because of the economic conditions affecting the building construction and automobile manufacturing industries. These industries use flat glass, which comprises about 16% of the glass sector. Bottle and container glass represents approximately 72% of the glass market. This sector also experienced a reduction in the use of glass in the soft drink industry where polyethylene terephthalate (PET) bottles are replacing the traditional 1- and 2-liter glass bottles. The total U.S. primary demand for soda ash in 1980 was 7,131,320 short tons. The estimated consumption of soda ash in each of the end uses follows:

Table 4.—Consumption of soda ash, by end use in 1980

(Thousand short tons)

Glass:	
Bottle and container	2,773
Flat	616
Fiber	193
Other	269
Total	3,851
Chemical	1,426
Soaps and detergents	499
Pulp and paper	250
Water treatment	250
Other[1]	856
Total	3,281
Grand total	7,132

[1]Includes soda ash used in petroleum and metal refining, leather tanning, enamels, etc.

Apparent consumption of sodium sulfate increased about 5% in 1980 to 1,354,805 short tons. Although most of the end uses of sodium sulfate have reached maturity, the use of sodium sulfate as a coal conditioner represents a growing market.

STOCKS

Yearend stocks of natural sodium compounds, as reported by producers, were as follows:

	Thousand short tons	
	1979	1980
Natural soda ash	68	133
Natural sodium sulfate	29	33

PRICES

The values of natural soda ash and natural sodium sulfate, f.o.b. mine or plant, as reported by producers, were as follows:

	Value, dollars per short ton		Change, percent
	1979	1980	
Bulk soda ash	64.55	89.85	+39.2
Bulk sodium sulfate	55.69	57.28	+2.9

Yearend 1980 quoted prices of sodium carbonate and sodium sulfate were as follows:

		1979	1980
Sodium carbonate (soda ash):			
Light, paper bags, carlots, works	per ton	$57.00-$78.00	$150.00
Light, bulk, carlots, works	do	57.00- 64.00	123.00
Dense, paper bags, carlots, works	do	87.00	112.00
Dense, bulk, carlots, works	do	61.00- 62.00	86.00
Sodium sulfate (100% Na_2SO_4):			
Technical detergent, rayon-grade, bags, carlots	do	70.00- 72.00	$70.00- 72.00
Sodium sulfate, bulk, carlots, works[1]	do	78.00	78.00
Domestic salt cake, bulk, works[1]	do	47.00- 52.00	47.00- 52.00
National Formulary (N.F. XII), drums	per pound	.235	.235

[1]East of Mississippi River.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 215, No. 26, Dec. 31, 1979, p. 34; v. 218, No. 26, Dec. 29, 1980, p. 34.

FOREIGN TRADE

The United States produced over one-fourth of the world's soda ash in 1980 and exported a total of 1,094,340 short tons to 57 countries. The distribution of exports on a regional basis were North America, 32.2%; South America, 30.5%; Africa, 13.9%; Asia, 13.0%; Europe, 4.1%; Oceania, 2.9%; Caribbean, 1.8%; and Central America, 1.6%.

Table 5.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1977	759	52,943	43	2,801
1978	779	61,454	84	5,475
1979	997	86,663	102	8,516
1980	1,094	121,945	129	12,740

Table 6.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)[1]		Anhydrous		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1977	121	5,702	102	5,528	223	11,230
1978	41	1,701	96	4,890	[2]136	[2]6,590
1979	[r]85	[r]3,763	104	5,748	[r 2]188	[r]9,511
1980	97	4,872	133	8,370	230	13,242

[r]Revised.
[1]Includes Glauber's salt as follows: 1975-77, none; 1978, 1 ton ($1,157); 1979, 926 tons ($24,854); 1980, 1,418 tons ($37,372).
[2]Crude and anhydrous quantities may not add to totals shown because of independent rounding.

Table 7.—U.S. imports for consumption of sodium carbonate and bicarbonate

(Thousand short tons and thousand dollars)

	1979		1980	
	Quantity	Value	Quantity	Value
Soda ash	40	4,292	18	2,389
Sodium bicarbonate	3	616	2	425
Total	43	4,908	20	2,814

WORLD REVIEW

A European Economic Council Commission investigation into Western European soda ash pricing policies revealed there were possible restraints in competition from U.S. producers. Counterallegations by Belgian soda ash industry representatives cited factors such as employment impact and consumer preference for a local soda ash supplier as reasons for their contract justifications.[8]

Imperial Chemical Industries (ICI) of the United Kingdom agreed to renegotiate contracts with its soda ash customers. Under the new agreement, consumers will be offered a choice of short-term contracts or spot purchases rather than the previous arrangement that called for a total sales obligation with a 2-year notice of termination clause.[9]

Argentina.—A $92 million synthetic soda ash project is under development near Antonio Oeste. The 250,000-ton-per-year facility will be operated by Alcalis de la Patagonia with startup scheduled in 1983.[10]

Bangladesh.—A recommendation for the construction of a 55,000-short-ton-per-year capacity soda ash plant was made by the Bangladesh Chemical Industries Corp. and the Fertilizer Development and Planning Corp. of India. The plant would utilize ammonia and salt as the raw materials and recover ammonium sulfate as a commercial byproduct.[11]

Brazil.—Akzo Chemie of the Netherlands and Klöckner Industrie-Anlagen GmbH of the Federal Republic of Germany are constructing a 200,000-ton-per-year capacity synthetic soda ash facility for Alcalis de Norte. The plant will be located near Rio de Janeiro.[12]

France.—A soda ash plant, salt plant, chloralkali complex, or a combination of these, may be constructed in the Alsace Region in an attempt to end the dumping of 7 million tons of salt annually into the Rhine River. The potash mining operations of Mines de Potasse d'Alsace are allegedly responsible for 40% of the Rhine pollution. Recommendations on solving the problem will be discussed by the International Rhine Commission during 1981.[13]

Mexico.—Soda ash consumption in Mexico is expected to grow more than 8% through 1985, mainly in the glass and chemical industries. As a result, Mexican producers are exploring for additional natural deposits and considering building a second Solvay plant to meet the expected demand.[14]

The discovery of a brine deposit containing 8% to 14% sodium sulfate was reported near Laguna Salada del Huso, about 138 miles northwest of Chihuahua. The Chihua-

Table 8.—Sodium carbonate: World production, by country[1 2]

(Thousand short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Albania[e]	23	25	28	36	40
Australia[e]	170	175	180	180	190
Austria[e]	185	185	190	190	190
Belgium	388	487	471	[e]480	480
Brazil	165	155	133	154	165
Bulgaria	1,152	1,343	1,426	1,651	[3]1,630
Canada[e]	500	500	500	500	500
Chad[e 4]	6	12	12	12	9
Chile[e]	10	11	12	12	12
China:					
Mainland	[e]1,100	[e]1,200	1,465	1,638	[3]1,778
Taiwan	[r]88	[r]88	85	89	[3]102
Colombia	165	[r]155	184	[e]155	155
Czechoslovakia	131	130	133	128	135
Denmark[5]	1	1	2	3	3
Egypt	23	[r e]10	4	6	6
France	1,451	[r]1,505	1,492	1,708	1,700
German Democratic Republic	914	925	939	948	960
Germany, Federal Republic of	1,503	[r]1,489	1,356	1,544	1,550
Greece[e]	1	1	1	1	1
India	622	[r]626	650	[e]670	660
Italy	741	783	[e]800	[e]800	800
Japan	1,197	1,300	1,280	1,493	1,800
Kenya[4]	120	121	168	[r e]175	175
Korea, Republic of	171	188	194	225	[3]245
Mexico[6]	430	[e]460	456	454	400
Netherlands	299	304	309	[e]460	460
Norway[e]	25	[r]27	29	30	30
Pakistan	70	67	82	83	85
Poland	800	740	746	754	750
Portugal	126	143	145	[e]145	145
Romania	897	949	991	984	[3]987
Spain	578	[e]350	550	[e]550	555
Sweden[e]	1	1	1	1	1
Switzerland[e]	50	50	50	50	52
Turkey[e]	60	65	70	75	65
U.S.S.R	5,337	[r]5,375	5,355	5,271	5,300
United Kingdom[e]	1,540	1,650	1,760	1,550	1,500
United States[6]	7,560	8,040	8,290	8,253	[3]8,275
Yugoslavia	151	173	183	181	200
Total	[r]28,751	[r]29,809	30,722	31,639	32,091

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 15, 1981.
[2]Synthetic unless otherwise noted.
[3]Reported figure.
[4]Natural only.
[5]Production for sale only; excludes output consumed by producers.
[6]Includes natural and synthetic.

hua Economic Development Commission claims the deposit contains about 10 million tons of sodium sulfate.[15]

Thailand.—The Association of Southeast Asian Nations (ASEAN) soda ash project has been indefinitely delayed as a result of political and environmental objections over site selection. The $226 million, 440,000-ton-per-year capacity facility was to be built at either Laem Chabang or Sattahip.[16]

United Kingdom.—In an effort to improve its competitive stand against U.S. imports of natural soda ash, ICI has allocated $16.2 million for processing improvements at its Wallerscote plant.[17] It will also reduce the company work force at its three plants by 18%, or 600 jobs, over the next 2 years.[18]

Table 9.—Sodium sulfate: World production, by country[1]

(Thousand short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Natural:					
Argentina	39	40	41	40	[3]42
Canada	507	435	415	498	[3]500
Chile[4]	16	15	4	2	6
Egypt	[r]4	6	3	[e]4	4
Iran	28	44	39	[e]25	10
Mexico[5]	[r]276	[r]288	329	350	440
Spain	181	200	229	229	150
Turkey	97	80	71	53	53
U.S.S.R.[e 6]	340	350	365	375	385
United States[7]	663	636	605	533	[3]583
Total	[r]2,151	[r]2,094	2,101	2,109	2,173
Synthetic:					
Austria[e]	60	60	60	60	60
Belgium[e]	340	275	275	275	275
Chile[8]	31	33	48	76	66
Finland[e]	70	50	55	50	50
France	143	131	138	168	165
German Democratic Republic	164	152	144	[e]140	140
Germany, Federal Republic of	283	267	233	221	223
Greece[e]	6	7	7	8	9
Hungary[e]	11	11	11	11	11
Italy[e]	104	105	105	105	105
Japan	345	357	353	373	319
Netherlands	55	55	55	[e]55	55
Portugal	[r]49	51	56	[e]50	50
Spain[9]	[e]183	192	134	190	190
Sweden	114	116	116	116	116
U.S.S.R.[e 6]	240	250	265	265	280
United States[10]	569	605	630	647	[3]676
Total	[r]2,767	2,717	2,685	2,810	2,790

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through May 15, 1981.

[2]In addition to the countries listed, mainland China, Norway, Poland, Romania, Switzerland, and the United Kingdom are known to or are assumed to have produced synthetic sodium sulfate, and other unlisted countries may have produced this commodity, but production figures are not reported and available general information is inadequate for the formulation of reliable estimates of output levels.

[3]Reported figures.

[4]Natural mine output, excluding byproduct output from the nitrate industry, which is reported separately under manufactured.

[5]Series revised to reflect output reported by Mexico's principal producer, Industrias Peñoles, S.A. In 1979, and probably in other years, an additional 20,000 tons (estimated) of natural sodium sulfate was produced by a smaller producer.

[6]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.

[7]Sold or used by producers.

[8]Byproduct of nitrate industry.

[9]Quantities of synthetic sodium sulfate credited to Spain are reported in official sources in such a way as to indicate that they are in addition to the quantities reported as mined (reported in this table under "Natural"), but some duplication may exist.

[10]Derived approximate figure; data presented are the difference between reported total sodium sulfate production (natural and synthetic, undifferentiated) and reported natural sodium sulfate sold or used by producers (reported under "Natural" in this table).

TECHNOLOGY

FMC Corp. and Vulcan Materials Co. announced plans to conduct solution mining tests in the deeper trona deposits in the southern part of Wyoming's Green River Basin. The new technology is estimated to lower soda ash manufacturing costs by about 25% because of reduced labor, energy, and safety costs compared with underground mining costs. The socioeconomic impact on local communities will also be reduced. If the tests are successful, the deeper and thinner trona beds, once considered to be impractical and uneconomic to mine conventionally, may be economically recovered using solution mining.

By mid-1981, FMC Corp. plans to begin hydrofracking tests with subsequent solvent injection and solution recovery. If successful, it plans to expand its existing processing plant's capacity by an additional 1 million tons by the mid-1980's.[19]

Vulcan Materials Co. also is engaged in a solution mining project with the goal of constructing a 1-million-ton-per-year-capacity processing plant pending the successful completion of a multi-phase field study.[20] Allied also has expressed interest in utilizing solution mining to recover additional trona resources.

Researchers at the Ames Laboratory at Iowa State University developed a method to recover valuable aluminum, iron, and titanium minerals from the fly ash produced from coal-fired plants. A pelletized mixture of fly ash, limestone, and soda ash was sintered at 1200° C to form soluble aluminate compounds. The resultant was leached with a dilute sodium carbonate solution to recover about 90% of the aluminum present in the ash. The residue, dicalcium silicate, can be used as an additive in portland cement.[21] Fly ash from domestic bituminous, subbituminous, and lignite coals can produce an estimated 18% of domestic iron supplies, 50% of titanium, and 80% of primary aluminum.[22]

A joint industry-Federal Government project developed a method to increase the performance of high-temperature electrostatic precipitators by adding 0.52 pound of sodium sulfate to 100 pounds of low-sulfur coal (equals about 20 cents of sodium sulfate per ton of coal) before being introduced into the furnace. The test site was at the Lansing Smith station in Panama City, Fla., operated by Gulf Power Co. Prior to the tests, the precipitator would clog because of the density of the particles in the plume and the lack of sufficient sodium oxide in the ash matrix to maintain an ideal electrical field. As a result, the unit had to be shut down for maintenance every 6 to 8 weeks. The addition of sodium sulfate stabilized the reaction within the precipitator so that clogging was avoided, and the particulate capture rate improved by over 500%.[23]

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[1]Physical scientist, Section of Nonmetallic Minerals.
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[3]———. Mar. 29, 1980, p. 10E.
[4]Chemical Marketing Reporter. FMC Financial Goals. V. 218, No. 19, Nov. 10, 1980, p. 7.
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[13]Industrial Minerals. A Solution for Pollution in the Rhine? No. 162, March 1981, p. 7.
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[21]———. The Fly Ash Route to Metals Will Get a Pilot Test. V. 127, No. 14, Oct. 1, 1980, pp. 54-55.
[22]Mining Engineering. Industry Newswatch—Fly Ash From Coal-fired Plants Used to Make Portland Cement. V. 32, No. 12, December 1980, p. 1686.
[23]Engineering News Record. Precipitator Clogging Solved. Nov. 20, 1980, p. 14.

Stone

By Richard H. Singleton[1]

U.S. production of crushed stone decreased 11% in 1980 to 980 million tons. About three-quarters of crushed stone production continued to be limestone, followed by granite, traprock, sandstone, shell, marl, and marble, in order of volume. Value of crushed stone production was $3.25 billion, nearly the same as that in 1979.

Crushed stone was produced in every State except Delaware and North Dakota. Leading States were Texas, Florida, and Pennsylvania in order of tonnage. Crushed stone output decreased in all regions of the United States except the West South Central region where output increased by 1%. There were 1,865 companies operating approximately 4,150 crushed stone quarries in 1980. Output per quarry in 1980 was about 236,000 tons, compared with 260,000 tons in 1979, and 180,000 tons in 1969. Only about 4% of these quarries were of the 1-million-ton-per-year capacity or larger, but these accounted for 33% of total output in 1980. Approximately three-quarters of U.S. crushed stone was used in road, railroad, and bridge construction; other uses were, in order of volume, cement production (10%), agriculture (3.5%), chemical production (3%), aggregate for building construction (3%), and metallurgical flux (1.6%).

U.S. production of dimension stone decreased 3% to 1.31 million tons. Approximately 50% of 1980 dimension stone production was granite, followed by limestone, sandstone, slate, marble, and traprock, in order of volume. Value of dimension stone increased 13% in 1980 to $139 million. Value of dimension stone imports, about one-half marble and mainly from Italy, increased 35% in 1980 to $88.9 million.

Dimension stone was produced in 38 States in 1980. Leading States were Georgia, Vermont, and Indiana. There were 263 companies operating approximately 430 dimension stone quarries. Approximately one-quarter of U.S.-produced dimension stone was used in monuments and the remainder was used in the construction of buildings and other structures.

The Bureau of Mines canvass of dimension stone does not include processors of purchased rough stone. All producers are covered; if the producer sells rough stone to a processor, it is tabulated as rough stone; if the producer processes finished stone, only the finished stone is tabulated, and the rough stone is deducted. The Bureau of Mines generally accepts the stone classification reported by producers.

Granite usually includes all coarser-grained igneous rocks. Limestone may be pure calcium carbonate, or may be bituminous, dolomitic, or siliceous. The term "traprock" pertains to all dense, dark, fine-grained igneous rocks. Marble may include any calcareous rock that will polish. Sandstone may be calcareous, quartz or quartzite, or a conglomerate. Quartzite may be described as any siliceous-cemented sandstone. Quartzite that has been comminuted to sand is included in the sand and gravel chapter.

Capacity figures and stocks are not available. Inventories on hand at quarries and plants are estimated at about 1 month's supply, or 100 million tons.

Table 1.—Salient stone statistics in the United States

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
Sold or used by producers:					
Dimension stone	1,400	1,416	1,394	r1,350	1,315
Value	$104,400	$103,900	$113,100	r$122,800	$138,900
Crushed stone[1]	900,300	954,000	1,049,600	r1,096,300	980,300
Value	$2,117,000	$2,353,000	$2,773,000	r$3,265,300	$3,254,600
Total stone[2]	901,700	955,400	1,051,000	r1,097,600	981,600
Total value[2]	$2,221,000	$2,457,000	$2,886,000	r$3,388,100	$3,393,500
Exports (value)	$24,000	$22,600	$31,400	$40,200	$36,400
Imports for consumption (value)	$46,600	$48,600	$64,800	r$81,800	$102,000

rRevised.
[1]Does not include American Samoa, Guam, Puerto Rico, and Virgin Islands.
[2]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Dimension Stone.—Dimension stone was produced by 263 companies at 426 quarries in 38 States. Leading States, in order of tonnage, were Georgia, Vermont, and Indiana, producing, together, 43% of the Nation's total. The large, 45% increase in production in 1979 in Indiana previously reported in the 1980 stone chapter was found to be incorrect. In fact, a 23% decrease had occurred in Indiana in 1979. Notable in 1980 was a 20% increase in output from New Hampshire. Of the total U.S. production, 50% was granite, 22% was limestone, 13% was sandstone, 7% was slate, and 5% was marble. In 1980, there occurred a 23% decrease in sandstone production and a 24% decrease in marble output. Leading companies were, in 1980, Rock of Ages Corp. in Vermont and Cold Spring Granite Co. in California, Minnesota, South Dakota, and Texas.

Crushed Stone.—Crushed stone was produced by 1,865 companies at about 4,150 quarries, in every State except Delaware and North Dakota. Leading States, in order of tonnage, were Texas, Florida, Pennsylvania, Illinois, Missouri, Virginia, and Ohio; these seven States produced 40% of U.S. crushed stone. Compared with 1979, all geographic regions (see table 4 and figure 1) of the United States showed a decrease in crushed stone output of between 13% and 16% except the South Atlantic and West South Central regions. The latter was the only region to show an output gain, 1%. Production in the South Atlantic region decreased by 6%. The only States showing increased production were, in order of tonnage, Texas, Florida, Arkansas, Nevada, and Alaska. Total production in Oregon and Washington decreased by 28% compared with that of 1979. Of the total U.S. production, 74% was limestone, 12% was granite, 8% was traprock, 3% was sandstone, and 1.1% was shell. Notable in 1980 was a 20% decrease in traprock output and a 40% increase in marl production. Leading producers in 1980, in order of tonnage, remained Vulcan Materials Co., Martin Marietta Corp., Koppers Co., Inc., Lone Star Industries, Inc., and General Dynamics Corp.

Disagreement continued between industry and Government regulators regarding particulate levels in the crushed stone industry's water effluents. The Environmental Protection Agency had issued, in 1977, regulations governing settling pond facilities and noxious effluents in the industry. Industry continued technical studies, lobbying efforts, and litigation to modify these regulations, particularly when compliance caused economic hardship. Many of the regulations issued in 1977 had been struck down in a 1979 U.S. Court of Appeals decision. By yearend, it appeared that Government and industry were ready to work together in formulating new regulations.

Following publication in 1979 of the final report of its Committee on Surface Mining and Reclamation (COSMAR) regarding the applicability of the Federal Surface Mining Control and Reclamation Act of 1977 to the surface mining of noncoal minerals, the Council of Environmental Quality (CEQ) held extensive hearings on this matter. The act applies only to coal mining. Based on the COSMAR report's conclusions and recommendations as well as the hearings, CEQ recommended that Congress should not enact any new legislation regulating noncoal minerals mining and reclamation on public or private lands.

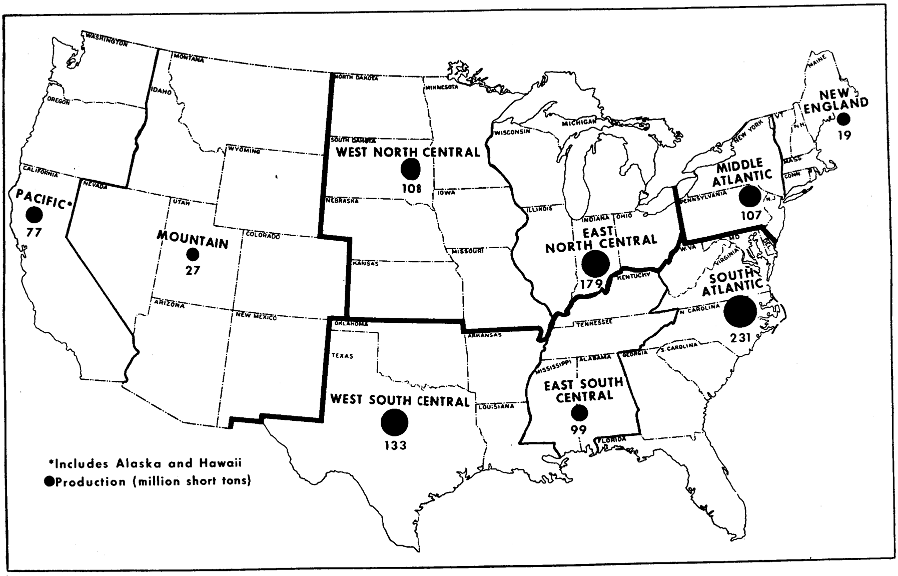

Figure 1.—Production of crushed stone by geographic region in 1980.

LIMESTONE

Limestone includes dolomite.

Dimension.—Compared with 1979, 1980 output of dimension limestone decreased 5% in tonnage and increased 27% in value to 295,000 tons and $21.3 million. Dimension limestone was produced by 59 companies at 75 quarries in 18 States. Indiana continued to be the leading State producing 54% of the U.S. total, followed by Wisconsin. The top two producers, in order of value, were Indiana Limestone Co. and Independent Limestone Co., both in Indiana.

Crushed.—Compared with 1979, 1980 output of crushed limestone decreased 11% in tonnage and 1% in value to 723 million tons and $2,316 million. It was produced by 1,261 companies at 2,806 quarries in 46 States. Leading States, in order of tonnage, were Texas, Florida, Illinois, Pennsylvania, and Missouri; these five States accounted for 40% of U.S. output. Texas and Florida each produced 3% more than in 1979 while output decreased in the other three leading States. Leading producers were, in order of tonnage, Vulcan Materials Co., Martin Marietta Corp., and Lone Star Industries, Inc. These three producers accounted for 9% of total U.S. output.

GRANITE

Dimension.—Compared with 1979, 1980 output of dimension granite increased 5% in tonnage and 15% in value to 662,000 tons and $79.9 million. Dimension granite was produced by 85 companies at 164 quarries in 21 States. Georgia continued to be the leading State producing 30% of the U.S. total, followed by New Hampshire and Vermont. These three States together produced 60% of the U.S. total. Leading producers were Rock of Ages Corp. and Cold Spring Granite Co. It was estimated that the three leading companies produced 36% of U.S. output.

Crushed.—Compared with 1979, 1980 output of crushed granite decreased 4% in tonnage and increased 8% in value to 118 million tons and $418 million. It was produced by 137 companies at 406 quarries in 30 States. Leading States continued to be, in order of tonnage, Georgia, North Carolina, Virginia, and South Carolina; these four States accounted for 75% of U.S. output. Leading producers, in order of tonnage, were Vulcan Materials Co., Martin Marietta Corp., and Koppers Co., Inc. The three leading companies accounted for 49% of U.S. output.

TRAPROCK

Dimension.—Compared with 1979, 1980 output of dimension traprock increased nearly ninefold to 14,700 tons valued at $226,000. Oregon became the leading State, producing 87% of the U.S. total, with Hawaii a distant second producing 8% of the U.S. total. The U.S. Forest Service became the leading producer, operating mostly in Oregon, followed by J. W. Glover, Ltd., in Hawaii.

Crushed.—Compared with 1979, 1980 output of crushed traprock decreased 20% in tonnage and 8% in value to 81 million tons and $300 million. It was produced by 306 companies at 579 quarries in 26 States. Leading States were, in order of total tonnage, Oregon, New Jersey, and Washington; these three States accounted for 42% of U.S. output. Notable were tonnage decreases of 31% and 33% in Oregon and Washington, respectively. Leading producers, in order of tonnage, were Thomas Tilling, Ltd., mainly in Connecticut, the U.S. Forest Service, mainly in the Pacific States, and Koppers Co., Inc. The top three producers accounted for 19% of U.S. output.

SANDSTONE

Dimension.—Compared with 1979, 1980 output of dimension sandstone decreased 23% in tonnage and 13% in value to 170,000 tons and $7.7 million. Dimension sandstone was produced by 68 companies at 148 quarries in 24 States. Leading States continued to be, in order of volume, Pennsylvania, Ohio, and New York; these three States accounted for 51% of U.S. output. Leading producers were, in order of tonnage, Delaware Quarries in Pennsylvania and Standard Slag Co. in Ohio. The top three producers accounted for 62% of U.S. production.

Crushed.—Compared with 1979, 1980 output of crushed sandstone decreased 7% in tonnage and 4% in value to 29 million tons and $102 million. Crushed sandstone was produced by 168 companies at 317 quarries in 27 States. Leading States continued to be, in order of volume, Arkansas, California, and Pennsylvania; these three States accounted for 45% of U.S. output. Leading producers were Martin Marietta Corp., East Bay Excavating Co. of California, and the U.S. Forest Service, mainly in the Pacific States. The top three producers accounted for 14% of U.S. output in 1980.

MARBLE

Dimension.—Dimension marble included crystalline marble, certain hard limestones, and any other calcareous stone capable of accepting a polish. Output of dimension marble decreased 24% to 60,000 tons valued at $14.2 million. Total value did not change significantly compared with that of 1979. Dimension marble was produced by 12 companies at 20 quarries in 13 States. Georgia, Vermont, and Texas, in order of tonnage, were the three leading States, accounting for about three-quarters of U.S. output. Leading producers were, in order of tonnage, Georgia Marble Co. and Moretti-Harrah Marble Co. in Alabama. The top three producers accounted for 81% of U.S. output.

Crushed.—Compared with 1979, 1980 output decreased 8% to 1.35 million tons valued at $23.7 million. Crushed marble was produced by 12 companies at 27 quarries in 9 States. Leading States, in order of tonnage, were Alabama, Georgia, and Texas. These States together produced more than 90% of U.S. crushed marble. Alabama accounted for 57% of U.S. output in 1980. Leading producers were, in order of tonnage, Georgia Marble Co., Standard Oil Co. of Indiana in Alabama, and Moretti-Harrah Marble Co. in Alabama. These top three producers accounted for 81% of U.S. output.

SLATE

Dimension.—Compared with 1979, 1980 output of dimension slate increased 4% to 90,000 tons valued at $14.8 million. Dimension slate was produced by 32 companies at 43 quarries in 5 States. The two leading States, Vermont and Pennsylvania, in order of volume, accounted for 53% of U.S. output. The top three producers accounted for an estimated 41% of U.S. output.

Crushed.—Compared with 1979, 1980 output of crushed slate decreased 18% to 1.06 million tons valued at $12.0 million. Crushed slate was produced by 10 companies at 11 quarries in 5 States. The three leading States, Virginia, Georgia, and Arkansas, accounted for 98% of U.S. output. Leading producers were, in order of tonnage, Galite Corp. in Georgia and Solite Corp. in Virginia. The top three producers accounted for an estimated 57% of U.S. output.

SHELL

Shell is mainly fossil reefs of oyster shell. Compared with 1979, 1980 output of crushed shell decreased 10% to 10.9 million tons valued at $40.1 million. Crushed shell was produced by 8 companies at 15 quarries in 6 States. Louisiana accounted for 67% of U.S. output. The other producing States were, in order of volume, Texas, Alabama, Florida, Maryland, and California. Leading producers, in order of tonnage, continued to be Radcliff Materials Inc. (a subsidiary of Dravo Corp.) and Parker Brothers & Co., Inc.; the top three producers accounted for 76% of U.S. output.

MARL

Compared with 1979, 1980 output of marl increased 40% to 3.7 million tons valued at $7.9 million. Marl was produced by 26 companies at 26 quarries in 9 States. South Carolina accounted for 62% of U.S. marl output. Other leading States, in order of tonnage, were Texas, Mississippi, North Carolina, and Florida. The top five States accounted for 99% of U.S. output. Dundee Cement Co. became the largest U.S. producer, followed by Giant Portland Cement Co. and Gifford-Hill Co., Inc., all located in South Carolina. These three leading producers were also manufacturers of portland cement.

MISCELLANEOUS STONE

Dimension.—Compared with 1979, 1980 output of miscellaneous dimension stone decreased 7% to 22,000 tons valued at $786,000.

Crushed.—Compared with 1979, 1980 output of miscellaneous crushed stone decreased 5% to 11.9 million tons valued at $35 million.

CONSUMPTION AND USES

Dimension stone was marketed over wide areas. Crushed stone was generally marketed in a limited area, usually in the State where produced. Stockpiles were not monitored and output during the year was assumed to equal consumption.

Dimension.—Compared with 1979, 1980 consumption of dimension stone decreased 3% to 1.3 million tons valued at $138.9 million. Consumption of stone for monuments decreased 3% to 313,000 tons, 24% of total dimension stone tonnage and 36% of total value. Notable during 1980 was a 22% increase in flooring slate to 28,000 tons valued at $5.3 million.

Crushed.—Compared with 1979, 1980 use of crushed stone decreased 11% to 980 million tons valued at $3.25 billion. Notable during 1980 were a 49% increase in filter stone to 5.66 million tons valued at $19.5 million and a 29% decrease in whiting to 969,000 tons valued at $23.3 million.

Highway and road construction continued to account for approximately two-thirds of crushed stone consumption. The National Research Council reported[2] that funding at all levels of government remained inadequate for maintenance of the U.S. road system. The Council studies indicated that the approximately $7 billion spent on road maintenance in 1980 represented only about one-half of that required. This disparity was expected to increase unless substantial increases in funding were to be provided in the future. Proper funding for maintenance would significantly increase demand for crushed stone. Capital expenditures for new highways in 1980 totaled about $20 billion.

LIMESTONE

Dimension.—Notable during 1980 were a 25% decrease in rough blocks and irregular shapes to 97,000 tons valued at $3.8 million, a 30% increase in rough flagging to 19,000 tons valued at $358,000, and a 96% increase in sawed stone to 53,000 tons valued at $5.3 million.

Crushed.—Notable during 1980 were a 28% decrease in flux stone to 15.3 million tons valued at $56 million, a 39% decrease in whiting to 666,000 tons valued at $20.7 million, a 30% increase in filter stone to 3.50 million tons valued at $11.3 million, and a 44-fold increase in refractory stone to 880,000 tons valued at $2.0 million. Also notable during 1980 were significant increases in aglime consumption in Kentucky, Pennsylvania, Florida, and Minnesota, in order of 1980 tonnage, and significant decreases in aglime consumption in Alabama, Georgia, and Michigan, in order of 1980 tonnage; a 16% increase in purchases for lime production in Texas to 2.45 million tons; and significant increases in riprap consumption in Kentucky, Oklahoma, and Illinois, in order of tonnage, and a 38% decrease in riprap usage in Alabama to 573,000 tons.

The breakdown by end use of crushed limestone consumption in 1980 was aggregate, 69%; cement, 13%; agricultural, 5%; lime, 4%; flux stone, 2%; riprap, 2%; railroad ballast, 2%; and other, 3%.

GRANITE

Dimension.—Notable during 1980 was a 150% increase in rubble. Use of granite in monuments showed a 5% decrease in tonnage. The end-use breakdown in 1980 was: Monumental, 46%; curbing, 18%; and other construction, the remaining 36%.

Crushed.—Notable during 1980 was a 55% increase in macadam aggregate to 1.9 million tons, a 260% increase in filter stone to 1.5 million tons, a 55% decrease in surface treatment aggregate to 3.4 million tons, and a 66% increase in granite sand to 3.0 million tons. The end-use breakdown was aggregate, 83%; railroad ballast, 10%; riprap, 2%; terrazzo and roofing granules, 2%; other, 3%.

TRAPROCK

Dimension.—Flagging continued to account for more than three-quarters of dimension traprock use in 1980; the other major use was as rubble.

Crushed.—Notable during 1980 were a 38% increase in macadam aggregate to 2.6 million tons and a 46% decrease in surface treatment aggregate to 3.9 million tons. The 1979 end-use breakdown was aggregate, 87%; riprap, 5%; railroad ballast, 4%; roofing granules, 2%; traprock sand, 1%; and other, 1%.

SANDSTONE

Dimension.—Notable during 1980 were a 40% decrease in rough blocks and irregular shapes to 61,000 tons valued at $1.77 million and a 54% increase in house stone veneer to 14,600 tons valued at $713,000.

Crushed.—Notable during 1980 were a 26% increase in railroad ballast to 1.45 million tons, a 34% increase in riprap to 1.14 million tons, a 27% decrease in flux stone to 810,000 tons, and a 72% decrease in refractory stone to 133,000 tons. The 1980 end-use breakdown was aggregates, 84%; railroad ballast, 5%; flux stone, 3%; cement, 2%; and other, 6%.

MARBLE

Dimension.—No significant change in end-use pattern was apparent during 1980.

Crushed.—No significant change in end-use pattern was apparent during 1980.

SLATE

Dimension.—Notable during 1980 was a 22% increase in flooring slate to 28,000 tons valued at $5.3 million. The 1980 end-use breakdown by value was flooring, 36%; structural and sanitary, 23%; roofing, 24%; flagging, 13%; and other, 4%.

Crushed.—Crushed slate was used for lightweight aggregate (48%), roofing granules (7%), slate flour (5%), and other. Output of slate for lightweight aggregate decreased 15% to 503,000 tons valued at $8.1 million.

SHELL

Notable during 1980 were a 21% decrease in dense-graded roadbase shell to 2.65 million tons valued at $13.9 million and a 45% decrease in poultry grit to 228,000 tons valued at $547,000. The 1980 end-use breakdown was dense-graded roadbase; other construction aggregate and roadstone, 70%; cement, 11%; and other, 19%.

MARL

Crushed marl was used primarily for cement manufacture (87%) and soil conditioning (8%). Notable during 1980 was a 38% increase in marl use in cement manufacture to 3.2 million tons valued at $6.3 million and a 13% increase in use of marl in soil conditioning to 289,000 tons valued at $1.10 million.

MISCELLANEOUS STONE

Dimension.—Miscellaneous types of dimension stone were used in 1980 primarily as rough blocks and irregular shapes (68%) and rubble (17%). Use as rubble decreased 34% to 3,800 tons valued at $106,000.

Crushed.—Miscellaneous types of crushed stone were used in 1980 primarily as aggregate in road construction (88%) and riprap (5%). Use as riprap decreased 41% to 592,000 tons valued at $1.4 million.

PRICES

Dimension.—Compared with 1979, the average 1980 price of dimension stone increased 16% to $105.67 per ton. The price of dimension marble increased 32% to $235 per ton and this was accompanied by a 24% decrease in tonnage sales. The price of dimension limestone increased 33% to $72 per ton and this was accompanied by a 5% increase in tonnage sales. No significant dependence of price on demand is apparent.

The 22% increase in flooring slate tonnage was accompanied by a 7% increase in price, indicating no correlation between constant dollar price and demand.

Crushed.—Compared with 1979, the average 1980 price of crushed stone increased 11% to $3.32 per ton. The price of crushed slate increased 27% during this period to $11.36 per ton and this was accompanied by a 40% increase in tonnage sales. The price of marl increased 24% to $2.12 per ton while tonnage sales increased by 40%, indicating a positive relationship between constant dollar price and demand.

The 29% decrease in whiting tonnage was accompanied by no significant price change. The 49% increase in filter stone tonnage was accompanied by a 12% increase in price.

FOREIGN TRADE

Exports.—Exports of dimension stone, nearly one-half granite in 1980, decreased 17% to 187,000 tons, and 12% in value to $15.2 million. Most of the decrease was in rough limestone blocks. Exports to Canada increased 38% and accounted for 52% of total exports in 1980.

Exports of crushed stone decreased 27% to 3.1 million tons, and 7% in value to $21.2 million. Eighty-nine percent (89%) of the crushed stone exported in 1980 was limestone, and 90% of it was exported to Canada.

Imports.—Value of imports of dimension stone increased 35% in 1980 to $89 million; of this, 72% came from Italy and 9% came from Canada. On a value basis, marble accounted for 44% of imports (77% from Italy); followed by granite, 26% (51% from Italy and 35% from Canada); travertine, 15% (90% from Italy); and slate, 8% (85% from Italy). Notable was a doubling of the unit value of imported dressed granite from Italy, to $42 per cubic foot; this accounted for most of the increase in customs value for dressed granite in table 37.

Imports of crushed stone and chips decreased 8% in 1980 to 3.5 million tons valued at $9.8 million. Approximately 66% of this tonnage was limestone, over 90% of which came from Canada. Imports of quartzite, 97% from Canada, decreased 84% to 16,000 tons valued at $302,000. The remainder of crushed stone imports was nearly all unidentified crushed stone.

Imports of calcium carbonate fines decreased 42% to 294,000 tons valued at $3.2 million; of this, aragonite from the Bahamas accounted for 95% on a tonnage basis but only 11% on a value basis. Imports of chalk whiting, 94% from France, decreased 74% to 8,200 tons. About 6,400 tons of precipitated calcium carbonate was imported in 1980; of this, 56% came from the United Kingdom and nearly all of the remainder was imported from France and Japan.

WORLD REVIEW

World annual production, excluding centrally planned economy countries, was approximately 3 billion tons for crushed stone and about 13 million tons for dimension stone. Of this, the United States produced about one-third of the total crushed stone and Italy produced nearly one-half of the total dimension stone. Approximately 40% of U.S. supply, by value, of dimension stone was imported from Italy in 1980.

Canada.—Stone production decreased 10% in 1980, to 121 million tons valued at $331 million. Average unit price increased by 11%. Dimension stone accounted for about 0.5% of total stone tonnage and 2% of total value. Construction accounted for 95% of crushed stone use. The Province of Quebec produced 58% of Canadian stone in 1980 followed by Ontario, 30%. Of total stone, production by type was limestone, 50%; granite, 45%; and sandstone, 3%.

Italy.— Production of marble, Italy's leading type of dimension stone in value, continued at approximately 1.5 million tons per year. Other types of dimension stone produced in quantity were travertine, a type of marble, and granite. However, about 0.5 million tons of dimension granite was imported annually. About two-thirds of dimension stone production was exported.

United Kingdom.—Crushed stone production increased 3% in 1980 to about 157 million tons; of this, approximately two-thirds was limestone.

TECHNOLOGY

The high cost of asphalt has made the recycling of asphalt road surfaces, and its accompanying content of crushed stone, more attractive economically. A rejuvenation agent is added to soften the brittle asphalt before reuse. It is important that future recycling of this kind be allowed to seek its natural economic level, and that its use not be mandated by Government and product quality levels not be compromised. Environmental controls should be maintained, but not at a level different from that used in the application of road surfaces using virgin materials. Recycling of cement concrete roads is sometimes also viable although only aggregate is produced.

A 15-mile length of Chicago's Edens Expressway was completed in 1980 using recycled concrete pavement as the subbase. Similar cost and energy savings have been realized in several States using recycled asphalt mixtures in highway resurfacing and repair. This recycling reduces the need for additional aggregate.

Tests at Argonne National Laboratories demonstrated that the efficiency of utilization of limestone in removal of sulfur during fluidized bed combustion of coal could be increased greatly by recycling the limestone after a simple water treatment. The calcium sulfate layer on the surface of the limestone particles, which inhibited the reaction, was fractured by enlargement of the particles caused by chemical reaction with the water, to form calcium hydroxide. By a triple recycling, calcium utilization could be approximately tripled to as high as 86%.

After several years of study, the Environmental Protection Agency concluded that asbestos fibers in crushed serpentine or related stone quarried in Montgomery County, Md., were not a serious health problem when the stone was used in paved roads and playgrounds and in riprap. This issue had caused the county to pave over, in 1976, many roads and areas where the crushed serpentinitic stone had been used.

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[1]Supervisory physical scientist, Section of Nonmetallic Minerals.

[2]National Research Council. Dollar Needs to Preserve and Restore U.S. Roads. Transportation Research News, No. 93, March-April 1981, pp. 2-5.

Table 2.—Dimension stone sold or used by producers in the United States, by State

State	1979			1980		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Alabama	12,352	158	$2,071	10,812	133	$2,259
Arizona	5,224	76	110	W	W	45
Arkansas	14,268	178	528	8,104	101	355
California	40,914	492	2,258	36,103	443	1,967
Colorado	3,295	42	163	6,124	78	259
Connecticut	13,040	156	475	15,397	175	723
Georgia	244,390	2,535	17,908	231,496	2,374	17,466
Hawaii	1,052	12	W	W	W	11
Illinois	3,000	35	128	2,238	26	103
Indiana	r180,575	r2,301	r10,504	160,791	2,173	14,046
Iowa	10,197	120	508	9,645	113	509
Kansas	--	--	--	18,435	248	937
Maryland	29,980	375	1,150	14,659	183	612
Massachusetts	48,118	579	4,389	51,458	616	7,018
Michigan	8,977	112	166	6,805	85	144
Minnesota	38,446	458	11,543	44,464	534	14,189
Missouri	344	4	85	W	W	W
New Hampshire	85,553	1,005	5,774	103,039	1,216	7,167
New Mexico	20,184	277	117	17,750	244	91
New York	27,000	314	2,626	25,022	294	2,414
North Carolina	48,536	594	3,932	55,365	682	4,536
Ohio	49,750	681	1,702	34,809	476	1,558
Oklahoma	38,485	r429	1,383	15,984	221	678
Oregon	265	3	4	14,556	171	231
Pennsylvania	76,646	714	5,961	65,399	780	6,397
South Carolina	8,586	98	482	11,660	141	703
South Dakota	35,500	403	13,268	42,315	489	15,035
Tennessee	11,988	144	1,000	10,318	125	883
Texas	17,074	214	3,636	36,887	454	7,095
Utah	4,953	64	216	3,450	44	272
Vermont	180,232	1,898	23,006	169,276	1,782	23,649
Virginia	8,530	97	2,042	27,439	327	2,287
Washington	3,807	48	268	5,686	70	248
Wisconsin	54,317	665	4,204	45,431	559	4,501
Other[1]	24,620	320	1,168	13,615	165	521
Total[2]	r1,350,198	r15,603	r122,772	r1,314,532	15,523	138,907
Puerto Rico	78,978	1,053	1,105	129,288	1,724	2,271

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Idaho, Montana, New Jersey, Rhode Island, West Virginia (1979), and Wyoming (1979).
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Crushed stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Alabama	26,443	83,566	23,433	82,270
Alaska	3,656	15,458	3,990	19,978
Arizona	5,769	21,401	5,224	21,565
Arkansas	19,978	53,723	20,666	61,399
California	r38,593	r103,342	37,250	116,321
Colorado	6,835	19,435	6,277	20,068
Connecticut	8,271	38,767	7,977	40,283
Florida	W	W	66,209	215,972
Georgia	40,902	154,021	40,884	162,642
Hawaii	6,868	28,969	6,341	30,634
Idaho	2,952	r8,787	2,007	7,240
Illinois	63,551	188,130	53,309	180,656
Indiana	r34,147	r92,630	30,910	92,106
Iowa	32,471	103,215	26,542	92,603
Kansas	19,308	56,038	17,398	54,731
Kentucky	W	W	W	W
Louisiana	W	W	W	W
Maine	2,069	7,492	1,130	3,969
Maryland	21,561	80,550	18,945	77,431
Massachusetts	8,586	39,570	7,316	36,804
Michigan	39,809	99,832	32,121	91,727
Minnesota	9,751	22,175	8,606	21,731
Mississippi	W	W	W	W
Missouri	56,380	139,944	48,296	130,254
Montana	2,527	7,806	1,962	6,302
Nebraska	4,995	19,362	3,775	16,301
Nevada	1,602	6,439	1,809	7,407
New Hampshire	866	2,172	590	2,281
New Jersey	13,950	63,174	11,830	61,886
New Mexico	2,589	6,743	2,217	7,259
New York	r37,499	r114,174	34,483	120,764
North Carolina	39,864	125,319	34,764	125,019
Ohio	50,717	149,819	42,441	136,929
Oklahoma	28,312	66,666	28,173	76,267
Oregon	25,738	65,074	18,380	48,190
Pennsylvania	r71,432	r224,014	61,143	218,231
Rhode Island	249	1,148	203	1,208
South Carolina	16,589	48,352	16,107	49,207
South Dakota	3,891	10,317	3,151	8,942
Tennessee	45,718	133,727	38,584	126,993
Texas	74,612	188,746	76,483	220,265
Utah	3,424	11,059	2,919	11,776
Vermont	2,077	13,927	1,320	4,787
Virginia	51,080	165,223	44,615	167,839
Washington	15,192	35,783	11,062	29,024
West Virginia	11,713	37,624	9,766	36,305
Wisconsin	23,924	52,804	20,603	49,245
Wyoming	5,013	15,634	4,374	14,835
Other	r114,798	343,136	44,718	146,923
Total[1]	r1,096,271	r3,265,287	980,305	3,254,572
American Samoa	r1	r6	W	167
Guam	669	2,483	529	2,163
Puerto Rico	r14,040	r58,554	23,917	101,908
Virgin Islands	W	W	W	W

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Data may not add to totals shown because of independent rounding.

Table 4.—Crushed stone sold or used in the United States, by region

(Thousand short tons and thousand dollars)

Region	1979		1980	
	Quantity	Value	Quantity	Value
Northeast:				
New England	22,118	103,076	18,536	89,332
Middle Atlantic	122,881	401,362	107,456	400,881
North Central:				
East North Central	212,148	583,215	179,384	550,663
West North Central	126,796	351,051	107,768	324,562
South:				
South Atlantic	245,496	799,985	231,290	834,415
East South Central	114,002	339,573	98,886	324,567
West South Central	132,073	341,095	133,171	389,550
West:				
Mountain	30,711	97,305	26,790	96,452
Pacific	90,047	248,626	77,023	244,147
Total[1]	1,096,271	3,265,287	980,305	3,254,572

[1]Data may not add to totals shown because of independent rounding.

Table 5.—Crushed stone sold or used by producers in the United States, by size of operation

(Thousand short tons)

Size range	1979			1980		
	Number of operations	Quantity	Percent	Number of operations	Quantity	Percent
0 to 25	r1,171	r10,937	1	1,056	9,026	1
25 to 50	r539	r18,991	2	601	21,940	2
50 to 75	r328	r20,359	2	286	17,674	2
75 to 100	r245	r21,219	2	218	18,988	2
100 to 200	544	79,682	7	660	89,849	9
200 to 300	r338	r83,296	8	351	85,906	9
300 to 400	220	76,209	7	207	71,490	7
400 to 500	184	82,731	7	185	81,846	8
500 to 600	r134	r73,511	7	149	63,540	6
600 to 700	117	75,761	7	105	68,134	7
700 to 800	80	60,005	5	76	56,921	6
800 to 900	73	61,928	6	56	47,686	5
900 to 999[1]	r357	r431,642	39	30	28,543	3
1,000 and over[2]	--	--	--	171	318,760	33
Total	4,330	r1,096,271	100	4,151	[3]980,305	100

rRevised.
[1]In 1979, data for operations was 900,000 plus.
[2]Data for 1980 operations only.
[3]Data do not add to total shown because of independent rounding.

Table 6.—Crushed stone sold or used by producers in the United States, by method of transportation

(Thousand short tons)

Method	1979		1980	
	Quantity	Percent	Quantity	Percent
Truck	r899,870	82	805,418	82
Rail	86,201	8	81,838	9
Water	62,818	6	51,642	5
Other	47,381	4	41,407	4
Total	r [1]1,096,271	100	980,305	100

rRevised.
[1]Data do not add to total shown because of independent rounding.

Table 7.—Dimension limestone sold or used by producers in the United States, by State

State	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
Alabama	7,880	105	$898	7,596	101	$970
California	5,443	68	142	15,800	198	492
Illinois	3,000	35	128	2,238	26	103
Indiana	r177,685	r2,264	W	158,135	2,133	W
Iowa	10,197	120	508	9,645	113	509
Kansas	W	W	W	18,435	248	937
Michigan	W	W	W	442	5	30
Minnesota	9,832	122	1,831	10,339	128	2,239
Ohio	2,399	28	125	1,646	19	79
Texas	5,201	72	165	6,926	96	240
Virginia	W	W	W	1,213	15	W
Washington	W	W	59	W	W	W
Wisconsin	47,757	600	1,599	40,677	510	1,464
Other[1]	40,452	542	r11,350	22,293	327	14,218
Total[2]	r309,846	r3,956	r16,806	295,385	3,920	21,281
Puerto Rico	78,978	1,053	1,105	129,288	1,724	2,271

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Colorado, Oklahoma, New Mexico, Rhode Island, and Utah.
[2]Data may not add to totals shown because of independent rounding.

Table 8.—Crushed limestone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Alabama	24,597	68,264	21,412	65,948
Alaska	2,080	9,315	2,848	13,811
Arizona	4,903	17,660	4,580	19,017
Arkansas	7,955	20,261	8,737	24,215
California	r17,986	r51,943	17,359	61,054
Colorado	4,451	13,412	4,052	13,608
Connecticut	292	2,676	W	W
Florida	63,609	188,467	65,252	213,760
Georgia	6,442	27,540	6,143	23,738
Hawaii	1,429	5,606	W	W
Idaho	423	900	420	1,063
Illinois	63,551	188,130	53,309	180,656
Indiana	r34,134	r92,610	30,896	92,079
Iowa	32,471	103,215	26,542	92,603
Kansas	18,853	53,552	16,949	52,370
Kentucky	39,298	116,641	33,687	105,207
Maine	1,135	3,643	900	2,964
Maryland	13,889	53,950	12,018	50,659
Michigan	39,721	99,571	32,056	91,629
Minnesota	7,068	15,330	5,797	14,314
Mississippi	2,150	4,889	1,996	4,667
Missouri	54,246	135,364	46,248	125,987
Montana	1,731	5,346	1,400	4,648
Nebraska	4,995	19,362	3,775	16,301
Nevada	1,278	5,514	1,208	5,485
New Mexico	1,677	4,543	1,273	4,396
New York	r33,176	r94,139	30,894	103,404

See footnotes at end of table.

Table 8.—Crushed limestone sold or used by producers in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
North Carolina	5,478	18,483	4,592	17,736
Ohio	49,703	143,535	41,938	134,923
Oklahoma	27,649	64,599	27,091	72,684
Pennsylvania	r55,857	r175,367	47,620	171,358
South Carolina	W	W	3,185	9,470
South Dakota	2,789	6,640	2,237	5,428
Tennessee	45,714	133,584	38,580	126,827
Texas	70,661	175,357	72,956	202,517
Utah	2,838	9,697	2,712	11,246
Vermont	1,484	12,129	1,123	4,036
Virginia	22,689	67,514	18,496	62,704
Washington	1,646	4,115	1,380	3,630
West Virginia	10,684	33,827	8,277	30,506
Wisconsin	20,625	43,251	16,957	39,405
Wyoming	3,241	9,021	2,646	9,524
Other[1]	6,633	34,311	3,624	29,931
Total[2]	r811,231	r2,333,275	723,166	2,315,511
American Samoa	W	W	--	--
Guam	669	2,483	529	2,163
Puerto Rico	r11,535	r50,950	20,981	91,214

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Massachusetts, New Jersey, Oregon, and Rhode Island.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Dimension granite sold or used by producers in the United States, by State

State	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
California	15,152	185	$1,552	9,670	119	$1,180
Connecticut	4,667	49	222	8,480	87	413
Georgia	197,121	1,989	9,500	199,249	1,987	9,646
Massachusetts	46,618	564	4,249	49,719	598	W
Minnesota	26,820	313	9,680	32,359	384	11,917
Missouri	344	4	85	--	--	--
New Hampshire	85,553	1,005	5,774	103,039	1,216	7,167
North Carolina	40,092	496	3,072	49,169	608	3,849
Oklahoma	28,981	346	1,246	7,292	84	559
Oregon	14	(1)	(1)	--	--	--
South Carolina	8,586	98	482	11,660	141	703
South Dakota	35,500	403	13,268	42,315	489	15,035
Texas	11,873	142	3,471	21,521	259	6,399
Vermont	111,295	1,138	12,740	94,565	958	11,780
Other[2]	14,571	148	3,907	32,521	372	11,283
Total[3]	627,187	6,881	69,246	661,559	7,303	79,930

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Colorado, New York, Pennsylvania, Rhode Island (1980), Virginia, Washington, and Wisconsin.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—Crushed granite sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
Alabama	--	--	251	1,048
Alaska	940	3,885	767	4,142
Arizona	409	1,047	396	1,031
Arkansas	6,962	18,498	6,754	19,466
California	4,730	14,016	5,847	17,665
Colorado	2,105	4,812	1,935	5,205
Georgia	32,030	108,764	32,581	121,002
Idaho	W	W	368	1,458
Maine	30	30	--	--
Massachusetts	1,133	4,051	756	2,848
Minnesota	2,441	5,948	2,591	6,582
Montana	W	131	8	16
New Mexico	44	117	57	287
North Carolina	30,486	93,616	26,792	94,418
Oklahoma	W	W	W	144
Pennsylvania	151	550	W	W
Rhode Island	145	W	W	W
South Carolina	10,595	33,285	10,614	35,173
South Dakota	77	77	--	--
Texas	W	W	23	528
Utah	--	--	1	2
Virginia	18,845	62,380	18,238	72,578
Washington	153	413	W	W
Wyoming	1,594	W	1,703	4,754
Other[1]	r9,464	r34,009	8,267	29,640
Total[2]	122,335	385,628	117,949	417,985
Puerto Rico	W	W	W	W

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes Connecticut, Maryland, Michigan (1979), Missouri, Nevada, New Hampshire, New Jersey, New York (1979), Oregon, Vermont, and Wisconsin.
[2] Data may not add to totals shown because of independent rounding.

Table 11.—Crushed traprock sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
Alaska	492	1,788	268	1,703
California	7,421	17,725	6,440	19,077
Colorado	83	245	84	271
Connecticut	7,856	35,331	7,346	35,653
Hawaii	5,393	23,191	4,944	24,326
Idaho	2,067	4,561	795	2,086
Maine	111	493	W	W
Maryland	3,770	13,032	3,728	14,311
Massachusetts	6,589	24,377	5,790	22,949
Michigan	W	W	37	44
Montana	410	1,332	123	290
New Jersey	10,380	42,041	8,936	42,511
New Mexico	269	707	178	426
New York	3,516	17,410	2,746	14,530
North Carolina	3,578	12,053	3,128	11,805
Oregon	24,349	60,562	16,781	43,051
Pennsylvania	4,155	12,491	3,493	12,374
Texas	50	198	52	220
Utah	--	--	160	399
Virginia	6,718	23,382	5,866	24,052
Washington	12,388	28,654	8,287	21,735
Wisconsin	1,162	5,208	1,402	5,278
Wyoming	--	--	10	21
Other[1]	724	2,216	803	3,086
Total[2]	101,478	326,999	81,396	300,198
American Samoa	--	--	W	167
Puerto Rico	1,739	4,380	2,146	6,657
Virgin Islands	W	2,828	W	W

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes Minnesota, Nevada, and New Hampshire
[2] Data may not add to totals shown because of independent rounding.

Table 12.—Dimension sandstone sold or used by producers in the United States, by State

State	1979			1980		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Arizona	1,128	28	$34	W	W	(1)
Arkansas	14,268	178	528	8,085	101	$353
Colorado	2,855	37	91	5,629	72	182
Connecticut	8,373	107	253	6,917	89	310
Indiana	2,890	37	W	2,656	40	148
Maryland	20,692	259	775	5,767	72	242
Michigan	W	W	W	6,363	80	114
Minnesota	1,794	22	32	1,766	22	34
Missouri	--	--	--	200	3	W
New York	19,658	231	1,726	19,378	231	1,768
North Carolina	W	W	W	4,133	52	206
Ohio	47,351	653	1,577	33,163	456	1,479
Oregon	15	(1)	(1)	1,450	17	42
Pennsylvania	42,717	344	1,381	34,809	446	1,107
Utah	4,953	64	216	3,320	43	266
Virginia	1,899	24	43	192	2	8
Washington	1,940	24	179	864	11	40
Other[2]	50,150	r599	1,957	35,266	451	1,382
Total[3]	220,683	r2,607	8,794	169,958	2,187	7,681

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
1Less than 1/2 unit.
2Includes Alabama (1979), California, Georgia, Idaho, Montana (1979), New Jersey, Oklahoma, Tennessee, West Virginia (1979), and Wisconsin.
3Data may not add to totals shown because of independent rounding.

Table 13.—Crushed sandstone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
Arizona	394	1,837	194	758
Arkansas	4,916	12,835	5,053	15,215
California	4,625	10,058	4,131	9,482
Colorado	196	966	206	984
Georgia	1,654	5,898	W	W
Idaho	W	W	421	2,623
Kansas	454	2,486	449	2,361
Maryland	331	2,478	271	2,191
Montana	W	W	430	1,348
New Mexico	580	1,313	710	2,149
New York	708	2,297	833	2,744
Ohio	1,013	6,284	503	2,006
Oklahoma	W	W	950	3,170
Oregon	574	2,453	708	2,508
Pennsylvania	r5,298	r20,318	3,850	17,059
South Dakota	1,025	3,600	914	3,515
Texas	1,938	6,804	1,613	7,437
Utah	210	588	W	W
Virginia	1,482	5,760	1,154	3,707
Washington	705	1,971	695	1,854
West Virginia	1,028	3,798	1,489	5,799
Other[1]	4,023	14,777	4,302	15,587
Total[2]	r31,154	r106,520	28,874	102,497

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
1Includes Alabama, Connecticut (1979), Kentucky, Maine, Minnesota, Missouri, North Carolina (1979), and Wisconsin.
2Data may not add to totals shown because of independent rounding.

Table 14.—Dimension marble sold or used by producers in the United States, by State

State	1979			1980		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Alabama	W	W	W	3,216	32	$1,288
Arizona	W	W	W	2,544	30	45
California	10,327	121	$339	--	--	--
Massachusetts	1,500	15	140	1,739	17	W
Texas	--	--	--	8,440	99	456
Vermont	W	W	W	18,055	201	4,111
Other[1]	67,893	755	13,656	26,417	299	8,283
Total[2]	79,720	891	r14,134	60,411	679	14,184

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Georgia, Idaho (1980), Missouri (1980), Montana, New Mexico, North Carolina, Tennessee, and Washington (1980).
[2]Data may not add to totals shown because of independent rounding.

Table 15.—Crushed marble sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
Alabama	741	12,611	766	12,544
Arizona	63	857	54	758
California	7	212	--	--
Missouri	5	240	4	197
Nevada	([1])	2	--	--
Tennessee	4	143	4	166
Texas	59	838	112	2,117
Wyoming	W	W	15	536
Other[2]	583	10,182	393	7,413
Total[3]	1,461	25,085	1,348	23,732
Puerto Rico	W	W	W	W

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Georgia, North Carolina (1979), Utah, and Washington (1980).
[3]Data may not add to totals shown because of independent rounding.

Table 16.—Crushed calcareous marl sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
Indiana	13	19	13	27
Michigan	23	50	27	54
North Carolina	260	957	252	1,046
South Carolina	W	W	2,308	4,564
Virginia	W	10	5	10
Other[1]	2,355	3,497	1,113	2,200
Total[2]	2,650	4,533	3,719	7,901

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Florida, Maine, Mississippi, and Texas.
[2]Data may not add to totals shown because of independent rounding.

Table 17.—Crushed miscellaneous stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Alaska	144	470	107	322
California	r3,809	r9,002	3,455	8,569
Hawaii	46	172	W	W
Idaho	--	--	3	10
Maryland	433	1,264	466	1,327
Nevada	W	W	187	529
New Mexico	20	W	--	--
Oklahoma	W	W	W	270
Oregon	141	231	273	620
Pennsylvania	5,971	W	W	W
Virginia	487	1,264	160	391
Washington	299	631	626	1,626
Wyoming	W	225	--	--
Other[1]	1,149	19,912	6,604	21,009
Total[2]	r12,499	r33,171	11,882	34,674

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Louisiana, Massachusetts, Rhode Island, Vermont, and Utah (1979).
[2]Data may not add to totals shown because of independent rounding.

Table 18.—Dimension stone sold or used by producers in the United States, by use

Use	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
Rough stone:						
Rough blocks	r263,477	r3,092	r$8,638	198,708	2,439	$7,871
Irregular-shaped stone	129,667	r1,522	4,275	112,108	1,386	4,234
Rubble	99,296	r1,257	1,807	114,989	1,375	2,052
Monumental	268,124	2,779	21,583	246,521	2,504	20,912
Flagging	53,901	692	2,231	53,220	662	2,229
Other rough stone	2,265	33	50	2,276	28	58
Dressed stone:						
Cut stone	r134,537	r1,490	r25,646	144,565	1,817	30,026
Sawed stone	r58,423	r751	r9,603	71,820	949	8,690
House stone veneer	r59,205	r747	r3,221	62,147	792	3,795
Construction	16,413	197	1,574	19,103	230	2,186
Monumental	53,153	604	21,216	66,022	767	29,117
Curbing	98,311	1,177	7,621	116,859	1,393	10,519
Flagging	r52,688	r587	r2,581	42,712	477	2,399
Paving block	W	W	W	3,232	39	336
Roofing slate, standard	9,520	105	3,114	7,478	82	3,447
Roofing slate, architectural	W	W	W	140	2	60
Structural shapes	8,885	98	3,763	8,736	96	3,421
Blackboards	146	2	58	W	W	W
Flooring slate	22,956	253	4,082	28,114	309	5,345
Other dressed stone[1]	19,231	218	1,709	15,782	176	2,208
Total[2]	r1,350,198	r15,603	r122,772	1,314,532	15,523	138,907

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes billiard table tops and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 19.—Crushed stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Agricultural limestone	r32,875	r116,319	33,262	130,272
Agricultural marl and other soil conditioners	691	3,118	680	3,267
Poultry grit and mineral food	2,905	21,110	2,621	21,826
Concrete aggregate (coarse)	r141,540	r443,450	126,729	453,472
Bituminous aggregate	r99,706	r331,837	90,512	339,412
Macadam aggregate	26,090	71,433	25,131	79,515
Dense-graded roadbase stone	r254,508	r676,769	219,322	649,173
Surface treatment aggregate	r55,476	r170,735	45,294	156,303
Other construction aggregate and roadstone	r204,960	r587,217	180,717	566,012
Riprap and jetty stone	r24,735	r69,415	23,650	75,808
Railroad ballast	30,439	85,305	30,179	91,286
Filter stone	3,795	11,630	5,656	19,453
Manufactured fine aggregate (stone sand)	r19,506	r66,636	20,241	80,078
Terrazzo and exposed aggregate	1,211	14,921	1,131	13,006
Cement manufacture	r107,801	r229,084	99,106	234,576
Lime manufacture	34,702	99,556	30,261	95,051
Dead-burned dolomite	1,779	4,903	2,001	6,329
Ferrosilicon	466	2,344	133	965
Flux stone	22,381	71,026	16,123	60,133
Refractory stone (including ganister)	488	6,172	1,012	4,749
Chemical stone for alkali works	1,966	6,409	1,852	5,739
Abrasives	214	1,243	68	680
Mine dusting	1,268	10,388	1,331	10,412
Asphalt filler	1,250	6,012	948	7,141
Whiting or whiting substitute	1,361	32,537	969	23,286
Other fillers or extenders	3,755	49,250	3,730	50,511
Building materials	130	354	90	262
Chemicals	41	152	W	W
Bedding materials	34	178	308	1,118
Dam construction	45	89	--	--
Drain fields	65	179	72	150
Fill	3,004	5,567	3,803	8,129
Slate flour	70	857	54	1,067
Glass manufacture	2,190	14,727	2,134	15,841
Lightweight aggregate	590	7,635	503	8,053
Paper manufacture	128	446	89	397
Roofing granules	5,264	18,221	4,460	17,295
Sugar refining	1,367	6,507	1,518	7,433
Waste materials	39	76	53	145
Sulfur removal from stack gases	967	2,942	667	2,129
Other[1]	6,469	18,540	3,893	14,095
Total[2]	r1,096,271	r3,265,287	980,305	3,254,572

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes acid neutralization, carbon dioxide (1980), disinfectant and animal sanitation (1979), magnesium metal manufacture (1979), porcelain (1979), and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 20.—Dimension limestone sold or used by producers in the United States, by use

Use	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
Rough stone:						
Rough blocks	r123,361	r1,507	r$3,891	89,477	1,179	$3,483
Irregular-shaped stone	5,785	74	172	7,987	128	335
Rubble	43,939	573	647	37,845	492	587
Flagging	26,645	357	414	18,667	249	358
Other rough stone	45	1	1	56	1	2
Dressed stone:						
Cut stone	r37,563	r501	r6,817	42,074	564	8,302
Sawed stone	r27,005	r368	r2,263	52,955	719	5,317
House stone veneer	r37,619	r481	r2,143	38,851	498	2,432
Construction	5,823	69	223	5,493	66	223
Curbing	311	4	15	196	2	12
Flagging	r1,470	r18	r101	1,510	19	106
Other	280	4	118	274	3	125
Total[1]	r309,846	r3,956	r16,806	295,385	3,920	21,281

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 21.—Crushed limestone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Agricultural limestone	r32,875	r116,319	33,262	130,272
Agricultural marl and other soil conditioners	436	2,136	391	2,167
Poultry grit and mineral food	2,442	19,567	2,335	20,664
Concrete aggregate	r113,437	r342,697	98,158	336,576
Bituminous aggregate	r66,930	r213,132	57,835	204,794
Macadam aggregate	22,646	59,884	19,897	59,719
Dense-graded roadbase stone	r169,508	r423,392	151,869	418,500
Surface treatment aggregate	r38,537	r122,582	36,445	126,260
Other construction aggregate and roadstone	r135,020	r371,625	116,622	355,856
Riprap and jetty stone	r16,253	r43,163	15,321	46,709
Railroad ballast	14,035	37,635	12,966	38,631
Filter stone	2,689	7,911	3,497	11,308
Manufactured fine aggregate (stone sand)	r15,625	r51,422	15,204	58,716
Terrazzo and exposed aggregate	624	7,531	577	6,091
Cement manufacture	r103,474	r219,880	94,009	222,167
Lime manufacture	34,054	98,042	29,662	93,629
Dead-burned dolomite	1,779	4,903	2,001	6,329
Flux stone	21,271	64,945	15,313	55,885
Refractory stone	20	64	880	2,001
Chemical stone for alkali works	1,966	6,409	1,852	5,739
Abrasives	141	656	49	526
Mine dusting	1,267	10,379	1,307	10,349
Asphalt filler	1,007	r4,887	761	6,048
Whiting or whiting substitute	1,085	29,970	666	20,742
Other filler or extenders	2,792	31,691	2,808	32,964
Building products	129	350	88	258
Other chemicals	41	152	W	W
Dam construction	22	44	--	--
Fill	2,127	4,090	2,092	4,804
Glass manufacture	2,146	14,507	2,134	15,841
Paper manufacture	128	446	89	397
Roofing granules	376	2,307	476	3,589
Sugar refining	1,367	r6,507	1,518	7,433
Waste material	39	76	53	145
Sulfur removal from stack gases	967	2,942	667	2,129
Other[1]	3,977	11,033	2,362	8,275
Total[2]	r811,231	r2,333,275	723,166	2,315,511

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes acid neutralization, bedding material (1980), drain fields, carbon dioxide (1980), disinfectant and animal sanitation (1979), ferrosilicon, magnesium metal manufacture (1979), porcelain (1979), and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 22.—Dimension granite sold or used by producers in the United States, by use

Use	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
Rough stone:						
Rough blocks	95,140	998	$3,600	84,591	948	$3,504
Irregular-shaped stone	13,328	145	485	26,464	303	1,002
Rubble	18,017	209	238	45,091	469	782
Monumental	267,011	2,767	21,511	245,406	2,492	20,832
Flagging	W	W	W	154	2	9
Other rough stone	234	2	14	350	4	17
Dressed stone:						
Cut stone	59,132	716	13,918	65,214	785	16,740
Sawed stone	4,030	48	181	1,172	14	217
House stone veneer	4,932	60	167	5,425	66	220
Construction	5,126	64	690	8,398	103	1,265
Monumental	50,147	571	19,864	56,215	653	23,639
Curbing	97,673	1,169	7,572	116,340	1,386	10,473
Flagging	W	W	W	61	1	3
Paving block	W	W	W	3,232	39	336
Other	12,417	133	1,007	3,446	38	890
Total[1]	627,187	6,881	69,246	661,559	7,303	79,930

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 23.—Crushed limestone sold or used by producers

(Thousand short tons

State	Aggregates		Cement		Aglime		Lime	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	11,939	35,812	3,735	9,241	991	3,993	2,606	10,293
Alaska	2,847	13,809	--	--	--	--	--	--
Arizona	149	810	W	W	--	--	950	4,851
Arkansas	4,555	12,855	W	W	470	1,651	W	W
California	2,670	8,292	12,053	31,102	39	216	416	1,146
Colorado	W	1,954	2,643	8,769	3	8	39	126
Connecticut	W	W	11	20	80	585	8	15
Florida	57,691	187,358	2,337	5,615	1,729	8,299	449	1,120
Georgia	3,937	15,222	W	W	242	1,316	--	--
Hawaii	557	3,623	786	2,388	W	W	W	W
Idaho	11	31	W	W	29	86	--	--
Illinois	41,506	135,808	2,597	6,453	5,158	17,647	W	W
Indiana	24,123	72,048	2,769	5,936	2,446	7,881	--	--
Iowa	18,491	66,662	2,864	4,944	3,074	11,041	W	W
Kansas	12,166	41,309	3,322	6,892	719	1,828	--	--
Kentucky	24,874	79,364	935	1,740	2,111	7,008	W	W
Maine	246	749	W	W	W	W	--	--
Maryland	8,979	31,311	2,250	3,807	W	W	W	W
Massachusetts	W	W	--	--	142	1,420	W	W
Michigan	8,364	23,749	6,589	14,455	221	773	7,698	22,580
Minnesota	4,663	11,145	--	--	527	1,411	5	19
Mississippi	404	961	W	W	632	1,955	--	--
Missouri	28,726	82,758	5,519	11,646	4,009	11,679	2,902	5,635
Montana	292	W	W	W	--	--	37	W
Nebraska	2,305	10,382	W	W	204	808	11	41
Nevada	50	121	W	W	--	--	W	W
New Mexico	734	2,209	W	W	--	--	84	320
New York	22,917	83,273	5,222	9,758	346	2,165	W	W
North Carolina	3,506	13,585	W	W	W	W	--	--
Ohio	29,291	91,601	2,744	10,894	1,838	7,103	3,165	7,845
Oklahoma	20,577	55,087	2,352	4,248	457	995	W	W
Pennsylvania	29,897	102,224	7,320	17,073	1,992	12,712	2,768	10,470
South Carolina	2,659	6,778	--	--	W	W	--	--
South Dakota	1,111	3,300	W	W	W	W	210	398
Tennessee	32,035	102,789	1,783	5,383	1,864	5,973	324	1,171
Texas	57,219	161,183	9,490	17,276	299	639	2,446	7,792
Utah	84	430	1,076	3,544	178	1,228	W	W
Vermont	778	2,428	--	--	W	W	--	--
Virginia	12,584	41,234	1,470	2,556	1,678	9,421	1,488	3,731
Washington	196	667	W	W	24	307	--	--
West Virginia	6,031	23,296	W	W	60	368	W	W
Wisconsin	15,504	34,033	--	--	837	2,848	135	427
Wyoming	1,271	4,966	W	W	46	197	--	--
Total (excluding withheld)	495,939	1,565,216	79,867	183,740	32,445	123,561	25,741	77,980
Total withheld[2]	1,144	4,885	14,141	38,427	820	6,711	3,920	15,650
U.S. total[3]	497,083	1,570,000	94,009	222,167	33,262	130,272	29,662	93,629
Guam	516	2,131	--	--	--	--	--	--
Puerto Rico	W	W	W	W	--	--	--	--

W Withheld to avoid disclosing company proprietary data; included with "Total withheld."
[1]Less than 1/2 unit.
[2]Includes New Jersey, Oregon, and Rhode Island.
[3]Data may not add to totals shown because of independent rounding.

in the United States in 1980, by State and use

and thousand dollars)

Flux stone		Riprap		Railroad ballast		Other uses		Total[3]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
468	1,248	573	1,866	200	574	900	2,920	21,412	65,948
--	--	1	2	--	--	--	--	2,848	13,811
276	1,317	W	W	W	2,813	3,204	9,227	4,580	19,017
W	W	274	859	328	943	3,111	7,906	8,737	24,215
142	652	106	284	--	--	1,933	19,361	17,359	61,054
418	W	W	88	--	--	949	2,662	4,052	13,608
W	W	--	--	--	--	W	W	W	W
--	--	59	398	W	W	2,987	10,970	65,252	213,760
--	--	39	134	W	W	1,926	7,065	6,143	23,738
--	--	--	--	--	--	W	W	W	W
--	--	--	--	--	--	380	947	420	1,063
586	1,994	631	1,974	857	2,634	1,975	14,148	53,309	180,656
W	W	295	1,021	791	2,313	473	2,881	30,896	92,079
W	W	278	1,128	659	1,881	1,176	6,946	26,542	92,603
--	--	381	1,265	34	138	327	938	16,949	52,370
31	110	3,413	9,357	308	943	2,015	6,686	33,687	105,207
--	--	2	11	W	W	652	2,203	900	2,964
--	--	146	747	78	160	565	14,634	12,018	50,659
W	W	(1)	(1)	--	--	W	W	W	W
7,702	25,910	443	1,168	W	W	1,039	2,996	32,056	91,629
--	--	102	313	W	W	499	1,427	5,797	14,314
--	--	170	447	W	W	790	1,304	1,996	4,667
W	W	3,735	8,979	177	359	1,179	4,931	46,248	125,987
45	174	--	--	--	--	1,025	4,474	1,400	4,648
3	16	77	388	W	W	1,175	4,667	3,775	16,301
W	W	2	4	--	--	1,156	5,359	1,208	5,485
16	W	6	8	W	W	434	1,859	1,273	4,396
W	W	543	2,390	327	1,057	1,538	4,761	30,894	103,404
--	--	W	W	W	W	1,086	4,151	4,592	17,736
1,924	5,535	450	1,577	1,134	3,053	1,393	7,316	41,938	134,923
--	--	1,163	3,406	1,897	5,783	645	3,165	27,091	72,684
2,307	10,846	491	2,168	1,170	4,288	1,675	11,577	47,620	171,358
--	--	W	W	W	W	526	2,692	3,185	9,470
--	--	W	W	78	163	838	1,567	2,237	5,428
--	--	595	1,842	218	660	1,762	9,010	38,580	126,827
364	1,039	229	1,004	871	2,866	2,037	10,718	72,956	202,517
W	W	W	W	W	W	1,374	6,045	2,712	11,246
--	--	13	51	W	W	332	1,558	1,123	4,036
137	346	73	262	120	343	947	4,811	18,496	62,704
--	--	W	W	--	--	1,160	2,657	1,380	3,630
--	--	53	236	507	1,060	1,626	5,546	8,277	30,506
13	38	380	1,862	14	25	74	171	16,957	39,405
--	--	W	W	W	W	1,328	4,360	2,646	9,524
14,432	49,225	14,722	45,239	9,768	32,056	48,211	216,616	719,541	2,285,577
881	6,660	597	1,467	3,197	6,575	2,039	21,879	3,624	29,931
15,313	55,885	15,321	46,709	12,966	38,631	25,550	158,119	723,166	2,315,511
--	--	3	6	--	--	10	26	529	2,163
--	--	--	--	--	--	--	--	20,981	91,214

Table 24.—Crushed granite sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Poultry grit and mineral food	25	248	36	422
Concrete aggregate	15,834	53,875	18,144	70,435
Bituminous aggregate	14,644	50,037	16,694	66,583
Macadam aggregate	1,205	4,432	1,863	7,564
Dense-graded roadbase stone	37,642	113,654	32,228	109,432
Surface treatment aggregate	7,596	24,742	3,422	12,408
Other construction aggregate and roadstone	25,890	83,249	22,718	77,636
Riprap and jetty stone	2,436	7,928	2,836	11,074
Railroad ballast	11,564	30,581	12,278	35,231
Filter stone	405	1,424	1,458	5,574
Manufactured fine aggregate (stone sand)	1,820	5,484	3,026	10,101
Terrazzo and exposed aggregate	61	480	206	1,393
Asphalt filler	143	671	144	810
Fill	244	445	322	630
Roofing granules	1,764	4,717	1,599	4,594
Other[1]	1,061	3,659	975	4,097
Total[2]	122,335	385,628	117,949	417,985

[1]Includes bedding material, and uses not specified.
[2]Data may not add to totals shown because of independent rounding.

Table 25.—Crushed traprock sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Concrete aggregate	9,145	34,569	7,635	35,144
Bituminous aggregate	12,791	50,572	11,633	52,384
Macadam aggregate	1,864	5,889	2,579	9,429
Dense-graded roadbase stone	31,539	93,600	20,222	69,769
Surface treatment aggregate	7,231	16,617	3,925	11,729
Other construction aggregate and roadstone	27,351	85,976	25,074	82,106
Riprap and jetty stone	4,015	11,820	3,665	11,577
Railroad ballast	3,642	13,554	3,397	13,041
Filter stone	345	989	409	1,479
Manufactured fine aggregate (stone sand)	957	5,194	986	7,041
Terrazzo and exposed aggregate	7	76	10	56
Mine dusting	--	--	24	63
Other filler	W	W	22	117
Building products	W	W	2	4
Bedding materials	W	W	W	19
Drain fields	W	W	1	2
Fill	165	327	W	W
Roofing granules	2,131	6,705	1,526	5,138
Other[1]	296	1,112	285	1,099
Total[2]	101,478	326,999	81,396	300,198

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes asphalt filler and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 26.—Dimension sandstone sold or used by producers in the United States, by use

Use	1979			1980		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Rough stone:						
Rough blocks	37,475	504	$730	17,343	232	$424
Irregular-shaped stone	63,512	r769	1,526	43,600	556	1,344
Rubble	28,053	r364	655	26,590	348	552
Flagging	24,667	305	1,741	20,104	244	1,610
Other rough stone	1,985	30	35	1,776	22	34
Dressed stone:						
Cut stone	33,480	224	2,380	30,339	389	1,972
Sawed stone	10,607	144	607	8,120	112	488
House stone veneer	9,457	122	415	14,560	191	713
Construction	1,645	21	38	2,226	28	61
Flagging	8,361	104	452	4,488	55	335
Other dressed stone[1]	1,441	18	215	812	11	148
Total[2]	220,683	r2,607	8,794	169,958	2,187	7,681

rRevised.
[1]Includes monumental (1980), curbing, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 27.—Crushed sandstone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Concrete aggregate	2,772	11,145	2,393	10,096
Bituminous aggregate	4,749	16,263	3,699	13,332
Macadam aggregate	W	W	228	1,084
Dense-graded roadbase stone	6,892	19,159	7,123	21,062
Surface treatment aggregate	1,361	4,701	1,219	5,101
Other construction aggregate and roadstone	7,234	19,093	7,373	22,986
Riprap and jetty stone	850	3,070	1,143	4,371
Railroad ballast	1,153	3,425	1,448	4,075
Filter stone	344	1,271	227	971
Manufactured fine aggregate (stone sand)	1,092	4,283	934	3,815
Terrazzo and exposed aggregate	254	1,627	100	1,446
Cement manufacture	r710	r2,435	669	2,382
Ferrosilicon	191	1,348	87	848
Flux stone	1,110	6,081	810	4,248
Refractory stone	469	6,108	133	2,749
Abrasives	72	587	18	155
Asphalt filler	7	40	--	--
Other fillers or extenders	110	916	W	W
Drain fields	W	W	67	131
Fill	443	673	205	261
Dam construction	23	45	--	--
Roofing granules	W	W	751	1,876
Other[1]	1,316	4,251	247	1,508
Total[2]	r31,154	r106,520	28,874	102,497

rRevised.
W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes poultry grit, mine dusting (1979), glass manufacture (1979), and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 28.—Dimension marble sold or used by producers in the United States, by use

Use	1979			1980		
	Short tons	Cubic feet (thousands)	Value (thousands)	Short tons	Cubic feet (thousands)	Value (thousands)
Rough stone:						
Rough blocks	5,846	61	$364	5,765	61	$413
Irregular-shaped stone	33,450	371	1,661	20,390	235	1,066
Rubble	3,597	42	118	--	--	--
Monumental stone	W	W	W	1,115	12	80
Flagging	975	11	42	W	W	W
Dressed stone:						
Cut stone	3,597	41	2,492	6,083	69	2,961
Sawed stone	16,781	190	6,552	9,573	104	2,668
House stone veneer	W	W	W	3,198	36	426
Construction stone	W	W	W	1,286	13	562
Monumental stone	W	W	W	9,801	113	5,477
Other dressed stone[1]	15,474	175	2,904	3,200	36	531
Total	79,720	891	r [2]14,134	60,411	679	14,184

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes flagging (1980) and other uses.
[2]Data do not add to total shown because of independent rounding.

Table 29.—Crushed marble sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Poultry grit and mineral food	16	163	15	166
Manufactured fine aggregate (stone sand)	W	W	14	267
Terrazzo and exposed aggregate	200	4,919	169	3,840
Whiting or whiting substitute	276	2,567	W	W
Other[1]	970	17,435	1,150	19,459
Total[2]	1,461	25,085	1,348	23,732

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes concrete aggregate, roadbase aggregate (1979), riprap (1980), other fillers or extenders, and roofing granules.
[2]Data may not add to totals shown because of independent rounding.

Table 30.—Dimension slate sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979		1980	
	Quantity	Value	Quantity	Value
Flagging	35,362	1,632	36,599	1,953
Roofing slate, standard	9,520	3,114	7,478	3,447
Roofing slate, architectural	W	W	140	60
Structural and sanitary	8,675	3,583	8,736	3,421
Blackboards, bulletin boards, school slates	146	58	W	W
Flooring slate	22,956	4,082	28,114	5,345
Other[1]	10,623	352	9,295	593
Total	87,282	12,821	90,362	[2]14,820

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes house stone veneer, billiard tables, and other uses.
[2]Data do not add to total shown because of independent rounding.

Table 31.—Crushed shell sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Poultry grit and mineral food	415	1,100	228	547
Dense-graded roadbase stone	3,344	11,828	2,652	13,871
Other construction aggregate and roadstone	5,392	17,468	5,001	16,881
Cement manufacture	1,272	3,298	1,200	3,751
Fill	W	W	W	1,039
Other[1]	1,754	4,878	1,834	3,969
Total[2]	12,177	38,572	10,914	40,060

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes bituminous aggregate, riprap, lime manufacture, and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 32.—Miscellaneous dimension stone sold or used by producers in the United States, by use

Use	1979 Short tons	1979 Cubic feet (thousands)	1979 Value (thousands)	1980 Short tons	1980 Cubic feet (thousands)	1980 Value (thousands)
Rough stone:						
Rough blocks	1,500	19	$41	1,500	19	$44
Irregular-shaped stone	13,551	163	429	13,658	164	487
Rubble	5,690	69	149	3,756	46	106
Flagging	101	1	6	610	7	21
Dressed stone:						
House stone veneer	--	--	--	31	(1)	1
Flagging	W	W	W	50	1	1
Other[2]	2,975	34	303	2,555	30	125
Total[3]	23,817	287	928	22,160	268	786

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes dressed construction stone, cut stone, and structural shapes (1979).
[3]Data may not add to totals shown because of independent rounding.

Table 33.—Crushed miscellaneous stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1979 Quantity	1979 Value	1980 Quantity	1980 Value
Concrete aggregate	318	911	372	995
Bituminous aggregate	519	1,657	579	2,132
Macadam aggregate	372	1,221	563	1,719
Dense-graded roadbase stone	r5,498	r14,958	5,074	16,133
Surface treatment aggregate	751	2,093	283	808
Other construction aggregate and roadstone	3,669	8,836	3,529	9,477
Riprap and jetty stone	1,006	2,233	592	1,395
Railroad ballast	45	111	90	308
Filter stone	12	35	W	W
Terrazzo and exposed aggregate	64	288	70	180
Other fillers	2	10	5	30
Fill	9	15	556	1,113
Roofing granules	32	148	W	W
Other[1]	202	656	168	384
Total[2]	r12,499	r33,171	11,882	34,674

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes manufactured fine aggregate (stone sand).
[2]Data may not add to totals shown because of independent rounding.

Table 34.—Unit values of stone sold or used by producers in the United States

Stone	1979 Dimension stone Per ton	1979 Dimension stone Per cubic foot	1979 Crushed stone, per ton	1980 Dimension stone Per ton	1980 Dimension stone Per cubic foot	1980 Crushed stone, per ton
Limestone	r$54.24	r$4.25	$2.88	$72.04	$5.43	$3.20
Granite	110.41	r10.06	3.15	121.00	10.94	3.54
Traprock	25.09	2.10	3.22	15.39	1.30	3.69
Sandstone	39.85	r3.37	3.42	45.19	3.51	3.55
Marble	177.30	15.85	17.17	234.79	20.89	17.61
Slate	146.89	13.36	8.94	164.00	14.90	11.36
Shell	--	--	3.17	--	--	3.67
Marl	--	--	1.71	--	--	2.12
Miscellaneous	38.98	3.24	2.65	35.45	2.93	2.92
Average	r90.93	r7.87	2.98	105.67	8.95	3.32

rRevised.

Table 35.—Exports of dimension stone, by destination and type[1]

(Thousand short tons)

Type	Canada		Japan		Other		Total	
	1979	1980	1979	1980	1979	1980	1979	1980
Granite:								
Rough blocks	28	42	35	21	14	16	77	79
Other	3	4	1	(2)	5	5	9	9
Total[3]	31	46	36	21	19	21	86	88
Limestone:								
Rough blocks	12	6	--	--	47	1	59	7
Other	7	16	--	(2)	1	1	8	17
Total[4]	19	22	--	(2)	48	2	67	24
Marble[5]	7	14	--	1	20	20	27	35
Slate[6]	6	5	1	(2)	4	8	11	13
Other:								
Rough blocks	6	7	15	5	5	5	26	17
Other including alabaster	2	4	1	1	5	5	8	10
Total[7]	8	11	16	6	10	10	34	27
Grand total	71	98	53	28	101	61	225	187

[1]Partly estimated from reported values.
[2]Less than 1/2 unit.
[3]Includes Costa Rica (1979), Italy, Mexico, the Bahamas (1980), Austria (1979), the United Kingdom (1979), and Saudi Arabia, in order of volume.
[4]Includes Venezuela (1979), Chile (1979), Mexico (1980), and Peru (1980), in order of volume.
[5]Includes Taiwan, Mexico, the Bahamas, Saudi Arabia, Ecuador (1979), and the Netherlands Antilles (1979), in order of volume.
[6]Includes Saudi Arabia, Mexico (1980), and the Bahamas (1980), in order of volume.
[7]Includes Mexico (1980), the Federal Republic of Germany, Belgium (1980), and the Bahamas (1980), in order of volume.

Table 36.—Exports of crushed stone, by destination and type

(Thousand short tons)

Country	Limestone		Other[1]		Total	
	1979	1980	1979	1980	1979	1980
North America:						
Bahamas	(2)	(2)	88	57	88	57
Canada	3,629	2,647	132	128	3,761	2,775
Other[3]	7	8	13	16	20	24
Total	3,636	2,655	233	201	3,869	2,856
South America:						
Venezuela	301	68	2	23	303	91
Other[4]	1	18	2	5	3	23
Total	302	86	4	28	306	114
Europe:						
France	--	--	20	18	20	18
Other[5]	1	2	30	15	31	17
Total	1	2	50	33	51	35
Asia:						
Japan	--	--	4	60	4	60
Other[6]	(2)	(2)	4	8	4	8
Total	(2)	(2)	8	68	8	68

See footnotes at end of table.

Table 36.—Exports of crushed stone, by destination and type —Continued

(Thousand short tons)

Country	Limestone 1979	Limestone 1980	Other[1] 1979	Other[1] 1980	Total 1979	Total 1980
Oceania	([2])	1	1	9	1	10
Middle East	([2])	([2])	1	1	1	1
Grand total	3,939	2,744	[r]297	[7]340	[r]4,236	3,084

[r]Revised.
[1]Includes quartzite, slate, and other stone.
[2]Less than 1/2 unit.
[3]Includes the Bahamas, Mexico, Costa Rica (1979), Honduras (1980), Guatemala (1980), and the Dominican Republic, in order of tonnage.
[4]Includes Brazil (1980), Argentina (1980), Uruguay (1980), Guyana (1979), and Chile (1979), in order of tonnage.
[5]Includes the United Kingdom, Sweden (1979), the Netherlands (1979), Belgium, and the Federal Republic of Germany, in order of tonnage.
[6]Includes Philippine Islands, the Republic of Korea (1979), Singapore, and India (1979), in order of tonnage.
[7]Quartzite, 10,000 tons; slate waste and powder, 17,000 tons.

Table 37.—U.S. imports of dimension stone, by type

Type	1979 Quantity	1979 Customs value (thousands)	1980 Quantity	1980 Customs value (thousands)
Granite:				
Rough blocks thousand cubic feet	201	$2,787	260	$2,958
Dressed including monumental do	396	9,713	456	18,383
Other, n.s.p.f.	([1])	325	([1])	1,427
Total	XX	12,825	XX	22,768
Marble, breccia, and onyx:				
In block, rough, or squared cubic feet	14,798	241	15,374	324
Sawed or dressed, over 2 inches thick do	1,003	19	448	22
Slabs and tiles thousand square feet	8,382	17,518	9,332	23,725
All other manufactures	([1])	14,019	([1])	15,504
Total	XX	31,797	XX	39,575
Travertine stone:				
Rough, unmanufactured cubic feet	15,838	89	35,886	164
Dressed, suitable for monumental and other uses short tons	42,182	8,544	29,997	12,206
Other, n.s.p.f.	([1])	632	([1])	1,133
Total	XX	9,265	XX	13,503
Limestone:				
Rough blocks cubic feet	[r]38,819	71	16,434	29
Dressed manufactured short tons	289	109	471	214
Other, n.s.p.f.	([1])	51	([1])	129
Total	XX	231	XX	372
Slate:				
Roofing square feet	36,200	22	79,850	38
Other, n.s.p.f.	([1])	6,570	([1])	7,484
Total	XX	6,592	XX	7,522
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures short tons	([1])	[r]492	([1])	384
Stone, unmanufactured do	12,230	204	11,248	249
Building stone, rough cubic feet	19,399	30	3,961	18
Building stone, dressed short tons	530	68	1,030	183
Other including alabaster	([1])	4,299	([1])	4,374
Total	XX	[r]5,093	XX	5,208
Grand total	XX	[r]65,803	XX	88,948

[r]Revised. XX Not applicable.
[1]Quantity not reported.

Table 38.—U.S. imports of crushed stone fines, by type

Type	1979 Quantity	1979 Customs value (thousands)	1980 Quantity	1980 Customs value (thousands)
Crushed stone and chips:				
Limestone thousand short tons	2,302	$5,434	2,375	$6,966
Marble, breccia, onyx short tons	r4,287	210	2,109	113
Quartzite thousand short tons	r97	822	16	302
Slate short tons	281	4	--	--
Other thousand short tons	1,432	3,484	1,198	3,286
Total do	r3,835	9,954	3,591	10,667
Calcium carbonate fines:				
Chalk, natural crude do	461	600	280	369
Chalk, whiting do	34	3,282	8	858
Precipitated do	9	2,145	6	2,021
Total do	504	6,027	294	3,248
Grand total do	r4,339	15,981	3,885	13,915

rRevised.

Sulfur and Pyrites

By John E. Shelton[1]

The net shipment value f.o.b. mine or plant for elemental sulfur increased 58% in 1980 over that of 1979. Production, shipments, stocks of elemental sulfur, apparent consumption, and exports all decreased in 1980. Imports increased slightly in 1980. The average net shipment value f.o.b. mine or plant for Frasch and recovered elemental sulfur increased from $55.75 per metric ton in 1979 to $88.93 per metric ton in 1980. The 1980 yearend quoted price for Frasch sulfur was $119.09 per metric ton, Gulf ports, and $137.79 per metric ton, exterminal Tampa.

Production of sulfur in all forms was down 2% in 1980. For the fifth year, domestic production was less than apparent domestic consumption. Production of elemental sulfur was concentrated in Texas and Louisiana. Together, these two States accounted for 66% of the total output in 1980. Shipments of sulfur in all forms by U.S. producers to domestic and export markets were 12.9 million tons, a decrease of 3% below those of 1979. The total value of

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise noted)

	1976	1977	1978	1979	1980
United States:					
Production:					
Frasch	6,365	5,915	5,648	6,357	6,390
Recovered elemental	3,188	3,624	4,062	4,070	4,046
Other forms	1,326	1,188	1,465	1,674	1,403
Total	10,879	10,727	11,175	12,101	11,839
Shipments:					
Frasch	5,954	6,030	5,736	7,507	7,400
Recovered elemental	3,196	3,627	4,088	4,108	4,091
Other forms	1,326	1,188	1,465	1,674	1,403
Total	10,476	10,845	11,289	13,289	12,894
Imports, elemental and pyrites	1,755	2,009	2,177	2,494	2,523
Exports, crude and refined[1]	1,217	1,088	827	1,963	1,673
Consumption, apparent, all forms[2]	10,941	11,657	12,600	13,739	13,635
Stocks, Dec. 31: Producer, Frasch and recovered elemental	5,652	5,557	5,345	4,239	3,091
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$299,999	$294,733	$279,918	$449,433	$720,511
Recovered elemental	118,322	133,849	163,799	198,137	301,390
Other forms	59,050	57,304	68,295	89,643	84,332
Total	477,371	485,886	512,012	737,213	1,106,233
Imports, elemental[3]	$59,494	$65,154	$75,671	$94,147	$138,852
Exports, crude and refined[3] [4]	$63,584	$52,111	$34,667	$142,966	$185,866
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$45.72	$44.38	$45.17	$55.75	$88.93
World production: All forms (including pyrites)	50,908	52,383	53,948	55,207	56,077

[1]Excludes exports from the Virgin Islands to foreign countries.
[2]Measured by shipments, plus imports, minus exports.
[3]Declared customs valuation.
[4]Excludes value of exports from the Virgin Islands to foreign countries.

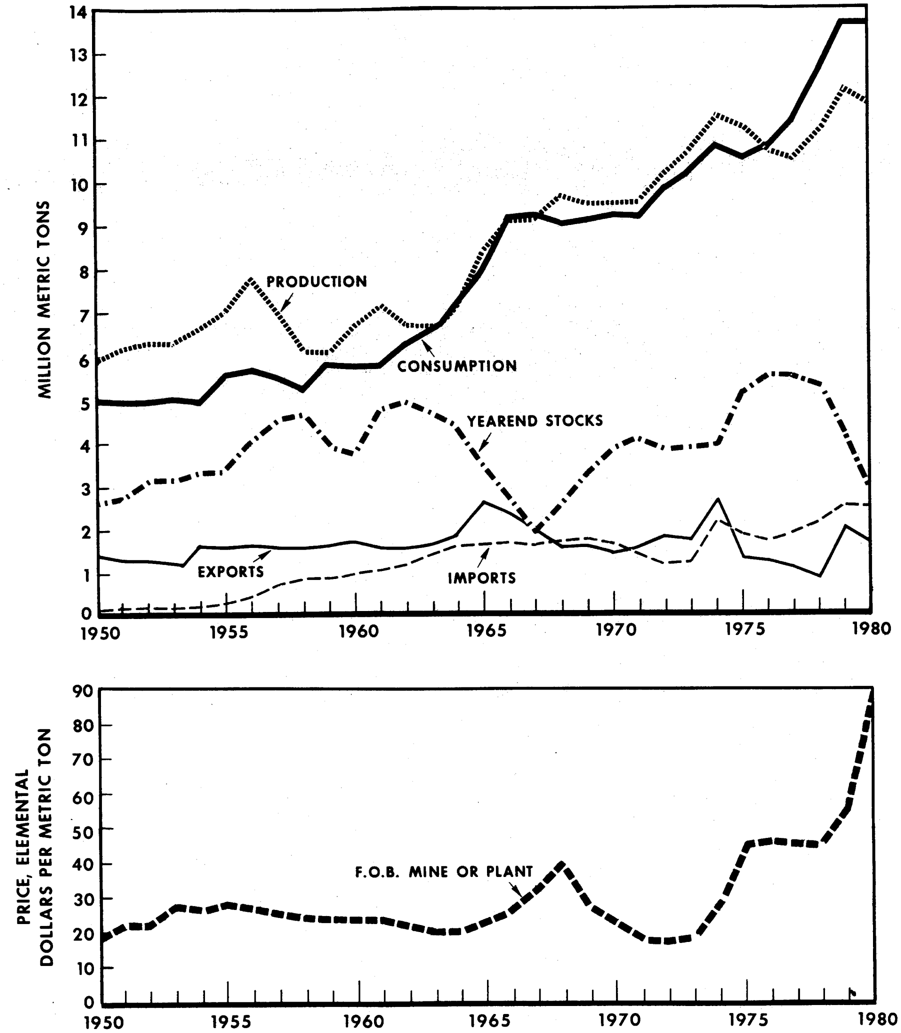

Figure 1.—Trends in the sulfur industry in the United States.

shipments f.o.b. mine or plant was $1.1 billion in 1980, up from $737 million in 1979. The apparent domestic consumption of sulfur in all forms declined slightly to 13.6 million tons in 1980. The United States was a net importer again in 1980.

Legislation and Government Programs.—A report evaluating the sources of sulfur and the impact of byproduct sulfur on sulfur supply prepared by the University of Arizona under contract with the Bureau of Mines was completed. The report was placed on open file at the U.S. Department of the Interior library and Bureau of Mines Field Operations Centers in Pittsburgh, Pa.; Denver, Colo.; Spokane, Wash.; Tuscaloosa, Ala.; and the Boulder City Engineering Laboratory, Boulder City, Nev.

DOMESTIC PRODUCTION

Frasch Sulfur.—In 1980, there were 10 Frasch mines, all in Louisiana and Texas. Mines in Louisiana were Freeport Minerals Co.'s at Garden Island Bay, Grand Isle, and the newly opened mine at Caillou Island. Producers' mines in Texas were Farmland Industries, Inc., at Fort Stockton; Duval Corp. at Culberson and Phillips Ranch; Jefferson Lake Sulfur Co. at Long Point Dome; and Texasgulf, Inc., at Boling Dome, Moss Bluff Dome, and at Comanche Creek. The eight mines operated by Duval, Freeport Minerals, and Texasgulf accounted for most of the Frasch sulfur production. A relatively small portion of the output was from the other two producers operating one mine each.

Of producers' shipments of Frasch sulfur, 23% were for export. The value of Frasch sulfur shipments in 1980 reached a new high of $721 million. Reported stocks after inventory adjustments were drawn down by 1.1 million metric tons to 2,954,000 tons.

Recovered Sulfur.—Production in 1980 of recovered elemental sulfur, a nondiscretionary byproduct from natural gas and petroleum refinery operations, electric utilities, and coking plants, declined slightly to 4.0 million tons. This type of sulfur was produced by 63 companies at 160 plants in 28 States, 2 plants in Puerto Rico, and 1 plant in the Virgin Islands. Most of the plants were of relatively small size, with only four reporting an annual production exceeding 100,000 tons.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand metric tons)

	1977		1978		1979		1980	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	5,915	5,915	5,648	5,648	6,357	6,357	6,390	6,390
Recovered elemental sulfur	3,624	3,624	4,062	4,062	4,070	4,070	4,046	4,046
Byproduct sulfuric acid (basis 100%) produced at copper, zinc, and lead plants	2,936	960	3,373	1,103	3,570	1,167	[1]3,069	[1]1,003
Pyrites	442	169	778	301	1,049	400	847	322
Other forms[2]	85	59	93	61	182	107	124	78
Total	XX	10,727	XX	11,175	XX	12,101	XX	11,839

XX Not applicable.
[1]Includes byproduct sulfuric acid from molybdenum plants.
[2]Hydrogen sulfide and liquid sulfur dioxide.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total	Quantity	Value[1]
1976	3,838	2,527	6,365	5,954	299,999
1977	3,454	2,461	5,915	6,030	294,733
1978	3,720	1,928	5,648	5,736	279,918
1979	3,897	2,460	6,357	7,507	449,433
1980	4,081	2,309	6,390	7,400	720,511

[1]F.o.b. mine.

Table 4.—Recovered sulfur produced and shipped in the United States

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Natural gas plants	Petroleum refineries[1]	Total	Quantity	Value[2]
1976	1,298	1,890	3,188	3,196	118,322
1977	1,426	2,198	3,624	3,627	133,849
1978	1,753	[3]2,309	4,062	4,088	163,799
1979	1,760	[3]2,310	4,070	4,108	198,137
1980	1,730	[3]2,316	4,046	4,091	301,390

[1]Includes a small quantity from a coking operation.
[2]F.o.b. plant.
[3]Includes a small quantity from utility plants.

Table 5.—Recovered sulfur produced and shipped in the United States, by State

(Thousand metric tons and thousand dollars)

State	1979			1980		
	Production (quantity)	Shipments Quantity	Shipments Value	Production (quantity)	Shipments Quantity	Shipments Value
Alabama	373	375	20,318	376	374	32,010
California	475	493	12,261	480	480	17,616
Florida	335	335	W	303	304	W
Illinois	196	196	8,269	207	208	12,507
Indiana	62	61	2,542	68	68	2,089
Kansas	22	23	1,008	21	21	1,337
Louisiana	186	186	11,093	209	209	17,382
Michigan and Minnesota	84	85	2,865	79	81	3,085
Mississippi	539	563	35,618	534	569	57,272
New Jersey	108	109	5,668	120	118	7,273
New Mexico	67	66	3,051	61	62	4,264
Ohio	23	23	905	21	21	1,377
Oklahoma	11	11	461	8	8	586
Pennsylvania	70	71	3,222	58	57	3,403
Texas	1,081	1,084	54,851	1,111	1,104	87,986
Wisconsin	1	1	34	1	1	23
Wyoming	47	48	W	47	46	1,506
Other States[1]	388	379	35,971	345	361	51,676
Total[2]	4,070	4,108	198,137	4,046	4,091	301,390

W Withheld to avoid disclosing company proprietary data; included with "Other States."
[1]Combined to avoid disclosing company proprietary data; includes Arkansas, Colorado (1980), Delaware, Kentucky, Missouri, Montana, New York, North Dakota, Utah, Virginia, Washington, Virgin Islands, and Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.

The 10 largest plants accounted for 42% of the output. By source, 57% was produced by 45 companies at 88 refineries or satellite plants treating refinery gases, 2 coking operations, and 2 utility plants, and 43% was produced by 28 companies at 68 natural gas treatment plants. The five largest recovered elemental sulfur producers were Atlantic Richfield Co.; Chevron U.S.A., Inc.; Exxon Co., U.S.A.; Shell Oil Co.; and Standard Oil Co. (Indiana). Together, their 44 plants accounted for 61% of recovered elemental sulfur production in 1980.

The leading States in production of recovered elemental sulfur were Texas, Mississippi, California, Alabama, and Florida. Together these States contributed 69% of the total 1980 output. The total value of shipments of recovered elemental sulfur in 1980 was an alltime high of $301 million.

Byproduct Sulfuric Acid.—Production of byproduct sulfuric acid at copper, lead, molybdenum, and zinc smelters and roasters was by 13 companies at 27 plants in 14 States. Thirteen acid plants operated in conjunction with copper smelters and 14 plants were accessories to lead, molybdenum, and zinc roasting and smelting operations. The five largest acid plants accounted for 50% of the output, and production in five States was 74% of the total. The five largest producers of byproduct sulfuric acid were ASARCO Incorporated, Magma Copper Co., Kennecott Copper Corp., Phelps Dodge Corp., and AMAX Inc., whose 18 plants produced 75% of the byproduct sulfuric acid in 1980.

Table 6.—Byproduct sulfuric acid[1] (sulfur content) produced in the United States

(Thousand metric tons and thousand dollars)

Year	Copper plants[2]	Lead and zinc plants[3]	Zinc plants[3]	Lead and molybdenum plants[3]	Total	Value
1976	677	280	--	--	957	46,181
1977	699	261	--	--	960	46,236
1978	812	291	--	--	1,103	49,848
1979	821	346	--	--	1,167	51,815
1980	686	--	183	134	1,003	55,897

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

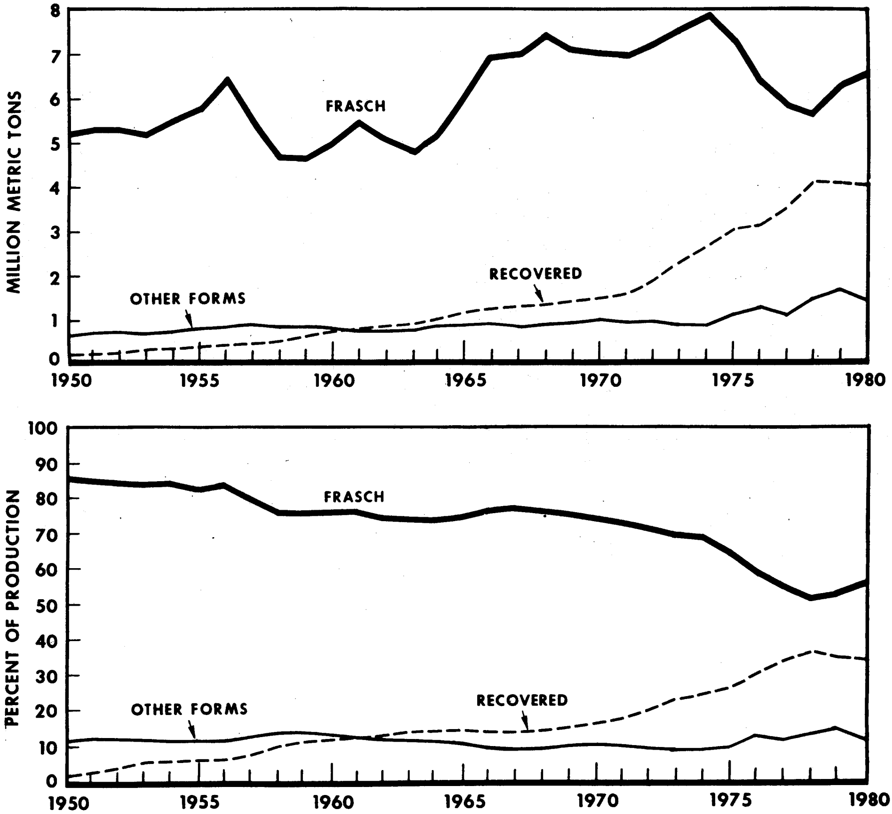

Figure 2.—Trends in the production of sulfur in the United States.

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—Pyrites was produced by three companies at three mines in three States; hydrogen sulfide, by three companies at four plants in three States; and sulfur dioxide, by three companies at five plants in five States. The three largest producers of these products were Cities Service Co., (pyrites and sulfur dioxide), Shell (hydrogen sulfide), and Stauffer Chemical Co. (sulfur dioxide). These companies combined, at one mine and six plants, accounted for 93% of the contained sulfur produced in the form of these products.

Table 7.—Pyrites, hydrogen sulfide, and sulfur dioxide sold or used in the United States

(Thousand metric tons sulfur content and thousand dollars)

Year	Pyrites	Hydrogen sulfide	Sulfur dioxide	Total	Value
1976	291	78	(1)	369	12,869
1977	169	59	(1)	228	11,068
1978	301	61	(1)	362	18,447
1979	400	35	72	507	37,828
1980	322	36	42	400	28,435

[1]Included with "Hydrogen sulfide," 1976-78.

CONSUMPTION AND USES

In 1980, apparent domestic consumption of sulfur in all forms was 13.6 million tons, slightly less than in 1979. Eighty-one percent of this consumption was from domestic sources. The supply sources of sulfur were domestic Frasch sulfur, 42%; domestic recovered elemental sulfur, 29%; and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 10%. The remaining 19% of the sulfur was from imports of Frasch and recovered elemental sulfur.

The Bureau of Mines collected data on the end uses of sulfur and sulfuric acid by Standard Industrial Classification (SIC) of industrial activities. Shipments by end use of elemental sulfur were reported by 67 companies and shipments by end use of sulfuric acid were reported by 72 companies. Of these companies, 14 reported shipments of both sulfur and sulfuric acid.

Producers of sulfur who responded to the canvass reported shipments of 13.3 million metric tons of sulfur in 1980. Of these reported shipments, 1.3 million tons was for export. The largest use, sulfuric acid production, represented 85% of shipments for domestic consumption. Some identified end uses were tabulated in the unidentified uses because data were proprietary. Data collected on other forms from some companies who did not identify shipments by end use were also tabulated as unidentified.

Reported shipments of 100% sulfuric acid totaled 40.3 million metric tons in 1980. Shipments of acid for phosphatic fertilizers, the largest end use and 64% of the total, totaled 26.0 million tons in 1980. Shipments of sulfuric acid for petroleum refining and other petroleum and coal production, the second largest end use of sulfuric acid, were 2.6 million tons.

Usage of sulfuric acid for copper ore leaching decreased from 2.1 million tons in 1979 to 1.4 million tons in 1980. Shipments for other categories are shown in table 10. Several end uses for sulfuric acid such as leather tanning, water treatment, and cotton seed linting were tabulated as unidentified because the data were proprietary.

In 1980, a total of 2.1 million metric tons of spent sulfuric acid was returned for reclaiming. Petroleum refineries and petroleum and coal products accounted for 67% of the spent acid returned in 1980. The petroleum refining industry was a net user of about 1.2 million tons of sulfuric acid.

According to reports received, spent acid returned for reclaiming from the industrial organic chemicals industry totaled 317,000 tons. The remaining reclaimed acid was from production of phosphatic fertilizers, copper ore processing, inorganic chemicals, other ore processing, soaps and detergents, paints and allied products, other agricultural chemicals, inorganic pigments, water treating, explosives, and pesticides.

Table 11 shows the domestic uses of sulfur including the sulfur contained in sulfuric acid. The largest identified end use for sulfur (as sulfuric acid) was for phosphatic fertilizers, which accounted for 57% of the total use of sulfur.

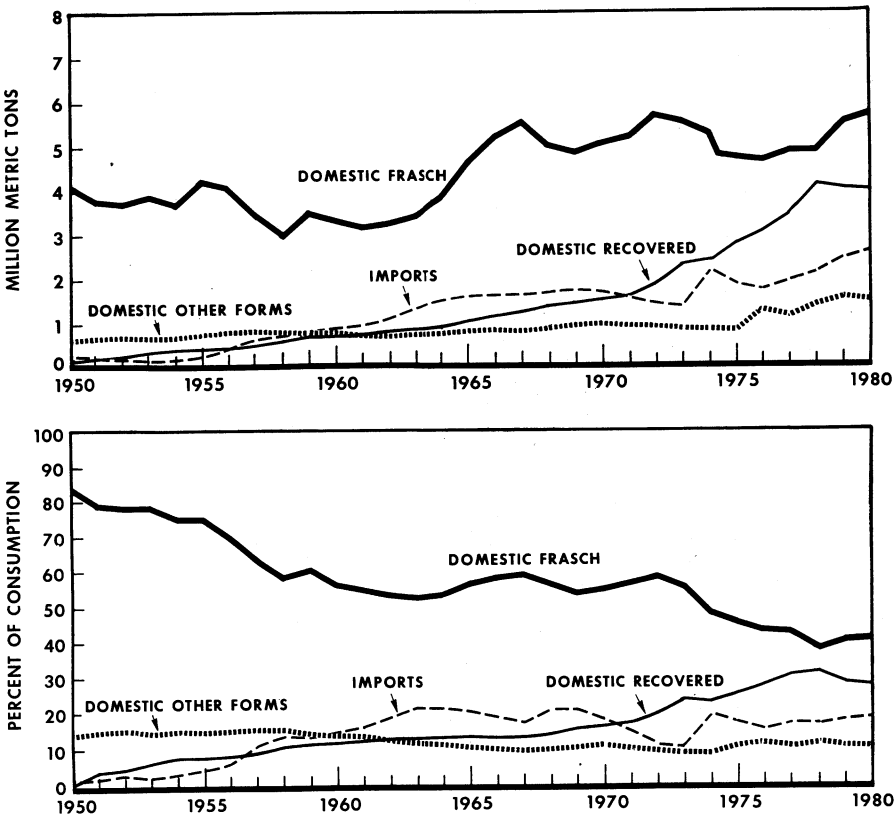

Figure 3.—Trends in the consumption of sulfur in the United States.

Table 8.—Apparent consumption of sulfur in the United States[1]

(Thousand metric tons)

	1976	1977	1978	1979	1980
Frasch:					
Shipments	5,954	6,030	5,736	7,507	7,400
Imports	743	781	993	1,229	990
Exports	1,217	1,088	827	1,963	1,673
Total	5,480	5,723	5,902	6,773	6,717
Recovered:					
Shipments	3,196	3,627	4,088	4,108	4,091
Imports	1,012	1,228	1,185	1,265	1,533
Exports from the Virgin Islands	73	109	39	81	109
Total	4,135	4,746	5,234	5,292	5,515
Pyrites, shipments	291	169	301	400	322
Byproduct sulfuric acid	957	960	1,103	1,167	1,003
Other forms[2]	78	59	61	107	78
Total, all forms	10,941	11,657	[3]12,600	13,739	13,635

[1]Crude sulfur or sulfur content.
[2]Includes consumption of hydrogen sulfide and liquid sulfur dioxide.
[3]Data do not add to total shown because of independent rounding.

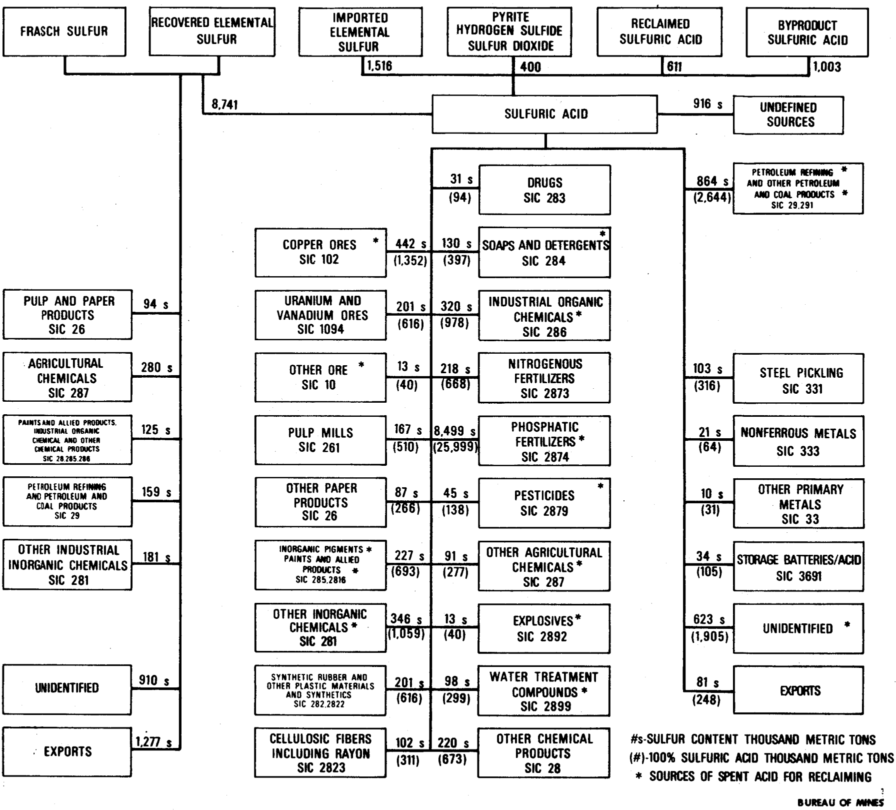

Figure 4.—Sulfur-sulfuric acid supply/end-use relationship, 1980.

Table 9.—Elemental sulfur sold or used in the United States, by end use

(Thousand metric tons)

SIC	Use	1979	1980
20	Food and kindred products	W	W
26, 261	Pulp and paper products	124	94
282, 2822, 2823	Synthetic rubber, cellulosic fibers, and other plastic products	W	W
287	Agricultural chemicals	272	280
28, 285, 286	Paints and allied products, industrial organic chemicals, and other chemical products	166	125
29, 291	Petroleum refining and petroleum and coal products	103	159
281	Other industrial inorganic chemicals	192	181
30	Rubber and miscellaneous plastic products	18	W
	Sulfuric acid:		
	Domestic sulfur	7,793	8,741
	Imported sulfur	1,754	1,516
	Total sulfuric acid	9,547	10,257
	Unidentified	r942	910
	Total domestic uses	r11,364	12,006
	Exports	r1,892	1,277
	Total	13,256	13,283

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

Table 10.—Sulfuric acid sold or used in the United States, by end use

(Thousand metric tons of 100% H_2SO_4)

SIC	Use	Quantity 1979	Quantity 1980
102	Copper ores	2,119	1,352
1094	Uranium and vanadium ore	391	616
10	Other ore	25	40
261	Pulpmills	683	510
26	Other paper products	77	266
285, 2816	Inorganic pigments and paints and allied products	628	693
281	Other inorganic chemicals	1,159	1,059
282, 2822	Synthetic rubber and other plastic materials and synthetics	647	616
2823	Cellulosic fibers including rayon	252	311
283	Drugs	293	94
284	Soaps and detergents	370	397
286	Industrial organic chemicals	1,178	978
2873	Nitrogenous fertilizers	546	668
2874	Phosphatic fertilizers	23,192	25,999
2879	Pesticides	148	138
287	Other agricultural chemicals	189	277
2892	Explosives	57	40
2899	Water-treating compounds	617	299
28	Other chemical products	509	673
29, 291	Petroleum refining and other petroleum and coal products	r2,360	2,644
30	Rubber and miscellaneous plastic products	49	W
331	Steel pickling	880	316
333	Nonferrous metals	105	64
33	Other primary metals	20	31
3691	Storage batteries/acid	157	105
	Unidentified	r1,341	1,905
	Total domestic	r37,992	40,091
	Exports	r132	248
	Total	r38,124	40,339

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

Table 11.—Sulfur and sulfuric acid sold or used in the United States, by end use

(Thousand metric tons sulfur content)

SIC	Use	Elemental sulfur[1]		Sulfuric acid (sulfur equivalent)		Total	
		1979	1980	1979	1980	1979	1980
102	Copper ores	--	--	693	442	693	442
1094	Uranium and vanadium ores	--	--	128	201	128	201
10	Other ores	--	--	8	13	8	13
20	Food and kindred products	W	W	--	--	W	W
261, 26	Pulpmills and paper products	124	94	248	254	372	348
2816, 285, 28, 286	Inorganic pigments, paints and allied products, industrial organic chemicals, and other chemical products	166	125	205	227	371	352
281	Other inorganic chemicals	192	181	379	346	571	527
2822, 2823, 282	Synthetic rubber, cellulosic fibers, other plastic materials, and synthetics	W	W	294	303	294	303
283	Drugs	--	--	96	31	96	31
284	Soaps and detergents	--	--	121	130	121	130
286	Industrial organic chemicals	--	--	385	320	385	320
2873	Nitrogenous fertilizers	--	--	179	218	179	218
2874	Phosphatic fertilizers	--	--	7,581	8,499	7,581	8,499
2879	Pesticides	--	--	48	45	48	45
287	Other agricultural chemicals	272	280	62	91	334	371
2892	Explosives	--	--	19	13	19	13
2899	Water-treating compounds	--	--	202	98	202	98
28	Other chemical products	--	--	166	220	166	220
291, 29	Petroleum refining and other petroleum and coal products	103	159	r772	864	r875	1,023
30	Rubber and miscellaneous plastic products	18	W	16	W	34	W
331	Steel pickling	--	--	288	103	288	103
333	Nonferrous metals	--	--	34	21	34	21
33	Other primary metals	--	--	6	10	6	10
3691	Storage batteries	--	--	51	34	51	34
	Exported sulfuric acid	--	--	r43	81	r43	81
	Total identified	875	839	r12,024	12,564	r12,899	13,403

See footnotes at end of table.

Table 11.—Sulfur and sulfuric acid sold or used in the United States, by end use —Continued

(Thousand metric tons sulfur content)

SIC	Use	Elemental sulfur[1]		Sulfuric acid (sulfur equivalent)		Total	
		1979	1980	1979	1980	1979	1980
	Unidentified	r942	910	r439	623	r1,381	1,533
	Total	r1,817	1,749	r12,463	13,187	r14,280	14,936

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Does not include elemental sulfur used for production of sulfuric acid.

STOCKS

Yearend 1980 producers' inventory of Frasch sulfur decreased 27% as Frasch producers shipped from inventory to supply domestic needs and world trade markets. Combined yearend stocks amounted to approximately 3.2 months supply based on 1980 domestic and export demands for domestically produced Frasch and recovered elemental sulfur.

Table 12.—Producers' yearend stocks

(Thousand metric tons)

Year	Frasch	Recovered	Total
1976	5,382	270	5,652
1977	5,288	269	5,557
1978	5,123	222	5,345
1979	4,058	181	4,239
1980	2,954	137	3,091

PRICES

The quoted price for liquid sulfur Gulf ports was $119.09 per metric ton and exterminal Tampa, Fla., $137.79 per metric ton at yearend 1980.

On the basis of shipments and total value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur f.o.b. mine for combined domestic consumption and exports during 1980 rose sharply to $97.36 per metric ton from $59.87 per ton in 1979. Shipment values for recovered elemental sulfur varied widely in different regions; lowest in the West, somewhat higher in the midcontinent, and near the values for Frasch sulfur in the East and South. Overall, the reported unit shipment sulfur value for recovered elemental sulfur f.o.b. plant in 1980 was $73.68 per metric ton, compared with $48.23 per ton in 1979.

Marketing sulfur produced in other than elemental form reflected competitive positions in the limited regional markets for these products. In 1980, the average price per ton of sulfur contained in byproduct sulfuric acid increased from $44 in 1979 to $56 in 1980. The average unit value for sulfur contained in pyrites, hydrogen sulfide, and sulfur dioxide, combined, decreased to $71 per ton compared with $75 in 1979.

Table 13.—Reported sales values of shipments of elemental sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Total
1976	50.38	37.02	45.72
1977	48.88	36.91	44.38
1978	48.80	40.07	45.17
1979	59.87	48.23	55.75
1980	97.36	73.68	88.93

FOREIGN TRADE

The United States was a net importer of sulfur in 1980 for the sixth year. Exports from the United States, excluding the Virgin Islands in 1980, were down 15% from 1979 to about 1.7 million tons. Imports in the form of elemental sulfur were 2.5 million tons in 1980.

Exports from the United States were almost entirely in the form of Frasch sulfur. The total value of exports in 1980 increased 30% over that of 1979. The reported average export value was $111.12 per ton in 1980.

Exports to Belgium-Luxembourg and the Netherlands were 51% of the total in 1980. Not included in the above were exports from the Virgin Islands, which were 109,000 tons valued at $12.9 million in 1980.

Imports of Frasch sulfur from Mexico were 990,000 tons in 1980. Imports of recovered elemental sulfur, mostly from Canada, totaled 1.5 million tons in 1980. The unit value of imports of sulfur from Canada increased $14.88 from $19.32 in 1979 to $34.20 in 1980, and the value of imports from Mexico increased from $56.67 in 1979 to $86.19 in 1980.

Table 14.—U.S. exports of crude and refined sulfur, by country

(Thousand metric tons and thousand dollars)

Destination	1979		1980	
	Quantity	Value	Quantity	Value
Argentina	31	2,748	23	3,040
Australia	112	8,213	33	4,415
Belgium-Luxembourg	590	37,422	604	58,888
Brazil	120	9,836	124	15,825
Canada	7	471	3	447
Chile	13	1,131	50	5,810
Colombia	(1)	82	15	1,942
Egypt	32	2,872	51	7,214
France	53	3,084	24	2,552
Greece	78	6,013	(1)	25
India	225	18,908	49	7,061
Italy	68	6,495	--	--
Lebanon	26	2,177	--	--
Mexico	5	316	33	2,187
Morocco	132	9,596	128	16,372
Netherlands	286	16,164	251	22,479
Romania	41	2,722	59	7,156
South Africa, Republic of	61	5,002	92	10,519
Spain	(1)	6	4	452
Trinidad	15	1,165	--	--
Tunisia	22	1,732	35	4,127
United Kingdom	(1)	36	62	6,645
Uruguay	26	1,972	20	2,523
Other countries	20	r4,803	14	6,189
Total[2] [3]	1,963	142,966	1,673	185,866

rRevised.
[1]Less than 1/2 unit.
[2]Excludes exports from the Virgin Islands to foreign countries: 1979—80,772 metric tons ($6,182,667); 1980—108,802 metric tons ($12,887,185) (see table 15).
[3]Data may not add to totals shown because of independent rounding.

Table 15.—Sulfur exported from the Virgin Islands to foreign countries

(Thousand metric tons and thousand dollars)

Country	1979		1980	
	Quantity	Value	Quantity	Value
Argentina	--	--	12	1,484
Brazil	--	--	41	5,026
Bulgaria	--	--	13	1,502
Egypt	--	--	12	1,573
Italy	14	720	--	--
Jamaica	--	--	3	346
Morocco	14	1,005	--	--
South Africa, Republic of	30	2,188	--	--
Tunisia	11	1,072	--	--
Turkey	12	1,197	14	1,648
United Kingdom	--	--	13	1,309
Total[1]	81	6,183	109	12,887

[1]Data may not add to totals shown because of independent rounding.

Table 16.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1979		1980	
	Quantity	Value	Quantity	Value
Canada	1,265	24,440	1,517	51,875
Germany, Federal Republic of	(1)	42	(1)	40
Mexico	1,229	69,648	990	85,316
Trinidad	--	--	16	1,620
Other countries[2]	(1)	17	(1)	1
Total	2,494	94,147	2,523	138,852

[1]Less than 1/2 unit.
[2]1979—France and the People's Democratic Republic of Yemen (Aden); 1980—Japan.

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Western world demand of about 40 million metric tons of sulfur essentially was met by shipments of newly produced sulfur coupled with the drawdown of producer and consumer stocks, despite interruption of shipments from Iraq, Iran, and Poland.

Canada.—Production of sulfur in all forms was about 7.0 million tons in 1980. Recovered elemental sulfur representing about 90% of the total output in 1980 was produced at 50 sour natural gas plants: 46 in Alberta, 3 in British Columbia, and 1 in Saskatchewan. Production of contained sulfur from smelter gases was 900,000 tons in 1980.[2] Exports from Canada were 6.9 million tons of which 5.1 million tons were from the Port of Vancouver.

In Alberta, production of sulfur was about 6.0 million tons in 1980.[3] Of the total in 1980, 300,000 tons was from tar sands operations. Exports were a record high of 6.4 million tons in 1980. Of total shipments in 1980, 5.0 million tons was exports to offshore markets, 1.4 million tons to the United States, and 850,000 tons for consumption in Canada. Producers' plant stocks in Alberta were 18.9 million metric tons at the end of 1979. The average market value of sulfur f.o.b. plant rose to $72.47 per metric ton in December 1980, compared with $29.15 per ton in December 1979.

Chile.—Sulfur is being mined on the slopes of the dormant volcano Aucanquilch in northern Chile. The mine at more than 6,000 meters elevation is one of the highest mines in the world.[4]

France.—Production of recovered elemental sulfur was 1.8 million tons in 1980. Exports were about 1.1 million tons.

Germany, Federal Republic of.—Exports of sulfur have continually increased to about 400,000 metric tons in 1980. Sulfur production at petroleum refineries was about 220,000 tons in 1980 and recovery from natural gas processing was about 700,000 tons.[5]

Iraq.—Although production of sulfur continued at the Mishraq Mine, shipments were essentially halted after the outbreak of the war with Iran.

Japan.—Recovery of sulfur at petroleum refineries in 1980 was about 1.3 million metric tons.

Mexico.—In 1980, Frasch sulfur production by Azufrera Panamericana S.A. at Jaltipan and Cie. Exploradora de Istmo at Texistepic was about 1.7 million tons. A new Frasch mine went onstream at Coachapa with an annual capacity of about 680,000 tons of sulfur. Producton of recovered elemental sulfur by Pemex was about 400,000 tons.

Poland.—Sulfur production in 1980 was 4.9 million tons and exports were about 3.9 million tons, 50% to market-economy countries.

Changes in the sulfur industry of Poland since 1968 were reviewed. Sulfur production rose from 1.3 million metric tons in 1968 to 5.4 million metric tons in 1978.

Saudi Arabia.—The sulfur recovery plant in Berris with a capacity of 1,450 metric tons per annum has been operated at a rate of about 900 tons per day in 1980. The plant at Shokgum (capacity of 1,650 tons per day) started production in March 1980 at a rate of about 460 tons per day.[6]

Table 17.—Sulfur: World production in all forms, by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
Algeria: Byproduct, petroleum and natural gas	10	10	15	15	14
Argentina:					
Native (from caliche)	20	27	18	--	--
Byproduct, all sources[e]	19	20	20	20	20
Total	39	47	38	20	20
Australia:[4]					
Pyrite[5]	108	108	93	22	--
Byproduct:					
Metallurgy[6]	[r]121	[r]115	130	[e]140	140
Petroleum	7	11	10	11	11
Total	[r]236	[r]234	233	173	151
Austria:					
Byproduct:					
Metallurgy	8	8	9	10	10
Petroleum and natural gas	18	25	22	24	23
Gypsum	23	27	27	27	27
Total	49	60	58	61	60
Bahamas: Byproduct, petroleum	5	[e]5	[e]5	[e]5	5
Bahrain: Byproduct, petróleum	10	7	26	25	25
Belgium: Byproduct, all sources	218	257	267	[e]270	270
Bolivia:[7] Native	[r] [8]14	[8]6	[8]14	[8]15	[9]11
Brazil:[10] Byproduct, petroleum	30	44	57	61	67
Bulgaria:					
Pyrite[e]	280	305	310	315	300
Byproduct, all sources[e]	60	65	70	75	70
Total[e]	340	370	380	390	370
Canada:					
Pyrite	15	12	5	12	[9]12
Byproduct:					
Metallurgy	705	[r]736	676	667	[9]903
Natural gas	6,241	6,475	6,248	5,935	[9]6,000
Petroleum	200	160	200	200	190
Tar sands	100	100	118	213	[9]300
Total	7,261	[r]7,483	7,247	7,027	7,405
Chile:[7]					
Native:					
Refined	16	5	14	12	14
From caliche	2	27	18	65	37
Byproduct, metallurgy	30	29	20	27	27
Total	48	61	52	104	78
China:					
Mainland:					
Native[e]	150	[r]200	200	200	200
Pyrite[e]	900	[r]1,252	[r]1,605	[r]1,682	1,700
Byproduct, all sources[e]	300	[r]300	350	400	400
Total[e]	1,350	[r]1,752	2,155	2,282	2,300
Taiwan:					
Pyrite	[r]3	3	([11])	([11])	([9] [11])
Byproduct, all sources	[r]6	[r]7	10	9	8
Total	[r]9	[r]10	10	9	8
Colombia:					
Native	24	22	18	20	20
Byproduct, petroleum	2	2	3	3	3
Total	26	24	21	23	23
Cuba:					
Pyrite	[r]27	[r]34	[r]23	[r]12	10
Byproduct, petroleum[e]	8	8	8	8	8
Total[e]	[r]35	[r]42	[r]31	[r]20	18
Cyprus:[12] Pyrite	95	81	63	65	60

See footnotes at end of table.

Table 17.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
Czechoslovakia:					
Native	12	5	5	5	5
Pyrite	50	55	60	60	60
Byproduct, all sources	10	9	10	10	10
Total	72	69	75	75	75
Denmark: Byproduct, petroleum	10	11	14	8	8
Ecuador:					
Native[r e]	4	5	5	5	5
Byproduct:					
Natural gas[e]	5	5	5	5	5
Petroleum[e]	3	3	5	5	5
Total[e]	[r]12	[r]13	15	15	15
Egypt: [10] Byproduct, petroleum and natural gas	5	5	3	3	3
Finland:					
Pyrite	234	130	87	151	150
Byproduct:					
Metallurgy	283	280	232	263	260
Petroleum[e]	25	25	30	30	30
Total[e]	542	435	349	444	440
France:					
Byproduct:					
Natural gas[13]	1,737	1,911	1,900	1,940	[9]1,839
Petroleum[13]	88	89	86	90	[9]88
Unspecified[14]	143	160	160	160	150
Total	1,968	2,160	2,146	2,190	2,077
German Democratic Republic:					
Pyrite[e]	10	10	10	10	10
Byproduct, all sources[e]	329	340	350	350	350
Total[e]	339	350	360	360	360
Germany, Federal Republic of:					
Pyrite	233	235	221	203	200
Byproduct:					
Metallurgy[15]	390	385	348	361	380
Natural gas[13]	460	[r]624	666	690	700
Petroleum[13]	119	186	190	214	220
Unspecified[14]	161	[r]197	195	343	300
Total	1,363	[r]1,627	1,620	1,811	1,800
Greece:					
Pyrite	[r]74	[r]54	61	63	64
Byproduct, petroleum[e]	3	3	3	3	3
Total[e]	[r]77	[r]57	64	66	67
Hungary:					
Pyrite[e]	3	3	3	3	3
Byproduct, all sources	8	8	9	9	10
Total[e]	11	11	12	12	13
India:[4]					
Pyrite	19	14	26	29	[9]34
Byproduct:					
Metallurgy[e]	111	117	115	115	115
Petroleum	7	7	7	7	[9]5
Total[e]	137	138	148	151	154
Indonesia:[12] Native	3	2	([11])	([11])	([11])
Iran:					
Native[e]	188	188	[e]150	[e]75	70
Byproduct, petroleum and natural gas	399	[e]400	[e]300	[e]200	150
Total[e]	587	588	[e]450	[e]275	220

See footnotes at end of table.

Table 17.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
Iraq:					
Frasch	582	620	600	550	600
Byproduct, petroleum and natural gas[e]	40	40	40	70	60
Total[e]	622	660	640	620	660
Ireland: Pyrite	31	22	20	14	14
Israel: Byproduct, petroleum and natural gas	10	[e]10	[e]10	[e]10	10
Italy:					
Native	35	36	16	16	[9]23
Pyrite	366	371	330	330	[9]331
Byproduct, all sources[e 16]	211	259	299	225	250
Total	612	666	645	571	604
Japan:					
Pyrite	471	389	327	303	300
Byproduct:					
Metallurgy[17]	1,252	1,336	1,296	[e]1,350	1,300
Petroleum[18]	[r]926	1,100	1,105	1,241	1,300
Total	[r]2,649	2,825	2,728	2,894	2,900
Korea, North:					
Pyrite[e]	245	250	255	255	255
Byproduct, metallurgy[e]	20	12	10	10	10
Total[e]	265	262	265	265	265
Korea, Republic of:					
Pyrite	([11])	--	--	([11])	([9 11])
Byproduct:					
Metallurgy[e]	22	[r]33	[r]47	[r]54	54
Petroleum[e]	25	[r]31	[r]34	[r]36	36
Total[e]	47	[r]64	[r]81	[r]90	90
Kuwait: Byproduct, petroleum and natural gas	61	79	100	100	120
Libya: Byproduct, petroleum and natural gas[e]	[r]16	[r]17	[r]19	20	22
Mexico:					
Frasch	2,054	1,723	1,818	2,025	[9]2,102
Byproduct:					
Metallurgy[e]	75	80	100	100	150
Petroleum and natural gas	96	[r]146	168	249	300
Total[e]	2,225	[r]1,949	2,086	2,374	2,552
Morocco: Pyrite	23	45	61	[e]60	60
Namibia: Pyrite	4	4	3	4	4
Netherlands: Byproduct:					
Metallurgy[e]	85	64	60	88	90
Petroleum[e]	65	64	65	75	75
Total[e]	150	128	125	163	165
Netherlands Antilles: Byproduct, petroleum	95	94	95	95	95
New Zealand: Byproduct, all sources	1	1	1	1	1
Norway:					
Pyrite	188	158	152	150	150
Byproduct:					
Metallurgy[e]	33	38	36	40	40
Petroleum[e]	7	7	7	6	6
Total[e]	228	203	195	196	196
Pakistan:					
Native	1	1	1	1	1
Byproduct, all sources	12	12	14	14	14
Total	13	13	15	15	15
Peru:					
Native	1	1	([11])	1	1
Byproduct, all sources	16	20	18	20	20
Total	17	21	18	21	21
Philippines: Pyrite	77	50	51	55	56

See footnotes at end of table.

Table 17.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
Poland:[19]					
Frasch[e]	4,341	4,321	4,546	4,310	4,000
Native[e]	550	450	505	520	500
Byproduct:					
Metallurgy[e 20]	239	314	315	310	300
Petroleum[e 20]	25	35	35	35	30
Gypsum[e]	55	30	20	20	20
Total[e]	5,210	5,150	5,421	5,195	4,850
Portugal:					
Pyrite	181	156	138	154	155
Byproduct, all sources	1	2	1	2	2
Total	182	158	139	156	157
Romania:					
Pyrite[e]	375	395	400	425	450
Byproduct, all sources[e]	98	110	120	130	140
Total[e]	473	505	520	555	590
Saudi Arabia:					
Native[e]	1	1	1	1	1
Byproduct: Petroleum and natural gas[e]	[r]12	[r]12	[r]14	125	700
Total	[r]13	[r]13	[r]15	126	701
Singapore: Byproduct, petroleum	[e]7	23	25	26	25
South Africa, Republic of:					
Pyrite	294	332	340	340	320
Byproduct:					
Metallurgy	91	105	[e]100	[e]100	100
Petroleum	27	28	[e]25	[e]25	25
Total	412	465	465	465	445
Spain:					
Pyrite	1,052	1,102	1,071	1,019	1,100
Byproduct:					
Metallurgy	123	129	117	120	125
Petroleum	4	5	10	10	12
Coal (lignite) gasification[e]	1	2	3	3	3
Total[e]	1,180	1,238	1,201	1,152	1,240
Sweden:					
Pyrite	205	204	233	[e]240	240
Byproduct:					
Metallurgy	140	135	130	[e]130	130
Unspecified[21]	[e]28	[e]30	[e]18	[e]20	20
Total	373	369	381	390	390
Switzerland: Byproduct, petroleum	2	2	3	3	3
Syria: Byproduct, petroleum and natural gas	5	[e]4	[e]6	[e]6	5
Trinidad and Tobago: Byproduct, petroleum[4]	[r]74	[r]34	54	77	80
Turkey:					
Native	21	20	28	[e]30	30
Pyrite	38	18	14	[r e]14	14
Byproduct, all sources[e]	69	80	80	[r]70	70
Total[e]	128	118	122	114	114
U.S.S.R.:					
Frasch[e]	500	500	800	800	900
Native[e]	2,200	2,400	2,700	2,700	2,800
Pyrite[e]	3,300	3,500	3,500	3,500	3,550
Byproduct:[e]					
Coal	40	40	40	40	40
Metallurgy	2,040	2,180	2,210	2,210	2,310
Natural gas	870	920	1,100	1,100	1,100
Petroleum	190	200	200	200	200
Total[e]	9,140	9,740	10,550	10,550	10,900

See footnotes at end of table.

Table 17.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
United Kingdom:					
Byproduct:					
Metallurgy	37	61	52	50	50
Spent oxides	6	5	5	5	6
Unspecified	[r]77	[r]60	70	70	70
Total	[r]120	[r]126	127	125	126
United States:					
Frasch	6,365	5,915	5,648	6,357	[9]6,390
Pyrite	291	169	301	400	[9]322
Byproduct:					
Metallurgy	957	960	1,103	1,167	[9]1,003
Natural gas	1,298	1,426	1,753	1,760	[9]1,730
Petroleum	1,890	2,198	2,309	2,310	[9]2,316
Unspecified	78	59	61	107	[9]78
Total	10,879	10,727	11,175	12,101	[9]11,839
Uruguay: Byproduct, petroleum	2	2	2	2	2
Venezuela: Byproduct, petroleum and natural gas	90	95	95	85	85
Yugoslavia:					
Pyrite	185	166	170	190	190
Byproduct:					
Metallurgy[e]	200	200	200	200	190
Petroleum[e]	5	5	7	7	8
Total[e]	390	371	377	397	388
Zaire: Byproduct, metallurgy	37	31	[e]30	[e]30	30
Zambia:					
Pyrite	9	8	([11])	--	([9] [11])
Byproduct, all sources	91	87	109	74	100
Total	100	95	109	74	100
Zimbabwe:					
Pyrite[e]	40	40	40	30	35
Byproduct, all sources[e]	5	5	5	5	5
Total[e]	45	45	45	35	40
Grand total	[r]50,908	[r]52,383	53,948	55,207	56,077
Of which:					
Frasch	13,842	13,080	13,412	14,042	13,992
Native	[r]3,242	[r]3,396	3,693	3,666	3,718
Pyrite	[r]9,425	[r]9,675	9,973	10,110	10,149

See footnotes at end of table.

Table 17.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1976	1977	1978	1979[p]	1980[e]
Byproduct:					
Coal and coal gasification	41	42	43	43	43
Metallurgy	[r]6,999	[r]7,348	7,336	7,542	7,717
Natural gas	10,611	[r]11,361	11,672	11,430	11,374
Petroleum	[r]3,859	[r]4,386	4,617	4,815	4,878
Tar sands	100	100	118	213	300
Petroleum and natural gas, undifferentiated	[r]762	[r]843	792	907	1,492
Spent oxides	6	5	5	5	6
Unspecified sources	[r]1,943	[r]2,090	2,240	2,387	2,361
Gypsum	78	57	47	47	47

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 8, 1981.

[2]In addition to the countries listed, a number of nations may produce limited quantities of either elemental sulfur or compounds (chiefly H_2S or SO_2) as a byproduct of petroleum, natural gas, and/or metallurgical operations, but output, if any, is not quantitatively reported, and no basis is available for the formulation of reliable estimates of output. Countries not listed in this table which may recover byproduct sulfur from oil refining include: Albania, Bangladesh, Brunei, Burma, Costa Rica, Guatemala, Honduras, Jamaica, Malaysia, Nicaragua, Paraguay, and the People's Democratic Republic of Yemen. Albania and Burma may also produce byproduct sulfur from crude oil and natural gas extraction. No complete listing of other nations that may produce byproduct sulfur from metallurgical operations (including processing of coal for metallurgical use) can be compiled, but the total of such output is considered as small. Nations listed in the table that may have production from sources other than those listed are identified by individual footnotes.

[3]The term "source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrite (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrite-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw material; in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

[4]In addition, may produce limited quantities of byproduct sulfur from natural gas.

[5]Excluding sulfur content of auriferous pyrites, for which data are not available.

[6]Excluding sulfur recovered, if any, from processing copper concentrates.

[7]In addition, may produce limited quantities of byproduct sulfur from crude oil and natural gas and/or from petroleum refining.

[8]Exports; regarded as tantamount to production owing to minimal domestic consumption levels.

[9]Reported figure.

[10]In addition, may produce limited quantities of byproduct sulfur from metallurgical operations and/or coal processing.

[11]Less than 1/2 unit.

[12]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[13]Elemental byproduct recovered sulfur only; sulfur recovered as SO_2, H_2S, and/or other compounds are included under unspecified.

[14]Comprises all byproduct sulfur recovered in the form of compounds including that, if any, recovered from petroleum and natural gas operations, as well as total recovery from metallurgical operations.

[15]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under undifferentiated.

[16]Includes recovery from gypsum, if any.

[17]Presumably includes sulfur recovered from coal processed to coke at metallurgical facilities, and excludes sulfur, if any, recovered by metallurgical facilities in elemental form.

[18]Includes sulfur recovered in the form of acid from coal, heavy oil, and other unspecified sources as well as sulfur, if any, recovered by metallurgical facilities in elemental form.

[19]Official Polish sources report total mined elemental sulfur output annually; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources. Therefore, although both numbers are estimates, the total is not an estimate. Estimates for production of byproduct and gypsum-derived sulfur are based on officially published data on sulfuric acid production and additional information from unofficial sources.

[20]Estimates reported under "Metallurgy" represent byproduct recovery in the form of compounds (principally sulfuric acid) from all sources (including coal and fertilizer plants); estimates reported under "Petroleum" represent only elemental sulfur recovery from petroleum, with any recovery in the form of compounds included under "Metallurgy."

[21]Elemental sulfur only.

TECHNOLOGY

To support research in the citrate process for flue gas desulfurization, analytical methods were developed to analyze known sulfur compounds and to detect unknown compounds possibly present in process solutions.[7]

Sulphate-reducing bacteria were discussed in a book that described classification, cultivation and growth, structure, chemical composition, metabolism, evolution, ecology, and economic activities in the human environment.[8]

Research was reported on the recovery of sulfur from gypsum and low-grade pyrites.[9] The quantity of recharge water needed to establish a barrier to movement of water in a sulfur mine can be determined by modeling.[10] Production of sulfur at the Lacq Gasfield in France was started in 1957, reached a peak in 1979, and may begin declining because of operational problems.[11]

In Wyoming, Utah, and Montana, the Overthrust belt could be a source of as much as 3 million tons of sulfur annually by 1990.[12] The technology of flue gas desulfurization system using various processes was evaluated based on process design, performance information, and capital and annual costs.[13]

A new prilling plant went onstream at Gulf Canada Resources Inc.'s gas plant at Strachen, Alberta, Canada.[14] The details of a new sulfur prilling process at Stockton, Calif., were described.[15]

Sulfur is critical to the fertilizer industry as well as an essential plant nutrient.[16]

Sulfur concretes exhibit high corrosion resistance in acid and salt environments.[17] The use of sulfur in asphalt paving has been growing, and experiments using sulfur-extended asphalts (SEA) have been initiated in more than 30 States. A mixture of sulfur and hydrocarbons has been tested as a binder for asphalt paving.[18]

The status of research programs under contract with the Federal Highway Administration was reviewed. Sulfur extended asphalt laid at 14 test sights in several States were performing satisfactorily after 6 months. Additional evaluations were underway in 15 States.[19] Studies to develop mixture design methods and establish mix design criteria for flexible Sulphlex paving mixtures and examine chemical properties and behavior of Sulphlex binders were described.[20] In highway paving, sulfur may be used to upgrade poorly graded mineral aggregates, as a partial replacement for asphalt, or as a total replacement for asphalt binders.[21] The results of research during the 1970's on new uses for sulfur in highway paving, sulfur-extended asphalts, molded sulfur blocks, and sulfur in agriculture were discussed.[22] [23]

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Talc and Pyrophyllite

By Robert A. Clifton[1]

Increasing demand for talc and a decreasing demand for pyrophyllite in the domestic market led to a slight increase in the combined total domestic production of these commodities for 1980. Production of talc set a new record high in 1980, as pyrophyllite production decreased 38%. The value of crude talc and pyrophyllite produced increased 26% during the year.

Table 1 shows the increases in total sales value of crude and processed talc and pyrophyllite. Apparent domestic consumption increased 6% during 1980. Exports were down markedly in 1980, but tonnages were still the third highest on record. The value of exported talc, however, was 2% below that of 1979.

Legislation and Government Programs.—The National Institute of Occupational Safety and Health did not publish its "Criteria Document for Exposure to Talc" in 1980. The original draft was severely criticized by the talc industry when it was circulated for review late in 1978.

The national stockpile inventory of steatite, block or lump, was at a reported 1,092 short tons at the end of 1980. This still far exceeded the goal of 28 tons. The ground steatite inventory, with a goal of zero, was at 1,089 tons.

Table 1.—Salient talc and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Mine production, crude:					
Talc	W	1,099	1,268	1,268	1,359
Pyrophyllite	W	106	116	185	114
Total	1,092	1,205	1,384	1,453	1,473
Value:					
Talc	$9,542	$12,524	$14,956	$19,365	$22,897
Pyrophyllite	360	561	811	998	2,729
Total	9,902	13,085	15,767	[1]20,364	25,626
Sold by producers, crude and processed:					
Talc	794	996	1,155	1,119	1,173
Pyrophyllite	107	118	116	195	158
Total	901	1,114	1,271	1,314	1,331
Value:					
Talc	$33,014	$50,647	$68,781	$80,529	$84,523
Pyrophyllite	934	1,708	2,804	4,413	4,254
Total	33,948	52,355	71,585	84,942	88,777
Exports[2]	212	322	267	316	275
Value	$9,034	$9,166	$12,359	$15,210	$14,963
Imports for consumption	20	22	19	22	21
Value	$1,861	$2,094	$1,946	$2,822	$3,720
Apparent consumption	709	814	1,023	1,020	1,077
World: Production	[r]5,813	[r]6,237	[r]6,586	[r]7,109	7,595

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data do not add to total shown because of independent rounding.
[2]Excludes powders—talcum (in package), face, and compact.

The allowable depletion rates established under the Tax Reform Act of 1969 remained at 22% for domestic block steatite and 14% for foreign steatite through 1980.

Tariff rates on imported talc minerals follow: Crude and unground, 0.02 cent per pound; ground, washed, powdered and/or pulverized, 6% ad valorem; cut, sawed, or in blanks, crayons, cubes, disks, or other forms, 0.2 cent per pound; other not specifically provided for, 12% ad valorem.

DOMESTIC PRODUCTION

Talc.—Production from U.S. talc mines rose during 1980 and established a record high year. The value of mine production established another record high, exceeding that of 1979 by 18%.

Talc, including soapstone, was produced at 40 mines in 11 States in 1980. California's 12 mines were by far the largest number for any State. Mines in four States produced about 90% of the tonnage and value of talc in 1980. The States producing the highest tonnage, in decreasing order, were Texas, Vermont, Montana, and New York. Montana led all States in the value of the talc produced. Of the talc-producing States, only Nevada had no milling facilities.

The seven largest domestic producers of talc in 1980, listed alphabetically, were Cyprus Industrial Minerals Co., with mines in California, Montana, and Texas; Eastern Magnesia Talc Co., in Vermont; Pfizer Inc., Minerals, Pigments & Metals Div., in California and Montana; Southern Clay Products, Inc., in Texas; R. T. Vanderbilt Co., Inc., in New York; Westex Minerals, Inc., in Texas; and Windsor Minerals, Inc., in Vermont.

Pyrophyllite.—The only pyrophyllite-producing mines in the United States in 1980 were in North Carolina. The decrease in production put the total near the 1978 level. Three companies operated five mines during the year.

Table 2.—Talc and pyrophyllite produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1979		1980	
	Quantity	Value	Quantity	Value
California (talc)	176	6,960	100	1,863
Georgia (talc)	29	117	25	116
Montana (talc)	343	5,940	312	11,310
North Carolina[1]	128	667	114	2,729
Texas (talc)	207	1,544	401	4,295
Vermont (talc)	346	2,755	318	2,753
Other States[2] (talc)	224	2,381	203	2,560
Total	1,453	20,364	1,473	25,626

[1]Talc and pyrophyllite produced, pyrophyllite only reported.

[2]Includes Arkansas, Nevada, New York, North Carolina, Oregon, and Virginia.

CONSUMPTION AND USES

The apparent domestic consumption of talc and pyrophyllite increased again in 1980 and exceeded the 1979 record. The sales value of talc and pyrophyllite combined set a new record high.

The 1980 end use distribution showed 31% of the ground talc used in ceramics, 22% in paint, 12% in plastics, 11% in paper, 7% in cosmetics, 4% in rubber, 2% in roofing, 1% in insecticides, with the remainder going to other uses.

The largest portion (49%) of the ground pyrophyllite was used in refractories, 20% was used in insecticides, 9% in ceramics, 7% in roofing, and the remainder in other uses.

The steatite industry has been growing at a modest rate for the past few years but recently has been running near capacity. Several new firms with additional capacity were scheduled to come onstream.

Table 3.—End uses for ground talc and pyrophyllite

(Thousand short tons)

Use	1979 Talc	1979 Pyrophyllite	1979 Total[1]	1980 Talc	1980 Pyrophyllite	1980 Total[1]
Ceramics	260	63	323	282	13	295
Cosmetics[2]	74	--	74	59	--	59
Insecticides	13	32	46	11	28	39
Paint	237	1	238	197	1	198
Paper	105	--	105	102	--	102
Plastics	112	1	113	110	1	111
Refractories	6	56	62	2	69	71
Roofing	19	13	32	20	10	30
Rubber	39	--	40	37	1	38
Other uses[3]	95	21	115	83	19	102
Total[1]	960	188	1,148	903	141	1,045

[1]Data may not add to totals shown because of independent rounding.
[2]Incomplete data. Some cosmetic talc known to be included in "Other uses."
[3]Includes art sculpture, asphalt filler, crayons, floor tile, foundry facings, rice polishing, stucco, and other uses not specified.

PRICES

Depending on quality and degree and method of processing, talc prices vary over a wide range. In general, prices rose during 1980. Engineering and Mining Journal, December 1980, quoted prices for domestic talc, ground, in carload lots, f.o.b. mine or mill, containers included, per short ton, as follows:

Vermont:	
98% through 325 mesh, bulk	$64.00
99.99% through 325 mesh, bags:	
Dry processed	116.00
Water beneficiated	$194.00-208.00
New York:	
96% through 200 mesh	47.00- 51.00
98% to 99.25% through 325 mesh	56.00- 74.00
100% through 325 mesh, fluid-energy ground	123.00
California:	
Standard	69.50
Fractionated	37.00- 71.00
Micronized	62.00-104.00
Cosmetic steatite	44.00- 65.00
Georgia:	
98% through 200 mesh	40.00
99% through 325 mesh	50.00
100% through 325 mesh, fluid-energy ground	100.00

American Paint & Coatings Journal, December 8, 1980, listed the following prices per ton for paint-grade talcs in carload lots:

California:	
Bags, mill:	
White, Hegman No. 3-3-1/2	$93.00
Hegman No. 4-5	119.00
Montana: Ultrafine grind, f.o.b. mill	135.00
New York:	
Nonfibrous, bags, mill:	
98% through 325 mesh	$46.50- 50.50
99.4% through 325 mesh	55.50
Trace retained on 325 mesh	105.00
Fine micrometer talcs (origin not specified)	144.00

The approximate equivalents, in dollars per short ton, of the price ranges quoted in Industrial Minerals (London), December 1980, for steatite talc, c.i.f. main European ports, were as follows:

Australian, cosmetic (ex store)	$251-$263
Norwegian:	
Ground (ex store)	132- 168
Micronized (ex store)	187- 261
French, fine-ground	251- 275
Italian, cosmetic-grade	359
Chinese, normal (ex store):	
UK 200 mesh	263- 275
UK 300 mesh	275- 287

FOREIGN TRADE

Exports.—There was a 13% decrease in talc exports during 1980. The loss in tonnage left exports at the third highest level ever. The value of exported talc declined only 2% and averaged a record high of $54 per ton. The value received for talc exported in 1980 varied between $23 per ton to Mexico and $257 per ton to Jamaica. Decreases in the quantity of talc exported to the smaller consumer nations in 1980 were noteworthy in this decline in total exports.

Mexico again was the major importer of U.S. talc in 1980. Mexico's 53% of the tonnage was followed by Canada with 22%, Belgium with 9%, and Japan with 5%. A total of 58 countries imported U.S. talc in 1980.

The average annual growth rate for exported talc during the past 5 years has been over 3%.

Imports.—U.S. imports of talc decreased 8% in 1980, and the average value was $181 per ton. The cosmetic grades accounted for the high prices. Italy, with 47%, was the leading source of imported talc, followed by France and Canada.

Table 4.—U.S. exports of talc

(Thousand short tons and thousand dollars)

Year	Belgium-Luxembourg		Canada		Japan		Mexico		Other		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1976	21	1,083	40	2,596	12	671	116	2,110	23	2,574	212	9,034
1977	21	744	132	2,842	19	870	124	1,808	26	2,902	322	9,166
1978	20	1,106	55	3,734	19	1,304	133	2,274	40	3,941	267	12,359
1979	18	1,043	60	4,485	19	1,145	164	3,539	55	4,998	316	15,210
1980	24	1,412	68	4,960	13	957	161	3,648	9	3,986	275	14,963

Table 5.—U.S. imports for consumption of talc, by class and country

Year and country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Total unmanufactured	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value[1] (thousands)
1978	14,200	$1,097	4,312	$404	807	$445	19,319	$1,946
1979:								
Canada	3	2	2,161	144	148	76	2,312	222
France	3,971	203	461	67	--	--	4,432	270
Italy	11,460	1,276	359	88	--	--	11,819	1,364
Japan	(2)	(2)	17	12	389	532	406	544
Korea, Republic of	57	5	517	88	327	102	901	195
Other[3]	2,417	169	50	4	37	54	2,504	227
Total	17,908	1,655	3,565	403	901	764	22,374	2,822
1980:								
Canada	--	--	3,759	385	142	90	3,901	475
France	3,968	319	384	71	--	--	4,352	390
Italy	9,425	1,443	289	86	--	--	9,714	1,529
Japan	--	--	26	14	571	831	597	845
Korea, Republic of	577	47	876	153	269	122	1,722	322
Other[4]	75	9	49	8	190	142	314	159
Total	14,045	1,818	5,383	717	1,172	1,185	20,600	3,720

[1]Does not include talc, n.s.p.f.; 1977—$593,240; 1978—$784,877; 1979—$1,291,043; 1980—$1,292,902.
[2]Less than 1/2 unit.
[3]Includes Australia, Austria, Belgium-Luxembourg, China (mainland and Taiwan), the Federal Republic of Germany, India, Mexico, Morocco, Spain, and the United Kingdom.
[4]Includes Brazil, China (mainland and Taiwan), Hong Kong, India, Peru, Saudi Arabia, the Republic of South Africa, and the United Kingdom.

WORLD REVIEW

The 14 nations producing over 100,000 tons per year of talc and pyrophyllite share more than 90% of the world production. The two leaders, Japan and the United States, produce over 40% of the world supply. However, because less than 10% of Japan's reported production is talc, that country is both the world's largest producer of pyrophyllite and the largest importer of talc. The United States is by far the largest producer of talc.

China, Mainland.—The China National Metals & Minerals Import & Export Corp. is aggressively advertising and selling its Shandong Talc Powder. It claims a whiteness of 90% to 94% for its best grade (A).

Finland.—With another new company, Myllykoski Oy, producing in 1979, a trade journal reported a significant increase in Finland's talc production.[2] The production, all floated, rose 37% over that of 1978 to 295,000 short tons. Talc now accounts for 40% of the minerals used in Finland's large paper industry.

France.—The sole French talc producer, Société des Talcs de Luzenac, with its 100-

Table 6.—Talc and pyrophyllite: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada (shipments)	75,876	79,807	67,970	99,572	[3]95,901
Mexico	212	180	2,909	[e]3,000	3,000
United States	1,092,433	1,204,835	1,383,752	1,452,733	[3]1,473,292
South America:					
Argentina (talc, steatite, pyrophyllite)	59,698	[r]60,748	53,055	38,390	[3]65,387
Brazil (talc and pyrophyllite)[4]	235,727	279,857	287,174	402,870	402,300
Chile	[r]1,222	471	476	937	770
Colombia	[e]1,100	1,268	1,455	6,708	6,600
Paraguay	154	143	176	231	210
Peru (talc and pyrophyllite)	16,050	16,535	14,234	16,502	16,200
Uruguay	1,398	1,829	[e]1,900	1,984	2,000
Europe:					
Austria (unground talc)	110,945	[r]114,357	117,780	128,860	130,000
Finland	163,727	172,604	215,126	294,515	300,000
France (ground talc)	281,970	[r]315,812	322,646	333,416	[3]331,881
Germany, Federal Republic of (marketable)	20,152	17,605	17,026	16,519	17,000
Greece (steatite)	6,110	--	1,188	--	--
Hungary[e]	17,600	17,600	19,000	19,000	19,000
Italy (talc and steatite)	169,575	179,056	193,077	173,484	174,000
Norway	130,305	108,122	106,611	[r] [e]105,000	103,000
Portugal	1,659	1,775	1,521	3,006	3,000
Romania[e]	66,000	66,000	66,000	66,000	66,000
Spain (steatite)	52,489	66,215	68,224	78,316	77,000
Sweden	22,533	23,384	23,503	[r] [e]23,000	23,000
U.S.S.R.[e]	485,000	500,000	520,000	530,000	540,000
United Kingdom	16,314	16,535	19,842	19,842	20,000
Africa:					
Angola[e]	55	--	--	--	--
Botswana	[5]159	317	345	115	110
Egypt	6,213	7,708	6,509	4,857	4,850
South Africa, Republic of[6]	14,135	[r]14,555	13,940	16,806	15,400
Zambia	117	[e]110	[e]110	--	[3]258
Zimbabwe	[e]880	[e]880	[e]1,100	1,224	1,300
Asia:					
Afghanistan[7]	9,574	6,295	1,957	[e]550	--
Burma	262	222	431	434	440
China:					
Mainland[e]	165,000	165,000	165,000	165,000	165,000
Taiwan	17,065	11,200	10,964	12,339	[3]10,925
India	[r]280,075	310,431	371,350	398,887	[3]381,523
Japan[8]	1,482,875	[r]1,497,810	1,399,767	1,434,465	1,932,200
Korea, North[e]	[r]145,000	[r]145,000	[r]165,000	[r]175,000	185,000
Korea, Republic of (talc and pyrophyllite)	547,262	667,151	733,128	857,825	[3]792,752
Nepal[9]	57	85	562	358	440
Pakistan (pyrophyllite)	5,550	10,118	27,877	35,846	35,000
Philippines	1,555	[r]1,389	4,476	3,935	4,400
Thailand (talc and pyrophyllite)	[r]7,118	11,429	16,411	14,927	15,900
Oceania: Australia	101,519	[r]142,153	161,989	172,919	180,000
Total	[r]5,812,720	[r]6,236,591	6,585,561	7,109,372	7,595,039

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 28, 1981.
[2]In addition to the countries listed, Czechoslovakia produces talc, but available information is inadequate to make reliable estimates or output levels.
[3]Reported figure.
[4]Total of beneficiated and salable direct shipping production of talc and pyrophyllite.
[5]Exports.
[6]Includes talc and wonderstone.
[7]Data are for calendar year beginning March 20 of that stated.
[8]Includes talc and pyrophyllite; in addition, pyrophyllite clay is produced; output was as follows in short tons: 1976—497,911; 1977—[r]485,248; 1978—467,379; 1979—[e]480,000; 1980, not available.
[9]Data based on Nepalese fiscal year, beginning mid-July of year stated.

year-old mine, is Europe's largest.[3] It is an open pit on the northern slopes of the Pyrenees, near Aix les Thermes. About one-half the production, 322,000 tons in both 1978 and 1979, is used in France's paper industry. The high chlorite content of the talc makes it ideally suited for the manufacture of low-expansion refractories, that is, cordierite. Luzenac, in fact, exports an annual 4,400 tons to the United States to be ground for this market.

Ireland.—The discovery of an Irish talc-magnesite prospect was announced in late 1980.[4] The reported 4 million tons of ore on the Island of Inishbofin in County Galway is the first significant mineral find in Ireland in 10 years.

Italy.—The mining and processing of talc from the major mines of the dominant talc company of Italy was described recently.[5]

Societá Talco e Grafite Val Chisone's mines are in the western Alps, about 65 kilometers northwest of Pinerolo. Veins 200 to 500 meters below the mountain peaks are reached through horizontal adits near the Fontane Valley floor. Selective mining is combined with hand sorting at the adit before the talc is trucked 35 kilometers to the mill, located at a rail terminus on the Chisone River. After drying, some of the talc is optically sorted to produce an extremely high degree of whiteness. As most of the talc is for cosmetic and pharmaceutical uses, it is ground to a minimum 98% minus 200-mesh in roller mills to maintain the integrity of the talc plates. The United States provides the fourth largest export market for Italian talcs.

Portugal.—The small (two-company) Portugese talc industry in 1979 finally exceeded its 1970 high in production. The country's economic recovery resulted in a talc industry with a 6.65% average annual growth for 1975-79.

TECHNOLOGY

The competition between talc and mica for a portion of the extender market was described.[6] It appears that several producers of superquality house paints were moving to mica either partially or totally. The mica imparts structure to the film, which increases durability, but at a nominal $300 per ton in truckload lots, it does not compete economically with talc.

The current steatite industry, manufacturing ceramic electrical insulators made from talc, has been concisely described.[7] The talcs, supplied in ground form, are readily adaptable to the conventional and sophisticated ceramic processing, extruding, firing, coloring, and machining techniques.

The highly valued steatite properties are high physical strength, dimensional stability, high dialectric strength, volume resistivity, low dialectric loss, resistance to moisture, and low production cost.

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[1]Physical scientist, Section of Nonmetallic Minerals.
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Thorium

By William S. Kirk[1]

Monazite, the principal source of thorium, continued to be recovered as a byproduct at two locations in Florida in 1980. Most of the thorium compounds used by the domestic industry during the year, however, came from imports or existing company stocks.

No major developments occurred in the nonenergy uses of thorium, which include mantles for incandescent lamps, refractories, hardeners in magnesium alloys, welding rods, and electronics.

The only commercial thorium-fueled nuclear reactor in the United States, located at Fort St. Vrain, Colo., continued to run at 70% of its electrical power capacity in 1980. The experimental thorium-fueled, light-water breeder reactor (LWBR) at Shippingport, Pa., continued to operate in 1980.

DOMESTIC PRODUCTION

Exploration.—Thorium resources were assessed in a U.S. Geological Survey report for (1) veins in the larger districts, (2) massive carbonatites, (3) disseminated deposits, and (4) stream placers of North and South Carolina.[2] In a sequel to that report, the Geological Survey published a report that assessed thorium resources in (1) Florida beach placers, (2) Idaho stream placers, (3) veins and pipes in the Bokan Mountain District, Alaska, (4) carbonatite dikes, and (5) apatite-bearing iron deposits near Mineville, N.Y.[3] Thorium resources for each of these categories were divided into reserves and probable potential resources. Where data were available, each of these were divided into the following cost categories: (1) the amount of thorium oxide (ThO_2) producible at a cost of less than $15 per pound, (2) the amount producible at a cost of between $15 and $30 per pound, and (3) the amount producible at a cost of between $30 and $50 per pound. Another Geological Survey report presented analytical data used in resource calculations for some of the deposits reported earlier.[4] The Geological Survey also published a report on thorium in a carbonatite stock in the Powderhorn District, Colo.[5]

Another Geological Survey report evaluated the possibilities of finding economic deposits of thorium in New Hampshire and adjacent States by reviewing information concerning (1) the known occurrences of thorium, (2) the types of deposits that might be found, (3) the possible source rocks of thorium, (4) the structures that might be favorable for containing economic deposits, (5) the geologic conditions that may conceal such deposits at the surface, and (6) the zoning of metal deposits.[6] Pleistocene sands of the Georgia coast were evaluated for thorium content by means of an aeroradiometric survey.[7]

A report prepared for the U.S. Department of Energy (DOE) assessed the thorium potential of Bayer process muds from eight domestic alumina plants and one abandoned mud impoundment.[8]

Table 1.—Companies with thorium processing and fabricating capacity

Company	Plant location	Operations and products
Atomergic Chemetals Corp	Plainview, N.Y	Processes oxide, fluoride, and metal.
Babcock & Wilcox Co	Lynchburg, Va	Nuclear fuels.
Bettis Atomic Power Laboratory	West Mifflin, Pa	Nuclear fuels, Government research and development.
Cerac, Inc	Milwaukee, Wis	Processes compounds.
Ceradyne, Inc	Santa Anna, Calif	Processes oxide.
Consolidated Aluminum Corp	Madison, Ill	Magnesium-thorium alloy.
Controlled Castings Corp	Plainview, N.Y	Do.
General Atomic Co	San Diego, Calif	Nuclear fuels.
W. R. Grace & Co	Chattanooga, Tenn	Processes domestic and imported monazite; stocks thorium-containing residues.
Hitchcock Industries, Inc	South Bloomington, Minn	Magnesium-thorium alloys.
Union Carbide Corp., Nuclear Div	Oak Ridge, Tenn	Nuclear fuels, test quantities.
Wellman Dynamics Corp	Creston, Iowa	Magnesium-thorium alloys.
Westinghouse Electric Corp	Bloomfield, N.J	Processes compounds; produces metallic thorium.

Mine Production.—Associated Minerals Consolidated Ltd. (AMC), an Australian mineral sands mining company, became one of the major mineral sands suppliers in the United States with its purchase of Titanium Enterprises' mining lease and plant at Green Cove Springs, Fla. The reserves in the lease were said to be large enough to insure profitable operation for at least 16 years. Dredging operations were resumed in 1980, and AMC said that most of the monazite production from Green Cove Springs would be exported.

Refinery Production.—In 1980, the only domestic firm with facilities for processing large tonnages of monazite was W. R. Grace & Co., Davison Chemical Div., at Chattanooga, Tenn. Although W. R. Grace did not produce for sale any thorium compounds from monazite, thorium was extracted from monazite and stored during the refining of rare-earth elements. W. R. Grace had about 4,200 tons of thorium residues stored at its plant site at the end of 1980.

Rhône-Poulenc Chemical Co., a French firm, began construction of a facility in Freeport, Tex., to recover rare-earth materials from monazite. The plant was to be capable of processing 7,000 tons of monazite per year. Approximately 400 tons per year of thorium residues that will be generated are to be stored.

CONSUMPTION AND USES

Based on imports, sales from the national stockpile, and other data, the estimated domestic consumption of thorium (in ThO_2 equivalence) was about 33 tons in 1980. The major nonenergy uses were mantles for Welbasch incandescent lamps (10 tons) and refractories (10 tons). Other nonenergy uses included hardeners in magnesium-thorium alloys (3 tons), thoriated tungsten welding rods (2 tons), and electronic, electro-optical, chemicals and other applications and research (5 tons).

DOE's experimental LWBR at Shippingport, Pa., continued producing electrical power for the Duquesne Light Co. power distribution grid during 1980. As of October 1980, the reactor, which uses the thorium-uranium-233 fuel system, had produced more than 1.1 billion kilowatt-hours net electrical output and was available for power production more than 90% of the time since its startup in 1977. Initial loading of about 46 tons of thorium took place in 1977. At the end of its life, the spent core will be removed from Shippingport and sent to DOE's National Engineering Laboratory in Idaho for detailed examination and determination of breeding performance.

The Fort St. Vrain high-temperature, gas-cooled reactor continued to run at 70% of its electrical power capacity in 1980. The Public Service Co. of Colorado was developing a test program to take the reactor up to 100% of its power capacity. The core of the reactor contained about 22 tons of thorium and was the Nation's first commercial reactor to use a prestressed concrete reactor vessel, helium coolant, steam turbine-drive, primary coolant helium circulators, and a fully ceramic core utilizing the uranium-thorium fuel cycle.

STOCKS

On December 31, 1980, the stockpile of the General Services Administration contained 7,145,112 pounds of thorium nitrate (1,708 short tons ThO_2 equivalent). The thorium nitrate stockpile goal was reduced in 1980 from 1.8 million pounds (418 short tons ThO_2 equivalent) to 600,000 pounds (143 short tons ThO_2 equivalent). The DOE inventory as of December 31, 1980, was 1,410 tons of thorium contained in various compounds.

PRICES

The average declared value of imported monazite at U.S. ports was $468 per short ton in 1980. The price per short ton of Australian monazite quoted in the Metal Bulletin (London) was A$317 to A$363 (US$365 to US$417) at the end of 1980.

Prices for thorium compounds, in U.S. dollars, varied depending upon quality. Thorium oxide, 99% pure, was quoted at $9.63 per pound at the end of 1980, and thorium oxide, 99.99% pure, was $17.27. Catalyst and lamp-grade thorium oxide were $17.95 and $21.14, respectively, at the end of the year.

FOREIGN TRADE

The United States exported thorium ores and concentrates in 1980, following a year in which none of these materials were exported. Export data for thorium in other forms were combined with those for uranium. Although these two elements were not statistically differentiated, it was believed that the amount of thorium in other forms was minor.

Monazite containing about 6% thorium oxide was imported from Australia and Malaysia. Imports of monazite, thorium oxide, and mantles fell below 1979 levels.

Table 2.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in pounds unless otherwise specified)

	1978		1979		1980		Principal sources and destinations, 1980
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate[1]	1,091,220	$87,500	--	--	6,898	$17,226	France 6,898
Metals and alloys[2]	5,434	76,524	10,651	$216,630	2,652	61,321	Canada 1,048; Israel 900; Federal Republic of Germany 359; Others 345.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	7,711	1,602,320	6,931	1,676,939	5,674	1,849,767	Australia 5,438; Malaysia 236.
ThO_2 content	925,320	XX	831,720	XX	680,880	XX	
Compounds:							
Nitrate	47,567	147,044	47,415	162,837	59,962	210,219	France 54,341; Canada 5,621.
Oxide	40,406	239,956	31,509	160,490	20,557	144,038	France 17,506; Netherlands 3,040; Others 11.
Oxide equivalent, in gas mantles[e 3]	1,215	206,754	2,867	476,842	3,713	677,642	Malta 3,234; Brazil 288; Others 191.
Metals and alloys	6,412	256,480	7,607	342,315	4,695	248,835	United Kingdom 4,695.
Other	953	102,138	181	33,688	501	65,478	United Kingdom 350; Federal Republic of Germany 143; Switzerland 8.

[e]Estimated. XX Not applicable.
[1]No thorium ore and concentrates were exported in 1979.
[2]Includes uranium; thorium and uranium are undifferentiated in official statistics.
[3]Based on the manufacture of 1,000 gas mantles per pound ThO_2.

WORLD REVIEW

The chief source of the world's thorium is monazite, a byproduct of mineral sands mining for titanium in many countries and for tin in Malaysia. Australia, India, Brazil, Malaysia, and the United States continued to be the leading monazite producers among market-economy countries. Of those countries, Malaysia was the only significant source of monazite without government export restrictions. Australia and Malaysia had little or no domestic processing capabilities beyond the monazite concentrating stage at the mine. Production quantities do not reflect world demand for thorium because monazite is processed mainly for its rare-earth element content.

Australia.—Allied Eneabba Ltd. announced that its facilities at Narngulu, Western Australia, were to be significantly expanded.[9] Construction was underway to expand monazite production capabilities by 30%, improve efficiency, and provide new storage facilities to accommodate the increase in production. The new facilities were to be operational at the end of the year.

D. M. Minerals Pty. Ltd., a partnership between Murphyores Pty. Ltd. and a U.S. firm, Dillingham Corp., was effectively prevented from mining heavy minerals on Fraser Island, Queensland, through a federal government export ban.[10] The firm still hoped to renew mining on Fraser Island and reportedly was planning to develop heavy mineral reserves it held in the Gladstone area of Queensland.

India.—Construction of the first phase of India Rare Earth Ltd.'s Orissa Mineral Sands Complex (OMSC) near Chatrapur fell behind schedule because of shortages of building materials. Now scheduled to come onstream in mid-1982, the first phase of OMSC should produce about 4,400 tons of monazite annually, doubling total Indian monazite production.

India Rare Earth Ltd. was reportedly considering mechanizing some of its manual mining operations at the Manavalakurichi, Tamil Nadu, heavy mineral sands project, owing, in part, to the decreasing concentration of monazite at other heavy mineral deposits. This project in 1980 accounted for the bulk of the country's monazite production.

Table 3.—Monazite concentrate: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Australia	5,853	9,377	16,526	17,864	16,200
Brazil	1,775	2,691	2,801	2,555	2,900
India[3]	3,300	3,014	3,465	3,086	3,200
Korea, Republic of	([4])	([4])	([4])	([4])	--
Malaysia[5]	2,071	2,179	1,392	737	900
Nigeria[e]	20	20	20	20	20
Sri Lanka	1	[e]5	[e]220	[e]280	280
Thailand	--	--	([6])	13	10
United States	W	W	W	W	W
Zaire	265	[r]107	85	85	85
Total	[r]13,285	[r]17,393	24,509	24,640	23,595

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in world total.

[1]Table includes data available through Apr. 27, 1981.

[2]In addition to the countries listed, mainland China, Indonesia, and North Korea may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Data are for years beginning Apr. 1 of that stated.

[4]Revised to zero.

[5]Exports.

[6]Revised to zero; figure previously reported (845 short tons) was the 1978 export, and apparently was possible because of production in 1975 and before that had not been shipped when mined. Exports were not permitted in 1976 and 1977.

TECHNOLOGY

The absorption of thorium from waste uranium leach liquor by clays and other materials was investigated, and tailings and soil samples from New Mexico were evaluated for their potential to absorb thorium from tailing liquors. Thorium absorption values ranged from zero to 60%.[11]

The radiological dose associated with the use of thorium-uranium carbide fuel in the core and thorium carbide in the blankets of a fast-breeder reactor (FBR) were investigated.[12] It was concluded that reprocessing of thorium-uranium carbide fuel for FBR's should meet applicable standards in terms of radiological impact during routine operations.

In 1980, the Nuclear Regulatory Commission investigated the possible use of ThO_2 as a means of protecting the concrete basemat in certain commercial nuclear powerplants in the event of a core meltdown accident.

The reduction in projected sodium outlet temperatures for commercial liquid-metal FBR's has renewed interest in metal fuels which contain thorium and other metals.[13]

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[1]Physical scientist, Section of Nonferrous Metals.

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Tin

By James F. Carlin, Jr.[1]

World tin production increased slightly in response to continued record high tin prices through most of the year. The 1980 average Metals Week composite price of Straits (Malaysian) tin was $8.46 per pound, the highest price on record. The general worldwide economic slowdown caused a decline in tin consumption that resulted in a slight excess of tin metal supply relative to demand for the first time in many years.

Legislation and Government Programs.—In January, the Strategic and Critical Materials Transaction Authorization Act of 1979 was implemented, authorizing the disposal of materials determined to be in excess to the current needs of the national defense stockpile. The act provided for the sale of up to 35,000 long tons of tin, including a contribution of up to 5,000 long tons to the International Tin Council (ITC) buffer stock. Starting in July, the General Services Administration (GSA) conducted biweekly stockpile auctions of up to 500 metric tons each time, with a maximum offering of 10,000 metric tons per year. Only 5 metric tons were sold at these auctions through November. Starting December 1, GSA converted to a daily fixed-price tin sale program and sold a total of 20 metric tons during December.

The United States continued as a member of the Fifth International Tin Agreement (ITA), the only metal agreement in which the United States has participated. Negotiations were conducted for the Sixth ITA.

The depletion allowances for tin remained 22% for domestic deposits and 14% for foreign deposits.

Table 1.—Salient tin statistics

(Metric tons)

	1976	1977	1978	1979	1980
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	r5,733	r6,724	5,900	4,600	3,000
Secondary	16,446	18,503	21,100	21,493	18,638
Exports (including reexports)	2,338	5,480	4,692	3,417	4,294
Imports for consumption:					
Metal	45,055	47,774	46,776	48,355	45,982
Ore (tin content)	5,733	6,724	3,873	4,529	840
Consumption:					
Primary	51,767	47,596	48,403	49,496	44,342
Secondary	11,161	13,136	13,128	12,969	12,020
U.S. industry yearend stocks	21,485	21,366	17,217	8,126	7,816
Prices, average cents per pound:					
New York market	349.24	499.38	587.03	711.45	773.44
New York composite	379.82	534.60	629.58	753.89	846.00
London	347.42	486.92	583.83	700.93	761.99
Penang	338.94	485.96	567.65	672.33	745.56
World production:					
Mine	r218,412	r230,220	r241,355	p245,318	e246,247
Smelter	r224,063	r226,450	r241,918	r246,602	e248,104

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Domestic production of tin was less than 200 tons. Molybdenum mining in Colorado provided some tin as a byproduct, and some tin concentrates were produced in Alaska.

Smelter Production.—Gulf Chemical & Metallurgical Corp. (GCMC) imported some tin concentrate, mostly from Bolivia. However, the tin concentrate imported declined sharply as increased smelter capacity in Bolivia absorbed most tin concentrates domestically. These imported and domestic concentrates, as well as secondary tin-bearing materials and its own stockpile of tin residues and slags, formed the feed for the Texas City, Tex., smelter. Tin smelter production was estimated at 3,000 tons.

SECONDARY TIN

The United States remained the world's largest producer of secondary tin. Secondary tin production declined as the economic slowdown cut consumption requirements.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1979	1980
Tinplate scrap treated ... metric tons	841,430	766,940
Tin recovered in the form of:		
Metal ... do	1,536	1,457
Compounds (tin content) ... do	433	321
Total[1] ... do	1,969	1,778
Weight of tin compounds produced ... do	1,256	1,533
Average quantity of tin recovered per metric ton of tinplate scrap used ... kilograms	2.34	2.32
Average delivered cost of tinplate scrap ... per metric ton	$90.73	$89.39

[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 220 metric tons (213 metric tons in 1979) of tin as metal and in compounds from tin-base scrap and residues in 1980.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons)

Form of recovery	1979	1980
Tin metal:		
At detinning plants	1,749	1,677
At other plants	18	26
Total	1,767	1,703
Bronze and brass:		
From copper-base scrap	12,044	10,352
From lead- and tin-base scrap	46	[e]50
Total	12,090	10,402
Solder	5,282	4,423
Type metal	584	525
Babbitt	441	378
Antimonial lead	867	856
Chemical compounds	433	321
Miscellaneous[1]	29	[e]30
Total	7,636	6,533
Grand total	21,493	18,638
Value (thousands)	$336,900	$317,625

[e]Estimated.
[1]Includes foil and terne metal.

Table 4.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States

(Metric tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
1980									
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	3,602	61,118	--	60,971	60,971	3,749	--	2,622	2,622
Brass, composition or red	2,194	57,758	10,470	45,829	56,299	3,653	353	1,690	2,043
Brass, low (silicon bronze)	445	3,443	1,057	2,303	3,360	528	--	16	16
Brass, yellow	3,768	41,348	6,776	34,895	41,671	3,445	8	361	369
Bronze	1,587	17,583	3,062	14,430	17,492	1,678	241	1,134	1,375
Low-grade scrap and residues	12,188	226,674	177,767	50,420	228,187	10,675	28	--	28
Nickel silver	605	2,832	357	2,536	2,893	544	3	22	25
Railroad-car boxes	194	1,548	--	1,488	1,488	254	--	71	71
Total	24,583	412,304	199,489	212,872	412,361	24,526	633	5,916	6,549
Brass mills:[1]									
Brass, low (silicon bronze)	3,012	50,932	50,932	--	50,932	3,724	--	--	--
Brass, yellow	21,600	247,867	247,867	--	247,867	19,864	154	--	154
Bronze	480	4,414	4,414	--	4,414	775	211	--	211
Nickel silver	3,670	13,934	13,934	--	13,934	3,756	--	--	--
Total	28,762	317,147	317,147	--	317,147	28,119	365	--	365
Foundries and other plants:[2]									
Auto radiators (unsweated)	680	4,351	1,433	3,142	4,575	456	--	142	142
Brass, composition or red	697	11,855	212	11,660	11,872	680	10	554	564
Brass, low (silicon bronze)	53	1,239	1,134	107	1,241	51	--	2	2
Brass, yellow	433	10,039	5,398	4,725	10,123	349	13	59	72
Bronze	900	524	356	199	555	869	25	15	40
Low-grade scrap and residues	--	--	--	--	--	--	--	--	--
Nickel silver	10	442	31	407	438	14	--	--	--
Railroad-car boxes	707	6,284	--	6,140	6,140	851	--	291	291
Total	3,480	34,734	8,564	26,380	34,944	3,270	48	1,063	1,111
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	1,046	6,979	8,025
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	254	6,851	--	6,938	6,938	167	--	520	520
Battery lead plates	42,381	719,438	--	727,095	727,095	34,724	--	1,505	1,505
Drosses and residues	20,145	125,525	133,186	--	133,186	12,484	3,403	--	3,403
Solder and tinny lead	1,315	11,564	--	10,948	10,948	1,931	--	1,752	1,752
Type metal	2,528	13,793	--	14,413	14,413	1,908	--	753	753
Total	66,623	877,171	133,186	759,394	892,580	51,214	3,403	4,530	7,933
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	13	90	--	90	90	13	--	75	75
Block-tin pipe	9	65	--	71	71	3	--	70	70
Drosses and residues	27	1,038	1,011	--	1,011	54	415	--	415
Pewter	--	13	--	13	13	--	--	11	11
Total	49	1,206	1,011	174	1,185	70	415	156	571

See footnotes at end of table.

Table 4.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States —Continued

(Metric tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
1980 —Continued									
Tinplate and other scrap:									
Detinning plants	--	--	766,940	--	766,940	--	2,109	--	2,109
Grand total	XX	XX	XX	XX	XX	XX	6,973	11,665	18,638

XX Not applicable.

[1]Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, lines and total in brass-mill section do not balance.

[2]Omits "machine-shop scrap."

CONSUMPTION AND USES

Tin consumption declined owing to the economic slowdown that affected most usage categories. While primary tin consumption declined noticeably, secondary tin usage dropped only slightly. Tinplate regained its position as the major usage category, while the solder sector assumed second place.

Tinplate continued to encounter strong competition in the traditional container markets, especially from aluminum. Out of a total of 87.9 billion metal cans shipped, steel (tinplate and tin-free steel) accounted for 52% and aluminum for 48%; this compares with a total of 89.3 billion metal can shipments in 1979, with steel accounting for 61% and aluminum for 39%. Two-piece cans continued their domination of the beverage markets, accounting for 92% of metal can shipments. Overall, two-piece cans now represent 60% of total metal can shipments. Of a total of 50.8 billion two-piece metal cans shipped, steel accounted for 18%.[2]

Brass mills consumed 715 tons of primary tin and 385 tons of secondary tin compared with 801 tons of primary tin and 525 tons of secondary tin in 1979.

Table 5.—Consumption of primary and secondary tin in the United States

(Metric tons)

	1976	1977	1978	1979	1980
Stocks Jan. 1[1]	19,510	16,894	16,858	13,584	4,497
Net receipts during year:					
Primary	49,995	48,215	46,821	44,914	46,968
Secondary	2,019	4,025	2,541	2,636	2,461
Scrap	10,189	10,604	10,499	7,430	7,821
Total receipts	62,203	62,844	59,861	54,980	57,250
Total available	81,713	79,738	76,719	68,564	61,747
Tin consumed in manufactured products:					
Primary	51,767	47,596	48,403	49,496	44,342
Secondary	11,161	13,136	13,128	12,969	12,020
Total	62,928	60,732	61,531	62,465	56,362
Intercompany transactions in scrap	1,891	2,148	1,604	1,602	835
Total processed	64,819	62,880	63,135	64,067	57,197
Stocks Dec. 31 (total available less total processed)	16,894	16,858	13,584	4,497	4,550

[1]Includes tin in transit in the United States.

Table 6.—Tin content of tinplate produced in the United States

(Metric tons)

Year	Tinplate waste-waste, strips, cobbles, etc., gross weight	Tinplate (all forms) Gross weight	Tin content[1]	Tin per metric ton of plate (kilograms)
1976	439,988	4,372,639	20,766	4.7
1977	355,841	4,228,325	18,539	4.4
1978	338,351	4,022,524	17,280	4.3
1979	360,852	4,236,578	17,929	4.2
1980	311,770	3,699,920	16,346	4.4

[1]Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 7.—Consumption of tin in the United States, by finished product

(Metric tons of contained tin)

Product	1979			1980		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	2,248	180	2,428	W	134	134
Babbitt	1,830	413	2,243	1,537	843	2,380
Bar tin	567	W	567	486	W	486
Bronze and brass	2,709	5,981	8,690	2,147	5,331	7,478
Chemicals	4,797	W	4,797	W	W	W
Collapsible tubes and foil	686	W	686	526	W	526
Solder	13,249	4,773	18,022	11,653	3,965	15,618
Terne metal	(1)	(1)	(1)	(1)	(1)	(1)
Tinning	2,498	86	2,584	2,531	46	2,577
Tinplate[2]	17,929	--	17,929	16,346	--	16,346
Tin powder	1,435	W	1,435	1,098	11	1,109
Type metal	26	114	140	W	W	W
White metal[3]	1,258	W	1,258	914	W	914
Other	264	1,422	1,686	7,104	1,690	8,794
Total	49,496	12,969	62,465	44,342	12,020	56,362

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Included in "Alloys (miscellaneous)."
[2]Includes secondary pig tin and tin acquired in chemicals.
[3]Includes pewter, britannia metal, and jewelers' metal.

STOCKS

Plant stocks of pig tin were 3,799 tons at yearend, about a month's supply. The lowered consumption rates, owing to the economic slowdown, the increased worldwide availability of tin from smelter sources and GSA stockpile sales, and high interest rates, all combined to keep stock levels low.

Table 8.—U.S. industry yearend tin stocks

(Metric tons)

	1976	1977	1978	1979	1980
Plant raw materials:					
Pig tin:					
Virgin[1]	6,647	6,173	4,129	3,480	3,570
Secondary	243	645	694	191	229
In process[2]	10,004	10,040	8,761	826	751
Total	16,894	16,858	13,584	4,497	4,550
Additional pig tin:					
Jobbers-importers	1,009	1,436	275	258	564
Afloat to United States	3,582	3,072	3,358	3,371	2,702
Total	4,591	4,508	3,633	3,629	3,266
Grand total	21,485	21,366	17,217	8,126	7,816

[1]Includes tin in transit in the United States. In 1979, the figure represents scrap purchased only.
[2]Tin content, including scrap. In 1980, data represents scrap only.

PRICES

The price of tin metal rose in the first half of the year, then fell during the second half, with the average price being substantially higher than for 1979. Prices were influenced by the uncertainty about the start of the U.S. tin stockpile sales program, high interest rates, and the economic slowdown.

The average Metals Week composite price of tin metal for the year was $8.46, about $1 above the 1979 figure.

Table 9.—Monthly composite price of Straits tin for delivery in New York

(Cents per pound)

Month	1979			1980		
	High	Low	Average	High	Low	Average
January	701.00	668.31	684.23	863.92	817.46	837.36
February	737.24	700.00	720.08	921.37	835.29	868.73
March	754.46	727.36	741.80	959.93	867.26	898.60
April	752.54	726.72	735.91	907.75	854.55	876.66
May	751.35	727.73	740.77	894.39	851.80	868.50
June	768.48	744.11	753.92	868.23	843.60	853.46
July	773.07	727.01	759.52	853.36	833.79	843.16
August	753.35	732.42	739.52	845.59	832.85	839.22
September	784.61	747.45	761.95	884.10	849.02	868.98
October	792.72	772.99	781.40	852.67	821.00	840.00
November	824.95	783.13	799.63	819.93	772.13	797.79
December	842.02	809.79	827.95	776.47	745.02	759.56
Average	XX	XX	753.89	XX	XX	846.00

XX Not applicable.

Source: Metals Week.

FOREIGN TRADE

Imports of tin metal declined in line with lessened U.S. consumption. Imports of tin concentrates dropped sharply; Bolivia, traditionally the major source of tin concentrates, increased its smelter capacity, thus leaving less concentrates available for export.

The tariff on tin in all forms, ore and concentrate, metal, and waste and scrap, remained free to all nations.

Malaysia, Thailand, Indonesia, and Bolivia remained the major sources for tin metal.

Table 10.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips, and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1978	498	$5,926	4,194	$51,901	339,529	$142,389	3,836	$1,479	([1])	([1])	5,234	$749
1979	568	8,074	2,849	42,783	399,525	204,986	2,942	1,292	([1])	([1])	5,471	513
1980	595	10,194	3,699	62,382	641,401	440,671	NA	NA	([1])	([1])	6,497	405

NA Not available.
[1]Included with exports of tinplate and terneplate.

Table 11.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f.	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin scrap and other tin-bearing material, except tinplate scrap	Quantity (metric tons)	Value (thousands)
	Value (thousands)	Quantity (metric tons)	Value (thousands)	Value (thousands)		
1978	$32,276	709	$5,365	$11,232	240	$2,472
1979	16,732	1,350	11,011	12,513	202	2,473
1980	9,154	1,312	4,215	13,819	171	2,285

Table 12.—U.S. imports for consumption of tin, by country

Country	1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Concentrates (tin content):				
Bolivia	3,745	$48,493	528	$7,505
Canada	583	2,968	13	85
Indonesia	--	--	27	376
Mexico	--	--	1	2
Peru	169	2,218	--	--
South Africa, Republic of	32	339	125	1,536
Thailand	--	--	146	1,585
Total	4,529	54,018	840	11,089
Metal:[1]				
Australia	135	2,030	145	2,400
Belgium-Luxembourg	100	1,532	190	3,365
Bolivia	5,387	77,595	5,597	90,730
Brazil	933	13,423	2,031	34,211
Canada	58	116	113	1,939
Chile	276	3,865	--	--
China, Mainland	185	2,686	858	13,855
Germany, Federal Republic of	25	405	--	--
Hong Kong	1	17	--	--
India	40	591	--	--
Indonesia	5,429	78,917	6,477	104,383
Japan	--	--	10	158
Korea, Republic of	--	--	20	350
Macao	20	300	20	332
Malaysia	23,448	343,814	15,548	265,819
Mexico	5	89	--	--
Nigeria	--	--	770	13,092
Peru	--	--	260	3,496
Rhodesia	--	--	63	1,092
Singapore	1,070	16,451	864	14,685
South Africa, Republic of	253	883	181	3,113
Switzerland	--	--	5	85
Thailand	10,440	148,803	12,414	205,515
United Kingdom	550	8,533	416	7,562
Total	48,355	700,050	45,982	766,182

[1]Bars, blocks, pigs, or granulated.

WORLD REVIEW

International Tin Agreement.—Negotiations for the Sixth ITA, due to take effect on July 1, 1981, continued throughout 1980. As the gap between consumer country and producer country positions on such issues as the ITC buffer stock and export controls remained considerable, it was decided in mid-1980 to extend the provisions of the Fifth ITA one more year, until July 1, 1982, to allow additional time for negotiations. On March 13, 1980, the ITC revised upward by 10% the buffer stock price range as shown in table 13. The ITC accepted a contribution of 1,500 metric tons of tin metal to the buffer stock from the U.S. Government. During the year there was considerable opposition voiced by producer countries to the sale of GSA stockpile tin by the U.S. Government.

Table 13.—Changes in ITC buffer stock range

	Previous range		Effective Mar. 3, 1980	
	M$ per picul[1]	U.S. equivalent dollars per pound	M$ per picul[1]	U.S. equivalent dollars per pound
Floor price	1,500	5.25	1,650	5.61
Lower sector	1,500-1,650	5.25-5.77	1,650-1,815	5.61-6.18
Middle sector	1,650-1,800	5.77-6.30	1,815-1,980	6.18-6.74
Upper sector	1,800-1,950	6.30-6.82	1,980-2,145	6.74-7.30
Ceiling price	1,950	6.82	2,145	7.30

[1]M$ Malaysian dollar; picul is a unit of weight equal to 133.33 pounds.

Australia.—Renison Ltd., 51% owned by Consolidated Gold Fields Australia Ltd., was the dominant producer, accounting for more than half of total Australian production. Renison reported that its mine at Renison Bell in Tasmania, had completed the first stage of its plan to expand milling capacity from 630,000 to 850,000 tons per year, and that the second and final stages were scheduled for completion by the end of 1980. Renison reported that its combined, proved, and probable reserves increased by 707,000 tons of tin ore, and that there was a further 11 million tons of possible ore at a grade of 1.05% tin. After successful matte-fuming trials of low-grade concentrate at a plant in Freiberg, German Democratic Republic, Renison began an engineering study to assess the feasibility of a fuming plant.

Greenbushes Tin N.L. commissioned an electric tin smelter at its Greenbushes Mine, with an annual capacity of 2,000 tons of concentrates. The company announced test drilling of its property yielded evidence of reserves of 9.7 million tons of ore containing 0.15% tin.

Associated Tin Smelters Pty. Ltd. commissioned a vacuum distillation unit early in the year at its smelter near Sydney. The unit facilitated removal of some metallic impurities during refining of the tin.

Tin mineralization of 0.6% was discovered near the old Mount Bischoff Mine in Tasmania by a group headed by Metals Exploration Ltd. Geochemical surveys by the Australian Bureau of Mineral Resources near Georgetown, indicated there may be commercial alluvial cassiterite deposits along the Gilbert River. Newmont Pty. Ltd. was assessing whether to develop the Baal Gammon tin property in New South Wales. The prospect, considered as an opencast operation, was estimated to contain 4.5 million tons of ore assaying 0.3% tin and 1.3% copper, with a further 7 million tons of ore assaying 0.24% tin.

A new flotation plant was to be added to Ardlethan Tin Ltd.'s mill facility in New South Wales, with startup expected in 1981. Exploration programs at the Ardlethan tin mine intersected a new body of tin mineralization and indicated that the life of this mine could be significantly extended.

Belgium.—The 18,000-ton-per-year capacity tin smelter of Metallurgie Hoboken-Overpelt S.A. at Hoboken was scheduled to close at the end of the year. The smelter, operating since 1908, had reportedly been operating at under 25% capacity for the past 15 years. Output of refined tin metal fell to 2,165 tons in 1980 as Belgium's import of tin concentrates, principally from Zaire and Rwanda, steadily declined over recent years.

Table 14.—Tin: World mine production, by country[1]

(Metric tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada	274	328	360	[2]337	264
Mexico	481	220	73	23	20
United States	W	W	W	W	W
South America:					
Argentina	[r] [3]358	[r] [3]537	[3]362	[2]480	582
Bolivia	30,315	[r]33,740	30,881	[2]27,648	27,272
Brazil	5,388	6,450	6,976	7,716	8,000
Peru	273	300	800	929	1,000
Europe:					
Czechoslovakia[e]	[3]180	[3]180	[3]180	[3]180	180
German Democratic Republic[e]	1,300	1,400	1,600	1,600	1,600
Portugal	332	267	269	225	220
Spain	390	[r]642	710	496	500
U.S.S.R.[e]	31,000	33,000	34,000	35,000	36,000
United Kingdom	3,323	[r]3,851	2,802	2,374	2,960
Africa:					
Burundi	[r]17	[r] [e]20	20	8	10
Cameroon	10	14	14	8	8
Niger	126	130	125	125	125
Namibia	800	994	1,250	1,042	1,000
Nigeria	3,710	3,267	2,935	2,750	2,500
Rwanda	1,605	1,598	1,502	1,337	1,200
South Africa, Republic of	2,799	2,864	2,886	2,697	2,800
Swaziland	2	2	1	1	--
Tanzania	3	--	9	10	12
Uganda[e]	[3]120	[3]120	[3]120	60	50
Zaire	3,776	5,073	4,390	3,879	3,000
Zambia[e]	([4])	3	([4])	1	[2] ([4])
Zimbabwe	[e]920	[r] [e]920	[e]950	969	960
Asia:					
Burma	507	362	757	1,169	1,136
China, mainland[e]	[r]11,000	[r]13,000	[r] [e]14,000	14,000	14,600
Indonesia	[r]23,435	25,926	27,411	29,535	[2]32,527
Japan	643	[r]605	603	660	540
Korea, Republic of	35	15	19	31	[2]8
Laos[e]	[3]576	[3]600	[3]400	300	350
Malaysia	63,401	58,703	62,650	62,995	[2]61,404
Thailand	20,452	24,205	30,186	33,962	[2]33,685
Vietnam[e]	250	[e]250	[e]250	[e]200	[2]370
Oceania: Australia	10,611	10,634	11,864	12,571	[2]11,364
Total	[r]218,412	[r]230,220	241,355	245,318	246,247

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Contained-tin basis. Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London, England. Table includes data available through May 25, 1981.
[2]Reported figure.
[3]Estimate by the International Tin Council.
[4]Less than 1/2 unit.

Bolivia.—Tin mine production continued to decline, lowering Bolivia to fourth place among leading world producers from the second place position it held for decades. Output declined steadily since 1977, and mine production in 1980 was the smallest since 1965.

The Corporación Minera de Bolivia (COMIBOL) remained the dominant factor in tin mining. Empressa Nacional de Fundiciones (ENAF), the State-owned smelting organization, increased Bolivia's tin smelting capacity to 30,000 tons annually. ENAF started a new 10,000-ton-per-year smelter at Vinto to process concentrates grading 8% to 15% tin at a maximum. Along with the existing Vinto smelter, with a capacity of 20,000 tons annually, ENAF had sufficient capacity to smelt all of Bolivia's domestic mine output.

Planning problems and cost overruns delayed the startup of production at the fuming plant in La Placa, built and financed by the U.S.S.R. The 400-ton-per-day plant was expected to be the largest of its kind in the world for treating low-grade tin tailings.

Starting March 1, Bolivia introduced a new tax system for the mining industry. The previous complex structure of national and regional production taxes was replaced

Table 15.—Tin: World smelter production, by country[1]

(Metric tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Mexico[2]	800	1,000	1,000	600	400
United States[3]	5,733	6,724	5,900	[4]4,600	3,000
South America:					
Argentina	120	120	120	120	120
Bolivia[5]	[r]9,790	[r]13,045	16,254	14,950	[4]18,191
Brazil	[r]6,423	[r]7,421	9,309	10,133	10,500
Europe:					
Belgium	4,068	3,520	3,295	3,000	3,000
German Democratic Republic[e]	1,200	1,200	1,200	1,600	1,600
Germany, Federal Republic of	1,449	2,897	3,241	2,488	2,400
Netherlands	2,000	2,100	1,800	1,445	1,500
Portugal	319	588	520	397	500
Spain	5,369	5,343	4,575	4,412	4,500
U.S.S.R.[e]	31,000	33,000	34,000	35,000	36,000
United Kingdom	11,161	10,458	8,445	8,025	6,500
Africa:					
Nigeria	3,667	3,315	2,984	2,858	2,000
South Africa, Republic of	683	582	637	819	1,100
Zaire	478	765	496	458	300
Zimbabwe	[r]915	[r]920	945	947	[4]934
Asia:					
China, mainland[e]	[r]11,000	[r]13,000	[r]14,000	[r]14,000	14,600
Indonesia	23,322	24,005	25,829	27,790	29,100
Japan	[r]1,129	1,280	1,141	[4]1,251	1,319
Malaysia[6]	[r]77,297	[r]66,304	71,953	73,068	72,000
Thailand	20,337	23,102	28,945	[4]33,058	33,500
Vietnam[e]	200	200	200	160	350
Oceania: Australia	5,603	5,561	5,129	5,423	[4]4,690
Total	[r]224,063	[r]226,450	241,918	246,602	248,104

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London, England. Output reported throughout is primary tin only unless otherwise specified. This includes data available through May 25, 1981.

[2]Smelter output from domestic ores is as follows, in metric tons: 1976—481; 1977—220; 1978—73; 1979—23; and 1980 (estimated)—20.

[3]Includes tin content of alloys made directly from ores.

[4]Reported figure.

[5]Excludes output of volatilization product (reported as "low-grade volatilized powder") as follows, in metric tons: 1976—675; 1977—964; 1978 through 1980—not available.

[6]Includes small production of tin from smelter in Singapore.

by a single tax. In the case of tin, the new tax was fixed at 53% of the difference between assumed production costs as established by the Government and the world tin price. Although reports estimated that the Government's revenue from this source would be reduced by about 25%, the new system was expected to encourage miners to increase production. In September, the Government introduced a new program of reduced royalties that provided for miners working low-grade areas to get tax rebates ranging from 45% to 5%.

Brazil.—Tin production continued the steady rise of recent years. About 80% of the Brazilian production of ore came from the mining district of Rondonia. The principal tin mining companies were Paranapanema S.A. Mineracao, Industria e Construcao (Lacombe Group), Mineracao Oriente Novo (Brumadinho Group), Mineracao Brasiliense S.A. (MIBRASA) (joint venture of Phibro and CESBRA, a Patino subsidiary), and Mineracao e Prospeccoes Minerais S.A. (PROMISA).

Several major mining companies including Tricontinental, Best, Mineralto, Mineracao Gonduwana, and the State of Goias mineral exploration company, METAGO, were reported to be actively prospecting for tin in the State of Goias. Prospecting was also reportedly being carried on in the Sao Felix do Xingu region in the State of Pará.

Brascan Ltd. of Toronto, Canada, purchased for $32.5 million Patino's 96% share of Brazilian tin mine and smelter Companhia Estanífera do Brasil (CESBRA). CESBRA owned a 7,000-metric-ton-per-year tin smelter near Rio de Janeiro, and also mined tin on land adjoining property held by

Brascan in Rondonia. Patino continued to maintain an interest in CESBRA through its 34% holding in Edper Equities, which owns 48% of Brascan.

There were 10 tin smelting companies in Brazil. Although only five had plant capacity to smelt over 1,000 tons of concentrates per year, there was sufficient capacity among those five companies to smelt all domestic production, and the total capacity of all the smelting plants was double the output of the tin mining industry.

Burma.—To upgrade its tin mining industry, Burma received a technical assistance grant from the Asian Development Bank. The grant was expected to fund development of 21 proven alluvial tin deposits in the southern region of the country. North Korea agreed to assist in the construction of a tin smelter in Burma; the plant was expected to cost $4 million and have an annual capacity of 1,000 tons of ore.

Canada.—The four tin producers in Canada were Cominco Ltd. from its lead-zinc mine at Sullivan, British Columbia, and from recovery processes at its smelter at Trail, British Columbia; Texasgulf Ltd. from its Kidd Creek Mine; Brunswick Mining & Smelting Corp., Ltd., from its mine at Belledune, New Brunswick; and Selco Mining Ltd. at its South Bay Mine in Uchi Lake, Ontario.

In New Brunswick, the joint venture operation of Billiton Canada Ltd., Brunswick Tin Mines Ltd., and Mount Pleasant Mines Ltd. to develop a tungsten-molybdenum deposit has been intensively explored and developed almost continuously since 1969. From the Fire Tower Zone of the orebody that was being prepared for production with startup scheduled for 1982, there was an overall tin content of about 0.04%, but the concentrator design did not include provision for the recovery of tin. One-half mile north of the Fire Tower Zone, a lower grade tungsten-molybdenum deposit was outlined with a satellite deposit known as the Tin Zone that contained 2.4 million tons of ore grading 0.42% tin. Reports indicated that this Tin Zone could conceivably be brought into production quickly if tin metal prices were favorable, although no major output was expected before 1985.

China, Mainland.—Tin reserves were located primarily in the Yunnan, Guangxi, and Guangdong Provinces. Most of the metal was produced in Yunnan by the Yunnan Mining Corp. whose main operations were in the Gejiu municipality; two major mines were the Laochang and the Wanzijie. Reportedly, at least 50% of tin mining in China was subsurface mining, and about 80% of tin metal output was consumed domestically. There were believed to be at least seven tin smelters in China, the largest being at Kokiu in Yunnan Province.

Indonesia.—Tin mine production continued the uptrend of recent years. Mine production was lead by Perusahaan Terbatas Tambang Timah (P. T. Timah), the national mining firm. The second leading producer was P. T. Koba Tin. The other producers were P. T. Broken Hill Pty., and P. T. Riau Tin Mining Co. Indonesia's tin industry was closed to additional foreign private enterprise.

P. T. Timah was expected to be a major factor in Indonesia's expansion plans as defined in its third 5-year plan which called for a sharp increase in tin mining capacity by 1984. The firm utilized dredges and hydraulic mining methods to exploit alluvial tin deposits, both inland and offshore, around the islands of Bangka, Belitung, and Singkep, and at Bangkinang on the mainland of Sumatra. Sufficient tin ore existed for Indonesia to reach its planned production targets, while exploration continued off the eastern coast of Sumatra south of Singapore and along the southwestern coast of Kalimantan. Government concerns reportedly centered on the aging dredge fleet, composed of many dredges that are more than 40 years old. The recent introduction of the Bangka II dredge was an important step in achieving expansion goals; the 202-meter-long dredge could dredge 975 cubic meters per hour in waters 50 meters deep.

All tin ore produced in Indonesia was smelted by P. T. Timah's Peltim smelter at Mentok on Bangka Island. Two types of refined tin bars were produced: Mentok tin (99.85% tin) and Bangka tin (99.92% tin).

Nippon Steel Co. of Japan agreed to cooperate with P. T. Timah on the construction of a new tinplate production plant.

Malaysia.—Tin mine production declined slightly, but Malaysia maintained its long-held position as the world's leading tin producer. At yearend 1980, there were 54 tin dredges, 746 gravel pump mines, and 52 opencast, underground, and other miscellaneous mines in operation, slightly less than the number of total active mines at yearend 1979. The labor force decreased slightly to

39,009. The Malaysia Mining Corp. (MMC), 71% owned by the Malaysian State producer Pernas and 29% owned by Charter Consolidated Ltd., of the United Kingdom, remained the largest tin mining group in the world and accounted for about 25% of the country's total tin output. Tin mining was largely centered in the States of Perak and Selangor.

Tin prospecting, both onshore and offshore, was recently intensified. Offshore prospecting was begun in the State of Perak, with plans to extend it to the States of Malacca and Negri Sembilan. Onshore, a comprehensive geochemical survey financed partially by a grant from the Canadian International Development Agency was commenced to locate new deposits in the central belt of peninsular Malaysia. The Malaysian Geological Survey Department (MGSD) and the Malaysian Mines Research Institute found new tin mineralization off Cape Rachard and in several areas in the States of Perak, Selangor, Negri Sembilan, and Pahang.

The MGSD established a Quarternary Geology Division to intensify investigation into areas which could become new producers of tin. The MGSD also planned to establish experimental mines as sources of information on costs of production, methods, and safety measures. The first experimental mine was reported to be a gravel pump operation in Perak. The MGSD had reportedly already undertaken geological mapping covering 65% of peninsular Malaysia and produced more than 11,000 copies of prospecting results which will be analyzed later.

The Malaysian Government, in cooperation with the Governments of Thailand and Indonesia, began organizing a tin research and development center in Ipoh, Perak. The center's main objective was to conduct research in areas ranging from mineral exploration to ingot production.

Conzinc Riotinto Sdn. Bhd., in a joint venture with the Pahang Tenggara Development Authority, a State Government agency, was exploring for tin in a 500-square-mile area in Pahang.

Perangsang Riotinto Sdn. Bhd., a joint venture of Conzinc Riotinto and the Selangor Economic Development Authority, and a bumiputra-(indigenous Malay) owned tin mining company, Syarikat Lombong Setapak, operated a dredge costing $10.2 million, currently the largest in Malaysia. The dredge was located in the Dengkil area in the district of Kuala Langat, Selangor.

In the State of Johore, large-scale tin mining was planned following the discovery of substantial tin deposits in the Sungai Pelawan area in the district of Kota Tinggi. Mining rights were awarded to a new joint venture company known as Syarikat Pelombong Sebina Johore Sdn. Bhd., with the Johore State Economic Development Corp. holding 51% and the Malaysia Mining Corp. holding 49%.

Southern Kinta Consolidated hired a dredge from Kampong Lanjut Tin Dredging Bhd. for a period of 14 years. The dredge was to be used to work the Bernam section north of Kuala Lumpur.

A new company, known as Timah Matang Sdn. Bhd., which was owned by Pernas Mining, Kamunting Tin Dredging Ltd., Saku Timah Sdn. Bhd., and state interests, was formed to dredge a new site in Selangor Province. The tin grade of the 500-acre site was reported to be high.

After several years of discussion, agreement was reached for the development of the major Kuala Langat tin dredging project in the State of Selangor. The operating company was named Kuala Langat Mining and was 65% owned by the State entity Kumpulan Perangsang Selangor Bhd. and 35% owned by the Malaysian Mining Corp. In assessing the deposits of the area, which included the Brooklands Estate, Selangor authorities termed the tin deposits as more inaccessible and difficult to mine economically compared with other Malay regions and may require substanial technological innovation. Initial output from the Kuala Langat alluvial tin deposits was expected in 1985, at a rate of 2,300 tons of tin-concentrate annually, rising to 6,250 tons yearly by 1990. The operation was considered likely to have a life of over 20 years. The firm's immediate objective was to make a detailed survey of the 5,000 acres covered by the 25-year mining lease. Meanwhile, work was proceeding on the design of three major dredging units, each capable of reaching depths of up to 75 meters.

Malaysian tin concentrates were smelted by Datuk Keramat Smelting (DKS) at Penang and The Straits Trading Co. Ltd., at Butterworth. DKS added a sixth reverberatory furnace which increased capacity by 20%. The two smelters had a combined annual capacity of 130,000 metric tons, but Malaysia produced only about 61,000 tons of tin concentrates. Malaysia did smelt an additional estimated 9,000 metric tons of tin concentrate from Australia and Thailand.

Nigeria.—Tin production continued the pattern of steady decline of recent years. For decades Nigeria extracted tin ore from surface desposits but these have become largely depleted. The Government wanted to exploit large, rich underground deposits; however, a hardcore basalt posed a problem and would require a huge investment in mining equipment. The Nigerian Enterprises Promotion Decree, which restricted foreign investors to 40% equity participation in tin mining, discouraged needed foreign investment. The Government found itself without sufficient funds to carry out its development plans. Industry sources reported that prospects for needed new, large investments were dim for the near future.

Tin ore was mined in the States of Plateau, which is headquarters for all mining firms and the States of Benue, Bauchi, and Kano. The Makeri Smelting Co. Ltd. smelts all the tin mined in the country.

Poland.—Prospecting by the Warsaw Institute of Geology revealed deposits of cassiterite near Krobica and Gierczyn in the Izera Mountain Range. The size of the deposit was not established and further prospecting was to be carried out to a depth of about 700 meters over a 20-square-kilometer area. The tin metal content varied from 0.2% to 0.4%. Mining was expected to start in 1981.

South Africa, Republic of.—There was a well-integrated, though fairly small tin mining industry, with production from three different primary sources, all located in the Transvaal region. The Rooiberg Field, operated by Rooiberg Tin Ltd. and located near Warmbaths, produced about two-thirds of the country's production. The Zaaiplaats Field, operated by Zaaiplaats Tin Mining Co. Ltd., was located near Potgietersrus. The Union Field was operated by Union Tin Mines Ltd. Rooiberg completed construction of its $2 million smelter.

Thailand.—Mine output continued its steady increase over recent years, almost doubling since 1975. The Government's new $18 million tin dredge was leased initially to Aokham Tin Co., Ltd. which operated it near Phuket Island.

Plans to develop a major new offshore tin dredging operation in Patong Bay, near Phuket, under concession owner Setthasap Kanrae reportedly encountered strong environmental opposition. The firm wanted to install a large bucket-ladder dredger. This deposit was considered by industry sources to be the country's last known major shallow-water deposit that had not been previously worked.

Pacific Tin Consolidated Corp. reported plans to expand production at its Sierra Mining Co. Ltd. property in southern Thailand.

U.S.S.R.—Primary tin production continued the steady rise of recent years. Although the Soviet tin production policy has been one of self-sufficiency, output continued to be inadequate and more than 20% of requirements were imported. The Soviet Far East, Yakutia, and Transbaykal were the main producing areas. The Maritime Kray was the major producing district; with the Khrustalnyy complex, which operated both lode and placer deposits, being the main enterprise there; in addition, this enterprise operated the Ege-Khaya, Imeni Lazo, Kholodnyy, and Alyaskavityy Mines.

The Khingan complex at Birobidzhan, Jewish Autonomous Oblast, Khabarovsk Kray, was the largest tin mining complex in the U.S.S.R. Three known tin smelters were operating in the country at Novosibirsk, Ryazan', and Podol'sk. Concentrates from Siberia and the Soviet Far East were shipped to Novosibirsk, the location of the largest smelter. Output of secondary tin was estimated at 12,000 tons by industry sources.

United Kingdom.—Rio Tinto Zinc Corp. Ltd., through its 95% owned Carnon Consolidated Tin Mines Ltd., started hoisting tin ore from the new Wheal Jane Mine in February. The mine actually encompassed two older operating mines, the original Wheal Jane and the adjacent Mount Wellington Mine. By yearend, the mine was expected to be producing at the rate of 280,000 tons of ore annually, containing 1,500 tons of tin.

Construction of a $2 million pilot plant at Hemerdon Ball, near Plymouth, was completed by Hemerdon Mining and Smelting Ltd., and AMAX Exploration of U.K. Inc. The cassiterite deposits were in a granite body 650 meters long, 150 meters wide, and 200 meters deep. The study was expected to continue through 1981.

The U.S.-financed Marine Mining Ltd. started a 1-year test of tin dredging at Padstow off the northern coast of Cornwall during which it planned to dredge 100,000 tons of sand with 0.2% tin content. The ore was then to be trucked to a special milling facility at Bissoe where it was to be concentrated to about 25% metal content. The company estimated possible production of 900 tons of tin annually.

TECHNOLOGY

A process was developed for extracting tin sulfide from tin ore or slag. The molten ore or slag material is heated along with sulfur dioxide, air or oxygen, and a gaseous or liquid hydrocarbon at a temperature of 900° to 1,300° C and a carbon dioxide-carbon monoxide partial pressure ratio of 3 to 1. A sulfide of the metal is formed, and the metal is recovered by volatilization or other methods.[3]

A process for the beneficiation of oxide ore of tin by selectively enhancing the magnetic susceptibility of the metal-rich particles was developed. Ore is heated to a temperature of 175° to 270° C and contacted with iron carbonyl to render the surfaces of the metal-rich particles more magnetic than they are naturally. The magnetized material is cooled and subjected to a magnetic concentration step.[4]

It was found that additions of tin, along with copper, act as an aid in the sintering of iron powder compacts. Not only did the tin permit significantly lower sintering temperatures to be used than when copper alone was added, but also—with additions of 3% copper, 2% tin—volume changes during sintering were much reduced. Also, the addition of tin and manganese to iron powders increases tensil strength and hardness.[5]

Low-cost, low-gold, corrosion-resistant dental alloys containing tin were developed that reportedly could be cast by conventional techniques.[6]

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[1]Physical scientist, Section of Nonferrous Metals.

[2]Can Manufacturer's Institute. Metal Can Shipments Report. 1980, pp. 3-8.

[3]Tin International. Mineral Processing. V. 53, No. 8, 1980, p. 326.

[4]———. Tin Recovery Processes. V. 53, No. 12, 1980, p. 520.

[5]Metallurgia. Powder Metallurgical Research. September 1980, pp. 461-462.

[6]Chemical & Engineering News. Science. Jan. 28, 1980, p. 32.

Titanium

By Langtry E. Lynd[1] and Ruth A. Hough[2]

Mill product shipments of titanium reached a new record level of 27,000 short tons[3] in 1980. Despite the peak consumption, supply and demand came into better balance as a result of increased domestic sponge production and higher imports of sponge. Domestic production and consumption of titanium dioxide pigment products decreased in 1980, reflecting a slowdown in the economy. Production of ilmenite decreased in 1980, despite the resumption of mining at Green Cove Springs, Fla. Production of rutile also began again at that location, which was the only U.S. facility to produce a natural rutile concentrate.

Prices for titanium concentrates increased about 5% to 20% during 1980, and pigment prices rose about 7%, while the sponge metal price climbed to $7.02 per pound, up 76% over the yearend 1979 level.

Legislation and Government Programs.—The Government stockpile goal for titanium sponge metal was increased in May 1980 to 195,000 tons, up 48% from the previous goal of 131,503 tons, because of the level of defense requirements for aircraft and the limited domestic sponge production capacity. The Government stockpile in December 1980 contained 21,465 tons of specification titanium sponge metal, and 10,866 tons of nonspecification material.

The Government stockpile goal for rutile was decreased in May 1980 from 173,928 tons to 106,000 tons, because requirements declined for applications other than titanium metal. The total rutile stockpile in-

Table 1.—Salient titanium statistics

	1976	1977	1978	1979	1980
United States:					
Ilmenite concentrate:					
Mine shipments ____short tons__	617,896	542,333	580,878	646,399	593,704
Value ____thousands__	$27,578	$25,201	$25,628	$32,965	$32,041
Imports for consumption ____short tons__	168,402	334,990	308,671	184,478	357,488
Consumption ____do____	822,259	866,504	792,289	791,063	853,215
Titanium slag:					
Imports for consumption ____do____	171,624	150,564	149,172	111,210	194,994
Consumption ____do____	203,964	149,454	128,826	144,708	181,582
Rutile concentrate, natural and synthetic:					
Imports for consumption ____do____	281,712	123,800	289,617	283,479	281,605
Consumption ____do____	237,718	185,419	263,184	313,761	261,434
Sponge metal:					
Imports for consumption ____do____	1,778	2,387	1,476	2,488	4,777
Consumption ____do____	13,315	16,236	19,854	23,937	26,943
Price, Dec. 31, per pound ____	$2.70	$2.98	$3.28	$3.98	$7.02
Titanium dioxide pigments:					
Production ____short tons__	712,940	687,103	700,755	[r]741,465	714,278
Imports for consumption ____do____	68,497	114,810	117,708	104,968	97,590
Apparent consumption ____do____	753,947	785,003	801,728	[r]836,426	[illegible]41,192
Price, Dec. 31, cents per pound:					
Anatase ____	41.0	43.5	46.0	53.0	57.0
Rutile ____	46.5	48.5	51.0	59.0	63.0
World production:					
Ilmenite concentrate ____short tons__	3,490,031	3,653,264	3,874,458	[p]3,871,756	[e]4,019,319
Titanium slag ____do____	901,193	[r]764,524	1,037,193	[p]842,040	[e]1,343,210
Rutile concentrate, natural ____do____	[r1]444,826	[1]380,833	[1]332,731	[p1]396,501	[e]466,501

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes U.S. production data to avoid disclosing company proprietary data.

ventory in December 1980 was 39,186 tons.

The Federal Trade Commission (FTC), in what was described as a major statement of antitrust policy, upheld an initial 1979 ruling by an FTC administrative law judge and agreed that E. I. du Pont de Nemours & Co., Inc., had not violated Federal antitrust laws in achieving a dominant position in the titanium dioxide market.[4]

As a result of procurement problems experienced during the titanium shortage in 1979-80, the Department of Defense and the Federal Emergency Management Agency (FEMA) developed a proposal for funding domestic cobalt and titanium development in the fiscal 1982 budget through Title III of the Defense Production Act. The titanium proposal was to involve a stockpile purchase guarantee program to encourage expansion of domestic titanium sponge production.[5]

DOMESTIC PRODUCTION

Concentrates.—Production of ilmenite in 1980 was the lowest since 1954. This low output was caused mainly by the shutdown of the Humphreys Mining Co. operations at Boulougne, Fla., and Folkston, Ga., and the short period of operation by Associated Minerals (U.S.A.) Inc. (AMU), at Green Cove Springs, Fla., where mining and milling was resumed in June 1980. Associated Minerals Consolidated Ltd. (AMC) of Australia, parent company of AMU, purchased the Titanium Enterprises property at Green Cove Springs in April 1980 for $11.7 million. The property was expected to have reserves for 16 years' operation, producing at a rate of 50,000 tons per year of ilmenite, 25,000 tons per year of rutile, and 25,000 tons per year of zircon. Production of synthetic rutile from the Green Cove Springs ilmenite, using AMC's process, was being considered.[6]

AMU was the only U.S. producer of natural rutile concentrate in 1980. Production of ilmenite at the mines of Du Pont at Starke, Fla., and Highland, Fla., and of ASARCO Incorporated at Manchester, N.J., was about the same as in 1979, while that of NL Industries, Inc., Tahawus, N.Y., was lower than in 1979.

Kerr-McGee Chemical Corp. resumed production at its synthetic rutile plant in Mobile, Ala., and planned to reach the design production capacity rate of 110,000 tons per year by 1982.

Ferrotitanium.—Ferrotitanium was produced by Shieldalloy Corp. at Newfield, N.J., the Pesses Co. at Solon, Ohio, Reactive Metals and Alloys Corp., West Pittsburg, Pa., and A. Johnson & Co., Inc. Lionville, Pa. Most of the production consisted of the 70% titanium grades.

Metal.—Production of titanium sponge metal in 1980 was 14% higher than in 1979, despite disruption of production by an 18-day strike at the sponge plant of the largest U.S. producer. Total U.S. sponge capacity reached about 28,000 tons in 1980, up 22% from that of 1979.

Sponge-producing companies during 1980 and their approximate annual capacities were Titanium Metals Corp. of America's TIMET Div., Henderson, Nev., jointly owned by NL Industries and Allegheny International, Inc., 14,000 tons; RMI Co., Ashtabula, Ohio, owned by National Distillers and Chemical Corp., and United States Steel Corp., 9,500 tons; Oregon Metallurgical Corp., Albany, Oreg., publicly owned with Armco Steel Corp. and Ladish Corp. as major stockholders, 3,000 tons; and Teledyne Wah Chang Albany, Albany, Oreg., which converted some of its idle zirconium reduction capacity to titanium production, 1,500 tons.

The following eight companies produced titanium ingot:

Company	Plant location
Crucible, Inc., Colt Industries	Midland, Pa.
Howmet Corp., Alloy Div	Whitehall, Mich.
Lawrence Aviation Industries, Inc	Port Jefferson, N.Y.
Martin Marietta Aluminum, Inc	Torrance, Calif.
Oregon Metallurgical Corp	Albany, Oreg.
RMI Co	Niles, Ohio.
Teledyne Allvac	Monroe, N.C.
Titanium Metals Corp. of America	Henderson, Nev.

Table 2.—Production and mine shipments of ilmenite concentrates[1] from domestic ores in the United States

Year	Production gross weight (short tons)	Shipments: Gross weight (short tons)	Shipments: TiO_2 content (short tons)	Shipments: Value (thousands)
1976	652,404	617,896	374,989	$27,578
1977	638,503	542,333	331,139	25,201
1978	589,751	580,878	352,842	25,628
1979	639,292	646,399	389,535	32,965
1980	548,882	593,704	358,181	32,041

[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 3.—Components of U.S. titanium metal supply and demand

(Short tons)

	1976	1977	1978	1979	1980
Production:					
Ingot	21,614	26,302	31,385	r37,414	41,804
Exports:					
Sponge	NA	NA	97	180	113
Other unwrought	NA	NA	210	155	344
Scrap	6,144	3,394	5,453	4,967	3,300
Ingot, slab, sheet bar, etc	1,065	1,050	1,340	1,984	3,278
Other wrought	--	--	689	1,316	1,845
Total	7,209	4,444	7,789	8,602	8,880
Imports:					
Sponge	1,778	2,387	1,476	2,488	4,777
Scrap	1,860	4,494	3,789	r6,140	4,138
Ingot and billet	323	354	561	338	191
Mill products	--	--	1,125	942	946
Total	3,961	7,235	6,951	r9,908	10,052
Stocks, end of period:					
Government: Sponge (total inventory)	32,329	32,331	32,331	32,331	32,331
Industry:					
Sponge	3,617	3,546	2,642	2,155	2,381
Scrap	5,764	6,770	6,447	6,733	8,641
Ingot	1,831	1,898	2,155	r2,366	1,868
Other	26	42	73	200	2
Total industry	11,238	12,256	11,317	r11,454	12,892
Reported consumption:					
Sponge	13,315	16,236	19,854	23,937	26,943
Scrap	9,211	10,889	12,318	13,986	15,406
Ingot	21,004	25,241	30,746	r35,987	42,494
Mill products (net shipments)[1]	14,498	15,466	17,648	r23,113	27,076
Castings (shipments)[1]	257	188	180	184	191

rRevised. NA Not available.
[1]Source: Bureau of the Census, Current Industrial Reports Series DIB-991 and ITA-991.

Following completion in June 1980 of a $3.5-million, 2,000-ton-per-year expansion of its titanium sponge plant, RMI announced an $8 million titanium mill products expansion, to be completed in late 1981, involving installation of a second 3,000-ton, open-die press-forging system to allow full utilization of sponge from RMI's recent and future sponge capacity expansions.

Oremet began a 50% expansion of its titanium sponge plant capacity to 4,500 tons per year, to be completed in June 1981. Oremet was also expanding its mill products facilities to produce from 6,000 tons to 7,500 tons per year of titanium bar, billet, and slab, at a cost of about $5 million, with completion scheduled by the end of 1980.

The new D-H Titanium Co. electrolytic titanium demonstration plant began operations in Freeport, Tex., in December 1980. D-H Titanium is a joint venture of The Dow Chemical Co. and Howmet Turbine Components Corp. D-H production of titanium sponge was expected to be 150 to 250 tons in 1981, and 500 to 1,000 tons in 1982. A commercial plant may be built, either at Freeport or some other location, with annual capacity reaching about 2,500 tons in 1984 and 5,000 tons or more by 1986.

Frankel Co. reportedly began a $3-million expansion of its titanium recycling facilities in Detroit, Mich., and in Crompton, Calif. Half of the cost was to be for expansion of chip-processing facilities and for plasma melting equipment to be used for converting chips into electrodes. The electrodes are sold to titanium producers, which remelt them into ingot.

Pigment.—Pigment production decreased in 1980 along with the slowdown in economic conditions. Rutile pigment accounted for 77% of total output in 1980 and was produced by six manufacturers. Five companies produced anatase pigment. Companies producing titanium dioxide pigment in 1980, with plant locations and estimated yearend capacity, were as follows:

Company and plant location	Pigment capacity (tons per year)	
	Sulfate process	Chloride process
American Cyanamid Co., Savannah, Ga	53,000	40,000
E. I. du Pont de Nemours & Co., Inc.:		
Antioch, Calif	--	35,000
De Lisle, Miss	--	150,000
Edge Moor, Del	--	167,000
New Johnsonville, Tenn	--	228,000
Gulf + Western Natural Resources Group, Chemicals Div. (formerly New Jersey Zinc Co.):		
Ashtabula, Ohio	--	30,000
Gloucester City, N.J	44,000	--
Kerr-McGee Chemical Corp., Hamilton, Miss	--	56,000
NL Industries, Inc., Sayreville, N.J	100,000	--
SCM Corp., Glidden Pigments Group, Chemical/Metallurgical Div.:		
Ashtabula, Ohio	--	42,000
Baltimore, Md	50,000	32,000
Total	247,000	780,000

Despite the lower TiO_2 production level in 1980, Glidden Pigments Group of SCM Corp. was planning to raise the annual capacity of its Baltimore, Md., chloride process plant to 42,000 tons, a 10,000-ton increase, to be completed in 1981. Gulf + Western Industries (G+W) announced plans to increase its capacity for production of titanium tetrachloride ($TiCl_4$) at its Ashtabula, Ohio, facility by about 21%, to 145,000 tons per year, at an anticipated cost of $3.7 million. G+W also planned to increase its titanium dioxide annual production capacity at Ashtabula from 30,000 tons to 35,000 tons. About 90% of G+W's $TiCl_4$ is used for making titanium dioxide pigments; the remaining 10% is sold to titanium metal manufacturers such as RMI and Oremet. NL Chemicals Div. of NL Industries, Inc., at its sulfate process pigment plant at Sayreville, N.J., successfully carried out plant scale production operations using a new process modification that NL calls liquid phase digestion. Conversion of the entire plant to the new technology is planned by late 1981 and will reportedly permit compliance with all existing environmental regulations while providing improved efficiency of operation.[7]

Table 4.—Components of U.S. titanium dioxide pigment supply and demand

(Short tons)

	1976	1977	1978	1979	1980[p]	
					Gross weight	TiO_2 content
Production	712,940	687,103	700,755	741,465	714,278	665,209
Shipments:[1]						
Quantity	711,774	696,552	714,547	753,780	731,546	681,264
Value (thousands)	$594,846	$602,383	$621,909	$720,265	$795,734	NA
Imports for consumption	68,497	114,810	117,708	104,968	97,590	[e]90,915
Exports	20,580	16,336	37,812	49,369	42,126	41,992
Stocks, end of period	113,873	114,447	93,370	54,008	82,558	[e]76,886
Apparent consumption[2]	753,947	785,003	801,728	836,426	741,192	[e]687,543

[e]Estimated. [p]Preliminary. NA Not available.
[1]Includes interplant transfers.
[2]Apparent consumption = production plus imports minus exports minus stock increase.

Sources: U.S. Bureau of the Census (1976-79 and gross weight of imports 1980); and U.S. Bureau of Mines (1980), 1980 is the first year for which both gross weight and actual TiO_2 content data are available for total production.

CONSUMPTION AND USES

Concentrates.—The total amount of TiO_2 consumed domestically in concentrates decreased in 1980, reflecting a drop in pigment production. In 1980, the market share of TiO_2 from ilmenite and slag sources increased while that from rutile decreased, mainly because of Kerr-McGee's resumption of production of synthetic rutile, which uses ilmenite as a source of TiO_2.

A relatively new use for ilmenite is in filtration media for water treatment. Demand in 1980 was reportedly about 3,000 tons. Ilmenite is preferred to other media such as garnet because of its higher specific gravity and higher degree of angularity, which make it form a more cohesive bed.

Metal.—Consumption of titanium sponge and shipments of mill products each set new records of about 27,000 tons in 1980, 13% and 17%, respectively, above 1979 levels. The high demand in 1980 continued to come mainly from the commercial aircraft market, with steady requirements for military aircraft, and increasing orders for other industrial applications.

Supply and demand came into better balance in 1980 as domestic sponge production and imports increased substantially. Delivery lead times for mill products were not as long as in 1979, and lower spot prices of sponge and scrap were further evidence of greater supply.

In 1980, mill product shipments were 62% in the form of bar and billet; 20% sheet, strip, and plate; 14% tubing and extrusions; and 4% other forms. Bar and billet were the major forms used for aerospace gas turbine engines and airframe forgings, while the other forms are used mainly for nonaerospace industrial applications.[8] It was estimated that in 1980, as in 1979, mill product usage was about 75% for aerospace and 25% for other industrial uses. Allowing for the portion of titanium scrap that was used in steel and other alloys, overall consumption of titanium was estimated at 60% for aerospace, 20% for other industrial applications, and 20% for alloying purposes.

The largest application for titanium is in aircraft gas turbine engines, for compressor

Table 5.—Consumption of titanium concentrates in the United States, by product

(Short tons)

Year and product	Ilmenite[1]		Titanium slag		Rutile (natural and synthetic)	
	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
1976	822,259	498,013	203,964	144,506	237,718	223,612
1977	[2]866,504	[2]521,194	149,454	106,201	[3]185,419	[3]173,840
1978	792,289	475,448	128,826	91,490	263,184	245,184
1979:						
Alloys and carbide	(4)	(4)	(5)	(5)	(4)	(4)
Pigments	775,681	475,342	144,708	106,346	247,334	230,776
Welding-rod coatings and fluxes	(4)	(4)	--	--	10,480	9,947
Miscellaneous[6]	15,382	11,886	--	--	55,947	52,189
Total	791,063	487,228	144,708	106,346	313,761	292,912
1980:						
Alloys and carbide	(4)	(4)	(5)	(5)	(4)	(4)
Pigments	838,807	504,338	181,582	133,993	[7]190,358	[7]178,705
Welding-rod coatings and fluxes	(4)	(4)	--	--	7,253	6,876
Miscellaneous[6]	14,408	11,155	--	--	63,823	59,407
Total	853,215	515,493	181,582	133,993	[7]261,434	[7]244,988

[e]Estimated.
[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2]Includes estimate of imported ilmenite used to make synthetic rutile in the United States.
[3]Includes imported synthetic rutile, but excludes synthetic rutile made in the United States from imported ilmenite.
[4]Included with "Miscellaneous" to avoid disclosing company proprietary data.
[5]Included with "Pigments" to avoid disclosing company proprietary data.
[6]Includes ceramics, chemicals, glass fibers, and titanium metal.
[7]Includes synthetic rutile made in the United States.

Table 6.—Distribution of titanium-pigment shipments, titanium dioxide content, by industry

(Percent)

Industry	1976	1977	1978	1979	1980
Paints, varnishes, lacquers	51.1	52.0	47.9	47.4	44.1
Paper	21.4	20.7	20.8	21.8	24.3
Plastics (except floor covering and vinyl-coated fabrics and textiles)	10.6	11.7	11.6	11.8	10.6
Rubber	2.7	3.1	2.8	2.9	2.1
Printing ink	2.0	2.0	2.0	1.9	2.8
Ceramics	1.9	1.9	2.1	1.9	1.7
Other	7.4	6.2	6.7	7.1	8.2
Exports	2.9	2.4	6.1	5.2	6.2
Total	100.0	100.0	100.0	100.0	100.0

Table 7.—Consumption of titanium products[1] in steel and other alloys

(Short tons)

	1976	1977	1978	1979	1980
Carbon steel	976	780	601	529	423
Stainless and heat-resisting steel	2,008	2,049	2,394	2,368	1,620
Other alloy steel (includes HSLA)	818	859	936	959	848
Tool steel	W	W	W	W	W
Total steel[2]	3,802	3,688	3,931	3,856	2,891
Cast irons	100	92	144	129	102
Superalloys	455	482	743	1,197	1,053
Alloys, other than above	768	537	255	234	272
Miscellaneous and unspecified	273	16	9	9	13
Total consumption	5,398	4,815	5,082	5,425	4,331

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]Includes ferrotitanium containing 20% to 70% titanium and titanium metal scrap.
[2]Excludes data withheld and unspecified included under "Miscellaneous and unspecified."

blades and wheels, stator blades, rotors, and other engine parts. The second largest use is in airframe structures of both military and commercial airplanes, such as wing carry-through structures, landing gears, ducting, weight and space critical forgings, and structures where resistance to heat is required.[9] The most rapid growth in titanium use has been for other industrial uses requiring superior resistance to corrosion, such as for surface condensers in powerplants, heat exchangers, and chemical industry equipment. New potential markets include use in offshore oil drilling platform structures to replace high-strength low-alloy steel equipment, in ocean thermal energy conversion heat exchangers, sour gas well drilling equipment, and environment control systems, including storage of nuclear wastes.[10]

Pigment.—Consumption of titanium dioxide pigment decreased 11% in 1980, while production decreased only 4%. The drop in consumption was attributed to a slowdown in the economy, particularly in the housing industry.

Ferrotitanium.—Consumption of ferrotitanium and titanium metal scrap in steel and other alloys decreased about 20% in 1980 because of lower steel production and possibly because of increased prices of titanium scrap.

STOCKS

Stocks of titanium materials in the United States are shown in table 8.

Table 8.—Stocks of titanium concentrates and pigment in the United States, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:		
1978	[e]810,757	510,430
1979	[r]728,874	[r]462,415
1980	889,677	559,779
Titanium slag:		
1978	105,685	75,097
1979	75,089	56,917
1980	171,898	127,981
Rutile:		
1978	[e]183,793	172,685
1979	[r e]127,443	[r]119,947
1980	146,513	138,192
Titanium pigment:[1]		
1978	NA	93,370
1979	NA	[r]54,008
1980	NA	83,237

[e]Estimated. [r]Revised. NA Not available.

[1]Source: U.S. Bureau of the Census.

PRICES

Concentrates.—Price quotations of ilmenite in domestic markets remained steady at $55 per long ton throughout the year while the Australian ilmenite price increased from $18-$19 per long ton in 1979 to $21-$23 per long ton, f.o.b. Australian ports, in April 1980, where it remained at yearend.

Rutile spot prices, bulk, f.o.b. cars at Atlantic, Gulf, and Great Lake ports, were quoted at $425-$450 per short ton for the entire year. Australian rutile, bulk lots, f.o.b. Australian ports, began the year at $291-$332 per short ton, decreased during first quarter 1980 to $285-$325 per short ton, increased in July to $308-$350 per short ton, and remained at that level for the rest of the year. Australian rutile, bagged lots, f.o.b. Australian ports, increased from $345-$394 per short ton at the beginning of 1980 to $371-$425 per short ton during April, at which level it closed the year. Domestic synthetic rutile, f.o.b. Mobile, Ala., was $310 per short ton at the end of 1980. Declared valuations of synthetic rutile shipments entering U.S. ports averaged $164 per short ton for the year, and c.i.f. value averaged $203 per short ton.

The price of titanium slag, 70% to 72% TiO_2, f.o.b. Sorel, Quebec, increased in March 1980 from $110 per long ton to $115 per long ton, while titanium slag, 85% TiO_2, f.o.b. Richards Bay, Republic of South Africa, closed the year at $137 per long ton.

Metal.—The published price of domestic titanium sponge rose in July 1980 from $3.98 per pound to $7.02 per pound where it remained at yearend. Japanese sponge, c.i.f. U.S. ports, increased to $7.50-$8.70 per pound in July and stayed at that level for the rest of the year. Prices for mill products, per pound, throughout the year were as follows: bar, $8.17 to $10.73; billet, $5.24 to $7.13; plate, $7.38 to $9.04; and sheet and strip, $12.07 to $14.10.

Pigment.—Prices of titanium dioxide pigment climbed during the first quarter of 1980 from 59 cents per pound to 63 cents per pound for rutile, and from 53 cents per pound to 57 cents per pound for anatase, and remained at these levels for the rest of the year.

FOREIGN TRADE

Exports and imports of titanium materials are shown in tables 9 through 12.

Table 9.—U.S. exports of titanium products, by class

Class	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Concentrates:						
Ilmenite	NA	NA	NA	NA	NA	NA
Rutile	NA	NA	9,903	$2,057	17,830	$3,444
Total	NA	NA	9,903	2,057	17,830	3,444
Metal:						
Sponge	97	$351	180	1,019	113	1,088
Other unwrought	210	1,141	155	1,125	344	2,891
Scrap	5,453	8,777	4,967	18,265	3,300	12,681
Ingots, billets, slabs, etc	1,340	11,290	1,984	26,456	3,278	61,962
Other wrought	689	11,768	1,316	25,912	1,845	51,589
Total	7,789	33,327	8,602	72,777	8,880	130,211
Pigment and oxides:						
Titanium dioxide pigments	37,812	26,967	49,369	43,940	42,126	43,352
Titanium compounds, except pigment-grade	1,529	2,505	2,087	4,211	3,669	6,005
Total	39,341	29,472	51,456	48,151	45,795	49,357

NA Not available.

Table 10.—U.S. imports for consumption of titanium concentrates, by country[1]

Country	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Ilmenite:						
Australia	308,649	$4,463	184,478	$2,846	338,676	$5,843
Finland	--	--	--	--	27	1
India	--	--	--	--	18,739	829
Netherlands[2]	--	--	--	--	46	2
Norway	22	3	--	--	--	--
Total[3]	308,671	4,466	184,478	2,846	357,488	6,674
Titanium slag:						
Canada	149,172	14,858	81,289	7,814	145,475	14,299
South Africa, Republic of	--	--	29,921	3,286	49,519	6,115
Total	149,172	14,858	111,210	11,100	194,994	20,414
Rutile, natural:						
Australia	242,505	45,667	140,291	25,357	143,038	30,379
Malaysia	--	--	--	--	267	2,451
Sierra Leone	--	--	7,980	1,484	40,900	9,515
South Africa, Republic of	5,453	841	10,819	2,068	18,907	4,806
Sri Lanka	6,063	990	6,305	1,432	--	--
Thailand	--	--	--	--	197	1,643
Other	8	1	18	113	33	951
Total	254,029	47,499	165,413	30,454	203,342	49,745
Rutile, synthetic:						
Australia	23,546	3,771	72,218	11,799	60,962	9,050
Germany, Federal Republic of	--	--	--	--	2	4
India	11,011	1,393	22,134	3,190	10,471	1,675
Japan	675	142	1,243	278	6,590	2,077
Taiwan	356	68	22,471	3,838	238	69
Total[3]	35,588	5,375	118,066	19,105	78,263	12,874
Titaniferous iron ore:[4]						
Canada	51,640	1,837	153,714	4,880	10,185	423

[1] Adjusted by the Bureau of Mines.
[2] Country of transshipment rather than country of production.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel furnace flux.

Table 11.—U.S. imports for consumption of titanium pigments

Country	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Australia	2,633	$1,654	6,119	$4,146	6,678	$5,830
Belgium-Luxembourg	8,936	7,082	2,620	1,893	422	385
Canada	17,242	13,847	19,808	16,948	10,325	10,445
Finland	5,110	3,644	5,791	4,533	4,392	4,018
France	11,054	7,943	5,564	4,816	12,771	12,470
Germany, Federal Republic of	39,973	33,935	34,961	32,025	27,126	25,921
India	451	250	80	46	240	163
Italy	650	430	688	496	152	133
Japan	3,562	2,926	4,736	4,362	4,471	4,741
Mexico	38	23	--	--	60	46
Netherlands	954	680	20	17	323	318
Norway	1,920	1,467	2,395	1,970	4,217	3,716
South Africa, Republic of	--	--	599	351	1,110	878
Spain	3,060	2,025	9,630	7,383	7,579	6,595
Sweden	--	--	--	--	116	104
United Kingdom	21,467	14,362	11,348	8,781	17,608	16,220
Yugoslavia	656	466	461	416	--	--
Other	2	5	148	127	--	--
Total[1]	117,708	90,741	104,968	88,310	97,590	91,986

[1]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. imports for consumption of titanium metal

Class and country	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Unwrought: Sponge						
China, mainland	--	--	99	$1,533	861	$17,474
Japan	756	$3,181	2,058	10,777	3,720	39,546
U.S.S.R	604	2,393	330	2,260	165	2,741
United Kingdom	116	514	1	10	(1)	1
Other	--	--	--	--	31	452
Total	1,476	6,088	2,488	14,580	4,777	60,214
Ingot and billet:						
Canada	24	295	2	49	(1)	2
China, mainland	--	--	--	--	45	1,625
France	--	--	2	38	--	--
Germany, Federal Republic of	1	6	(1)	(1)	24	812
Japan	6	75	13	154	61	1,459
U.S.S.R	500	2,131	313	2,473	48	613
United Kingdom	30	173	8	140	13	333
Other	--	--	(1)	5	1	10
Total[2]	561	2,681	338	2,859	191	4,854
Waste and scrap:						
Austria	174	448	59	286	57	702
Canada	299	587	332	1,319	284	1,792
China, mainland	--	--	--	--	454	4,842
Finland	65	107	93	160	181	792
France	62	163	41	244	144	1,874
Germany, Federal Republic of	393	1,391	321	1,706	568	3,722
Japan	105	359	469	2,706	211	2,227
South Africa, Republic of	--	--	170	1,762	10	136
Sweden	44	112	425	1,322	42	328
Switzerland	192	354	59	264	36	170
U.S.S.R	[3]1,863	[3]3,012	3,313	8,422	1,411	4,619
United Kingdom	556	1,522	726	3,552	668	6,472
Other	[r]37	[r]83	[r]132	[r]523	72	764
Total[2]	3,789	8,139	6,140	22,267	4,138	28,440
Wrought titanium:						
Canada	531	3,745	470	3,799	486	4,203
China, mainland	--	--	--	--	66	2,308
Germany, Federal Republic of	16	240	29	434	28	486
Japan	556	4,663	393	5,081	344	7,576

See footnotes at end of table.

Table 12.—U.S. imports for consumption of titanium metal —Continued

Class and country	1978 Quantity (short tons)	1978 Value (thousands)	1979 Quantity (short tons)	1979 Value (thousands)	1980 Quantity (short tons)	1980 Value (thousands)
Wrought titanium —Continued						
United Kingdom	13	$169	28	$312	10	$343
Other	10	226	22	518	12	352
Total[2]	1,125	9,044	942	10,144	946	15,269

[r]Revised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes 55 tons of a metal-slag mixture.

WORLD REVIEW

Australia.—Australia was still the dominant producer of titanium concentrates in 1980, turning out 37% of the world's ilmenite and 69% of its rutile. Australian exports of ilmenite in 1980 went mainly to the United States, the U.S.S.R., the United Kingdom, Japan, Brazil, and France. Exports of rutile were mainly to the United States, the United Kingdom, Japan, the Netherlands, and the Federal Republic of Germany.

U.S. aircraft manufacturers reportedly have discussed with Australian mining firms the possible construction of titanium sponge metal plants in Australia, as part of an offsetting agreement to satisfy Australian Government regulations, in connection with the Government's possible purchase of F-16 or F-18 fighter aircraft. The Australian Government reportedly deferred a decision on aircraft selection until mid-1981.[11]

Brazil.—Large reserves of titanium- and vanadium-bearing ore were reportedly discovered in the Campo Alegre de Lourdes area on the border of Bahia and Piaui States.

A mineral sands mine was to be developed by Nuclemon, a subsidiary of Nuclebras, at Largo near Campos, Rio de Janeiro State. Production was to include 16,000 tons per year of rutile and 24,000 tons per year of ilmenite.

China, Mainland.—Ilmenite was reportedly being recovered at a new plant utilizing vanadium-bearing titaniferous magnetite from the Panzihua deposit in Sichuan Province, north of Kunming. The ore is similar to that at Otanmäki, Finland, and is separated to provide, besides ilmenite, magnetite concentrate for vanadium extraction and pelletizing for use as blast furnace feed. Planned annual production of ilmenite concentrate was said to be 50,000 tons.[12]

One of China's titanium metal plants is located in Fushun and reportedly produces 550 tons of sponge metal per year. Melting into ingots is done at the No. 3 Shanghai steelworks.[13]

Germany, Federal Republic of.—Metallgeselleschaft AG, Frankfurt, reportedly was trying to find the most suitable location for a 4,400-ton-per-year sponge plant and other financial participation in the project. It seemed likely that a site outside Germany would be chosen because of high energy costs there. Estimated capital investment required for the plant was about $40 million.[14]

Bayer AG reportedly suspended operations at its 22,000-ton-per-year chloride process titanium dioxide pigment plant.

India.—A titanium tetrachloride plant was to be completed in the State of Kerala, and a titanium sponge metal plant was planned for the State of Tamil Nadu. The products of these plants were intended for export, as well as to supply titanium sponge to the defense project at the Mishra Dhatu Ngam (Midhani) plant near Hyderabad, which was to begin production of titanium products by yearend.[15]

Italy.—Development of the rutile deposit at Piampaludo in the Liguria region around Genoa was reportedly planned for the 1980's. This project would represent Europe's first domestic source of natural rutile. The deposit is owned by Mineraria Italiana S.p.A. and has proven reserves of 165 million tons of ore containing 3% to 5% rutile. A pilot plant has been designed.

Table 13.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by country[1]

(Short tons)

Concentrate type and country	1976	1977	1978	1979[p]	1980[e]
Ilmenite and leucoxene:[2]					
Australia:					
Ilmenite	[2]1,057,339	1,139,081	1,383,392	1,268,169	[3]1,443,180
Leucoxene	13,595	11,708	17,750	24,001	[3]29,539
Brazil	16,110	14,625	22,131	14,541	22,000
Finland	135,143	137,458	145,395	131,947	[3]165,000
India	[e]90,000	[4]151,402	[4]178,063	[4]158,733	[4]198,000
Malaysia[5]	198,410	169,388	205,929	220,262	176,000
Norway	845,101	913,267	845,461	903,576	[3]912,508
Portugal	405	252	165	[e]200	210
Sri Lanka	61,524	37,580	36,421	61,035	64,000
U.S.S.R.[e]	420,000	440,000	450,000	450,000	460,000
United States[6]	652,404	638,503	589,751	639,292	548,882
Total	3,490,031	3,653,264	3,874,458	3,871,756	4,019,319
Rutile:					
Australia	429,625	358,561	283,376	307,435	323,801
Brazil	56	141	402	484	500
India	[e]4,000	[4]6,053	[4]6,329	[4]5,396	[4]7,700
Sierra Leone[e]	--	--	--	11,000	55,000
South Africa, Republic of[e]	--	5,000	[r]19,951	[r]46,010	53,000
Sri Lanka	1,145	1,078	12,673	16,176	16,500
U.S.S.R.[e]	10,000	10,000	10,000	10,000	10,000
United States	W	W	W	W	W
Total	444,826	380,833	332,731	396,501	466,501
Titaniferous slag:					
Canada[7]	897,350	[r]763,170	937,000	525,840	964,210
Japan[7]	3,843	1,354	193	[e]200	--
South Africa, Republic of[e 8]	--	--	100,000	[r]316,000	379,000
Total	901,193	[r]764,524	1,037,193	842,040	1,343,210

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Table excludes production of anatase ore in Brazil (4,298,731 tons produced prior to 1979 and apparently largely mined in 1978; 7,373,074 tons mined during 1979; and an unreported quantity mined in 1980), all of which was stockpiled without beneficiation. This material reportedly contains 20% TiO_2. The table includes data available through June 23, 1981.

[2]Ilmenite is also produced in Canada and in the Republic of South Africa, but this output is not included here because it is almost entirely duplicative of output reported below under titaniferous slag.

[3]Reported figure.

[4]Data are for fiscal year beginning Apr. 1 of year stated.

[5]Exports.

[6]Includes a mixed product containing ilmenite, leucoxene, and rutile.

[7]Contains 70% to 72% TiO_2.

[8]Contains 85% TiO_2.

Possible byproducts include abrasive-grade garnet, building sand, and a small amount of pyrite containing some nickel and copper.[16]

Japan.—Japanese sponge producers expanded capacity further in 1980, with Osaka Titanium Co. Ltd. reaching 13,200 tons per year; Toho Titanium Co. Ltd., 10,000 tons per year; and Nippon Soda Co.'s subsidiary, New Metal Industry Co., 2,400 tons per year, bringing Japan's total capacity to 25,600 tons. Japanese production of titanium sponge in 1980 was 21,257 tons compared with 14,541 tons in 1979.

Sierra Leone.—Production of rutile by Sierra Rutile Ltd. has been increasing steadily and is expected to reach about 80,000 tons in 1981.

South Africa, Republic of.—By yearend 1980, the production rate of Richards Bay Minerals reportedly reached the annual capacity of 440,000 tons of 85% TiO_2 slag, 220,000 tons of low-manganese iron, 53,000 tons of rutile, and 110,000 tons of zircon. Proven reserves were estimated at 770 million tons grading 5% ilmenite, 0.3% rutile, and 0.65% zircon. Principal shareholders in Richards Bay Minerals at the end of 1980 were QIT-Fer et Titane, Inc. (32%), General Mining Union Corp. (30%), and the Industrial Development Corp. of South Africa Ltd. (16%).

United Kingdom.—Construction of a new 5,500-ton-per-year titanium sponge plant was started at Shotton, North Wales. The $65 million project was started by the National Enterprise Board but will be privately owned with Billiton International Metals, a Royal Dutch/Shell Group subsidiary, as the majority shareholder in the new company, Deeside Titanium Ltd. Rolls Royce, Ltd., and Imperial Metal Industries, Ltd., were expected to have minority holdings.[17]

As a result of slow European pigment demand, Laporte Industries reportedly closed down part of its sulfate process titanium dioxide plant capacity at Stallingborough and increased production of its chloride process plant. BTP Tioxide, Ltd., reportedly reduced capacity at its Billingham, Teesside pigment plant, and suspended work on expansion of its chloride process titanium dioxide plant.

U.S.S.R.—Production of titanium sponge metal in the U.S.S.R. was estimated at 45,000 tons in 1980, 7% higher than in 1979. U.S. sponge imports from the U.S.S.R. remained at a low level in early 1980 and ceased entirely after the first quarter. The U.S.S.R. has reportedly built three new classes of titanium-hulled submarines. The largest of these was said to have a displacement of about 30,000 tons.[18] The titanium hull was expected to provide greater strength and less weight, making possible deeper dives and higher speed.

TECHNOLOGY

The Bureau of Mines conducted batch-scale tests on a sample of porphyry copper mill tailings as part of a study to determine the feasibility of recovering rutile from this source. The tailings contained 0.75% TiO_2, about half of which was present as potentially recoverable rutile. Flotation of the tailings, after sizing and grinding to minus 200 mesh, yielded a rutile concentrate assaying 43.1% TiO_2 and containing 75.7% of the recoverable TiO_2.[19] In an investigation of the occurrence and recovery of byproduct heavy minerals from sand and gravel operations in central and southern California, the Bureau carried out beneficiation studies on sand samples from 63 locations. Ilmenite was recovered by magnetic and high-tension electrostatic techniques.[20] Under its program of advancing minerals technology, the Bureau invented a laboratory apparatus for continuous separation of minerals based on differences in dielectric properties. In typical two-stage tests, dielectric separation of a sample containing 10% rutile with quartz gangue was separated to produce a 92%-rutile concentrate, with overall rutile recovery of 86%.[21]

A U.S. Geological Survey study of the geological occurrence of rutile in the United States emphasized that the rutile content of porphyry copper deposits is a large potential domestic source of this mineral. However, it was recognized that technology for profitable recovery of rutile from this source has not yet been developed.[22]

In a review of the heavy minerals industry in North America, it was pointed out that heavy mineral requirements exceed domestic supply and that additional domestic reserves may be developed if product costs are competitive with those of imported materials.[23]

A report of recent experience in Australia confirmed that controlled additions of titania, in the form of ilmenite sand, to a blast furnace charge provides operators with another tool to increase the life of hearth sidewall refractories.[24] In a discussion of this report, it was stated that in addition to the TiO_2 that occurs naturally in materials charged to blast furnaces, more than 200,000 tons per year is charged intentionally for the purpose of limiting hearth lining erosion. The major source of this added titania is a titaniferous iron sand from New Zealand containing 7.5% TiO_2. The second major source is lump ilmenite ore containing 32% TiO_2, produced by QIT in the Province of Quebec. These materials are used mainly in Japan and the Republic of Korea. The QIT ore is also used by European steel producers, principally for hearth lining protection, but also to reduce nitrogen levels in the hot metal.[25]

A paper was published describing the Western Titanium process for production of synthetic rutile from ilmenite. The process involves direct reduction technology that can be applied to the direct reduction of iron ores.[26]

The Fourth International Conference on Titanium was held at Kyoto, Japan, May 19-22, 1980. The program included overviews of the titanium industry in the major producing and consuming countries and sessions on aerospace and other industrial uses, application of titanium in electrical powerplants, extractive metallurgy, fabrication methods, and several areas of physical metallurgy.[27]

The properties of a new high-strength titanium alloy, Ti-10V-2Fe-3A1, were described. This new alloy has higher strength and fatigue resistance than other commercially available titanium alloys and a considerable strength-to-weight advantage over comparable strength steels.[28]

A paper was published on shape-memory alloys. Some of these are Ni-Ti alloys, with potential uses in industry, energy, dental, and medical applications.[29]

Work continued on development of improved processes for forming titanium. An overview of titanium powder metallurgy[30] was presented as part of a symposium on titanium powder metallurgy.[31] Isothermal forging was described as an attractive alternative to machining of complex titanium parts.[32]

The use of titanium for chemical process equipment is reportedly increasing. An article on the properties of titanium in process plant equipment described why titanium is so well-suited for such applications.[33]

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[1]Physical scientist, Section of Nonferrous Metals.

[2]Statistical assistant, Section of Nonferrous Metals.

[3]Weight units used in this chapter are short tons unless otherwise specified.

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Tungsten

By Philip T. Stafford[1]

Domestic consumption of tungsten in 1980 declined for the first time in 5 years; however, tungsten imports continued to rise and were at record levels. Mine production was down 8% compared with 1979 output. Short-term price fluctuations continued to be narrow in 1980, extending the trend of the last 3 years.

During 1980, essentially all domestic production came from four mining operations: Two in California, one in Nevada, and one in Colorado. One mine in Nevada was being developed and was expected to begin production in early 1982. At yearend 1980 three new ammonium paratungstate (APT) plants were being constructed.

Legislation and Government Programs.—During the year, the General Services Administration (GSA) continued to sell excess stockpiled tungsten concentrate on the basis of monthly sealed bids. GSA offered material at a disposal rate of 1,000,000 pounds of contained tungsten per month and sold about 3.3 million pounds of concentrate during 1980: 1.9 million pounds for domestic use and 1.4 million pounds for export. Actual shipment of excess concentrate from the Government stockpile was in excess of 3.8 million pounds of contained tungsten in 1980.

New stockpile goals for tungsten materials, established in May by the Federal Emergency Management Agency, are shown in table 2.

On August 28, the Antitrust Division of the U.S. Department of Justice announced that it was dropping an investigation and that no action would be taken under U.S.

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Concentrate:					
Mine production	5,830	6,008	6,896	6,643	6,072
Mine shipments	5,869	6,022	6,901	6,646	6,036
Value	$37,266	$55,073	$56,691	$55,785	$50,575
Consumption	16,107	17,100	18,806	21,589	20,432
Shipments from Government stocks	4,004	5,015	r5,399	r5,183	3,755
Exports	1,729	1,283	1,853	1,929	2,029
Imports for consumption	5,301	6,919	9,138	11,352	11,372
Stocks, Dec. 31:					
Producer	150	124	87	84	106
Consumer	1,002	826	1,424	1,538	1,325
Ammonium paratungstate:					
Production	12,808	14,940	16,062	17,758	16,897
Consumption	15,921	15,744	17,572	18,720	18,585
Stocks, Dec. 31: Producer and consumer	1,438	1,975	1,037	879	966
Primary products:					
Production	18,226	19,005	19,028	21,178	20,138
Consumption	16,799	16,905	18,296	20,433	20,200
Stocks, Dec. 31:					
Producer	3,390	3,139	3,349	3,385	3,524
Consumer	2,778	2,581	2,376	2,543	2,370
World: Concentrate:					
Production	r83,883	r88,936	r96,137	r103,706	117,549
Consumption	80,403	78,852	86,247	88,109	84,326

rRevised.

antitrust laws challenging the participation of domestic producers and consumers of tungsten in the International Tunsten Indicator (ITI) information collection program. However, the Justice Department added that antitrust concerns may be raised in the future should it be determined that a horizontal agreement existed among the producers or consumers to use the ITI price average as a contractual point of reference. This decision by the Justice Department should facilitate greater U.S. involvement in the ITI data-gathering program.

Table 2.—U.S. Government tungsten stockpile material inventories and goals

(Thousand pounds of contained tungsten)

Material	Goals	Inventory by program, Dec. 31, 1980		
		National stockpile	DPA[1] inventory	Total[2]
Tungsten concentrate:				
Stockpile grade	55,450	57,957	159	58,117
Nonstockpile grade	--	30,897	195	31,092
Total	55,450	88,854	354	89,209
Ferrotungsten:				
Stockpile grade	--	841	--	841
Nonstockpile grade	--	1,185	--	1,185
Total[2]	--	2,025	--	2,025
Tungsten metal powder:				
Stockpile grade	1,600	1,567	--	1,567
Nonstockpile grade	--	332	--	332
Total	1,600	1,899	--	1,899
Tungsten carbide powder:				
Stockpile grade	2,000	1,921	--	1,921
Nonstockpile grade	--	112	--	112
Total	2,000	2,033	--	2,033

[1]Defense Production Act (DPA).
[2]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Domestic mine production fell 8% compared with that of 1979 and totaled about 6.1 million pounds of contained tungsten in 1980. Mine shipments declined 9% to 6 million pounds. Although 31 mines in Alaska and 7 Western States reported production, only 4 mines provided more than 95% of the 1980 domestic tungsten production. Only three mines operated continuously: The Pine Creek Mine and mill of the Metals Division, Union Carbide Corp. (UCC), located near Bishop, Calif., in Inyo County; the Climax Mine and mill of Climax Molybdenum Co., a division of AMAX Inc., at Climax, Colo., in Lake County; and the Emerson Mine and mill of the Metals Division, UCC, at Tempiute, Nev., in Lincoln County. The major mineral value recovered at Pine Creek continued to be tungsten with minor amounts of byproduct copper, gold, molybdenum, and silver. UCC processed ore to produce APT, an intermediate form of tungsten suitable for ready conversion to tungsten metal powder.

The principal mineral value recovered at Climax was molybdenum. Concentrates of tungsten, tin, and pyrite recovered as coproducts were dependent upon the rate of molybdenum production.

Scheelite ore was processed at Tempiute to a low-grade tungsten concentrate and shipped to UCC's Pine Creek facility, where it was converted to APT.

The Strawberry Mine and mill of Teledyne Tungsten, a subsidiary of Teledyne, Inc., near North Fork, Calif., in Madera County, produced tungsten concentrate except during the winter months when it was closed due to weather conditions.

National Resources Development Inc. began production of tungsten in April from the previously idle Nevada scheelite mine in northern Mineral County, Nev., about 45 miles southeast of Fallon.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity: Short tons, 60% WO_3 basis[2]	Quantity: Short ton units of WO_3[3]	Quantity: Tungsten content (thousand pounds)	Reported value, f.o.b. mine[1]: Total (thousands)	Reported value, f.o.b. mine[1]: Average per unit of WO_3	Reported value, f.o.b. mine[1]: Average per pound of tungsten
1976	6,168	370,069	5,869	$37,266	$100.70	$6.35
1977	6,331	379,729	6,022	55,073	145.03	9.15
1978	7,252	435,117	6,901	56,691	130.29	8.22
1979	6,984	419,040	6,646	55,785	133.13	[r]8.40
1980	6,343	380,561	6,036	50,575	132.90	8.38

[r]Revised.
[1]Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2]A short ton of 60% tungsten trioxide (WO_3) contains 951.6 pounds of tungsten.
[3]A short ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.86 pounds of tungsten.

Table 4.—Major producers of tungsten concentrate and principal tungsten processors in 1980

Company	Location of mine, mill, or processing plant
Producers of tungsten concentrate:	
Climax Molybdenum Co., a division of AMAX Inc	Climax, Colo.
Teledyne Tungsten	North Fork, Calif.
Union Carbide Corp., Metals Div.[1]	Bishop, Calif. and Tempiute, Nev.
National Resources Development Inc	Fallon, Nev.
Processors of tungsten:	
Adamas Carbide Corp	Kenilworth, N.J.
Fansteel Inc	North Chicago, Ill.
General Electric Co	Euclid, Ohio and Detroit, Mich.
GTE Sylvania Inc., a subsidiary of General Telephone & Electronics Corp	Towanda, Pa.
Kennametal Inc	Latrobe, Pa. and Fallon, Nev.
Li Tungsten Corp	Glen Cove, N.Y.
Teledyne Firth Stirling	McKeesport, Pa.
Teledyne Wah Chang Huntsville	Huntsville, Ala.
Union Carbide Corp., Metals Div	Niagara Falls, N.Y.
Westinghouse Electric Corp	Bloomfield, N.J.

[1]At its Pine Creek Mine and mill in California, UCC processes ore "straight through" to APT.

Additionally, intermittent tungsten concentrate production and shipments were reported from Southeastern Region, Alaska; Pima County, Ariz.; Inyo, Kern, Los Angeles, San Diego, and Tulare Counties, Calif.; Valley County, Idaho; Jefferson County, Mont.; Churchill, Clark, Elko, Esmeralda, Lincoln, Mineral, and White Pine Counties, Nev.; and Tooele County, Utah.

Utah International Inc., a subsidiary of General Electric Co. (GE), continued development and construction of the Springer Mine, mill, and APT plant in the vicinity of the abandoned Sutton Mine near Imlay in Pershing County, Nev. The facility will cost GE $50 million to construct and will have a capacity of 1.6 million pounds per year of tungsten in concentrate which will be used by the company's refractory metals division for production of tungsten wire and carbide powder. Full-scale operation is scheduled to begin in early 1982.

AMAX Inc. began construction of an APT plant at its Fort Madison, Iowa, molybdenum conversion facility. While the plant will be designed to handle a wide variety of tungsten concentrates, the majority of its feed will be scheelite from Canada. The plant is scheduled to begin operations in the fall of 1981. The Anschutz Mining Corp. continued the conversion of the idle NL Industries Inc. plant in Laredo, Tex., to an APT plant. The plant last produced synthetic scheelite in 1974 from low-grade concentrate shipped from Guatemala.

The major domestic companies engaged in tungsten operations during 1980 are listed in table 4.

CONSUMPTION AND USES

Domestic consumption of tungsten in primary products in 1980 declined for the first time since 1975. The major end use in 1980 continued to be in cutting and wear-resistant materials. This end use, primarily as tungsten carbide, accounted for 64% of total reported consumption. Other end uses were mill products, 16%; specialty steels, 7%; chemicals, 4%; superalloys, 3%; hard-facing rods and materials, 3%; and other uses, 3%.

The major consumption distribution of intermediate tungsten products used to make end-use items follows: Tungsten carbide, 56%; tungsten metal powder, 26%; and ferrotungsten, 2%.

Table 5.—Production, disposition, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed and crystal-line	Chemicals	Other[1]	Total
1979						
Gross production during year	18,426	12,044	2,507	7,203	328	40,508
Used to make other products listed here	12,390	256	282	6,402	--	19,330
Net production	6,036	11,788	2,225	801	328	21,178
Disposition:						
To other processors	266	3,215	518	223	143	4,365
To end-use consumers	8,956	7,223	428	656	163	17,426
To make products not listed in this table	1,592	1,949	1,823	9	--	5,373
Producer stocks, Dec. 31	1,746	674	716	191	58	3,385
1980						
Gross production during year	18,116	11,693	2,042	6,480	238	38,569
Used to make other products listed here	11,937	237	370	5,887	--	18,431
Net production	6,179	11,456	1,672	593	238	20,138
Disposition:						
To other processors	338	2,931	443	117	102	3,931
To end-use consumers	8,968	7,238	438	505	150	17,299
To make products not listed in this table	1,440	1,858	1,394	10	--	4,702
Producer stocks, Dec. 31	1,947	719	644	155	58	[2]3,524

[1]Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, and self-reducing oxide pellets.
[2]Data do not add to total shown because of independent rounding.

Table 6.—Consumption and stocks of tungsten products in the United States, by end use in 1980

(Thousand pounds of contained tungsten)

End use	Ferro-tungsten	Tungsten metal powder[1]	Tungsten carbide powder	Scheelite (natural, synthetic)	Tungsten scrap[2]	Other tungsten materi-als[3]	Total
Steel:							
Stainless and heat-resisting	105	--	--	63	5	5	178
Alloy	58	--	--	24	W	4	86
Tool	290	W	--	841	W	61	1,192
Cast irons	W	--	--	--	--	--	W
Superalloys	W	70	W	W	522	70	662
Alloys (excludes steels and superalloys):							
Cutting and wear-resistant materials	--	1,818	10,740	--	370	15	12,943
Other alloys[4]	14	180	251	--	49	5	499
Mill products made from metal powder	--	3,237	W	--	--	5	3,242
Chemical and ceramic uses	--	--	--	--	--	870	870
Miscellaneous and unspecified	27	9	304	104	84	--	528
Total	494	5,314	11,295	1,032	1,030	1,035	20,200
Consumer stocks, Dec. 31, 1980	109	136	1,634	100	125	266	2,370

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.
[2]Does not include that used in making primary tungsten products.
[3]Includes melting base self-reducing tungsten, tungsten chemicals, and others.
[4]Includes welding and hard-facing rods and materials and nonferrous alloys.

PRICES

In 1980, the average value of tungsten concentrate shipped from domestic mines and mills, as reported to the Bureau of Mines, decreased slightly to $132.90 per short ton unit of WO_3. Excess tungsten concentrate for domestic use was purchased from GSA during the year at prices ranging from $124.32 to $138.50 per short ton unit. The price of tungsten concentrate purchased for export ranged from $125.79 to $133.81 per short ton unit.

The European prices of tungsten concentrate as reported in Metal Bulletin (London), the U.S. spot quotations, and the International Tungsten Indicator prices showed similar trends and similar monthly and annual averages. The price of tungsten has been unusually stable since 1978.

The reported price of APT delivered to large-volume contract customers was $165 per short ton unit at the beginning of 1980. It rose to $173 on March 1 and fell to $168 on December 1, remaining at that level for the remainder of 1980.

The price of hydrogen-reduced tungsten metal powder (99.9% purity), f.o.b. shipping point, as quoted in Metals Week, remained stable throughout 1980 in the price range of $13.90 to $15.50 per pound. Within these ranges, the price was primarily dependent upon the tungsten powder particle size.

The quoted price of UCAR ferrotungsten, a proprietary high-purity ferroalloy containing 90% tungsten, increased from $11.55 per pound at the beginning of 1980 to $12.20 on March 1. The price fell to $11.90 per pound on December 1 and remained at that level for the remainder of the year.

Table 7.—Monthly price quotations of tungsten concentrate in 1980

Month	Metal Bulletin (London), wolframite, European market, 65% WO_3 basis[1]					Metals Week, U.S. spot quotations, dollars per short ton unit of WO_3 65% basis, c.i.f. U.S. ports[2]			International Tungsten Indicator, weighted average price,[3] 60% to 79% WO_3	
	Dollars per metric ton unit of WO_3		Equivalent prices, dollars per short ton unit of WO_3							
	Low	High	Low	High	Average	Low	High	Average	Dollars per metric ton unit	Dollars per short ton unit
January	131.00	145.00	118.84	131.54	127.46	118.00	129.00	124.00	136.53	123.86
February	137.50	146.00	124.74	132.45	128.34	126.50	135.00	130.40	138.90	126.01
March	141.00	149.00	127.91	135.17	132.62	127.00	135.00	132.13	141.35	128.23
April	139.00	149.00	126.10	135.17	131.12	128.00	135.00	131.50	142.56	129.33
May	137.50	144.00	124.74	130.63	127.79	126.00	133.00	130.30	142.08	128.89
June	137.00	146.00	124.28	132.45	128.76	124.50	130.00	128.38	142.65	129.41
July	143.00	149.50	129.73	135.62	132.42	127.50	130.00	128.75	142.98	129.71
August	147.00	153.00	133.36	138.80	135.82	127.50	133.81	130.01	144.81	131.37
September	150.00	154.00	136.08	139.71	138.14	130.00	133.81	131.91	146.42	132.83
October	144.00	153.00	130.63	138.80	134.72	130.00	133.81	131.91	147.48	133.79
November	136.00	146.00	123.38	132.45	128.03	130.00	133.81	131.91	144.96	131.51
December	136.00	145.00	123.38	131.54	126.89	124.00	128.50	126.50	141.46	128.33

[1]Low and high prices are reported semiweekly. Monthly equivalent averages are arithmetic average of semiweekly equivalent low and high prices. The equivalent average price per short ton unit of WO_3, which is an average of all semiweekly low and high prices, excluding duty, was $131.07 for 1980.

[2]Low and high prices are reported weekly. Monthly averages are arithmetic average of weekly low and high prices. The average price per short ton unit of WO_3, which is an average of all weekly low and high prices, excluding duty, was $129.87 for 1980.

[3]Weighted average price per short ton unit of WO_3, excluding duty, was $129.40 for 1980.

FOREIGN TRADE

The Tokyo Round of Multilaterial Trade Negotiations was completed in 1979, resulting in new tariff agreements with the developed nations of the world. Tariff rates for tungsten materials at the beginning (January 1, 1980) and ending (January 1, 1987) dates of the staging period, as published in the Tariff Schedules of the United States, Annotated (1980), are shown in table 17.

Table 8.—U.S. exports of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
Austria	374	2,318	--	--
Brazil	60	404	55	551
Germany, Federal Republic of	582	4,743	1,263	10,064
Guatemala	--	--	2	13
Japan	693	3,760	89	542
Netherlands	136	1,051	91	620
Sweden	--	--	466	3,147
United Kingdom	84	633	63	517
Total	1,929	12,909	2,029	15,454

Table 9.—U.S. exports of ammonium paratungstate, by country

(Thousand pounds and thousand dollars)

	1979			1980		
	Gross weight	Tungsten content[1]	Value	Gross weight	Tungsten content[1]	Value
Australia	(2)	(2)	1	1	(2)	1
France	5	4	14	3	2	8
Germany, Federal Republic of	1	1	7	--	--	--
Japan	--	--	--	(2)	(2)	1
United Kingdom	(2)	(2)	4	4	3	32
Total[3]	7	5	26	8	6	42

[1]Tungsten content estimated by multiplying gross weight by 0.7066.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. exports of tungsten carbide powders, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
Argentina	21	291	36	402
Australia	9	153	6	36
Austria	93	1,006	27	295
Belgium-Luxembourg	30	520	21	355
Brazil	23	481	31	917
Canada	364	5,764	260	4,030
Chile	(1)	4	4	21
Denmark	64	595	100	1,123
Finland	14	259	32	315
France	65	721	144	1,577
Germany, Federal Republic of	256	3,873	217	3,333
India	(1)	15	2	49
Ireland	11	210	8	137
Israel	20	341	98	999
Italy	69	1,385	74	1,784
Japan	61	817	88	1,107
Mexico	123	2,540	109	2,404
Netherlands	51	850	31	734
Peru	3	33	1	1
Singapore	2	42	3	79
South Africa, Republic of	4	64	1	27
Spain	2	41	2	60
Sweden	18	234	55	828
Switzerland	15	258	13	280
Taiwan	9	259	--	--
Trinidad	1	12	--	--
United Kingdom	60	1,287	60	1,452
Venezuela	2	30	(1)	7
Other	(1)	12	17	364
Total[2]	1,392	22,096	1,440	22,716

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

(Thousand pounds and thousand dollars)

Country	1979			1980		
	Gross weight	Tungsten content[1]	Value	Gross weight	Tungsten content[1]	Value
Australia	2	1	27	(2)	(2)	8
Austria	11	9	128	38	30	478
Belgium-Luxembourg	(2)	(2)	3	--	--	--
Brazil	1	1	23	3	3	50
Bulgaria	--	--	--	21	16	297
Canada	57	46	837	67	54	1,035
Finland	8	6	96	31	25	406
France	10	8	97	6	5	71
Germany, Federal Republic of	206	164	4,135	170	136	3,767
Israel	360	288	3,415	1,051	841	11,647
Italy	6	5	72	1	1	22
Japan	31	25	405	3	3	41
Mexico	30	24	403	11	9	151
Singapore	20	16	228	(2)	(2)	3
Spain	(2)	(2)	6	(2)	(2)	2
Sweden	58	47	618	3	2	18
Switzerland	--	--	--	4	3	66
Taiwan	12	10	200	(2)	(2)	1
Turkey	8	6	119	--	--	--
United Kingdom	6	5	76	7	5	106
Other	2	1	r19	9	7	140
Total[3]	827	662	10,907	1,425	1,140	18,308

rRevised.
[1]Tungsten content estimated by multiplying gross weight by 0.80.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials

(Thousand pounds and thousand dollars)

Product and country	1979		1980	
	Gross weight	Value	Gross weight	Value
Tungsten and tungsten alloy wire:				
Brazil	18	1,648	21	1,067
Canada	44	2,644	50	2,788
Italy	8	704	11	869
Mexico	21	2,079	23	1,597
United Kingdom	15	1,430	15	1,554
U.S.S.R.	8	276	31	1,078
Other	47	5,235	60	5,919
Total[1]	162	14,016	211	14,872
Unwrought tungsten and alloy in crude form, waste, and scrap:				
Austria	87	699	--	--
Canada	126	1,150	223	1,805
Germany, Federal Republic of	562	3,886	325	2,656
Israel	2	22	141	1,560
South Africa, Republic of	49	552	79	953
Sweden	50	573	52	608
United Kingdom	89	486	100	557
Other	60	467	150	1,765
Total	1,025	7,835	1,070	9,904
Other tungsten metal:				
Austria	52	772	5	80
Canada	51	1,180	57	2,302
Germany, Federal Republic of	167	3,425	300	6,773
Netherlands	(2)	8	8	245
United Kingdom	79	1,973	96	2,701
Other	88	2,536	86	2,792
Total[1]	438	9,894	552	14,893

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 13.—U.S. imports for consumption of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
Australia	398	2,856	235	1,762
Bolivia	2,980	22,511	2,794	21,730
Brazil	26	188	63	503
Burma	253	1,802	--	--
Canada	3,127	23,558	2,914	22,943
Chile	4	15	--	--
China, mainland	1,168	9,315	2,025	16,130
France	251	1,749	154	995
Guatemala	--	--	25	45
Hong Kong	--	--	21	171
Korea, Republic of	84	640	19	147
Malaysia	61	479	67	550
Mexico	607	3,536	515	2,548
Netherlands	--	--	19	149
Peru	810	6,106	526	4,047
Portugal	195	1,546	576	4,322
Rwanda	6	46	46	356
Singapore	11	85	23	194
South Africa, Republic of	4	32	--	--
Spain	20	148	94	754
Sweden	15	123	--	--
Taiwan	--	--	36	242
Thailand	1,246	9,278	1,046	8,223
Turkey	--	--	60	452
United Kingdom	--	--	27	192
Zaire	86	648	87	674
Total	11,352	84,661	11,372	87,129

Table 14.—U.S. imports for consumption of ammonium paratungstate, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
China:				
Mainland	--	--	23	213
Taiwan	--	--	(1)	1
France	47	480	95	851
Germany, Federal Republic of	8	114	153	1,584
Japan	16	130	--	--
Korea, Republic of	204	1,805	133	1,312
Netherlands	--	--	19	181
Sweden	76	755	--	--
United Kingdom	86	892	23	236
Total	437	4,176	446	4,378

[1]Less than 1/2 unit.

Table 15.—U.S. imports for consumption of ferrotungsten, by country

(Thousand pounds and thousand dollars)

Country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
Argentina	--	--	17	160
Austria	104	926	68	583
Brazil	171	1,575	24	224
Canada	--	--	8	72
France	83	767	10	101
Germany, Federal Republic of	25	240	17	168
Portugal	82	752	125	1,138
Sweden	105	967	177	1,593
Total	570	[1]5,228	446	4,039

[1]Data do not add to total shown because of independent rounding.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials

(Thousand pounds and thousand dollars)

Product and country	1979 Tungsten content	1979 Value	1980 Tungsten content	1980 Value
Other metal-bearing materials in chief value of tungsten:				
Chile	--	--	102	1,405
Thailand	14	85	--	--
Other	21	49	10	88
Total[1]	34	135	112	1,493
Waste and scrap containing not over 50% tungsten:				
Germany, Federal Republic of	13	117	--	--
United Kingdom	--	--	22	66
Other	14	50	4	26
Total[1]	26	167	26	92
Waste and scrap containing over 50% tungsten:				
Belgium	22	282	31	198
Canada	22	205	72	648
France	110	1,041	20	153
Germany, Federal Republic of	66	783	10	101
Israel	192	1,644	73	579
Japan	35	358	38	342
Mexico	23	398	--	--
Singapore	23	236	47	571
Sweden	22	35	4	10
United Kingdom	111	1,100	42	327
Other	12	113	38	66
Total[1]	639	6,195	375	2,995
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
France	80	901	13	189
Germany, Federal Republic of	13	157	69	786
Japan	15	126	(2)	34
Korea, Republic of	509	5,161	361	3,948
Other	28	283	25	286
Total[1]	646	6,628	468	5,243
Unwrought tungsten, ingots and shot:	6	68	(2)	1
Unwrought tungsten, other:[3]				
Canada	(2)	5	1	8
Japan	11	154	8	117
Korea, Republic of	17	245	--	--
Singapore	11	158	15	244
Other	1	11	--	--
Total[1]	40	574	24	369
Unwrought tungsten, alloys	8	156	17	421
Wrought tungsten:[3]				
Austria	17	601	25	1,097
Canada	103	1,121	105	1,171
Japan	14	1,194	12	1,190
United Kingdom	--	--	8	212
Other	11	343	11	192
Total[1]	145	3,260	161	3,862
Calcium tungstate:				
Germany, Federal Republic of	41	1,016	24	640
United Kingdom	6	13	--	--
Total	47	1,029	24	640
Tungsten carbide:				
Canada	32	357	8	64
Germany, Federal Republic of	320	4,431	385	6,459
Korea, Republic of	72	747	72	791
Mexico	12	320	37	974
Sweden	113	2,436	--	--
United Kingdom	6	45	--	--
Other	2	35	13	229
Total	557	8,371	515	8,517

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

(Thousand pounds and thousand dollars)

Product and country	1979		1980	
	Tungsten content	Value	Tungsten content	Value
Other tungsten compounds:				
Australia	25	183	(2)	8
Germany, Federal Republic of	--	--	65	648
Other	2	48	1	19
Total	27	231	66	667
Mixtures, organic compounds, chief value in tungsten:				
Canada	8	135	13	275
Germany, Federal Republic of	5	97	5	79
Netherlands	--	--	(2)	6
Total	13	232	18	360

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Estimated from reported gross weight.

Table 17.—U.S. import duties on all forms of tungsten

Tariff classification	Article	Rate of duty effective Jan. 1, 1981	
		Most Favored Nation (MFN)	Non-MFN
601.54	Tungsten ore	17 cents per pound on tungsten content.	50 cents per pound on tungsten content.
603.45	Other metal-bearing materials in chief value of tungsten.	11 cents per pound on tungsten content and 5.2% ad valorem.	60 cents per pound on tungsten content and 40% ad valorem.
606.48	Ferrotungsten and ferrosilicon tungsten	21 cents per pound on tungsten content and 6% ad valorem.	35% ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten.	6.9% ad valorem	50% ad valorem.
629.26	Waste and scrap containing by weight over 50% tungsten.	4.5% ad valorem	Do.
629.28	Unwrought tungsten, except alloys, in lumps, grains, and powders.	21 cents per pound on tungsten content and 12.5% ad valorem.	58% ad valorem.
629.29	Unwrought tungsten, ingots and shot	10.5% ad valorem	50% ad valorem.
629.30	Unwrought tungsten, other	12.5% ad valorem	60% ad valorem.
629.32	Unwrought tungsten, alloys, containing by weight not over 50% tungsten.	6.4% ad valorem	35.5% ad valorem.
629.33	Unwrought tungsten, alloys, containing by weight over 50% tungsten.	12.5% ad valorem	60% ad valorem.
629.35	Wrought tungsten	11% ad valorem	Do.
416.40	Tungstic acid	13.9% ad valorem	55% ad valorem.
417.40	Ammonium tungstate	12.5% ad valorem	49.5% ad valorem.
418.30	Calcium tungstate	11% ad valorem	43.5% ad valorem.
420.32	Potassium tungstate	21.3% ad valorem	50.5% ad valorem.
421.56	Sodium tungstate	12% ad valorem	46.5% ad valorem.
422.40	Tungsten carbide	10 cents per pound on tungsten content and 12.5% ad valorem.	55.5% ad valorem.
422.42	Other tungsten compounds	11.4% ad valorem	45.5% ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value of tungsten.	do	Do.

WORLD REVIEW

A meeting was held in Geneva, Switzerland, during February by the Committee on Tungsten (COT) of the United Nations Conference on Trade and Development in an effort to resolve a 17-year deadlock between producing and consuming countries concerning the stabilization of the world tungsten market. No agreement was reached, but COT recommended that another meeting be convened in 1981.

Australia.—A joint venture between Minefields Exploration N.L. of Australia, and Australia and New Zealand Exploration Co. (ANZECO), a subsidiary of Union

Table 18.—Tungsten: World concentrate production, by country[1]

(Thousand pounds of contained tungsten)[2]

Country	1976	1977	1978	1979[p]	1980[e]
North and Central America:					
Canada	[r]3,792	[r]3,995	[r]5,046	5,690	[3]8,131
Mexico	[r]518	[r]421	[r]516	556	595
United States	[r]5,830	[r]6,008	[r]6,896	6,643	[3]6,072
South America:					
Argentina	137	154	[r]214	130	[3]158
Bolivia	7,015	6,515	6,288	6,865	[3]7,405
Brazil	[r]2,209	2,672	[r]2,568	2,595	2,650
Peru	1,303	1,160	1,283	1,243	1,210
Europe:					
Austria	1,193	2,460	2,599	3,298	[3]3,296
Czechoslovakia[e]	175	175	175	175	175
France	1,396	1,440	1,340	1,300	1,325
Portugal	2,776	2,216	[r]2,433	3,038	3,750
Spain	725	[r]677	[r]789	703	550
Sweden	428	439	1,279	703	710
U.S.S.R.[e]	17,600	18,100	18,700	[r]19,200	19,200
United Kingdom	[e]22	172	143	146	150
Africa:					
Burundi	4	[e]4	[e]4	--	--
Namibia[e 4]	310	330	330	360	330
Rwanda	952	1,252	[r]1,213	1,113	990
Uganda[e]	240	240	240	[r]120	110
Zaire	522	375	326	247	[e]159
Zimbabwe	[e]130	[e]130	[e]130	243	220
Asia:					
Burma	608	613	1,038	1,526	1,660
China, mainland[e]	[r]12,600	[r]14,600	[r]15,700	22,000	33,100
India	51	[r]49	46	44	[3]53
Japan	[r]1,795	[r]1,702	[r]1,709	1,645	1,410
Korea, North[e]	4,740	4,740	4,740	4,740	4,850
Korea, Republic of	5,703	5,809	[r]5,511	5,981	[3]6,034
Malaysia	141	218	159	117	130
Thailand	4,519	4,859	7,026	4,026	[3]3,563
Turkey	2,046	2,200	[r]1,765	[e]2,200	2,200
Oceania:					
Australia	[r]4,385	5,198	[r]5,911	7,039	[3]7,345
New Zealand	18	13	20	20	18
Total	[r]83,883	[r]88,936	[r]96,137	103,706	117,549

[e]Estimated. [p]Preliminary [r]Revised.
[1]Table includes data available through June 16, 1981.
[2]Conversion factors: WO_3 to W, multiply by 0.7931; 60% WO_3 to W, multiply by 0.4758.
[3]Reported figure.
[4]Production of Brandberg West Mine of South Africa Company, Ltd., only.

Carbide, has found promising indications of tungsten on the Mount Mulgine property in Western Australia. Exploration indicates that the deposit has an estimated 37 million metric tons of tungsten ore with 0.19% WO_3. Ore reserves include recoverable quantities of molybdenum, gold, and silver. Exploration is continuing, and production is reportedly expected to begin in the middle 1980's.

Efforts to develop tungsten properties continued in Tasmania during 1980. An Australian subsidiary of McIntyre Mines Pty. Ltd. conducted additional engineering studies on the expansion of the Kara scheelite deposit. The studies were directed toward the possibility of lowering the estimated $16 million development cost by reducing mill construction cost. The Oakleigh Creek Mine, a small underground tungsten mine in central Tasmania, was completed in early 1980. The project, owned by Serem (Australia) Pty. Ltd. (33 1/3%), Buka Minerals N.L. (25%), Triako Mines N.L. (25%), and Aquitaine Australia Minerals Pty. Ltd. (16 2/3%) began operations in June.

Canada.—Production of tungsten increased about 22% over that of 1979 at Canada's only producing mine, operated by Canada Tungsten Mining Corp. Ltd. (CTMC) near Tungsten, Northwest Territories. AMAX Inc. owns a 65% share of CTMC. According to the firm's annual report for 1980, the mine produced 442,000 short ton units of WO_3, which was recovered from the processing of 349,000 tons of ore with an average grade of 1.45% WO_3. Recovery was a record 87% of the in-place tungsten ore content. Output increased primarily owing to the expansion of ore processing capacity to about 1,000 tons of ore per day dring 1979. On November 14, operations at the mine were halted by a strike of union laborers; the strike continued into 1981.

Development of the Mount Pleasant tungsten-molybdenum mine in Charlotte

Table 19.—Tungsten: World concentrate consumption, by country[1]

(Thousand pounds of contained tungsten)

Country[2]	1977	1978	1979[p]	1980[e 3]
Reported consumption:				
Australia	88	88	90	80
Austria	3,183	5,240	5,800	4,800
Canada	730	679	700	700
France	2,207	3,611	2,600	1,400
Japan	4,667	4,489	4,500	5,400
Korea, Republic of	3,175	3,042	3,000	2,500
Mexico	130	[3]130	[3]130	[3]130
Portugal	302	388	400	424
Sweden	3,746	3,494	3,500	3,500
United Kingdom	3,657	4,383	4,300	4,100
United States	17,100	18,806	21,589	20,432
Apparent consumption:[4]				
Argentina	[3]130	[3]150	[3]150	[3]130
Belgium-Luxembourg	53	--	--	--
Brazil[e]	550	550	550	550
China, mainland[e 3]	5,100	5,300	5,500	5,500
Czechoslovakia[e 3]	2,900	2,900	2,900	2,900
German Democratic Republic[e]	600	600	600	550
Germany, Federal Republic of	2,943	3,585	3,700	3,400
Hungary[e]	1,320	1,320	[3]1,320	[3]1,300
India	597	[3]600	600	600
Italy[e]	110	130	130	130
Korea, North[e 3]	3,500	3,500	3,500	3,500
Netherlands	1,111	886	900	900
Poland	3,935	4,806	3,600	3,000
South Africa, Republic of[e]	550	550	550	600
Spain	168	320	300	300
U.S.S.R.[e 3]	16,300	16,700	17,200	17,500
Total	78,852	86,247	88,109	84,326

[e]Estimated. [p]Preliminary.
[1]Source, unless otherwise specified, is the Quarterly Bulletin of the UNCTAD Committee on Tungsten: Tungsten Statistics. V. 14, No. 1, January 1981, 54 pp.
[2]In addition to the countries listed, Bulgaria, Denmark, Finland, Israel, Norway, Romania, Switzerland, and Yugoslavia may consume tungsten concentrate, but consumption levels are not reported and available general information is inadequate to permit formulation of reliable estimates of consumption levels.
[3]Estimated by U.S. Bureau of Mines. (All estimates not so footnoted are reported in the primary source.)
[4]Production plus imports minus exports. For a few countries where data were available, variations in stocks were used in determining consumption.

County, New Brunswick, continued. The project is a joint venture between Brunswick Tin Mines Ltd. (89% controlled by Sullivan Mining Group Ltd.) and Billiton Canada Ltd. Financing of the estimated $80 million project was arranged by Billiton, which will also assume operating control of the mine. Construction of the underground mine and 2,200-ton-per-day mill was projected for completion by mid-1982. Expected annual output was approximately 3 million pounds of tungsten and 1.3 million pounds of molybdenite (MoS_2) in concentrates. The mineralized zone to be initially worked contains an estimated ore reserve of about 10 million tons grading 0.393% WO_3 and 0.204% MoS_2. The property includes other mineralized zones.

AMAX, through its subsidiary Amax of Canada, Ltd., completed a feasibility study and was expected to make a development decision in 1981 for mining of its large MacTung deposit near MacMillan Pass near the Yukon-Northwest Territories border. The company reported an estimated 63 million tons of mineralization, averaging 0.95% WO_3, at the property. Of this total, about 7.7 million tons, averaging 1.27% WO_3, has been outlined for extraction by underground mining methods. Reportedly, a 1,000-ton-per-day mine-mill facility was being considered if development is initiated, with output possibly beginning in 1985.

In southern Yukon Territory, Amax Minerals Exploration Ltd. (AMAX Inc.) conducted exploration drilling at the Logjam Creek prospect on option from Logtung Resources Ltd. Reserves at the site were reported to total 180 million tons grading 0.12% WO_3 and 0.052% MoS_2. Metallurgical testing of samples was underway.

France.—Sandvik Aktiebolag of Sweden, a manufacturer of steel and tungsten-based materials, purchased a 65% interest in Eurotungstene S.A. (a subsidiary of Péchiney Ugine Kuhlmann S.A.), the French maker of tungsten products. When Péchiney Ugine Kuhlman S.A. (PUK) began negotiating the sale of Eurotungstene in 1978, it was offering 80% of its shares, but the French Government insisted PUK retain at least 33.3%. Under the agreement, Sandvik will invest $6 million in its new subsidiary through 1982 and will allow the transfer of Eurotungstene's special alloy operation to another PUK subsidiary.

Thailand.—United Tungsten Industries (UTI) reportedly sought Government permission to construct an ammonium paratungstate (APT) plant near Bangkok. Plant capacity was given at 2.4 million pounds of APT per year. UTI is a consortium of Thai tungsten miners and ore traders. In 1979, Siam Tungsten International obtained Government approval to build a 6.6-million-ton-per-year APT plant. If both plants are constructed, APT capacity would be sufficient to process most of Thailand's output of tungsten concentrate.

United Kingdom.—A pilot plant was started up to test ore processing methods and metal recovery at the Hemerdon Ball tungsten-tin property located near Plymouth, England. The prospect, situated in a district with a long history of mining activity, has been explored since 1977 in a joint venture between Hemerdon Mining and Smelting (U.K.) Ltd. and Amax Exploration of U.K. Inc. To date, 49.6 million metric tons of mineralized rock averaging 0.17% tungsten trioxide and 0.025% tin have been established. The results of the pilot plant operation and a feasibility study underway in 1980 could lead to a decision regarding development as early as 1981. Reportedly, a 6,000-ton-per-day ore mining and processing facility could be constructed by 1985 at an approximate cost of $80 million. The mine would be the only open pit metal mine in the United Kingdom.

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[1]Physical scientist, Section of Ferrous Metals.

Vanadium

By Peter H. Kuck[1]

In 1980, demand for ferrovanadium declined in major market economy countries as a result of sharp cutbacks in steel production. Competition among producers of vanadium pentoxide and vanadium-bearing slag stiffened with the entry of Australian and Chinese material into the world market for the first time. Several domestic uranium-vanadium mining operations were hurt by a drop in the spot price for U_3O_8. The Republic of South Africa remained the world's largest producer of vanadium ores, slags, and concentrates. Domestic consumption of vanadium decreased while prices increased in response to inflation and rising energy costs. Record high interest rates forced consumers to reduce stocks of ferrovanadium and other vanadium additives.

Legislation and Government Programs.—On May 1, 1980, the General Services Administration announced new Government stockpile goals for both ferrovanadium and vanadium pentoxide, superseding earlier goals set in 1976. The new goals are 1,000 short tons of vanadium contained in ferrovanadium and 7,700 tons of vanadium contained in vanadium pentoxide. As of December 31, 1980, U.S. Government inventory consisted of 541 tons of contained vanadium in the form of pentoxide and 2 tons of vanadium metal.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium unless otherwise specified)

	1976	1977	1978	1979	1980
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	7,376	6,504	4,272	5,520	4,806
Value (thousand dollars)	81,279	74,488	56,776	73,892	64,370
Vanadium oxides recovered[2]	6,197	5,208	5,204	5,758	5,506
Consumption	4,720	5,261	6,630	6,719	6,139
Exports:					
Ferrovanadium (gross weight)	1,210	658	1,309	880	803
Ore and concentrate	}	}	191	101	46
Vanadium pentoxide, anhydride (gross weight)	99	192	1,239	630	724
Other compounds (gross weight)	}	}	291	316	190
Imports (general):					
Ferrovanadium (gross weight)	433	558	535	738	328
Ores, slags, residues	2,998	2,812	2,234	2,442	1,786
Vanadium pentoxide, anhydride	668	444	656	907	856
World production	31,209	33,313	34,219	38,301	[e]39,556

[e]Estimated.
[1]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.
[2]Produced directly from all domestic sources and includes metavanadates.

DOMESTIC PRODUCTION

Mine production of vanadium declined in 1980 because of decreased demand for ferrovanadium by the steel industry and weakened prices for uranium ores. Colorado was the leading producing State, followed by Utah. Union Carbide Corp. continued to process uranium-vanadium ores and liquors at its Rifle-Uravan complex in Colorado. However, Union Carbide cut back production at its Hot Springs mine and mill in Arkansas in response to consumer inventory reductions and the fall-off of domestic steel production. Kerr-McGee Chemical Corp. produced vanadium pentoxide from ferrophosphorus at Soda Springs, Idaho. Atlas Corp. improved pentoxide production at its Moab, Utah, mill and was processing uranium-vanadium ores from both Utah and Colorado. Cotter Corp., a subsidiary of Commonwealth Edison Co., suspended operations at six mines in the Naturita area of Colorado but continued to operate its new mill at Canon City in Fremont County. Ores from the Schwartzwalder Mine in Jefferson County and stockpiled material were being used as mill feed. Energy Fuels Nuclear, Inc., began operation of its White Mesa uranium-vanadium mill near Blanding, Utah. The new mill is designed to produce 4.5 short tons per day of fused pentoxide and 2.35 tons per day of yellowcake (U_3O_8) from Colorado Plateau ores. Pioneer Uravan, Inc., delayed construction of its uranium-vanadium processing mill in Disappointment Valley near Slick Rock, Colo. The Pioneer mill was to process ores from mines operated on the Colorado Plateau by Pioneer and Wisconsin Public Service.

The pentoxide recovered from imported vanadium-bearing materials and vanadium recovered directly as ferrovanadium from slags and residues (regardless of source) are not included in tables 2 or 3. Feed materials of foreign origin in these two categories included iron slags from Chile and the Republic of South Africa, utility ashes, spent catalysts from refineries, and a variety of petroleum residues.

Pentoxide concentrates were produced as a byproduct of the burning of Venezuelan and other Caribbean residual oils at a number of power-generating stations in the Eastern United States. Long Island Lighting Co. (LILCO) recovered high-grade ash containing 686 short tons of pentoxide in 1980, compared with 694 tons in 1979. The New York utility was able to improve vanadium recovery at its Northport and Port Jefferson powerplants by concentrating the vanadium in its low-grade fouling ash with a novel treatment system for the stack wash water. East coast utilities shipped limited quantities of ash for trial processing to a new extraction plant in Bartlesville, Okla. The Bartlesville plant is owned by Somex, Ltd., a subsidiary of Engelhard Minerals & Chemicals Corp., and is expected to recover 2,000 tons per year of pentoxide when in full operation. Gulf Chemical and Metallurgical Co. continued to recover pentoxide from spent catalysts at its Texas City plant in Brazoria County, Tex.

Producers of vanadium ferroalloys and vanadium aluminum alloys for use by the steel and titanium industries were Engelhard Minerals & Chemicals Corp., Strasburg, Va.; Foote Mineral Co., Cambridge, Ohio; Kawecki Berylco Industries, Inc. (KBI), of Boyertown, Pa., and Wenatchee, Wash.; Reading Alloys, Inc., Robesonia, Pa.; Shieldalloy Corp. (a division of Metallurg, Inc.), Newfield, N.J.; the Pesses Co., Solon, Ohio; and Union Carbide Corp. at Marietta, Ohio, and Niagara Falls, N.Y. KBI, a division of Cabot Corp., continued work on its new master alloys plant in Henderson County, Ky. The $13 million plant was expected to begin producing vanadium-aluminum and other nonferrous master alloys in July 1981.

Producers of primary vanadium chemicals included Foote Mineral Co., Cambridge, Ohio; Stauffer Chemical Co., Weston, Mich.; and Union Carbide Corp., Marietta, Ohio.

Table 2.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons of contained vanadium)

Year	Mine production[1]	Recoverable vanadium[2]
1976	8,076	7,376
1977	7,565	6,504
1978	4,446	4,272
1979	5,841	5,520
1980	5,832	4,806

[1]Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.

[2]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 3.—Production of vanadium oxides in the United States[1]

(Short tons)

Year	Gross weight	Oxide content[2]
1976	10,836	11,063
1977	9,341	9,297
1978	9,785	9,290
1979	10,338	10,279
1980	10,048	9,829

[1]Produced directly from all domestic sources; includes metavanadates.
[2]Expressed as equivalent V_2O_5.

CONSUMPTION AND USES

Reported domestic consumption of vanadium decreased 9% in 1980. Approximately 87% of the vanadium was consumed by the iron and steel industry as ferrovanadium or related vanadium-carbon ferroalloys. Despite increasing applications for vanadium-containing steels, especially high-strength low-alloy steels, weak demand by the automotive, machinery, and construction industries resulted in lower demand for ferrovanadium. However, demand for vanadium in titanium alloys and superalloys by the aerospace industry remained strong. Reported consumption of pentoxide by the chemical industry for catalysts declined 27% because of sharp cutbacks in the production of maleic anhydride and phthalic anhydride. These cutbacks were partially offset by a near-record output of sulfuric acid.

Table 4.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1979		1980	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium[1]	6,068	879	5,338	770
Oxide	47	r24	41	20
Ammonium metavanadate	38	6	22	16
Other[2]	566	67	738	73
Total	6,719	r976	6,139	879

rRevised.
[1]Includes other vanadium-iron-carbon alloys.
[2]Consists principally of vanadium-aluminum alloy, plus relatively small quantities of other vanadium alloys and vanadium metal.

Table 5.—Consumption of vanadium in the United States, by end use

(Short tons of contained vanadium)

End use	1980
Steel:	
Carbon	1,114
Stainless and heat resisting	40
Full alloy	1,420
High-strength low-alloy	1,986
Tool	653
Unspecified	4
Total steel	5,217
Cast irons	54
Superalloys	39
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	W
Welding and alloy hard-facing rods and materials	10
Nonferrous alloys	728
Other alloys[1]	W
Chemical and ceramic uses:	
Catalysts	59
Other[2]	W
Miscellaneous and unspecified	32
Total consumption	6,139

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."
[1]Includes magnetic alloys.
[2]Includes pigments.

STOCKS

In addition to the consumers' stocks shown in table 4, producers' stocks of vanadium as fused oxide, precipitated oxide, metavanadates, metal, alloys, and chemicals totaled 3,265 short tons of contained vanadium at yearend 1980, compared with 2,427 tons (revised) at yearend 1979.

PRICES

The price of domestic 98% fused vanadium pentoxide (metallurgical grade) was raised at the beginning of 1980 from $2.75-$4.04 per pound V_2O_5 to $3.05-$4.04 per pound. Technical air-dried vanadium pentoxide (chemical grade) went from $3.05-$3.80 per pound V_2O_5 to $3.35-$4.11 per pound. The metallurgical-grade price spread remained in effect throughout the entire year. However, the chemical-grade price spread widened on June 1 to $3.35-$4.57 per pound.

In spite of weak demand, prices for several vanadium alloying products were increased in January because of inflation and higher energy costs. Carvan and Ferovan changed from $6.52 per pound of contained vanadium to $7.05 per pound, while 70% to 80% ferrovanadium went from $6.80-$7.09 per pound of contained vanadium to $7.75 per pound.

FOREIGN TRADE

Exports of ferrovanadium totaled 803 short tons (gross weight) in 1980, 9% less than the 880 tons for 1979. The average declared value for the ferrovanadium was $4.36 per pound of alloy, compared with $4.48 for the previous year. Exports of vanadium pentoxide (anhydride) totaled 724 tons (gross weight), a 15% increase over the 630 tons of 1979.

Weak demand for vanadium by the iron and steel industry during 1980 resulted in a sharp decline in imports of ferrovanadium. Canada accounted for 86% of the imported alloy in terms of contained weight. Imports of vanadium pentoxide (anhydride) were only 6% lower than those of 1979. Finland and the Republic of South Africa continued to be the principal sources of imported pentoxide.

Imports of vanadium contained in slags, residues, and ashes totaled 1,786 short tons, a 27% decrease from 1979. The bulk of this material was slag produced in the Republic of South Africa from Bushveld titaniferous magnetite ores. Vanadium-bearing slag from mainland China entered the United States for the first time in August and was being evaluated at domestic processing facilities. No slags were received from either Chile or the U.S.S.R. The Netherlands Antilles, Venezuela, and the Dominican Republic provided domestic processors with vanadium-bearing petroleum residues.

Ammonium vanadate imports amounted to 37 short tons (gross weight), all of which came from the United Kingdom. Imports classified as "other vanadium compounds" totaled 88 tons (gross weight), 55 tons of which came from the Republic of South Africa and 33 tons from the Federal Republic of Germany. Imports of vanadium carbide and unwrought vanadium metal were relatively minor and totaled less than one-half ton each.

Table 6.—U.S. exports of vanadium in 1980, by country

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium (gross weight)		Vanadium ore and concentrate (vanadium content)		Vanadium compounds (gross weight)			
					Pentoxide (anhydride)		Other[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	29	173	--	--	--	--	--	--
Australia	4	18	--	--	26	117	--	--
Belgium-Luxembourg	--	--	12	66	469	616	--	--
Canada	530	2,380	6	40	9	19	14	4
Chile	--	--	--	--	--	--	32	43
France	--	--	--	--	1	10	8	29
Germany, Federal Republic of	642	2,217	--	--	1	5	146	392
Indonesia	1	7	--	--	4	19	11	42
Israel	--	--	--	--	470	737	--	--
Japan	--	--	6	33	--	--	--	--
Korea, Republic of	262	1,523	--	--	--	--	(2)	1
Mexico	78	363	68	377	309	956	14	79
Nicaragua	--	--	--	--	--	--	4	7
Philippines	--	--	--	--	[3]139	[3]180	--	--
Qatar	56	296	--	--	--	--	--	--
Saudi Arabia	--	--	--	--	--	--	21	89
South Africa, Republic of	--	--	--	--	(2)	1	(2)	3
Sweden	--	--	--	--	--	--	76	347
Switzerland	--	--	--	--	--	--	17	67
Taiwan	2	13	--	--	10	41	15	9
United Kingdom	--	--	--	--	--	--	(2)	21
Zambia	--	--	--	--	--	--	16	21
Other[4]	2	6	--	--	9	27	5	19
Total[5]	1,605	6,995	92	517	1,448	2,728	379	1,173

[1]Excludes vanadates.
[2]Less than 1/2 unit.
[3]Bureau of Mines interpretation of reported data; being questioned.
[4]Includes Malaysia (ferrovanadium), Brazil and Venezuela (vanadium pentoxide), and the Netherlands, Oman, Pakistan, and Yugoslavia (other compounds).
[5]Data may not add to totals shown because of independent rounding.

Table 7.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1979			1980		
	Gross weight	Vanadium content	Value	Gross weight	Vanadium content	Value
General imports:						
Austria	--	--	--	37	30	189
Canada	571	447	2,657	559	450	2,999
Germany, Federal Republic of	451	279	1,543	60	44	303
Sweden	188	152	839	--	--	--
United Kingdom	264	155	928	--	--	--
Total[1]	1,475	1,033	5,967	656	524	3,491
Imports for consumption:						
Austria	--	--	--	35	32	174
Canada	571	447	2,657	559	450	2,999
Germany, Federal Republic of	451	279	1,543	60	44	303
Sweden	188	152	839	--	--	--
United Kingdom	264	155	928	--	--	--
Total[1]	1,475	1,033	5,967	654	525	3,477

[1]Data may not add to totals shown because of independent rounding.

Table 8.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1979			1980		
	Gross weight (pounds)	Vanadium content (pounds)	Value	Gross weight (pounds)	Vanadium content (pounds)	Value
General imports:						
Canada	14,000	7,842	$1,300	--	--	--
China, mainland	--	--	--	44,092	24,699	$127,716
Finland	1,072,095	600,588	2,559,046	1,945,020	1,089,534	5,489,711
South Africa, Republic of	2,151,724	1,205,396	4,745,500	1,066,103	597,195	2,744,149
United Kingdom	3	2	416	4	2	2,155
Total	3,237,822	1,813,828	7,306,262	3,055,219	1,711,430	8,363,731
Imports for consumption:						
Canada	14,000	7,842	1,300	--	--	--
China, mainland	--	--	--	44,092	24,699	127,716
Finland	1,072,095	600,588	2,559,046	1,945,020	1,089,534	5,489,711
South Africa, Republic of	2,151,724	1,205,396	4,745,200	1,066,097	597,191	2,744,149
United Kingdom	3	2	416	4	2	2,155
Total	3,237,822	1,813,828	7,305,962	3,055,213	1,711,426	8,363,731

WORLD REVIEW

In addition to the countries listed in table 9, several others had relatively small vanadium production from secondary, waste, or byproduct materials. Japan, the Federal Republic of Germany, Sweden, and possibly France and India produced vanadium from such sources.

World capacity to produce vanadium increased and continued to exceed the rate of world vanadium consumption. Oversupply and declining sales to the steel industry in most parts of the Western World led to V_2O_5 production cutbacks by Highveld Steel and Vanadium Corp., Ltd., Ucar Minerals Corp., and Rautaruukki Oy.

Australia.—Agnew Clough Ltd. began processing ore in July at Australia's first vanadium mine. The open pit operation is located at Coates Siding, about 40 miles east of Perth, and is expected to produce 1,790 short tons per year of fused pentoxide flake. The initial production has all been committed and will be divided between Nissho-Iwai Co., Ltd., of Japan and Klöckner and Co. of the Federal Republic of Germany. The two supply contracts run for 7 years and have a combined value of US$55 million at current prices.

Western Mining Corp. Ltd. has been conducting pilot plant tests on carnotite from

Table 9.—Vanadium: World production from ores and concentrates, by country[1]

(Short tons of contained vanadium)

Country	1976	1977	1978	1979[p]	1980[e]
Australia[e]	--	--	--	--	650
Chile[e] [2]	1,199	950	760	500	400
China, mainland[e] (in vanadiferous slag product)	NA	NA	2,200	4,000	5,000
Finland (in vanadium pentoxide product)	1,598	2,055	3,092	3,051	3,100
Namibia (in lead vanadate concentrate)[3]	771	826	485	--	--
Norway[e]	580	590	510	630	600
South Africa, Republic of:[4]					
Content of pentoxide and vanadate product[e]	3,169	4,059	4,023	4,300	4,500
Content of vanadiferous slag product[e]	7,716	8,329	8,377	9,300	9,500
Total[e]	[5]10,885	[5]12,388	12,400	13,600	14,000
U.S.S.R. [e]	8,800	10,000	10,500	11,000	11,000
United States (recoverable vanadium)	7,376	6,504	4,272	5,520	[5]4,806
Grand total	31,209	33,313	34,219	38,301	39,556

[e]Estimated. [p]Preliminary. NA Not available.
[1]Table includes data available through May 13, 1981.
[2]Based on U.S. imports of vanadium-bearing slag for the years 1976 through 1979.
[3]Data represent output of South West Africa Co. Ltd. for the years ending June 30 of that stated.
[4]For 1976 and 1977 the Republic of South Africa officially reported the undistributed total production of vanadium in pentoxides and vanadate products as well as in vanadium-bearing slags. Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium-bearing slag (gross weight) multiplied by an assumed grade of 14% vanadium. Vanadium content of pentoxide and vanadate products represents the difference between the reported total and the calculated estimate for vanadium in slag.
[5]Reported figure.

its Yeelirrie ore body, 355 miles east-northeast of Geraldton. The company completed construction of a 1-ton-of-ore-per-hour metallurgical pilot plant at Kalgoorlie in August. Data obtained from the tests will be used to design a 2,800-short-ton-per-year U_3O_8 plant with an 880-ton-per-year byproduct V_2O_5 circuit. If the final feasibility study is approved, the Yeelirrie Mine could become operational by 1986.[2]

Brazil.—Production of ferrovanadium totaled 890 short tons in 1980, a decrease of 5% from the 938 tons reported for 1979. Installed capacity in December 1979 totaled 1,770 short tons per year and was divided between three producers: Termoligas Metalúrgicas S.A., Produtos Metalúrgicos S.A., and Eletrometalur S.A. Indústria e Comércio.[3]

China, Mainland.—In 1980, sizable quantities of Chinese vanadium pentoxide and slag entered Western World markets for the first time. Japan imported 94 short tons of pentoxide and 6 tons of ferrovanadium from mainland China during the calendar year.[4] Gesellschaft für Elektrometallurgie (GFE) has been conducting tests on 330 tons of Chinese slag at its Nuremberg metallurgical facility. If recovery proves economic, GFE will undertake a feasibility study for a processing plant at an undisclosed location in China.[5] The Panzhihua iron mine in Sichuan Province has a reported reserve of 1.16 billion short tons of titaniferous magnetite ore with an average grade of 33.2% Fe, 11.6% TiO_2, and 0.3% V_2O_5.[6]

Finland.—Rautaruukki Oy completed installation of a new underground crushing plant at its Otanmäki Mine. The Otanmäki Mine produced 2,832 short tons of pentoxide in 1980, a 21% increase over the 2,344 tons in 1979. However, repeated problems with the sintering furnace at the company's Mustavaara Mine caused production there to drop from 3,103 tons to 2,763 tons.[7] Declining sales to the European steel industry and projected competition from Australia and mainland China have also forced Rautaruukki to stockpile about 13% of its Mustavaara ore.[8]

India.—Although India has extensive resources of vanadiferous magnetite and produces metavanadate-rich sludges at its alumina plants, no large-scale facilities exist for extracting pentoxide. Ferrovanadium producers are therefore totally dependent on imports of pentoxide concentrates. To help solve this problem, the National Metallurgical Laboratory (NML) and Visvesavaraya Iron & Steel Ltd. have developed a smelting process that uses a submerged-arc furnace to produce 20% to 25% V_2O_5-rich slag and byproduct low-sulfur pig iron.[9] NML also recently developed a precipitation and calcination process for recovering vanadium from the alumina sludges.

Ferrovanadium production totaled 94 short tons in 1980, compared with 202 tons in 1979.

Japan.—According to the Japan Ferroalloy Association, 3,959 short tons of ferrovanadium were produced in 1980, a 26%

decrease from the 5,348 tons of 1979.[10] Imports of ferrovanadium decreased from 1,394 tons in 1979 to 337 tons in 1980. Austria, Brazil, the Federal Republic of Germany, and the United States were the principal suppliers. Japan also imported 3,752 tons of vanadium pentoxide, 90% of which came from the Republic of South Africa.[11]

Norway.—Elkem A/S was considering using the Otanmäki process at its Raudsand Mine to improve vanadium recoverability and overall profitability. The mine has run a deficit for several years and was expected to show a loss of $600,000 for 1980. In 1979 the operation produced 155,784 short tons of magnetite concentrates and 4,299 tons of ilmenite concentrates. Until now the concentrates have been shipped to the Bremanger Works at Svelgen for smelting into pig iron and ferrovanadium. If the Otanmäki process fails to make the operation profitable, Elkem may be forced to phase out mine production by 1986.[12]

South Africa, Republic of.—The Republic of South Africa was again the world's largest producer of vanadium with output in the form of slag, polyvanadate, metavanadate, and fused pentoxide. Demand for South African-produced vanadium weakened considerably during the second half of 1980. Highveld Steel and Vanadium Corp. Ltd. was forced to reduce fused pentoxide production and at yearend had only one of its eight roasting units at the Vantra division in operation. The company also shut down three recently recommissioned kilns in June.[13] Ucar Minerals Corp. suspended operations indefinitely at its Bon Accord recovery plant near Pretoria in October. The plant had a capacity of 2,800 short tons per year of pentoxide and was producing about 1,000 tons per year at the time of closure.[14]

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[1]Physical scientist, Section of Ferrous Metals.

[2]Engineering and Mining Journal. V. 182, No. 5, May 1981, p.59.

[3]Associação Brasileira dos Produtores de Ferro-Ligas. Anuário da Indústria Brasileira de Ferro-Ligas-1980 (Yearbook of the Brazilian Ferroalloys Industry). Rio de Janeiro, pp. 13, 23.

[4]Japan Tariff Association. Japan Exports and Imports. V. 12, 1980, pp. 125, 321.

[5]Business China. V. 6, No. 16, Aug. 20, 1980, p. 124.

[6]Fumin, Z. Brief Introduction of Metal Mines in the People's Republic of China, Special Session Paper No. B-1-1, Proc. 4th Joint Meeting MMIJ-AIME, Tokyo, Nov. 4-8, 1980. The Mining and Metallurgical Institute of Japan, Tokyo, 1980, pp. 119-127.

[7]Rautaruukki Oy. Annual Report for 1980. P. 17.

[8]Metal Bulletin. No. 6555, Jan. 13, 1981, p. 17.

[9]Altekar, V. A. The Role of Research. Miner. & Metals Rev., v. 6., No. 5, May 1980, pp. 25-27.

[10]Japan Metal Journal. V. 11, No. 20, May 18, 1981, p. 10.

[11]Work cited in footnote 4.

[12]Bergverks-Nytt. No. 1, January 1980, pp. 12-13.

[13]Highveld Steel and Vanadium Corp. Ltd. Ann. Rept., 1980, pp. 8-10.

[14]American Metal Market. V. 88, No. 211, Oct. 29, 1980, p. 3.

Vermiculite

By A. C. Meisinger[1]

U.S. production of vermiculite concentrate in 1980 declined 3% in quantity (337,000 tons) sold and used from that of 1979. Value of production continued to increase and was 7% higher than the 1979 value of $22 million.

Vermiculite was mined and beneficiated in 1980 from deposits in Montana, South Carolina, and Virginia. The only operation in Texas was idle during the year.

Exfoliated vermiculite was produced at 47 plants in 30 States in 1980, and the quantity sold and used was 3,000 tons above the 1979 total of 278,000 tons. Value of exfoliated vermiculite sold and used in 1980 was $54.5 million, compared with $51.3 million of 1979. W. R. Grace & Co. continued to be the leading domestic producer of vermiculite concentrate and the exfoliated material.

The principal uses of exfoliated vermiculite in 1980 were for concrete aggregate, 24%; fertilizer carriers, 16%; loose-fill insulation and premixes, 14% each; block insulation, 13%; soil conditioning, 9%; and horticulture, 7%.

Estimated world production of vermiculite was 583,000 tons in 1980, a decrease of 2% from the 595,200 tons estimated in 1979.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Sold and used by producers:					
Concentrate	304	359	337	346	337
Value	$14,000	$18,600	$19,700	$22,000	$23,500
Average value[1] (dollars per ton)	$46.05	$51.81	$58.46	$63.58	$69.73
Exfoliated	270	321	270	r278	281
Value	$42,300	$50,500	$49,000	r$51,300	$54,500
Average value[1] (dollars per ton)	$156.67	$157.32	$181.48	r$184.53	$193.95
Exports to Canada	41	e45	e29	NA	NA
Imports from the Republic of South Africa	40	e40	e28	NA	NA
World: Production[2]	576	r574	r599	e595	e583

eEstimated. rRevised. NA Not available.
[1]Based on rounded data.
[2]Excludes production by centrally planned economy countries.

DOMESTIC PRODUCTION

U.S. production of vermiculite concentrate in 1980 was 337,000 tons valued at $23.5 million, a decrease of 3% in quantity sold and used, but an increase of 7% in value over that of 1979.

The principal vermiculite mining and beneficiating operations in 1980 were those of W. R. Grace & Co. at Libby, Mont., and Enoree, S.C. Vermiculite was also mined and processed by Patterson Vermiculite Co. near Enoree, S.C., and by Virginia Vermiculite, Ltd., in Louisa County, Va. The Volite Co.'s operation in Llano, Tex., was inactive during the year.

Exfoliated vermiculite output in 1980 increased 3,000 tons in quantity sold and used over that of 1979. Production came from 47 plants in 30 States, the same as in 1979. The value of exfoliated vermiculite sold and used by producers in 1980 was $54.5 million, an increase of 6% over that of 1979. Producers and exfoliation plant locations are shown in table 3. An unknown quantity of vermiculite imported from the Republic of South Africa was also exfoliated in domestic plants in 1980.

The principal producing States, in descending order, of exfoliated vermiculite production in 1980, were Ohio, Texas, Florida, California, South Carolina, New Jersey, and Illinois.

Table 2.—Exfoliated vermiculite sold and used, by end use

Use	1979[r] Short tons	1979[r] Percent of total	1980 Short tons	1980 Percent of total
Aggregates:				
Concrete	63,900	23	66,700	24
Plaster	3,000	1	2,900	1
Premixes[1]	34,800	13	40,100	14
Total	101,700	37	109,700	39
Insulation:				
Loose fill	39,600	14	38,200	14
Block	44,800	16	37,200	13
Other[2]	1,800	1	2,700	1
Total	86,200	31	78,100	28
Agricultural:				
Horticultural	21,400	8	20,600	7
Soil conditioning	19,200	7	24,100	9
Fertilizer carrier	46,500	17	45,000	16
Total	87,100	32	89,700	32
Other uses[3]	3,200	1	3,100	1
Grand total[4]	[r]278,000	100	281,000	100

[r]Revised.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Includes high-temperature and packing insulation and sealants.
[3]Includes various industrial uses not specified.
[4]Data do not add to totals shown because of independent rounding.

Table 3.—Vermiculite exfoliating plants in the United States in 1980

Company	County	State
Strong-Lite Products Corp	Jefferson	Arkansas.
Verlite Co	Hillsborough	Florida.
Vermiculite of Hawaii, Inc	Honolulu	Hawaii.
International Vermiculite Co	Macoupin	Illinois.
Mica Pellets, Inc	De Kalb	Do.
Shelter Shield Products, Div. of Insulation Sales Co	Franklin	Kansas.
P & H Inc	Hennepin	Minnesota.
Brouk Co	St. Louis	Missouri.
Robinson Insulation Co	Cascade	Montana.
The Schundler Co	Middlesex	New Jersey.
Robinson Insulation Co	Ward	North Dakota.
Cleveland Gypsum Co., Div. of Cleveland Builders Supply Co	Cuyahoga	Ohio.
O. M. Scott & Sons	Union	Do.
J. P. Austin Associates, Inc	Beaver	Pennsylvania.
Patterson Vermiculite Co	Laurens	South Carolina.
Vermiculite Products, Inc	Harris	Texas.
Vermiculite-Intermountain, Inc	Salt Lake	Utah.
Koos, Inc	Kenosha	Wisconsin.
W. R. Grace & Co., Construction Products Div	Maricopa	Arizona.
	Pulaski	Arkansas.
	Los Angeles	California.
	Orange	Do.
	Denver	Colorado.
	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.

See footnotes at end of table.

Table 3.—Vermiculite exfoliating plants in the United States in 1980 —Continued

Company	County	State
W. R. Grace & Co., Construction Products Div.—Continued	Du Page	Illinois.
	Campbell	Kentucky.
	Orleans	Louisiana.
	Prince Georges	Maryland.
	Hampshire	Massachusetts.
	Wayne	Michigan.
	Hennepin	Minnesota.
	St. Louis	Missouri.
	Douglas	Nebraska.
	Mercer	New Jersey.
	Cayuga	New York.
	Guilford	North Carolina.
	Oklahoma	Oklahoma.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.
	Milwaukee	Wisconsin.

[1]Two plants in county.

CONSUMPTION AND USES

Exfoliated vermiculite sold and used by producers in 1980 totaled 281,000 tons, a 1% increase over that of 1979. Major end use categories of exfoliated vermiculite in 1980 were aggregates, 39% of total consumption (up 2 percentage points from that of 1979); insulation, 28% (down 3 percentage points); and agriculture, 32% (no change).

Aggregate uses totaled 109,700 tons sold and used in 1980, an 8% increase over that of 1979; insulation uses decreased 9% from that of 1979; and agricultural uses increased 3% over that of 1979. Other uses in 1980 totaled 3,100 tons, a slight decrease from that of 1979.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers in 1980 was $69.73 per ton, an increase of 10% over that reported in 1979. The average value for exfoliated vermiculite sold and used in 1980 was $193.95 per ton, an increase of 5% over the average value of 1979.

Engineering and Mining Journal quoted 1980 yearend prices for unexfoliated vermiculite as follows: Per short ton, f.o.b. mine, Montana and South Carolina, domestic, $64 to $98; and the Republic of South Africa, $100 to $160, c.i.f. Atlantic ports. For comparison, yearend 1979 quoted prices per ton were $59 to $92 for domestic and $50 to $100 for the Republic of South Africa.

FOREIGN TRADE

The United States annually imports large quantities of vermiculite from the Republic of South Africa and exports vermiculite to Canada. However, tonnage data in 1980 were not available.

WORLD REVIEW

Estimated world vermiculite production in 1980 (table 4) was 583,000 tons, a 2% decrease from the 1979 production. The United States and the Republic of South Africa, together, accounted for 93% of world production compared with 94% in 1979.

South Africa, Republic of.—Vermiculite concentrate production was reported to be 204,698 tons in 1980, a 3% decrease from that of 1979. Exports declined from approximately 189,600 tons in 1979 to 179,400 tons in 1980.

[1]Industry economist, Section of Nonmetallic Minerals.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Argentina	4,517	[r]5,319	5,890	6,478	[2]7,012
Brazil	1,043	[r]3,987	4,443	8,137	8,500
Egypt	--	--	654	770	800
India	3,786	3,172	2,079	3,376	[2]3,779
Japan[e]	14,000	15,000	16,000	17,000	19,000
Kenya	3,954	4,762	2,054	[e]2,200	2,200
South Africa, Republic of	244,798	182,343	230,485	211,173	[2]204,698
Tanzania[e]	20	20	20	20	20
United States (sold and used by producers)	304,000	359,000	337,000	346,000	[2]337,000
Total[3]	576,118	[r]573,603	598,625	595,154	583,009

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes production by centrally planned economy countries. Table includes data available through June 8, 1981.
[2]Reported figure.
[3]Series revised: Old series represented total crude mine output; revised series represents the sum of (1) crude mine output sold directly and (2) output of beneficiated product obtained from crude mine output not included under 1. Total crude mine output was as follows, in short tons: 1976—1,043; 1977—7,532; 1978—21,617; 1979—11,570; 1980—not available.

Zinc

By V. Anthony Cammarota, Jr.[1]

The opening of a new mine, the absence of strikes, and higher output from a number of mines contributed to greater zinc production over that of 1979. Smelter production was lower as a zinc smelter closed toward yearend and shortages of feed material developed. Consumption of slab zinc decreased mainly as a result of lower automobile production and reduced construction activity. Imports for consumption of zinc concentrates increased significantly as material was withdrawn from bonded warehouses, but slab zinc imports declined as demand slackened. Stocks held by producers, consumers, and merchants fell sharply. The price of zinc rose and fell several times during the year, but in the last trimester the average monthly price rose about 10%.

Table 1.—Salient zinc statistics

	1976	1977	1978	1979	1980
United States:					
Production:					
Domestic ores, recoverable content metric tons	439,543	407,889	302,669	267,341	334,862
Value thousands	$358,541	$309,338	$206,854	$219,841	$276,325
Slab zinc:					
From domestic ores metric tons	346,429	322,208	267,350	255,344	231,850
From foreign ores do	106,125	86,156	139,348	217,137	108,606
From scrap do	62,192	45,914	34,774	53,212	29,396
Total do	514,746	454,278	441,472	525,693	369,852
Secondary zinc[1] do	276,089	284,065	304,047	316,818	274,967
Exports of slab zinc do	3,187	215	723	279	302
Imports (general):					
Ores and concentrates (zinc content) do	88,101	111,410	188,003	224,952	129,923
Slab zinc do	648,174	523,206	617,840	527,212	410,642
Stocks, Dec. 31:					
Producer and consumer do	197,861	170,237	137,253	r151,661	92,151
Merchant do	NA	NA	NA	NA	33,650
Government stockpile do	349,440	347,828	345,872	345,684	342,380
Consumption:					
Slab zinc do	1,028,876	999,505	1,050,585	1,000,606	811,146
All classes do	1,394,244	1,367,704	1,441,810	1,394,314	1,142,409
Price: Prime Western, cents per pound (delivered)	37.01	34.39	30.97	37.30	[2]37.43
World:					
Production:					
Mine thousand metric tons	r5,725	r5,945	r5,928	r5,917	5,761
Smelter[3] do	r5,430	r5,582	r5,671	r6,016	5,806
Price: Prime Western grade, London, cents per pound	32.38	26.71	26.88	33.59	34.47

r Revised. NA Not available.
[1]Excludes redistilled slab zinc.
[2]Based on U.S. High Grade, cents per pound.
[3]Primary metal production only; includes secondary metal production where inseparably included in country total.

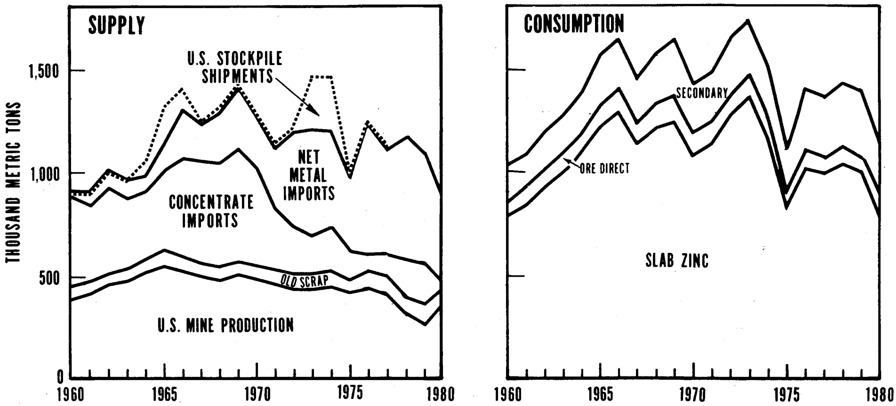

Figure 1.—Trends in supply and consumption in the United States.

Legislation and Government Programs.—The stockpile goal for zinc was increased from 1,191,134 tons to 1,292,739 tons in May by the Federal Emergency Management Agency (FEMA). The agency gave the loss of a large domestic producer as the reason for the increase. The total inventory of slab zinc in storage was 347,630 tons at yearend.

On December 11, 1980, the President signed the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510, commonly known as the Superfund. The tax, which is to be collected beginning April 1981 on a number of materials, was set at $2.22 per short ton for zinc chloride and $1.90 per short ton for zinc sulfate. A major provision of the law is to establish a $1.6 billion fund to clean up disposal sites and spills of hazardous substances. The tax terminates on September 30, 1985.

At its annual session in Geneva, Switzerland, in October, the International Lead and Zinc Study Group expected both production and consumption of zinc to be lower in 1980 than in 1979, but that supply and demand would be in close balance through 1981.

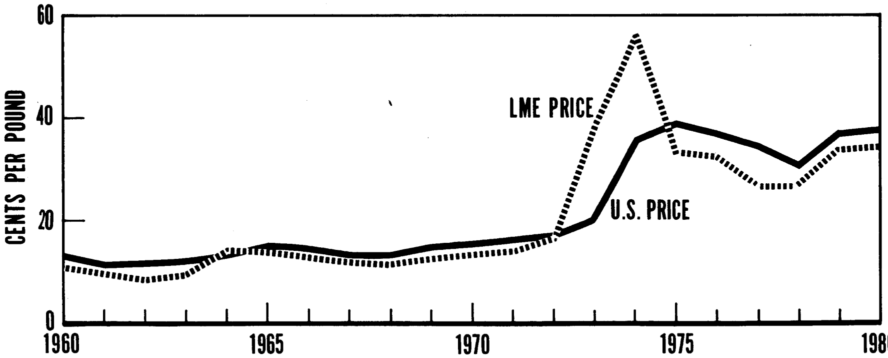

Figure 2.—Trends in average London Metal Exchange (LME) and domestic zinc prices.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine production of recoverable zinc from 13 States was significantly above that of 1979. Most of the increase in production took place in Colorado, Missouri, New York, and Tennessee. The 25 leading U.S. zinc mines accounted for 98% of the recoverable zinc mined in 1980, unchanged from that of 1979. The remaining 2% was obtained mainly as a byproduct from silver and copper ores from about 20 other mines in the Western States and two fluorspar mines in Illinois. The 10 leading mines accounted for 70% of total mine production in 1980, compared with 68% in 1979.

Tennessee was the foremost producer of zinc in 1980 where production from all mines was at or above the levels in 1979. In east Tennessee, The New Jersey Zinc Co. began production at its Beaver Creek Mine with output being processed at the Jefferson City mill. However, Jersey Miniere Zinc Co. stopped development at the Gordonsville Mine. ASARCO Incorporated increased production at its Tennessee mines from about 34,500 tons in 1979 to about 58,000 tons in 1980. The company cited the worldwide shortage of zinc concentrate as the reason for increasing production. The zinc concentrate produced from the Young and Immel Mines is used mainly for the production of zinc oxide at Asarco's own plants in Ohio and Illinois.

Zinc production as a coproduct came from seven lead mines in Missouri with Ozark Lead Co. reporting a significant increase from the expanded Milliken Mine. Ore production at the Buick Mine increased 4% in 1980 as a result of mine expansion and more efficient equipment. However, the ore grade declined from 2.4% zinc in 1979 to 2.2% zinc in 1980. Ore reserves were given as 42 million tons grading 5.9% lead and 1.6% zinc. Ore and concentrate production from the Magmont Mine declined slightly as ore grade declined to 1.0% zinc from 1.4% in 1979. Asarco began development of the West Fork Mine, which contains 13.6 million tons of ore assaying 5.5% lead, 1.2% zinc, and smaller quantities of silver and copper. Production is expected to begin in 1983 at a capacity of about 46,000 tons of lead, and 6,800 tons of zinc. Total cost of the project is $77 million.

In New York, at St. Joe Minerals Corp.'s Balmat, Hyatt, and Edwards Mines, production in 1980 was about double that of 1979 when a strike cut production. St. Joe announced reserves at the new Pierrepont ore body near Balmat as 2.3 million tons of ore assaying 15% zinc. The company plans to mill the ore at Balmat at the rate of 450 tons per day beginning in 1982.

In Colorado, zinc production was from three mines in 1980—the Leadville, Bulldog, and Sunnyside. Resurrection Mining Co., wholly owned by Newmont Mining Corp. and managed by Asarco, mined 16% more ore in 1980 than in 1979 at the Leadville Mine. Ore grade increased to 7.8% zinc, 4.2% lead, 68 grams of silver per ton, and 2.5 grams of gold per ton. The company continued a drilling program in areas adjacent to the mine. Homestake Mining Co. produced some byproduct zinc from its Bulldog silver mine near Creede.

Production of zinc in Idaho was reported from about 10 mines in 1980, but about half of them produced less than 100 tons each as a byproduct from other metal mining operations. At the Bunker Hill Mine, production in 1980 was about the same as in 1979 and ore grade remained at 2.9% zinc. Ore production from the Star-Morning Unit Area, owned 30% by Hecla Mining Co., decreased slightly in 1980 to 255,700 tons, and ore grade declined to 5.9% zinc, 4.6% lead, and 89 grams of silver per ton. Ore reserves at the mine decreased to 1.2 million tons as the result of higher cutoff grade. Hecla stated that this mine is more sensitive to lead and zinc prices than its other silver mines in the Coeur d'Alene District. Ore production at the Lucky Friday Mine was 171,800 tons, up 8% over that of 1979. Ore grade was 1.1% zinc and 10% lead, with 549 grams of silver per ton. Ore reserves increased in 1980 to 580,000 tons as development work continued.

In Utah, Noranda Mining, Inc., rehabilitated the Ontario Mine and processed mined ore plus some purchased ore, but the planned rate of 680 tons of ore per day would probably not be attained until late 1981. Proven and probable reserves were given as 1.3 million tons assaying 9.2% zinc, 5.9% lead, and 156 grams of silver per ton. Sunshine Mining Co. exercised its option to lease property, including the Burgin Mine, from Chief Consolidated Mining Co. Sunshine planned to reopen the Burgin Mine, closed since 1978, where drilling indicated substantial quantities of silver, lead, and zinc at depths below previously mined levels.

In northern Maine, Superior Oil Co. and Louisiana Land and Exploration Co. continued their drilling and bulk sampling program at the zinc-copper deposit at Bald Mountain. The company stated that its pilot plant tests were encouraging, but enactment of a proposed severance tax bill could adversely affect development of the deposit.

New Jersey Zinc cut back production at its Austinville and Ivanhoe Mine in Virginia and its Sterling Mine in New Jersey, in the second half of 1980, due to the depressed state of the zinc market and high shipping costs from the mines. The company planned to sell the concentrate from its Friedensville Mine in Pennsylvania on the open market.

In Wisconsin, the Exxon Minerals Co., U.S.A., decided against a test shaft at its Crandon zinc-copper deposit. The high State tax structure on mining and higher than expected costs led to the decision which will postpone mine development, if any, to the end of the decade. Eagle-Picher Industries, Inc., sold the mine and mill facilities at Shullsburg and Linden, Wis., and Galena, Ill. Total capacity of the mills was about 3,200 tons of ore per day.

Near Pinos Altos, Grant County, N. Mex., Exxon Minerals completed an environmental study in support of an application to conduct test mine activity at the site. According to a preliminary feasibility study, the company found Pinos Altos to be economically feasible.

In Washington, Callahan Mining Corp. completed a 4-month program of underground exploration at its Washington Zinc Unit, but the combined zinc-lead grade of 8% was insufficient to support profitable operations. In Virginia, the company joined with Boliden Minerals AB, a Swedish company, in exploring its Virginia property, but no additions were made to its estimate of a 5.4-million-ton deposit previously identified.

SMELTER AND REFINERY PRODUCTION

U.S. slab zinc production at 6 primary plants and 11 secondary plants decreased substantially in 1980 from that of the previous year, as the St. Joe smelter was closed most of the year. According to company annual reports, AMAX Zinc Co., Inc., produced 62,608 tons of zinc in Illinois; Asarco produced 42,600 tons in Texas; The Bunker Hill Co. produced about 69,990 tons in Idaho; and in the fiscal year ending July 31, 1980, New Jersey Zinc produced 71,700 tons in Pennsylvania and Jersey Miniere produced 73,646 tons in Tennessee. Asarco's Corpus Christi, Tex., electrolytic zinc plant processed domestic and foreign zinc concentrates as well as zinc fume. A 5-month strike at the El Paso, Tex., lead smelter interrupted the supply of zinc fume which makes up about 50% of the raw material to Corpus Christi. A modernization program continued at the plant to allow treatment of a wider variety of concentrates, reduce costs, and expand capacity by 25%. Completion was expected in early 1982.

AMAX produced slightly more zinc in 1980 than in 1979 at its Sauget, Ill., electrolytic zinc plant, although a shortage of concentrate limited output. About one-quarter of the feed for the facility came from AMAX's share of production from subsidiary companies in Missouri and one-fifth from the company's share in the Newfoundland Mine in Canada. Bunker Hill in Idaho produced less slab zinc in 1980 than in 1979 because of problems in obtaining sufficient concentrate supply. The company planned to improve its cell room for more efficient operation.

New Jersey Zinc ended slab zinc production at its smelter in Palmerton, Pa., in late 1980, resulting in the layoff of about one-half its work force of 1,380 employees. The reasons for the closure were escalating operating costs, low zinc prices, competition from imports, and the large capital investment required to bring the plant into compliance with environmental regulations. Ore from the Sterling Mine will continue to be shipped there for the production of zinc oxide, and concentrates from other company mines will be shipped to the electrolytic plant in Clarksville, Tenn.

St. Joe Minerals announced that it would not construct a new electrolytic plant in place of the electrothermic plant at Monaca, Pa. In late 1980, the company reactivated the Monaca plant on a limited basis to produce about 45,000 tons of zinc metal equivalent annually, about evenly split between slab zinc and zinc oxide. Management responsibility for the company's zinc business was transferred to its subsidiary, St. Joe Lead Co.

Secondary slab zinc was produced at four primary plants, with New Jersey Zinc being the largest producer. Of the 10 companies producing slab zinc solely from secondary materials, Pacific Smelting Co. and W. J. Bullock, Inc., were the largest producers. The grade of zinc from secondary plants was all Prime Western. Proler International Corp. installed new furnaces at its Jersey City, N.J., plant and began recovering secondary slab zinc. The company was in the process of installing similar equipment at its Los Angeles, Calif., plant.

Slag-Fuming Plants.—Slag-fuming plants processed lead blast furnace slags and residues to produce zinc oxide fume. The oxide was either sold or used as oxide or sent to smelters and refineries for processing into metallic zinc. Three plants operated in 1980—Asarco at El Paso, Tex., and East Helena, Mont.; and Bunker Hill at Kellogg, Idaho.

Byproduct Sulfuric Acid.—Production of byproduct sulfuric acid from zinc plants was 560,784 tons in 1980. Seven plants roasted zinc sulfide concentrates and produced sulfuric acid, with one plant operating solely to produce calcine for processing to zinc oxide or slab zinc.

Zinc Dust.—Federated Metals Corp. stated that lower sales of zinc dust were attributed to lower automobile production. The company temporarily suspended operations at its plant in Trenton, N.J., but continued operations at its other two plants.

CONSUMPTION AND USES

Zinc consumption in all end-use categories was lower in 1980, as low economic activity prevailed from 1979. Shipments of galvanized steel, as reported by the American Iron and Steel Institute, declined about 17% in 1980, roughly equal to the decline in zinc used in galvanizing. In 1980 reported slab zinc consumption for the first half of the year was 24% lower than that of the comparable 1979 period, but in the second half of 1980, consumption fell 17% compared with that of the second half of 1979. Most of the decline can be attributed to lower automobile production, which fell about 24%, and lower construction activity, as construction awards dropped about 12%.

Production of rolled zinc products decreased to 20,545 tons in 1980. Strip and foil accounted for 80% of the total. Production of rolled zinc from remelted clippings was 19,427 tons in 1980.

The Zinc Institute Inc. conducted a survey of over 400 diecasters in 1980 to determine the market distribution of zinc diecastings shipped by these companies. The results showed that automotive components continued to decline and accounted for 33% of the total in 1980. Builders' hardware increased to 27%, domestic appliances increased to 8%, and electrical components increased to 13%. Most other uses continued the upward trend of recent years. The Zinc Institute and the American Hot Dip Galvanizers Association, in a cooperative effort, reported on shipments of hot dip galvanized steel by end use. The largest end-use industry was electric utilities, 21%; followed by fabricated wire products, 21%; light construction, which is mainly nonresidential building, 16%; heavy construction, which is mainly industrial plants, 13%; and transportation, which is mainly highway construction, 11%.

ZINC PIGMENTS AND SALTS

Production.—The source of domestic zinc oxide production was slightly less than half from ore and concentrate (American process), about one-quarter from slab zinc (French process), and about one-quarter from secondary material. Total French process zinc oxide, including that from remelt and scrap, was 36% of the total in 1980. Lead-free zinc oxide was produced at 14 plants and leaded zinc oxide was produced at 1 plant. Asarco, a major producer, produced zinc oxide from concentrates produced by company mines in Tennessee and from zinc metal. New Jersey Zinc produced both American and French process zinc oxide and was the largest zinc oxide producer. Other large zinc oxide producers such as the Eagle-Picher, Hillsboro, Ill., plant and the Sherwin-Williams Co., Coffeyville, Kans., plant used calcines, fume, and secondary materials as raw materials. Late in 1980, Eagle-Picher sold its Hillsboro operation to Sherwin-Williams. Pacific Smelting announced plans to construct a new zinc-processing plant in Memphis, Tenn., for the production of zinc oxide from secondary materials.

Zinc sulfate production from 15 companies showed a significant increase in 1980, mainly because of additional reporting companies. Zinc sulfate production and shipments as given in tables 19, 20, and 22 have been revised to reflect quantities in terms of 100% zinc sulfate. Zinc sulfate production came from secondary material and from ore. Zinc chloride production from five companies was derived entirely from secondary material.

Consumption and Uses.—The apparent consumption of zinc oxide decreased to about 165,000 tons in 1980, down from 205,000 tons in 1979. Several new companies responded to the zinc chemical survey in 1980. Of the major uses of zinc oxide, only agriculture showed an increase, and paints showed the smallest decline. The use in photocopying continued the downward trend of recent years. Among miscellaneous uses, zinc oxide was used in floor coverings, fabrics, lubricants, plastics, and rayon manufacturing. The use of zinc sulfate in agriculture was up significantly in 1980 with lesser amounts assigned to rayon, flotation reagents, and chemicals. Leaded zinc oxide was used in rubber, and lithopone was used mainly in paints. Shipments of zinc chloride were lower in 1980 compared with those of 1979, with most of the zinc chloride used in wood preserving, soldering fluxes, and batteries.

Prices.—In January, the price for zinc oxide was 44.5 cents per pound for American process, lead-free pigment grade; 46 cents for French process, regular; 47.25 to 48.25 cents for photoconductive grade; and 39.25 cents for 12% leaded zinc oxide in 50-short-ton railcar quantities. The price for lead-free zinc oxide was increased 2 cents per pound in February, but reduced 2 cents per pound in June and August in relation to the price of zinc metal. As the price of zinc metal rose in the last trimester of the year, the price of zinc oxide was raised, so that by yearend the list price was 47.25 cents per pound for American process, 48.75 cents for French process, 50 to 51 cents for photoconductive grade, and 42.25 cents for 12% leaded zinc oxide.

The price of zinc sulfate, granular monohydrate industrial, 36% zinc, bags in carload lots, remained at $26.50 to $29 throughout 1980. The price of technical-grade zinc chloride, 50% solution, in tank car quantities, was quoted at $10 to $15.25 through August, when the quote became $15.25 to $17. At yearend the quote was reduced to $10 to $17.

Foreign Trade.—Exports of zinc oxide decreased with Belgium, Costa Rica, and Sri Lanka receiving most of the total. Imports of zinc oxide increased in 1980, but imports of zinc sulfate declined. Canada supplied 53% and Mexico supplied 45% of the zinc oxide; other European countries contributed most of the remainder.

STOCKS

Producer stocks at yearend 1980 were at their lowest yearend level since 1951 when they were 19,940 tons. The monthly data as reported by the American Bureau of Metal Statistics (ABMS) showed that producer stocks at plants and elsewhere declined early in the year, firmed at midyear, then further declined in the second half of the year.

Inventories of slab zinc at consumer plants generally trended downward during the first half of the year and firmed during the second half. Slack demand and higher interest and inventory costs were factors contributing to declining consumer stocks.

A new survey, zinc merchant stocks, was begun in January 1980 on a monthly basis. The survey covers about 30 firms that are agents, dealers, or marketers of domestic or imported zinc. On January 1, merchants held 63,637 tons of slab zinc in stock, much of which was shipped during the first 6 months of the year, so that by the end of August the total was reduced to 30,623 tons. Stocks held at around 30,000 tons for the balance of the year.

PRICES

In February, Asarco initiated a price increase of 2 cents per pound of zinc to 39.5 cents for Prime Western and High Grade zinc, 39.75 cents for Controlled Lead Grade, and 40 cents for Special High Grade and Continuous Galvanizing Grade. Most of the other producers followed the move, but Asarco rescinded its increase in April, as did the other producers soon afterward. In June, Asarco initiated another reduction of 2 cents per pound because of poor market conditions, discounting, and low London Metal Exchange (LME) prices. In mid-August, several U.S. producers changed their pricing system from one based on Prime Western to a system based on either Special High Grade or High Grade to reflect the premium for Prime Western Grade zinc from electrolytic plants. After the change prices ranged from 35.5 to 37.75 cents per pound for Prime Western, 36 to 37.25 cents for Special High Grade, 35.5 to 37.25 cents for High Grade, 35.75 to 37.75 cents for Controlled Lead Grade, and 36 to 38 cents for Continuous Galvanizing Grade. In October, the price was raised 2 cents per pound, and another 2 cents in December, to end the year at 41.25 cents per pound for High Grade; 41.5 to 41.75 cents for Prime Western, Special High Grade, and Controlled Lead Grade; and 41.75 to 42 cents for Continuous Galvanizing Grade. During the latter part of the year, prices were buoyed by the decline in U.S. producer stocks, the closure of another U.S. smelter, and worldwide tightness in the supply of zinc concentrates.

U.S. dealer prices for Special High Grade zinc increased from 34 to 37 cents in January to 38.75 cents in early March, falling to 34.25 cents in July, but recovering to 41.25 cents in late December.

The New York Commodity Exchange (Comex) prices began at 37.9 cents per pound on its Special High Grade zinc contract, rose to 43.7 cents in February, generally declined through August to 30.7 cents, but recovered to end the year at 39 cents.

In early 1980, the European producer price was increased from $780 per ton (35.4 cents per pound) to $825 per ton by Australian Mining & Smelting Ltd. The move was not widely followed. By spring, several price adjustments were made and the price was uniformly quoted at $780 per ton where it remained until September. In October, prices were mixed at $825 to $845, but by yearend settled at $825. Higher LME prices and the continuing shortage of concentrate were significant factors in the upward price movement by producers.

On the LME, average weekly prices increased from 34.2 cents per pound at the end of 1979 to 40.5 cents in February, then dropped in March to 30.4 cents. Reports of price discounting and weak demand in Europe contributed to the decline. By June the price had fallen to 30.1 cents, but in July the price began to climb fairly steadily, so that by late in the year the average was 36 to 37 cents. Prices fell off slightly in December to an average of 35.4 cents in the last week of the year.

FOREIGN TRADE

Exports of zinc ores and concentrates (zinc content) in 1980 almost tripled over those of 1979. The high level of zinc exports was a function of the tightness of the world concentrate supply and the prices smelters were willing to pay for concentrate.

General imports of zinc in ores and concentrates declined substantially in 1980, whereas imports for consumption increased by almost 100,000 tons. Of the general imports, 51,636 tons entered bonded warehouses in 1980 compared with 141,951 tons in 1979. Of the imports for consumption, 104,084 tons were withdrawn for consumption from bonded warehouses in 1980 compared with 4,497 tons in 1979. With the suspension of duties in late 1980, zinc in concentrate was being withdrawn from bonded warehouses free of duty.

The rates of duty on zinc materials on January 1, 1980, as a result of the Tokyo round of multilateral trade negotiations completed in 1979, were as follows:

Tariff Item	Number	Most Favored Nation (MFN)	Non-MFN
		Jan. 1, 1980	Jan. 1, 1980
Ore and concentrate	602.20	0.62 cent per pound on zinc content.	1.67 cents per pound on zinc content.
Fume	603.50	0.62 cents per pound on zinc content.	1.67 cents per pound on zinc content.
Unwrought, other than alloys	626.02	1.9% ad valorem	1.75 cents per pound.
Alloys	626.04	19% ad valorem	45% ad valorem.
Waste and scrap	626.10	4.8% ad valorem	11% ad valorem.

The duty on waste and scrap remained suspended until June 30, 1981, according to Public Law 95-508. The bill to suspend duties on imported zinc ores and concentrates through June 30, 1984, was signed by the President as Public Law 96-467 on October 17.

WORLD REVIEW

The World Bureau of Metal Statistics[2] indicated that world consumption of slab zinc was 6.1 million tons in 1980 compared with 6.3 million tons (revised) in 1979. Consumption was about the same or slightly higher in Asia, Europe, Africa, Australia, South America, and centrally planned economy countries, compared with that in 1979, but consumption dropped in North America. Major consuming countries exhibiting declines were Canada, the United States, the United Kingdom, and Japan. According to the Bureau of Mines, world mine production declined in 1980 as a result of declining ore grade in some mines, labor strikes, and technical problems. Primary smelter production declined in 1980, mainly in Japan, Spain, and the United States. Substantial quantities of secondary slab zinc were produced in France, the Federal Republic of Germany, Japan, the United States, and the U.S.S.R. Producer stocks worldwide decreased 8% during 1980 to 494,000 tons by yearend, and consumer stocks were about 163,000 tons at yearend 1980 compared with 199,000 tons a year earlier.[3] LME stocks increased about 40,000 tons, ending 1980 at 85,925 tons.

World mine capacity was estimated to be 8.1 million tons of zinc in 1980, based upon a directory of world lead and zinc mines and smelters as a reference.[4] The Wheal Jane Mine in the United Kingdom was reopened by Carnon Consolidated Tin Mines Ltd. and is expected to produce about 10,000 tons per year of byproduct zinc at full operation. In addition, the Broken Hill Mine at Aggeneys, Republic of South Africa, a mine in Canada, and another in the United States accounted for most of the increase in capacity.

World primary zinc smelter capacity decreased to about 7.65 million tons per year at the end of 1980, down from about 7.73 million tons (revised) at yearend 1979. The change reflects the closure of the St. Joe smelter in the United States, the expansion of existing smelters in the Netherlands, the Republic of South Africa, and the Republic of Korea, and new plants in Brazil and Portugal.

In India, the zinc refinery at Kerala, 40% owned by Cominco Binani Zinc Ltd., was closed during 1980 because of a labor dispute. In the Netherlands, Australian Overseas Smelting Pty. Ltd. increased capacity of its Budel electrolytic plant to 180,000 tons per year. The lead and zinc industry in the U.S.S.R. was reviewed, with an assessment of future Soviet production, consumption, and trade.[5] The report stated that demand was rising, but ore quality was declining, mines were being depleted, and mining and smelting developments were not keeping pace.

Australia.—Mine production was down from that of 1979, mainly because of labor disputes. Production at the Mount Isa Mine in Queensland decreased slightly in 1980 to 105,100 tons of zinc. Mount Isa Mines Ltd. began a 20% expansion program at the mine, and prepared for trials of mining methods at the nearby Hilton silver-lead-zinc ore body. Ore grade declined from 6.1% zinc in 1979 to 5.7% zinc in 1980. Changes in mining techniques resulted in a net increase in reserves to 56 million tons of ore grading 6.5% zinc, 6.4% lead, and 150 grams of silver per ton. Mount Isa and Western Selcast (Pty.) Ltd. developed the Teutonic Bore copper-zinc mine with production expected in early 1981 at an annual rate of 10,900 tons of copper, 27,200 tons of zinc, and 43,500 kilograms of silver. The ore body will be mined as an open pit initially, and then by underground mining toward the end of its 7-year expected lifetime.

At the West Coast Mines in Tasmania, EZ Industries Ltd. maintained the mining rate of 1979 of about 650,000 tons of ore grading 11.7% zinc. Reserves declined to 7.8 million tons of ore. The company began construction of a mine and mill at the Elura deposit scheduled for completion by 1982. Capacity is designed for 1.1 million tons of ore per year; reserves were given at 27 million tons of ore grading 8.3% zinc, 5.6% lead, and 139 grams of silver per ton. Aberfoyle Ltd., owned 47% by Cominco Ltd., neared completion of the Que River zinc-lead-silver deposit in Tasmania, and limited production began in December. At full operation, annual ore output is expected to be 200,000 tons. Australian Mining & Smelting Ltd. mined slightly more ore in 1980 from the Broken Hill Mines than in 1979, but production of concentrate declined with a lowering of ore grade to extend mine life. Cobar Mines Pty. Ltd., treated slightly less ore in 1980, but concentrate production increased reflecting higher ore grade and improved efficiency in metals recovery at the mill.

CRA Ltd. reported an indicated resource of 60 million tons of ore at Dugald River, Queensland, grading 9.4% zinc, 1.5% lead, and 2.6 grams of silver per ton.

EZ Industries produced 190,372 tons of zinc from the Risdon smelter in the fiscal year ending June 30, 1980, down from 203,650 tons produced in 1979, due to technical problems and difficulties in maintaining supplies of raw materials. The company started work on an effluent treatment system and a pilot plant for the extraction of zinc from residues. Combined production at the Cockle Creek smelter of Sulfide Corp. Pty. Ltd., and the Port Pirie plant of The Broken Hill Associated Smelters Pty. Ltd. decreased 5% in 1980 from that of 1979, with operations near 88% of capacity in 1980. The reduction was attributed to maintenance shutdowns, labor turnover, and a shortage of concentrate.

At the Woodlawn zinc-lead-silver-copper deposit in New South Wales, ore treated totaled 970,265 tons compared with 852,887 tons in 1979. The zinc content of the ore mined was higher than in 1979, and improvements in the mill operation led to higher zinc production.

Canada.—Mine output in 1980 was down from that of 1979 due to strikes, generally failing ore grades at several operations, and production problems at some of the larger mines. Mill capacity at producing mines increased to 97,500 tons of ore per day as one new mine opened during the year.[6]

In New Brunswick, Brunswick Mining & Smelting Corp. Ltd. mined 1.85 million tons of ore, compared with 2.97 million tons in 1979, because of a 4-month strike. The strike also delayed completion of the mine expansion until mid-1981. Ore grade from the No. 6 and No. 12 Mines was 8.8% zinc, with byproduct lead, copper, and silver. The company expected the No. 6 underground ore body to be exhausted in 1982, where reserves were given as 380,000 tons of ore grading 7.4% zinc.

In Ontario, ore milled by Mattabi Mines Ltd., decreased 19% from that of 1979 because of a 6-week labor strike. The grade of ore increased to 7.4% zinc, and modifications were made in the mill process to increase recoveries and concentrate grade. The Geco Div. of Noranda treated 1.4 million tons of copper-zinc ore grading 3.2% zinc, down slightly from that of 1979, and modifications were made at the mill to increase efficiency. Noranda began production at the Lyon Lake Mine in October. Ore treated was 83,000 tons assaying 5.5% zinc, and lesser quantities of copper, lead, and silver. Full production in 1981 is expected at the rate of 1,000 tons of ore per day. At the Kidd Creek Mine, Texasgulf Inc. milled 3.9 million tons of ore in 1980 compared with 3.7 million tons in 1979. Development work continued, and in October the underground ore crusher was put into operation. Full capacity of 4.5 million tons of ore per year is expected by the end of 1981. Production from the Little River Joint Venture, in which Heath Steele Mines Ltd. has a 75% interest, began in 1980. Concentrate containing 41,700 tons of zinc was produced from ore grading 1.5% lead, 4.3% zinc, 0.8% copper, and 55 grams of silver per ton. Noranda planned to start production at the "F" Group Mine in mid-1981 at a rate of 700 tons of ore per day grading about 8.2% zinc and lesser quantities of copper, lead, and silver.

Cominco Ltd. increased ore production at both the Sullivan Mine in British Columbia and the Pine Point Mine in the Northwest Territories. Average ore grade decreased from 3.7% zinc in 1979 to 2.7% in 1980 at the Sullivan Mine because of high dilution and the mining of lower grade open pit ore, but remained at 5.5% zinc at the Pine Point Mine. The company added ore reserves almost equal to production in 1980 at the Pine Point Mine. Cominco began development of the Polaris Mine on Little Cornwallis Island, Northwest Territories, which is scheduled to begin production in 1982 at a rate of about 170,000 tons of zinc concentrate and about 38,000 tons of lead concentrate per year. Noranda began development of the Goldstream deposit with startup planned for late 1982 at a rate of 1,500 tons of ore per day. Reserves were given as 3.9 million tons of ore assaying 2.7% zinc, 3.7% copper, and some silver.

In Quebec, the Matagami Div. of Noranda, which includes the Matagami Lake, Orchan, Norita, and Radiore No. 2 Mines, treated 1.3 million tons of ore, about the same as that in 1979, but ore grade declined to 4.8%. Les Mines Gallen Limitee continued development work at its open pit mine where production was expected to start in 1981 at a rate of about 350,000 tons of ore per year. The ore will be treated at Noranda's Horne mill. At the Gallen Mine, lime neutralization will be employed to treat water effluent for heavy metals reduction.

In Manitoba, ore production in 1980 by Hudson Bay Mining and Smelting Co., Ltd., was about the same as that of 1979, at 1.7 million tons, but ore grade declined to 2.6% zinc compared with 2.9% zinc in 1979. The company operated nine copper-zinc mines and two mills in the Flin Flon-Snow Lake Area. A shortage of skilled workers adversely affected production. At the Ruttan Mine, Sherritt Gordon Mines Ltd. completed open pit mining while phasing in underground mining. Production was lower due to labor shortages and water problems in the mine. While ore milled at the Ruttan and Fox Mines was higher than in 1979, zinc concentrate production was lower as a consequence of lower zinc grades.

In the Yukon Territory, Cyprus Anvil Mining Corp. was modifying the Faro mill to handle the output from the Grum and Vangorda deposits when open pit mining begins in 1983. Hudson Bay began a major underground exploration program at its Toms deposit.

Production at Asarco's Buchans Mine in Newfoundland continued into 1980 but at about half the rate of 10,200 tons of zinc produced in 1979. Teck Corp. mined about the same quantity of ore from the Newfoundland Mine in 1980, but zinc production declined with a reduction in ore grade to 8.3% zinc in spite of a slightly higher recovery rate to 98.2%.

In Nova Scotia, Imperial Oil Ltd. through its subsidiary, Esso Resources Canada, Ltd., continued production at Gays River. About one-half of the concentrates are exported to Europe and the other half to the United States.

Western Mines Ltd. mined slightly more ore in 1980 from the Lynx and Myra Mines in British Columbia, but concentrate production declined to 32,500 tons as the head grade declined to 7.6% zinc from 8.5% zinc, and mill recovery declined slightly to 82.5%. Exploratory drilling at Western's Price and H-W deposits nearby indicated the possibility of reserves much greater than the 1 million tons reported at the Lynx and Myra.

Texasgulf Canada Ltd. produced 101,600 tons of zinc metal at its smelter in Ontario, down from 106,700 tons in 1979. The company signed an agreement with Sherritt Gordon Mines Ltd. for the installation of a pressure leaching plant at the smelter. Cominco Ltd. produced about 211,000 tons of metal, up 2% over that of 1979, at Trail, British Columbia, where the company continued the modernization and expansion of its electrolytic plant. When completed in 1983, capacity will be 272,000 tons of slab zinc per year, an increase of 11% over current capacity. The pressure leaching plant was officially commissioned in October. Hudson Bay was installing an improved purification process in the zinc leaching plant and two new precipitators to remove dust from the roaster gas streams of its electrolytic zinc plant in Manitoba. The plant was also converted to mechanical anode stripping. Canadian Electrolytic Zinc operated its Valleyfield, Quebec, smelter at 95% of capacity to reach a record production of 207,700 tons. New roaster and sulfuric acid facilities being installed are expected to increase efficiency and reduce consumption of fossil fuels.

Honduras.—Rosario Resources Corp., which operated the El Mochito Mine, became a wholly owned subsidiary of AMAX Inc. During 1980, production began from the San Juan ore body, a large lower grade deposit which requires a greater degree of mechanization and larger tonnages to be economical. Grade of ore mined at El Mochito declined to 6.2% zinc from 6.8% in 1979 and 8.2% in 1978. The mill was being expanded from 1,000 tons to 2,200 tons of ore per day by 1983.

Ireland.—Tara Mines Ltd. treated a total of 2.1 million tons of ore, 30% over that of 1979, and though the grade decreased from 11.4% zinc to 10.1%, concentrate production increased 16%.

With the exhaustion of reserves, Northgate Exploration Ltd. ended underground mining operations at the Tynagh Mine, County Galway, in midyear, but later planned to begin treating surface stockpiled material for its silver content. Reclamation continued at the mine site, including contouring and seeding, to restore the landscape. Bula Ltd. encountered opposition to its proposed open pit lead-zinc mine near Navan by Tara Mines, the local government, and some citizen groups. Reasons given were mainly environmental in nature.

Mogul of Ireland Ltd. treated 562,000 tons of ore, somewhat less than in 1979, to produce concentrate containing 24,900 tons of zinc. Ore reserves after dilution were 1.3 million tons grading 5.4% zinc and 3.4% lead.

Japan.—The stockpile program, initiated in 1976 by the Metallic Minerals Stockpile Association, held a total of 117,720 tons by yearend 1980, made up of 17,000 tons in the Government stockpile and 100,720 tons in the private stockpile. Total releases were about 22,000 tons in 1980. A number of producers announced plans to cut production because of a rise in stocks, shortage of concentrates, and higher production costs. The Nisso Smelting Co., Ltd., changed the feed of its Aizu smelter completely to flue dust obtained from steelmakers.

Mexico.—Mine production was lower than in 1979, partly as a consequence of lower ore grades. Mexico Desarrollo Industrial Minero, S.A. (MEDIMSA) opened the new Velardena silver-lead-zinc mine in 1980 with a capacity of 800 tons of ore per day. MEDIMSA continued construction of the Rosario silver-lead-zinc mine for completion in 1981, and expansion projects at Taxco, Santa Barbara, and San Martin. When these projects are completed, MEDIMSA will have increased its mine capacity by about 70% in a 5-year period. The new electrolytic plant to produce 113,000 tons of slab zinc per year was expected to be completed in late 1981 at a cost of $175 million.

Peru.—Zinc mine production in 1980 was affected by labor problems. Centromin, the State mining company, accounted for 42% of the country's production in 1980. Cia. Minera Milpo S.A., one of the most important lead-zinc producers in the medium sector, increased production with the full operation of its new 1,800-ton-per-day concentrator. San Ignacio de Morococha S.A., Peru's second largest producer and largest private producer, continued with its mine and mill expansion, although hampered by labor unrest. Cia. Minera del Madrigal, a division of Homestake Mining Co., continued to mine copper-lead-zinc ore, and produced 20% more zinc in 1980 than in 1979 through mine expansion. Cia. Minerales Santander, Inc., a subsidiary of St. Joe Minerals, produced about 52,400 tons of zinc concentrates in 1980, up from 48,100 tons in 1979, due mainly to higher ore grade.

At the La Oroya zinc plant, metal recovery increased to 84% as new equipment and a leach residue treatment plant were put into operation. Construction continued on the 100,000-ton-per-year zinc refinery being built at Cajamarquilla, with startup expected in early 1981.

South Africa, Republic of.—Black Mountain Mineral Development Co. Ltd. reached full capacity at midyear at its Broken Hill Mine at Aggeneys. Annual production from the mine was expected to be about 90,000 tons of lead, 18,000 tons of zinc, and byproduct copper and silver. The zinc concentrates will be sold domestically, but the copper and lead concentrates will be exported.

Spain.—The Rubiales zinc-lead mine of Exploracion Minera International Espana, S.A., 47% owned by Cominco Ltd., increased concentrate production from 92,800 tons in 1979 to 118,400 tons in 1980, the highest production since operations began in 1977. Reserves at yearend 1980 were 12.9 million tons of ore grading 7.3% zinc, 1.3% lead, and 12 grams of silver per ton. A labor strike at Asturiana de Zinc, S.A., lowered slab zinc output at the San Juan de Nieva electrolytic plant in midyear.

Thailand.—Whashin Industrial Co., a South Korean firm, withdrew from the project to build an electrolytic zinc plant in Thailand because it was unable to secure financing for the project.

Zambia.—Ore treated by Nchanga Consolidated Copper Mines Ltd. grading 18.8% zinc was 238,000 tons, down slightly from that of the previous year. Ore reserves at the Broken Hill mining area were given as 1.9 million tons grading 22.7% zinc and 11.1% lead. Metal production was significantly lower than in 1979 because of mechanical problems in the Waelz kilns, and repairs and coke shortages in the smelter.

TECHNOLOGY

Precipitation and cementation are two of the oldest treatment methods to remove heavy metals from wastewaters, but other techniques have been developed that are conducive to recovery of the metals rather than their disposal. The starch-xanthate method was reported to offer a low-cost and effective method for removing heavy metals, including zinc, and their ultimate recovery.[7]

The American Institute of Mining, Metallurgical, and Petroleum Engineers held a symposium on the metallurgy of lead, zinc, and tin at its annual meeting.[8] One of the investigators reported that considerable improvements have been made in the electrolytic and Imperial smelting process, including almost universal adoption of fluid-bed roasting, and the increased extraction efficiency through the use of jarosite, goethite, and haematite processes.

Researchers have reported on the many aspects of zinc in the environment, including zinc in soils, water, and air, and the relationship of zinc to human health.[9]

Several zinc alloys containing 8%, 12%, or 27% aluminum have been developed for sand and permanent mold casting. Some of the advantages cited for the alloys are that they can substitute for cast iron, bronze, or aluminum; that energy savings accrue because of the lower melting point for zinc; that no fluxing or degassing was necessary; and that the alloys offer superior machinability and good corrosion properties.[10]

An increasing number of electric steel plants in the Federal Republic of Germany, coupled with environmental legislation mandating dust collection systems and special disposal sites, has resulted in greater recovery of zinc from steelmaking flue dusts. Dusts containing 20% to 45% zinc are processed through a Waelz kiln to produce an impure zinc oxide that is combined with feed material for the zinc smelter.[11]

A comprehensive coverage of zinc-related investigations and an extensive review of current world literature on the extraction and uses of zinc and its products are contained in quarterly issues of Zinc Abstracts published by the Zinc Development Association, London, England.

Progress reports of the projects supported by the International Lead and Zinc Research Organization, Inc. (ILZRO), are released annually in the ILZRO Research Digest.

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Table 2.—Mine production of recoverable zinc in the United States, by State

(Metric tons)

State	1976	1977	1978	1979	1980
Arizona	8,619	3,973	W	W	W
California	154	2	W	W	--
Colorado	45,923	36,530	22,208	9,910	13,823
Idaho	42,262	28,121	32,353	29,660	27,722
Illinois	W	W	W	W	W
Kentucky	54	--	52	--	--
Maine	7,085	6,594	--	--	--
Missouri	75,777	74,107	59,038	61,682	65,214
Montana	58	72	79	104	71
Nevada	1,305	1,517	1,371	W	2
New Jersey	30,633	30,358	28,915	31,118	28,859
New Mexico	W	W	W	W	W
New York	66,833	64,264	26,463	12,133	33,629
Pennsylvania	20,212	20,706	19,099	21,447	22,556
Tennessee	74,854	82,044	87,906	85,119	128,722
Utah	20,394	16,111	3,509	W	--
Virginia	10,198	12,040	10,974	11,406	12,038
Washington	W	5,055	W	--	--
Wisconsin	W	W	W	W	--
Other	35,182	26,395	10,703	4,762	2,226
Total	439,543	407,889	[1]302,669	267,341	334,862

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to total shown because of independent rounding.

Table 3.—Mine production of recoverable zinc in the United States, by month

(Metric tons)

Month	1979	1980
January	23,259	30,280
February	21,655	28,317
March	23,793	30,183
April	21,120	28,746
May	22,991	27,326
June	21,921	28,955
July	20,853	26,308
August	25,397	26,932
September	18,715	25,752
October	23,793	30,157
November	22,189	25,689
December	21,655	26,217
Total	267,341	334,862

Table 4.—Production of zinc and lead in the United States in 1980, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Metric tons)

State	Zinc ore			Lead ore			Zinc-lead ore		
	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead
Arizona	--	--	--	1,763	--	35	--	--	--
Colorado	--	--	--	39,818	--	280	297,876	(1)	8,533
Idaho	(1)	(1)	(1)	1,642	--	224	754,895	26,097	24,796
Missouri	--	--	--	9,091,559	65,214	497,170	--	--	--
Montana	--	--	--	9,140	(1)	178	--	--	--
Nevada	--	--	--	(1)	(1)	(1)	--	--	--
New Jersey	162,158	28,859	--	--	--	--	--	--	--
New York	394,843	33,629	876	--	--	--	--	--	--
Pennsylvania	492,491	22,556	--	--	--	--	--	--	--
Tennessee	5,056,929	125,028	--	--	--	--	--	--	--
Virginia	476,391	12,038	1,563	--	--	--	--	--	--
Other[2]	--	--	--	205	--	41	--	--	--
Total	6,582,812	222,110	2,439	9,144,127	65,214	497,928	1,052,771	26,097	33,329
Percent of total recoverable zinc and lead	XX	66	(3)	XX	20	91	XX	8	6

State	Copper-zinc, copper-lead, and copper-zinc-lead ores			All other sources[4]			Total		
	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead
Arizona	--	--	--	35,237,458	W	366	35,239,221	W	401
Colorado	(1)	--	(1)	[1]209,869	[1]13,823	[1]1,459	547,563	13,823	10,272
Idaho	--	--	--	[1]697,760	[1]1,625	[1]13,587	1,454,297	27,722	38,607
Missouri	--	--	--	--	--	--	9,091,559	65,214	497,170
Montana	--	--	--	20,990	[1]71	117	30,130	71	295
Nevada	--	--	--	[1]1,272	[1]2	[1]26	1,272	2	26
New Jersey	--	--	--	--	--	--	162,158	28,859	--
New York	--	--	--	--	--	--	394,843	33,629	876
Pennsylvania	--	--	--	--	--	--	492,491	22,556	--
Tennessee	1,901,533	3,694	--	--	--	--	6,958,462	128,722	--
Virginia	--	--	--	--	--	--	476,391	12,038	1,563
Other[2]	--	--	--	2,556,583	2,226	233	2,556,788	2,226	274
Total	1,901,533	3,694	(1)	38,723,932	17,747	15,788	57,405,175	334,862	549,484
Percent of total recoverable zinc and lead	XX	1	--	XX	5	3	XX	100	100

W Withheld to avoid disclosing company proprietary data; included in "Other." XX Not applicable.

[1]Zinc ore, lead ore, zinc-lead ore, copper-lead ore, and ore from "All other sources" combined to avoid disclosing company proprietary data.

[2]Other includes Alaska, California, Illinois, New Mexico, and Washington.

[3]Less than 1/2 unit.

[4]Zinc and lead recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 5.—Twenty-five leading zinc-producing mines in the United States in 1980 in order of output

Rank	Mine	County and State	Operator	Source of Zinc
1	Young	Jefferson, Tenn	ASARCO Incorporated	Zinc ore.
2	Buick	Iron, Mo	AMAX Lead Co. of Missouri	Lead ore.
3	Balmat	St. Lawrence, N.Y.	St. Joe Minerals Corp	Zinc ore.
4	Sterling	Sussex, N.J	The New Jersey Zinc Co	Do.
5	Freidensville	Lehigh, Pa	do	Do.
6	Elmwood	Smith, Tenn	do	Do.
7	Zinc Mine Works	Jefferson, Tenn	United States Steel Corp	Do.
8	New Market	do	ASARCO Incorporated	Do.
9	Immel	Knox, Tenn.	do	Do.
10	Star Unit Area	Shoshone, Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
11	Bunker Hill	do	The Bunker Hill Co	Do.
12	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Zinc ore.
13	Leadville	Lake, Colo	ASARCO Incorporated	Lead-zinc ore.
14	Jefferson City	Jefferson, Tenn	The New Jersey Zinc Co	Zinc ore.
15	Magmont	Iron, Mo	Cominco American Inc	Lead ore.
16	Idol	Grainger, Tenn	The New Jersey Zinc Co	Zinc ore.
17	Brushy Creek	Reynolds, Mo	St. Joe Minerals Corp	Lead ore.
18	Milliken	do	Ozark Lead Co	Do.
19	Viburnum No. 29	Washington, Mo	St. Joe Minerals Corp	Do.
20	Copperhill Plant	Polk, Tenn	Cities Services Co	Copper-zinc ore.
21	Viburnum No. 28	Iron, Mo	St. Joe Minerals Corp	Lead ore.
22	Fletcher	Reynolds, Mo	do	Do.
23	Edwards	St. Lawrence, N.Y.	do	Zinc ore.
24	Coy	Jefferson, Tenn	ASARCO Incorporated	Do.
25	Sunnyside	San Juan, Colo	Standard Metals Co	Lead-zinc ore.

Table 6.—Primary and redistilled secondary slab zinc produced in the United States

(Metric tons)

	1976	1977	1978	1979	1980
Primary:					
From domestic ores	346,429	322,208	267,350	255,344	231,850
From foreign ores	106,125	86,156	139,348	217,137	108,606
Total	452,554	408,364	406,698	472,481	340,456
Redistilled secondary:					
At primary smelters	34,132	26,448	24,085	40,343	13,113
At secondary smelters	28,060	19,465	10,689	12,868	16,283
Total[1]	62,192	45,914	34,774	53,212	29,396
Grand total (excludes zinc recovered by remelting)	514,746	454,278	441,472	525,693	369,852

[1]Data may not add to totals shown because of independent rounding.

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Metric tons)

Grade	1976	1977	1978	1979	1980
Special High	212,437	151,214	179,812	173,082	148,384
High	28,466	38,494	32,830	39,247	24,552
Continuous Galvanizing	--	--	41,250	62,683	45,275
Controlled Lead	--	--	25,422	40,319	18,650
Prime Western	264,328	256,238	162,158	210,362	132,991
Intermediate	9,515	8,332	--	--	--
Total	514,746	454,278	441,472	525,693	369,852

Table 8.—Annual slab zinc capacity of primary zinc plants in the United States

Type of plant	Plant location	Slab zinc capacity (metric tons) 1979	1980
Electrolytic plants:			
AMAX Zinc Co., Inc	Sauget, Ill	76,000	76,000
ASARCO Incorporated	Corpus Christi, Tex	98,000	98,000
The Bunker Hill Co	Kellogg, Idaho	103,000	103,000
Jersey Miniere Zinc Co	Clarksville, Tenn	82,000	82,000
National Zinc Co	Bartlesville, Okla	51,000	51,000
Vertical-retort plants:			
The New Jersey Zinc Co	Palmerton, Pa	109,000	109,000
St. Joe Zinc Co	Monaca, Pa	201,000	50,000

Table 9.—Secondary slab zinc plants, by group capacity, in the United States

(Metric tons)

Company	Plant location	Capacity 1979	1980
Arco Alloys Corp	Detroit, Mich	51,000	46,000
Belmont Smelting & Refining Works	Brooklyn, N.Y		
W. J. Bullock, Inc	Fairfield, Ala		
T. L. Diamond & Co., Inc	Spelter, W. Va		
Illinois Smelting & Refining Co	Chicago, Ill		
New England Smelting Works, Inc	West Springfield, Mass		
Prolerized Schiabo Neu Co	Jersey City, N.J		
Pacific Smelting Co	Torrance, Calif		
The New Jersey Zinc Co	Depue, Ill		
S-G Metals Industries Inc	Kansas City, Kans		

Table 10.—Stocks and consumption of new and old zinc scrap in the United States in 1980

(Metric tons, zinc content)

Class of consumer and type of scrap	Stocks, Jan. 1[1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Smelters and distillers:						
New clippings	35	442	435	--	435	42
Old zinc	576	7,876	--	7,870	7,870	582
Remelt zinc	760	3,418	--	3,961	3,961	217
Engravers' plates	56	661	--	663	663	54
Rod and die scrap	807	6,224	--	4,865	4,865	2,166
Diecastings	1,605	12,222	--	12,648	12,648	1,179
Fragmentized diecastings	2,227	14,108	--	15,179	15,179	1,156
Remelt die-cast slab	1,355	10,941	--	10,249	10,249	2,047
Skimmings and ashes	8,879	30,781	22,475	--	22,475	17,185
Sal skimmings	131	309	292	--	292	148
Die-cast skimmings	1,340	6,718	4,349	--	4,349	3,709
Galvanizers' dross	20,448	47,204	56,721	--	56,721	10,931
Flue dust	4,124	3,719	4,634	--	4,634	3,209
Chemical residues	295	2,375	2,375	--	2,375	295
Other	56	1,132	1,179	--	1,179	9
Total	42,694	148,130	92,460	55,435	147,895	42,929
Chemical plant, foundries, and other manufacturers:						
Old zinc	10	24	--	24	24	10
Rod and die scrap	24	82	--	96	96	10
Diecastings	18	268	--	268	268	18
Skimmings and ashes	3,302	3,123	3,845	--	3,845	2,580
Sal skimmings	1,506	3,441	3,227	--	3,227	1,720
Die-cast skimmings	150	275	264	--	264	161
Galvanizers dross	2	783	783	--	783	2
Flue dust	1,654	11,742	12,640	--	12,640	756

See footnote at end of table.

Table 10.—Stocks and consumption of new and old zinc scrap in the United States in 1980 —Continued

(Metric tons, zinc content)

Class of consumer and type of scrap	Stocks, Jan. 1[1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Chemical plant, foundries, and other manufacturers —Continued						
Chemical residues	3,765	7,222	7,152	--	7,152	3,835
Other	91	7,575	6,845	--	6,845	821
Total	10,522	34,535	34,756	388	35,144	9,913
All classes of consumers:						
New clippings	35	442	435	--	435	42
Old zinc	586	7,900	--	7,894	7,894	592
Remelt zinc	760	3,418	--	3,961	3,961	217
Engravers' plates	56	661	--	663	663	54
Rod and die scrap	831	6,306	--	4,961	4,961	2,176
Diecastings	1,623	12,490	--	12,916	12,916	1,197
Fragmentized diecastings	2,227	14,108	--	15,179	15,179	1,156
Remelt die-cast slab	1,355	10,941	--	10,249	10,249	2,047
Skimmings and ashes	12,181	33,904	26,320	--	26,320	19,765
Sal skimmings	1,637	3,750	3,519	--	3,519	1,868
Die-cast skimmings	1,490	6,993	4,613	--	4,613	3,870
Galvanizers' dross	20,450	47,987	57,504	--	57,504	10,933
Flue dust	5,778	15,461	17,274	--	17,274	3,965
Chemical residues	4,060	9,597	9,527	--	9,527	4,130
Other	147	8,707	8,024	--	8,024	830
Total	53,216	182,665	127,216	55,823	183,039	52,842

[1]Figures partly revised.

Table 11.—Production of zinc products from zinc-base scrap in the United States

(Metric tons)

Products	1976	1977	1978	1979	1980
Redistilled slab zinc	62,192	45,913	34,774	53,212	29,396
Zinc dust	36,715	35,992	33,346	34,141	35,557
Remelt zinc	310	268	94	89	229
Remelt die-cast slab	4,208	3,535	3,775	3,911	3,568
Zinc-die and diecasting alloys	6,395	7,560	6,024	6,328	4,146
Galvanizing stocks	2,255	2,088	2,686	2,731	2,461
Secondary zinc in chemical products	r44,602	55,312	r58,650	r59,148	55,890

rRevised.

Table 12.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1979	1980
KIND OF SCRAP		
New scrap:		
Zinc-base	150,008	122,654
Copper-base	138,565	115,909
Magnesium-base	222	268
Total	288,795	238,831
Old scrap:		
Zinc-base	52,691	42,424
Copper-base	27,824	22,300
Aluminum-base	524	591
Magnesium-base	196	217
Total	81,235	65,532
Grand total	370,030	304,363
FORM OF RECOVERY		
As metal:		
By distillation:		
Slab zinc[1]	53,212	29,396
Zinc dust	34,141	35,557
By remelting	2,820	2,690
Total	90,173	67,643
In zinc-base alloys	10,239	7,714
In brass and bronze	[r]209,528	172,040
In aluminum-base alloys	524	591
In magnesium-base alloys	418	485
In chemical products:		
Zinc oxide (lead free)	31,316	31,306
Zinc sulfate	[r]9,971	13,195
Zinc chloride	12,259	10,944
Miscellaneous	5,602	445
Total	279,857	236,720
Grand total	370,030	304,363

[r] Revised.
[1] Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 13.—Zinc dust produced in the United States

Year	Quantity (metric tons)	Value: Total (thousands)	Value: Average per pound
1976	42,055	$45,282	$0.488
1977	43,177	45,414	.477
1978	38,487	37,427	.441
1979	[r]36,186	[r]36,075	.452
1980	42,640	41,202	.438

[r] Revised.

Table 14.—Consumption of zinc in the United States

(Metric tons)

	1976	1977	1978	1979	1980
Slab zinc	1,028,876	999,505	1,050,585	1,000,606	811,146
Ores and concentrates (zinc content)[1]	91,844	86,490	89,959	79,710	58,986
Secondary (zinc content)[2]	273,524	281,709	301,266	313,998	272,277
Total	1,394,244	1,367,704	1,441,810	1,394,314	1,142,409

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 15.—Slab zinc consumption in the United States, by industry use

(Metric tons)

Industry and product	1976	1977	1978	1979	1980
Galvanizing:					
Sheet and strip	221,998	236,025	268,687	267,825	220,744
Wire and wire rope	24,314	21,459	22,801	23,557	22,748
Tubes and pipe	44,423	42,657	47,379	45,643	37,075
Fittings (for tube and pipe)	5,851	5,820	6,926	8,231	7,394
Tanks and containers	3,017	3,057	2,896	4,081	3,297
Structural shapes	33,204	26,623	33,264	33,875	33,376
Fasteners	3,654	3,891	4,839	4,993	3,189
Pole-line hardware	4,289	4,475	4,869	4,839	4,078
Fencing, wire cloth, netting	19,964	20,371	24,997	21,920	16,022
Other and unspecified uses	32,172	32,060	37,356	37,839	31,304
Total	392,886	396,438	454,014	452,803	379,227
Brass products:					
Sheet, strip, plate	82,696	70,168	70,181	64,222	37,730
Rod and wire	49,489	39,525	46,284	51,130	32,554
Tube	6,702	5,542	6,779	6,690	4,702
Castings and billets	3,847	4,076	4,427	3,634	2,808
Copper-base ingots	6,968	7,544	6,581	6,800	17,190
Other copper-base products	1,112	1,455	7,236	8,928	3,842
Total	150,814	128,310	141,488	141,404	98,826
Zinc-base alloy:					
Diecasting alloy	380,753	359,744	345,968	308,722	248,024
Dies and rod alloy	932	557	544	68	--
Slush and sand casting alloy	5,711	6,829	7,622	5,266	6,203
Total	387,396	367,130	354,134	314,056	254,227
Rolled zinc	27,088	27,406	24,869	22,044	21,100
Zinc oxide	35,405	38,514	37,202	35,513	27,047
Other uses:					
Light-metal alloys	5,232	5,585	11,030	12,850	11,137
Other[1]	30,055	36,122	27,848	21,936	19,582
Total	35,287	41,707	38,878	34,786	30,719
Grand total	1,028,876	999,505	1,050,585	1,000,606	811,146

[1]Includes zinc used in making zinc dust, wet batteries, desilverizing lead, powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 16.—Slab zinc consumption in the United States in 1980, by grade and industry use

(Metric tons)

Industry	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
Galvanizing	22,297	25,457	6,271	68,939	255,296	967	379,227
Brass and bronze	39,955	47,690	20	1,372	9,404	385	98,826
Zinc-base alloys	253,380	496	--	--	116	235	254,227
Rolled zinc	8,871	--	12,229	--	--	--	21,100
Zinc oxide	5,589	--	--	--	21,458	--	27,047
Other	24,226	2,515	--	--	3,978	--	30,719
Total	354,318	76,158	18,520	70,311	290,252	1,587	811,146

Table 17.—Slab zinc consumption in the United States in 1980, by industry and State

(Metric tons)

State	Galvanizers	Brass mills[1]	Die casters[2]	Other[3]	Total
Alabama	25,873	W	--	W	27,619
Arizona	W	--	--	W	W
Arkansas	W	--	W	W	W
California	28,838	1,989	16,742	1,391	48,960
Colorado	W	--	W	W	W
Connecticut	1,845	20,024	W	W	31,220
Delaware	W	W	--	W	W
Florida	3,766	--	--	--	3,766
Georgia	W	--	W	--	W
Hawaii	W	--	--	--	W
Idaho	--	--	W	W	W
Illinois	55,180	16,778	44,170	7,221	123,349
Indiana	43,858	W	4,835	W	61,747
Iowa	174	--	W	W	2,610
Kansas	W	--	W	W	W
Kentucky	W	W	--	--	14,141
Louisiana	2,653	--	W	W	3,965
Maine	W	--	--	--	W
Maryland	W	--	--	W	15,007
Massachusetts	W	W	--	W	4,218
Michigan	786	10,615	41,320	355	53,076
Minnesota	668	--	--	--	668
Mississippi	1,260	--	--	--	1,260
Missouri	5,095	W	W	W	7,044
Nebraska	5,305	W	W	W	5,733
New Jersey	2,153	4,652	W	W	13,155
New York	11,818	W	60,831	W	89,710
North Carolina	W	--	W	W	W
Ohio	56,420	W	32,595	W	95,810
Oklahoma	W	--	--	W	3,620
Oregon	938	W	--	W	947
Pennsylvania	48,310	6,712	W	W	96,506
Rhode Island	W	W	W	W	W
South Carolina	W	--	--	--	W
Tennessee	W	--	W	W	W
Texas	14,785	W	W	W	25,904
Utah	W	W	--	--	W
Virginia	W	W	W	W	599
Washington	W	--	--	W	2,367
West Virginia	W	--	--	W	21,342
Wisconsin	804	W	4,057	W	6,456
Undistributed	67,731	37,671	49,442	69,899	48,760
Total[4]	378,260	98,441	253,992	78,866	809,559

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes brass mills, brass ingot makers, and brass foundries.
[2]Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.
[3]Includes slab zinc used in rolled zinc products and in zinc oxide.
[4]Excludes remelt zinc.

Table 18.—Rolled zinc produced and quantity available for consumption in the United States

	1979			1980		
		Value			Value	
	Metric tons	Total (thousands)	Average per pound	Metric tons	Total (thousands)	Average per pound
Production:[1]						
Photoengraving plate	W	W	W	W	W	W
Strip and foil	16,374	$19,598	$0.616	16,453	$20,511	$0.660
Total rolled zinc[2]	21,100	26,944	.579	20,545	27,415	.605
Exports	1,824	3,385	.842	2,103	3,810	.821
Imports	244	267	.496	1,341	1,041	.352
Available for consumption	19,545	XX	XX	20,614	XX	XX

W Withheld to avoid disclosing company proprietary data; included in "Total rolled zinc." XX Not applicable.
[1]Figures represent net production. In addition, 18,556 tons in 1979 and 19,421 tons in 1980 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.
[2]Includes other plate over 0.375 inch thick, sheet zinc less than 0.375 inch thick, and rod and wire. Bureau of Mines not at liberty to publish separately.

Table 19.—Production and shipments of zinc pigments and compounds[1] in the United States

(Metric tons)

Pigment or compound	1979		1980	
	Production	Shipments	Production	Shipments
Zinc oxide	172,729	179,769	145,509	135,776
Zinc sulfate	r26,827	r25,875	35,159	35,696
Zinc chloride, 50°Baumé[2]	26,601	20,003	24,632	18,400

rRevised.
[1]Excludes leaded zinc oxide and lithopone.
[2]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 20.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by source

(Metric tons)

Pigment or compound	1979				1980			
	Zinc in pigments and compounds produced from—			Total zinc in pigments and compounds	Zinc in pigments and compounds produced from—			Total zinc in pigments and compounds
	Ore	Slab zinc	Secondary material		Ore	Slab zinc	Secondary material	
Zinc oxide	74,324	32,567	31,316	138,207	54,081	28,161	31,306	113,548
Zinc sulfate	887	--	r9,971	r10,858	1,045	--	13,195	14,240
Zinc chloride[2]	--	--	8,931	8,931	--	--	5,666	5,666

rRevised.
[1]Excludes leaded zinc oxide, zinc sulfide, and lithopone.
[2]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 21.—Distribution of zinc oxide shipments, by industry

(Metric tons)

Industry	1976	1977	1978	1979	1980
Rubber	94,954	101,729	97,989	93,075	61,796
Paints	14,242	12,519	13,237	12,503	12,165
Ceramics	7,650	7,354	9,245	9,236	5,702
Chemicals	30,106	26,327	27,057	27,710	17,551
Agriculture	3,158	5,499	4,847	4,397	6,930
Photocopying	21,907	21,352	19,096	16,148	9,604
Other	7,676	15,322	9,981	16,700	22,028
Total	179,693	190,102	181,452	179,769	135,776

Table 22.—Distribution of zinc sulfate shipments, by industry

(Metric tons)

Year	Agriculture	Other	Total
1977[r]	10,055	10,272	20,327
1978[r]	12,778	9,045	21,823
1979[r]	18,512	7,363	25,875
1980	27,768	7,928	35,696

[r]Revised.

Table 23.—Stocks of slab zinc in the United States, December 31

(Metric tons)

	1976	1977	1978	1979	1980
Primary producers	83,963	76,637	34,570	56,971	18,190
Secondary producers	3,989	7,123	3,358	2,095	4,362
Consumers	109,909	86,477	99,325	[r]92,595	69,599
Merchants	NA	NA	NA	[1]NA	33,650
Total	197,861	170,237	137,253	151,661	125,801

[r]Revised. NA Not available.
[1]Stocks on Jan. 1, 1980, were 63,637 tons, which can be considered identical to stocks at yearend 1979.

Table 24.—Consumer stocks of slab zinc at plants, December 31, by grade

(Metric tons)

Year	Special High Grade	High Grade	Continuous Galvinizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
1979	[r]34,891	[r]9,659	[r]2,840	3,886	[r]41,262	[r]57	[r]92,595
1980	25,459	7,541	934	3,098	32,504	63	69,599

[r]Revised.

Table 25.—Average monthly U.S., LME,[1] and European producer prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1979			1980		
	United States	LME cash	European producer	United States	LME cash	European producer
January	34.57	32.64	33.32	37.44	35.03	35.38
February	35.62	35.92	35.58	37.50	39.39	36.35
March	37.24	36.00	36.29	38.00	33.64	37.42
April	38.99	35.74	36.29	38.01	32.04	36.35
May	39.39	35.28	36.57	37.50	31.31	35.38
June	39.39	34.13	38.33	36.44	30.71	35.38
July	39.40	32.69	37.35	35.50	32.32	35.38
August	36.90	30.12	35.38	35.73	34.83	35.38
September	35.80	32.79	35.38	[2]36.63	36.07	35.38
October	36.21	32.00	35.38	[2]37.27	36.49	36.31
November	36.82	31.76	35.38	[2]38.58	36.33	37.43
December	37.23	33.98	35.38	[2]40.59	35.50	37.43
Average for year	37.30	33.59	35.89	37.43	34.47	36.13

[1]London Metal Exchange.
[2]Based on High Grade zinc.

Source: Metals Week.

Table 26.—U.S. exports of zinc and zinc alloys, by country

Destination	1978 Quantity (metric tons)	1978 Value (thousands)	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Unwrought zinc and zinc alloys:						
Argentina	8	$34	42	$77	1	$1
Australia	18	81	5	25	1	6
Bahrain	--	--	--	--	1	1
Belgium-Luxembourg	5	11	3	16	--	--
Canada	333	409	98	277	232	456
Chile	39	27	29	47	97	98
Colombia	5	10	2	4	--	--
Costa Rica	--	--	2	5	6	11
Dominican Republic	1	2	90	76	38	41
Ecuador	64	61	1	5	2	4
Egypt	--	--	27	56	20	61
France	([1])	4	--	--	--	--
Germany, Federal Republic of	9	6	14	23	1	4
Guatemala	([1])	2	1	3	63	112
Honduras	1	8	--	--	2	5
India	350	255	--	--	--	--
Iran	59	59	--	--	--	--
Israel	1	2	20	36	3	81
Italy	1	9	2	2	2	5
Japan	35	84	9	22	21	69
Korea, Republic of	([1])	1	([1])	5	--	--
Leeward and Windward Islands	--	--	--	--	13	33
Liberia	2	4	2	5	--	--
Mexico	215	127	98	242	73	544
Netherlands	2	1	19	25	20	45
Netherlands Antilles	1	4	--	2	--	--
New Zealand	1	5	([1])	2	1	2
Nicaragua	2	2	--	--	1	2
Nigeria	5	12	2	3	4	11
Panama	11	17	7	13	4	9
Philippines	7	14	7	9	9	10
Saudi Arabia	26	31	60	100	4	14
Singapore	--	--	--	--	64	119
South Africa, Republic of	18	95	31	47	1	2
Spain	--	--	([1])	3	9	20
Switzerland	9	21	3	7	--	--
Taiwan	8	10	11	41	45	57
United Arab Emirates	--	--	3	4	--	--
United Kingdom	5	18	9	115	27	92
Venezuela	24	104	31	43	1	3
Yugoslavia	--	--	--	--	9	21
Other	12	33	17	45	12	37
Total	1,277	1,563	645	1,385	787	1,976
Wrought zinc and zinc alloys:						
Afghanistan	10	14	--	--	--	--
Algeria	13	26	--	--	25	47
Argentina	65	106	86	142	67	125
Australia	12	33	9	12	15	37
Austria	10	24	19	46	--	--
Belgium-Luxembourg	7	15	110	64	11	20
Bermuda	12	11	--	--	([1])	1
Canada	1,453	1,641	897	1,601	631	994
Chile	60	113	13	18	15	27
Colombia	48	69	33	55	56	125
Denmark	2	2	3	6	6	14
Dominican Republic	4	5	70	106	704	585
Ecuador	61	157	552	522	21	52
Egypt	15	22	22	33	20	32
El Salvador	8	14	--	--	3	5
Finland	--	--	--	--	4	11
France	4	5	9	19	72	200
Germany, Federal Republic of	12	31	--	--	1	8
Greece	14	22	8	12	--	--
Guatemala	15	30	5	9	9	18
Guyana	12	34	4	9	5	12
Hong Kong	135	194	33	49	38	65
India	24	37	28	45	24	48
Israel	69	108	54	90	42	76
Italy	82	201	90	173	92	241
Japan	3	8	18	38	--	--
Korea, Republic of	2	2	2	6	31	55
Kuwait	5	33	1	2	1	2
Lebanon	30	48	15	25	26	51
Malaysia	15	19	50	84	26	78
Mexico	104	195	164	376	144	301

See footnotes at end of table.

Table 26.—U.S. exports of zinc and zinc alloys, by country —Continued

Destination	1978 Quantity (metric tons)	1978 Value (thousands)	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Wrought zinc and zinc alloys — Continued						
Netherlands	7	4	--	--	(1)	2
New Zealand	31	41	18	28	10	16
Pakistan	15	23	14	24	14	27
Panama	2	3	3	7	1	2
Peru	16	27	62	136	22	40
Philippines	69	105	61	105	101	161
Portugal	35	65	38	67	35	67
Saudi Arabia	48	62	33	59	11	51
Singapore	9	18	38	31	51	59
South Africa, Republic of	76	125	100	170	77	137
Spain	25	42	69	115	71	126
Sri Lanka	15	22	38	65	22	42
Sweden	1	3	4	9	1	6
Switzerland	--	--	--	--	2	6
Syria	16	26	10	18	27	59
Taiwan	69	111	241	336	127	195
Thailand	25	36	12	17	13	25
Turkey	21	30	7	12	14	26
United Arab Emirates	--	--	--	--	4	8
United Kingdom	156	277	79	187	125	596
Uruguay	6	17	27	49	6	10
Venezuela	100	136	49	80	21	49
Other	74	113	87	167	63	138
Total	3,122	4,505	3,285	5,224	2,907	5,078

[1]Less than 1/2 unit.

Table 27.—U.S. exports of zinc, by class

Year	Zinc ore and concentrates		Blocks, pigs, anodes, etc.				Wrought zinc and zinc alloys				Waste and scrap (zinc content)		Dust (blue powder)	
			Unwrought		Unwrought alloys		Sheets, plates, strip		Angles, bars, pipes, rods, etc.					
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1978	10,973	$4,356	723	$865	554	$698	2,262	$3,414	860	$1,091	14,986	$6,738	1,803	$2,018
1979	20,095	7,317	279	553	366	832	1,824	3,385	1,461	1,839	28,149	14,142	966	1,450
1980	54,457	29,473	302	664	485	1,312	2,103	3,810	804	1,268	29,542	14,121	4,512	7,491

Table 28.—U.S. exports of zinc ore and concentrates, by country

(Zinc content)

Country	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
Algeria	--	--	3,469	$2,592
Belgium-Luxembourg	10,935	$3,595	13,512	8,463
Canada	1,574	1,275	26,367	11,095
Chile	755	367	--	--
Dominican Republic	--	--	4	3
Finland	--	--	6,447	4,298
France	--	--	654	1,764
Germany, Federal Republic of	--	--	3,693	1,100
Mexico	--	--	15	17
Nigeria	3	6	--	--
Saudi Arabia	33	22	52	38
Singapore	--	--	3	1
Taiwan	75	33	241	102
United Kingdom	6,716	2,011	--	--
Venezuela	4	8	--	--
Total	20,095	7,317	54,457	29,473

Table 29.—U.S. general imports of zinc, by country

Country	1978 Quantity (metric tons)	1978 Value (thousands)	1979 Quantity (metric tons)	1979 Value (thousands)	1980 Quantity (metric tons)	1980 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Argentina	--	--	3	$3	--	--
Australia	1,851	$617	708	94	1,473	$195
Bolivia	397	72	11,935	5,157	--	--
Canada	143,318	50,408	143,957	57,938	63,017	25,631
Chile	5,933	3,347	1,240	683	14	2
Colombia	10	1	16	2	--	--
Germany, Federal Republic of	6,535	2,564	7,802	4,101	2,422	1,271
Honduras	13,141	4,888	13,383	5,112	7,031	2,558
Japan	101	39	--	--	--	--
Mexico	2,613	813	16,207	5,007	15,790	4,053
Nicaragua	4,046	1,681	4	3	--	--
Peru	10,058	2,885	29,697	14,419	40,176	19,879
Total	188,003	67,315	224,952	92,519	129,923	53,589
BLOCKS, PIGS, OR SLABS[1]						
Algeria	2,547	1,518	5,317	4,250	6,005	4,497
Australia	34,785	21,992	33,721	25,634	24,798	18,046
Austria	--	--	--	--	629	556
Belgium-Luxembourg	19,215	10,595	11,228	8,153	2,310	2,336
Canada	261,842	172,412	259,543	197,270	280,075	222,411
China:						
Mainland	801	384	208	90	1,220	886
Taiwan	--	--	104	16	--	--
Finland	32,964	21,535	26,410	21,361	18,128	12,998
France	22,824	13,875	13,445	10,608	6,835	5,619
Germany, Federal Republic of	36,955	22,058	19,110	14,813	12,056	8,939
Greece	244	144	--	--	--	--
Italy	11,149	6,303	5,492	3,880	1,999	1,514
Japan	8,605	6,290	10,118	7,971	--	--
Korea, Republic of	4,000	2,402	2,300	1,721	1,400	1,047
Mexico	51,471	30,433	39,332	28,873	23,859	17,881
Morocco	2,080	1,002	--	--	--	--
Netherlands	10,097	5,673	3,180	2,314	6,508	5,183
Peru	10,245	6,002	7,394	5,488	3,951	2,798
Poland	5,670	2,828	100	75	--	--
South Africa, Republic of	8,112	4,872	--	--	--	--
Spain	60,225	33,931	66,738	43,703	10,727	7,592
Tanzania	1,001	595	1,200	848	1,028	731
Hong Kong	--	--	105	79	--	--
United Kingdom	997	565	2,383	1,315	4,112	3,142
Yugoslavia	3,777	2,082	--	--	--	--
Zaire	25,630	14,682	14,880	11,812	--	--
Zambia	2,604	1,261	4,904	2,277	5,002	3,443
Total	617,840	383,434	527,212	392,551	410,642	319,619

[1]In addition, in 1980, 110 tons of zinc anodes were imported from Australia, Belgium, Canada, the Federal Republic of Germany, France, Hong Kong, the Netherlands, Sweden, Taiwan, and the United Kingdom.

Table 30.—U.S. imports for consumption of zinc, by country

Country	1978		1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Argentina	--	--	3	$3	--	--
Australia	1,346	$489	50	7	8,782	$4,590
Bolivia	397	72	11,935	5,157	--	--
Canada	66,551	21,744	9,912	3,277	110,285	42,093
Chile	5,933	3,347	1,240	683	--	--
Colombia	10	1	16	2	14	2
Germany, Federal Republic of	6,535	2,564	7,802	4,101	2,422	1,271
Honduras	13,141	4,888	13,383	5,112	7,031	2,558
Japan	101	39	--	--	--	--
Mexico	959	535	13,457	4,340	13,660	3,640
Nicaragua	2,727	1,066	4	3	--	--
Peru	8,615	2,425	29,697	14,419	40,176	19,879
Total	106,315	37,170	87,499	37,104	182,370	74,033
BLOCKS, PIGS, OR SLABS[1]						
Algeria	2,547	1,518	4,276	3,415	6,005	4,497
Angola	--	--	989	793	--	--
Australia	34,785	21,992	33,721	25,634	24,798	18,046
Austria	--	--	--	--	629	556
Belgium-Luxembourg	19,165	10,565	12,327	9,061	2,310	2,336
Canada	261,841	172,411	259,543	197,270	280,075	222,411
China:						
Mainland	801	384	236	93	1,327	934
Taiwan	--	--	104	16	--	--
Finland	32,964	21,535	25,160	20,298	18,128	12,998
France	22,477	8,238	13,792	10,873	7,799	6,486
Germany, Federal Republic of	36,955	22,058	19,110	14,813	12,056	8,939
Ghana	--	--	1,003	589	--	--
Greece	244	144	--	--	--	--
Hong Kong	--	--	--	--	105	62
Italy	14,148	13,610	5,492	3,880	1,999	1,514
Japan	4,990	3,547	10,118	7,971	--	--
Korea, Republic of	4,000	2,402	2,300	1,721	1,400	1,047
Mexico	48,712	28,865	36,833	27,385	23,652	17,728
Morocco	2,080	1,002	--	--	--	--
Netherlands	11,098	6,357	3,180	2,314	6,508	5,183
Peru	10,245	6,002	7,394	5,488	3,951	2,798
Poland	5,670	2,828	100	75	--	--
South Africa, Republic of	8,112	4,872	--	--	--	--
Spain	64,626	36,336	66,738	43,703	10,727	7,592
Switzerland	--	--	1	1	--	--
Tanzania	1,001	595	1,200	848	1,028	731
United Kingdom	997	565	2,383	1,315	2,064	1,607
Yugoslavia	3,777	2,082	--	--	--	--
Zaire	28,630	16,913	14,829	11,767	--	--
Zambia	2,605	1,261	3,301	1,276	5,602	3,823
Total	622,470	386,082	524,130	390,599	410,163	319,288

[1]In addition, in 1980, 110 tons of zinc anodes were imported from Australia, Belgium, Canada, the Federal Republic of Germany, France, Hong Kong, the Netherlands, Sweden, Taiwan and the United Kingdom.

Table 31.—U.S. imports for consumption of zinc, by class

Year	Ore (zinc content)		Blocks, pigs, slabs[1]		Sheets, plates, strips, other forms		Waste and scrap	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1978	106,315	$37,170	622,470	$386,082	337	$305	3,310	$1,250
1979	87,499	37,104	524,130	390,599	244	267	3,259	1,530
1980	182,370	74,033	410,163	319,288	1,342	1,041	3,470	1,361

Year	Dross and skimmings (zinc content)		Zinc fume (zinc content)		Dust, powder, flakes		Total value[2] (thousands)
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	
1978	7,436	$2,104	60	$10	8,978	$7,455	$434,376
1979	4,454	1,735	28	2	3,586	3,440	434,677
1980	4,062	1,732	25	7	3,928	3,672	401,134

[1]Unwrought alloys of zinc were imported as follows: 1978—23 metric tons ($13,319); 1979—78 metric tons ($72,725); and 1980—41 metric tons ($37,846).
[2]In addition, manufactures of zinc were imported as follows: 1978—$461,880; 1979—$213,699; 1980—$254,317.

Table 32.—U.S. imports for consumption of zinc pigments and compounds

Material	1979		1980	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zinc oxide	26,912	$21,415	29,843	$23,727
Zinc sulfide	741	680	409	401
Lithopone	168	91	1,189	598
Zinc chloride	1,201	788	1,008	726
Zinc sulfate	6,849	26,370	3,871	1,350
Zinc cyanide	41	68	20	37
Zinc hydrosulfite	336	266	337	371
Zinc compounds, n.s.p.f.	823	939	1,951	2,852

Table 33.—Zinc: World mine production (content of ore), by country[1]

(Thousand metric tons)

Continent and country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada[2]	982.1	1,070.5	1,066.9	1,099.9	[3]894.6
Guatemala	.5	1.0	1.0	[e]1.0	--
Honduras	24.8	26.5	24.3	22.1	22.0
Mexico[2]	259.2	265.5	244.9	245.5	[3]238.2
Nicaragua	[r]15.3	[r]11.2	3.6	--	--
United States[2]	439.5	407.9	302.7	267.3	[3]334.9
South America:					
Argentina	40.6	39.2	36.6	37.1	[3]33.8
Bolivia	48.5	61.4	53.9	51.6	50.3
Brazil	69.6	81.2	82.8	82.0	83.0
Chile[2]	5.0	3.9	1.8	1.8	1.8
Colombia	.1	--	--	--	--
Ecuador	.1	2.0	1.3	1.6	1.6
Peru[2]	421.3	405.4	457.5	490.8	[3]486.9
Europe:					
Austria	17.6	19.7	22.5	20.5	[3]19.1
Bulgaria[e]	85.5	87.0	88.0	85.0	87.0
Czechoslovakia	9.3	9.4	8.8	8.8	[3]7.2
Finland	61.1	62.9	52.9	54.6	58.4
France	34.7	41.8	39.9	37.0	[3]35.8
Germany, Federal Republic of[2]	111.2	111.4	97.4	96.9	[3]99.7
Greece	26.5	18.0	25.6	23.2	25.9
Greenland	81.0	76.6	82.4	87.3	92.1
Hungary	2.2	2.8	2.6	2.6	2.5
Ireland	62.8	116.3	176.0	212.2	[3]228.7
Italy	86.4	79.3	74.0	65.5	[3]58.4
Norway	29.1	[r]30.3	28.9	29.1	[3]28.2
Poland[2]	180.0	188.0	194.0	182.7	180.0
Romania	[e]67.0	[e]62.0	60.0	60.0	60.0
Spain	83.7	98.3	146.8	142.7	168.3
Sweden	128.3	140.2	162.8	169.9	167.4
U.S.S.R.[e 2]	720.0	735.0	770.0	770.0	785.0
United Kingdom	4.8	7.7	2.7	.6	4.4
Yugoslavia	106.6	112.4	103.8	101.7	100.0
Africa:					
Algeria	6.9	2.7	4.8	4.9	4.8
Congo (Brazzaville)	5.3	5.3	4.8	--	--
Morocco	17.7	7.8	4.3	4.5	6.4
Namibia	[r]26.9	[r]38.3	36.6	25.7	[3]22.7
Nigeria	.4	--	--	--	--
South Africa, Republic of	[r]75.0	[r]69.6	65.2	53.8	78.0
Tunisia	7.3	7.1	7.4	8.7	[3]7.6
Zaire[2]	67.8	73.0	73.7	68.0	67.0
Zambia[2]	48.8	45.0	50.0	46.6	36.6
Asia:					
Burma	2.2	1.8	2.6	3.0	[3]3.6
China, mainland[e 2]	[r]150.0	[r]150.0	[r]160.0	[r]160.0	160.0
Cyprus	.9	.2	--	--	--
India	27.4	32.5	39.8	39.0	27.0
Iran	72.0	61.5	[e]45.0	[r e]25.0	20.0
Japan[2]	260.0	275.7	274.6	243.4	[3]238.1
Korea, North[e 2]	[r]160.0	150.0	[r]145.0	[r]145.0	140.0
Korea, Republic of	59.1	68.4	66.4	62.4	[3]56.8
Philippines	11.6	12.4	9.5	10.8	7.2
Thailand[4]	([5])	.3	--	--	--
Turkey[e]	42.8	67.1	40.7	27.1	30.0
Vietnam[e]	10.0	10.0	8.0	6.0	6.5
Oceania:					
Australia	468.6	491.6	473.3	531.8	[3]493.7
New Zealand	--	.1	[e].1	.1	.1
Total	[r]5,725.1	[r]5,945.2	5,928.2	5,916.8	5,761.3

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 1, 1981.
[2]Recoverable content of concentrates.
[3]Reported figure.
[4]Content of zinc concentrates; additional quantities of zinc may be contained in lead concentrates produced, but information is inadequate to make reliable estimates of such production.
[5]Less than 1/2 unit.

Table 34.—Zinc: World smelter production by country[1]

(Thousand metric tons)

Country	1976	1977	1978	1979[p]	1980[e]
North America:					
Canada, primary	472.3	494.9	495.4	580.4	[2]591.6
Mexico, primary	175.2	174.4	173.1	161.7	[2]143.9
United States:					
Primary	452.5	408.4	406.7	472.5	[2]340.5
Secondary	62.2	45.9	34.8	53.2	[2]29.4
Total	514.7	454.3	441.5	525.7	[2]369.9
South America:					
Argentina, primary	35.2	29.0	23.9	36.7	25.4
Brazil:					
Primary	43.2	[r]47.0	56.1	63.5	[2]78.3
Secondary	[r]9.6	[r]8.5	12.2	12.7	13.5
Total	[r]52.8	[r]55.5	68.3	76.2	91.8
Peru, primary	[r]64.7	66.9	68.4	68.2	64.0
Europe:					
Austria, primary and secondary	16.5	16.7	21.7	23.0	[2]22.1
Belgium:					
Primary	234.7	247.6	233.9	252.6	243.2
Secondary	6.5	10.6	6.6	9.1	8.8
Total	241.2	258.2	240.5	261.7	252.0
Bulgaria, primary and secondary	92.5	90.0	91.0	89.0	90.0
Finland, primary	110.6	138.0	132.9	147.1	[2]146.7
France:					
Primary[e]	218.3	223.3	216.2	229.0	232.8
Secondary[e]	15.0	15.0	15.0	20.0	20.0
Total[e]	233.3	238.3	231.2	249.0	[2]252.8
German Democratic Republic, primary and secondary[e]	15.0	15.5	16.0	17.0	17.5
Germany, Federal Republic of:					
Primary	283.4	335.1	288.7	333.6	[2]342.8
Secondary	21.4	19.7	18.1	21.9	[2]22.4
Total	304.8	354.8	306.8	355.5	[2]365.2
Greece, secondary	(3)	(3)	--	--	--
Hungary, secondary	.7	.6	[e].6	[e].6	.6
Italy, primary and secondary	191.2	169.4	177.6	202.8	[2]206.4
Netherlands, primary and secondary	140.8	109.4	135.4	154.0	[2]169.5
Norway, primary	64.4	69.8	71.6	77.5	[2]79.1
Poland, primary and secondary	237.0	228.0	222.0	209.0	205.0
Portugal, primary	--	--	--	--	2.0
Romania, primary and secondary	53.4	51.9	49.8	50.0	50.0
Spain, primary	161.1	156.6	177.0	182.7	162.0
U.S.S.R.:					
Primary	720.0	735.0	770.0	770.0	785.0
Secondary	80.0	80.0	80.0	80.0	80.0
Total	800.0	815.0	850.0	850.0	865.0
United Kingdom, primary and secondary	41.6	81.5	73.6	76.7	[2]86.7
Yugoslavia:					
Primary	86.5	89.2	[r] [e]85.2	[e]87.9	77.5
Secondary	9.0	9.6	[e]10.0	[e]11.0	7.0
Total	95.5	98.8	95.2	98.9	[2]84.5
Africa:					
Algeria, primary	20.0	20.0	25.7	27.3	20.0
South Africa, Republic of, primary[4]	66.2	76.0	79.1	75.4	81.4
Zaire, primary	61.7	51.0	43.5	43.5	[2]43.8
Zambia, primary	36.3	40.1	42.4	38.2	[2]32.7
Asia:					
China, mainland, primary and secondary	[r]150.0	[r]155.0	160.0	160.0	160.0
India:					
Primary	26.8	36.0	59.4	63.3	43.6
Secondary	NA	NA	NA	NA	.3
Total	26.8	36.0	59.4	63.3	43.9

See footnotes at end of table.

Table 34.—Zinc: World smelter production by country[1] —Continued

(Thousand metric tons)

Country	1976	1977	1978	1979[p]	1980[e]
Asia—Continued					
Japan:					
Primary	742.0	778.4	767.9	789.4	[2]739.1
Secondary	34.0	26.6	24.8	27.0	43.0
Total	776.0	805.0	792.7	816.4	782.1
Korea, North, primary[4]	135.0	135.0	130.0	120.0	120.0
Korea, Republic of, primary	27.5	32.8	59.0	83.0	[2]79.1
Thailand, primary	(3)	(3)	(3)	(3)	--
Turkey, primary	2.3	20.9	20.0	20.0	18.0
Vietnam, primary[e]	9.0	9.0	7.2	5.4	5.5
Oceania: Australia:					
Primary	242.6	249.7	290.1	305.4	[2]301.0
Secondary[e]	6.6	6.7	4.7	4.2	[2]5.0
Total	249.2	256.4	294.8	309.6	[2]306.0
Grand total	[r]5,674.5	[r]5,804.7	5,877.3	6,255.5	6,036.2
Of which:					
Primary	[r]4,491.5	[r]4,664.1	4,723.4	5,034.3	4,799.0
Secondary	[r]245.0	[r]223.2	206.8	239.7	230.0
Undifferentiated	[r]938.0	[r]917.4	947.1	981.5	1,007.2

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Table combines data provided in tables 39 and 40 of the 1977 edition of this chapter. Wherever possible, detailed information on raw material source of output (primary—directly from ores, and secondary—from scrap) has been provided. In cases where raw material source is unreported and insufficient data are available to estimate the distribution of the total, that total has been left undistributed (primary and secondary). To the extent possible, this table reflects metal production at the first measurable stage of metal output. Table includes data available through July 1, 1981.

[2]Reported figure.

[3]Less than 50 metric tons.

[4]May include small quantities of secondary.

Zirconium and Hafnium

By William S. Kirk[1]

Zircon production by domestic mining companies decreased 21% in 1980, chiefly because of a slump in the market. Zircon exports decreased and imports increased in 1980, but domestic consumption was down considerably from that of 1979. Production and shipments of zirconium mill products fell 15% in 1980 because of weak demand in nuclear powerplant construction. Demand for hafnium strengthened partly because of the increased use of hafnium-columbium carbide in cutting-tool alloys.

The excess producer stocks of zircon in Australia had been substantially reduced by the end of 1980.

Zircon use was largely in foundry sands, refractories, abrasives, ceramics, and as a source of zirconium metal. The metal was used mostly in nuclear reactors, corrosion-resistant equipment for industrial plants, and refractory alloys. Hafnium was used in nuclear reactors, refractory alloys, and cutting-tool alloys.

Titanium Enterprises, Inc., Green Cove Springs, Fla., was purchased by an Australian mineral sands producer. Western Zirconium Co. announced plans to expand its facilities to produce hafnium. A new zirconium sponge plant in Japan was scheduled to begin production in 1980, and plans were reported for a new zirconium sponge plant in France.

Legislation and Government Programs.—There were no stockpile goals for zirconium or hafnium materials. The U.S. Department of Energy had an inventory as of December 31, 1980, of approximately 173 short tons of zirconium sponge, 977 tons of zirconium ingots and shapes, 1 ton of zirconium scrap, 27 tons of hafnium crystal bar, 12 tons of hafnium ingots and shapes, 5 tons of hafnium oxide, and 1 ton of hafnium scrap.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1976	1977	1978	1979	1980
Zircon:					
Production	W	W	W	W	W
Exports	9,428	14,364	7,671	8,856	7,727
Imports	64,643	65,204	91,009	110,842	113,784
Consumption[e 1]	155,000	162,000	164,000	168,000	144,000
Stocks, yearend, dealers' and consumers'[2]	38,625	26,052	38,307	37,465	[e]69,593
Zirconium oxide:					
Production[3]	8,000	7,414	8,605	11,130	[e]10,218
Producers' stocks, yearend[3]	667	718	931	975	[e]1,754

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes baddeleyite: 1976-[e]1,000 tons; 1977-[e]1,500 tons; 1978-[e]1,600 tons; 1979-[e]1,600 tons; 1980-[e]1,700 tons.
[2]Excludes foundries.
[3]Excludes oxide produced by zirconium metal producers.

Table 2.—Producers of zirconium and hafnium materials in 1980

Company	Location	Materials
ZIRCONIUM MATERIALS		
Associated Minerals Consolidated Ltd	Bow, N.H	Oxide.
Do	Green Cove Springs, Fla	Zircon.
The Carborundum Co	Falconer, N.Y	Refractories, oxide.
C-E Cast Industrial Products	Carson, Calif	Milled zircon.
C-E Refractories, Div. of Combustion Engineering, Inc	St. Louis, Mo	Refractories.
Do	King of Prussia, Pa	Refractories, zircon.
Do	Vandalia, Mo	Do.
CIBA-GEIGY Corp., Drakenfeld Colors	Washington, Pa	Ceramic colors, milled zircon.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
Corhart Refractories Co	Buckhannon, W. Va	Refractories.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
Didier-Taylor Refractories Corp	Cincinnati, Ohio	Do.
Do	South Shore, Ky	Do.
E. I. du Pont de Nemours & Co	Wilmington, Del	Zircon, foundry mixes.
Ferro Corp	Cleveland, Ohio	Ceramics, ceramic colors.
Foote Mineral Co	Cambridge, Ohio	Alloys.
A. P. Green Refractories Co., Remmey Div	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Lincoln Electric Co., Inc	Cleveland, Ohio	Welding rods.
M & T Chemicals, Inc	Andrews, S.C	Milled zircon.
Magnesium Elektron, Inc	Flemington, N.J	Alloys, chemicals, oxide.
Norton Co	Huntsville, Ala	Oxide.
Reading Alloys	Robesonia, Pa	Alloys.
Ronson Metals Corp	Newark, N.J	Baddeleyite (oxide).
Sherwood Refractories Co	Cleveland, Ohio	Zircon cores.
Shieldalloy Corp	Newfield, N.J	Welding rods, alloys.
Tam Ceramics	Hightstown, N.J	Milled zircon, oxide, alloys, chloride.
Teledyne Wah Chang Albany	Albany, Oreg	Oxide, chloride, sponge, ingot, powder, crystal bar.
Thiokol Corp., Ventron Chemicals Div	Beverly, Mass	Alloys, powder.
Transelco, Inc	Dresden, N.Y	Chemicals, ceramics, oxide.
Union Carbide Corp	Alloy, W. Va	Alloys.
Western Zirconium Co	Ogden, Utah	Oxide, sponge, ingot, mill products.
Zedmark, Inc	Butler, Pa	Refractories.
ZIRCOA Products	Cleveland, Ohio	Oxide, ceramics.
HAFNIUM MATERIALS		
Teledyne Wah Chang Albany	Albany, Oreg	Oxide, sponge, ingot, crystal bar.
Western Zirconium Co	Ogden, Utah	Oxide, sponge, crystal bar, ingot.

DOMESTIC PRODUCTION

Zircon was recovered as a coproduct of titanium mineral concentrates from mineral sands at the dredging and milling facilities owned and operated by E. I. du Pont de Nemours & Co. at Starke and Highland, Fla., and Associated Minerals Consolidated Ltd. (AMC) at Green Cove Springs, Fla. Production data were withheld from publication to avoid disclosing company proprietary data. The combined zircon capacity at these two plants was estimated to be 100,000 tons per year.

In 1980, AMC exercised its option to purchase the mining lease and operating plant at Green Cove Springs, Fla., formerly owned by Titanium Enterprises, at a price of $11.7 million.[2] AMC began dredging operations that had been closed down since 1978. These and other deposits are described in a report on the heavy minerals industry of North America.[3] Zirconium sponge production in 1980, estimated from published information, was about 3.5 million pounds, about one-third of U.S. capacity.

Approximately 2,423 tons of alloys containing 3% to 70% zirconium was produced in 1980, a 23% decrease from 1979 production.

Four firms produced 40,467 tons of milled (ground) zircon in 1980, from domestic and imported concentrates. Six companies, excluding those that produce metal, produced 10,218 tons of zirconium dioxide compared with 11,130 tons in 1979.

Hafnium crystal bar production was estimated at 50 tons in 1980, equaling that of 1979.

Teledyne Wah Chang Albany (TWCA) was reportedly at less than 50% of capacity in 1980 because of reduced demand for zirconium resulting from the continued slowdown in nuclear powerplant construction. About 180 TWCA employees were laid off during the year and the sand-chlorination and separation departments were closed.[4] The departments were to be restarted in 1981.

Western Zirconium's new plant in Ogden,

Utah, was going through the process of plant startup and material qualification with its nuclear customers in 1980. Western Zirconium produced small quantities of nuclear- and nonnuclear-grade zirconium during the year and announced plans for a $3 million expansion to permit recovery of hafnium as a byproduct of its zirconium operation.[5] The plant has an annual production capacity of 3 million pounds of zirconium sponge, bringing total U.S. capacity to 10 million pounds.

The Norton Co. built a $19.1 million addition to its zirconia-alumina material manufacturing plant in Huntsville, Ala., to provide material for the production of abrasives and grinding wheels. Production at the new facilities began in late 1980.

CONSUMPTION AND USES

Foundries used about 45% of domestic zircon consumption in 1980. The remainder was consumed by refractory, abrasive, ceramic, metal, and other industries. Domestic zircon was marketed in proprietary mixtures for use as foundry sand, zircon-refractory heavy mineral sand blends (with kyanite, sillimanite and staurolite), weighting agents, zircon-TiO_2 blends for welding rod coatings, and sandblasting applications. The zircon-bearing foundry sand was reportedly designed to provide consistent high-quality performance at low cost for critical casting applications.

In 1980 baddeleyite concentrate from the Republic of South Africa was used mainly in the manufacture of alumina-zirconia abrasives and also for ceramic colors, refractories, and other uses.

The nuclear power industry accounts for 90% of the consumption of zirconium metal with the remainder being used for corrosion-resistant applications in the chemical industry and for photographic flashbulbs.

U.S. production and shipments of zirconium mill products declined 15% in 1980, equaling the fall in 1979.[6] The decline in demand was a result of a combination of cancellations, deferrals, and delays in nuclear plant construction. Because of the lack of new orders for domestic reactors and the delays in plants already ordered, over 70% of the 1980 zirconium requirements were for fuel reloading of online nuclear plants.

Demand for zirconium in the chemical process industry accounted for almost 10% of total consumption.[7] Lead times of close to a year and steadily rising prices for titanium and Hastelloy, a nickel alloy, in contrast to the ready availability of and stable prices for zirconium, made zirconium an attractive alternative for chemical processors. Among the markets that zirconium successfully penetrated were the pulp and paper industry, desalinization, tubing, pumps and valves for heat exchangers, and strong acid manufacture.

Zirconium compounds, natural and manufactured, were used in refractories, abrasives, polishes, glazes, enamels, welding rods, chemicals, and sandblasting. Zirconium chemicals were finding increased application in the paint, textile, and pharmaceutical industries.

Hafnium metal consumption for control rods in nuclear reactors remained steady through 1980 but was expected to grow. The Nuclear Fuel Div. of Westinghouse Electric Corp. decided, in 1980, to substitute hafnium for silver-indium-cadmium alloy used in control rods in its nuclear reactors. Westinghouse reactors coming online in the future will use the hafnium control rods, and control rods in existing plants will be replaced by hafnium control rods as the need arises. A typical reactor would contain about 7,000 pounds of hafnium.

The use of hafnium continued to grow in cutting-tool alloys. Substituting a hafnium-columbium carbide for tantalum carbide could result in a cost savings of 25% or more.[8]

Table 3.—Estimated[1] consumption of zircon in the United States, by end use

(Short tons)

Use	1978	1979	1980
Zircon refractories[2]	27,000	26,000	29,000
AZS refractories[3]	11,000	12,000	8,000
Zirconia[4] and AZ abrasives[5]	17,000	20,000	18,000
Alloys[6]	3,000	3,000	2,000
Foundry applications	72,000	75,000	55,000
Other[7]	34,000	32,000	32,000
Total	164,000	168,000	144,000

[1]Based on incomplete reported data.
[2]Dense and pressed zircon brick and shapes.
[3]Fused cast and bonded alumina-zirconia-silica-based refractories.
[4]Excludes oxide produced by zirconium metal producers.
[5]Alumina-zirconia-based abrasives.
[6]Excludes alloys above 90% zirconium.
[7]Includes chemicals, metallurgical-grade zirconium tetrachloride, sandblasting, welding rods, and miscellaneous uses.

Table 4.—Estimated[1] consumption of zirconium oxide[2] in the United States, by end use

(Short tons)

Use	1979	1980
AZ abrasives	6,000	4,500
AZS refractories[3]	2,500	5,200
Other refractories	2,000	2,000
Chemicals	700	700
Glazes, opacifiers, colors	800	900
Total	12,000	13,300

[1]Based on incomplete reported data.
[2]Excludes oxide produced by zirconium metal producers. Includes baddeleyite.
[3]Fused cast and bonded.

Table 5.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	1979	1980
Zircon concentrate held by dealers and consumers, excluding foundries	r e32,639	e62,119
Milled zircon held by dealers and consumers, excluding foundries	r e4,826	e7,474
Zirconium:[1]		
Oxide	r e975	e1,754
Sponge, ingot, scrap, alloys	r383	469
Refractories	r e9,105	e7,490
Hafnium: Sponge and crystal bar[e]	40	35

[e]Estimated. [r]Revised.
[1]Excludes material held by zirconium sponge metal producers.

PRICES

The published prices of zirconium and hafnium materials are listed in table 6. The published prices of Australian zircon, in U.S. dollars, per ton, rose steadily in 1980, as follows:

	Standard grade	Intermediate grade	Premium grade
December 1979	51-61	61-77	77- 86
April 1980	56-66	66-81	81- 97
July 1980	68-78	78-89	89- 99
December 1980	75-80	80-91	91-102

Table 6.—Published prices of zirconium and hafnium materials

Specification of material	1979	1980
Zircon:		
Domestic, standard grade, f.o.b. Starke, Fla., bulk, per short ton[1]	$150.00	$165.00
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, Fla., bulk, per short ton[1]	99.00	99.00
Imported sand, containing 65% ZrO_2, f.o.b., bulk, per metric ton[2]	$55.00— 66.00	$83.00— 89.00
Domestic, granular, bags, bulk rail, from works, per short ton[3]	150.00	165.00—177.00
Domestic, milled, 200- and 325-mesh, rail, from works, bags, per short ton[3]	225.00	225.00
Baddeleyite, imported concentrate:[4]		
96% to 98% ZrO_2, minus 100-mesh, c.i.f. Atlantic ports, per pound	.27— .40	.33— .50
99+% ZrO_2, minus 325-mesh, c.i.f. Atlantic ports, per pound	.75— .90	.85— 1.00
Zirconium oxide:[3]		
Powder, commercial-reactor grade, drums, from works, bags, per pound	[5]3.00— 3.50	[5]4.25— 5.00
Chemically pure, white, ground, barrels or bags, works, per pound	2.22	4.75
Lump electric fused, bags, 500- to 1,999-pound lots, from works, per pound	NA	NA
Lump electric fused, bags, smaller lots, from works, per pound	NA	NA
Milled, bags, carlots, from works, per pound	NA	NA
Glass-polishing grade, ton lots, bags, 94% to 97% ZrO_2, from works, per pound	1.11	1.11
Opacifier grade, 3,300-pound lots, 85% to 90% ZrO_2, bags, per pound	.81	.81
Stabilized oxide, 100-pound bags, 91% ZrO_2, milled, per pound	1.57	1.57
Zirconium oxychloride: Crystal, cartons, 5-ton lots, from works, per pound[3]	.515	.515
Zirconium acetate solution:[3]		
25% ZrO_2, drums, carlots, 15-ton minimum, from works, per pound	.22	.97
22% ZrO_2, same basis, per pound	.38	.78
Zirconium hydride: Electronic grade, powder, drums, 100-pound lots, from works, per pound[3]	22.00	31.75
Zirconium:[6]		
Powder, per pound	70.00—100.00	75.00—125.00
Sponge, per pound	9.00— 12.00	10.00— 14.00
Sheets, strip, bars, per pound	18.00— 35.00	20.00— 35.00
Hafnium: Sponge, per pound	[5]60.00— 90.00	55.00—110.00

NA Not available.
[1]E. I. du Pont de Nemours & Co. price list (effective Jan. 1, 1980) December 1979; and (effective Jan. 1, 1981) December 1980.
[2]Industrial Minerals (London). No. 147, December 1979, p. 77; and No. 159, December 1980, p. 89.
[3]Chemical Marketing Reporter. V. 216, No. 27, Jan. 3, 1980 (effective Dec. 28, 1979), p. 37; and v. 218, No. 26, Dec. 29, 1980 (effective Dec. 26, 1980), p. 37.
[4]Ronson Metals Corp. Baddeleyite price lists. Jan. 1, 1980 and Jan. 1, 1981.
[5]Producer estimate.
[6]American Metal Market. V. 87, No. 251, Dec. 28, 1979, p. 5; and v. 88, No. 251, Dec. 31, 1980, p. 8.

Table 7.—U.S. exports of zirconium ore and concentrate, by country

Destination	1979		1980	
	Pounds	Value	Pounds	Value
Belgium-Luxembourg	--	--	118,400	$29,808
Brazil	1,357,737	$259,981	1,645,001	385,623
Canada	3,078,082	334,051	3,143,409	357,123
Colombia	1,477,538	390,571	2,123,060	492,962
Germany, Federal Republic of	3,474,875	641,042	3,532,411	725,790
Italy	443,582	128,848	643,463	126,692
Korea, Republic of	111,202	25,970	31,579	6,000
Mexico	6,560,911	515,150	3,348,996	355,512
United Kingdom	--	--	77,460	37,827
Venezuela	606,561	161,300	499,649	134,605
Other	601,447	131,962	291,241	80,047
Total	17,711,935	2,588,875	15,454,669	2,731,989

Table 8.—U.S. exports of zirconium, by class and country

Country	1979		1980	
	Pounds	Value	Pounds	Value
Zirconium and zirconium alloys, wrought:				
Belgium-Luxembourg	54,896	$2,519,236	14,610	$528,550
Canada	397,633	9,285,393	429,394	9,859,018
France	37,326	886,456	11,024	403,969
Germany, Federal Republic of	66,068	1,388,155	28,155	603,429
Japan	521,926	10,936,297	483,353	12,301,055
Sweden	32,413	2,865,888	25,700	418,787
Other	16,094	375,110	31,727	708,218
Total	1,126,356	28,256,535	1,023,963	24,823,026
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Belgium-Luxembourg	17,063	67,056	9,650	27,633
Canada	15,008	284,524	4,721	104,730
France	61,717	233,401	260	3,938
Germany, Federal Republic of	57,207	254,516	37,154	149,237
Italy	11,355	27,500	2,955	15,368
Japan	103,792	1,447,439	92,401	1,368,953
Korea, Republic of	--	--	132	57,914
Netherlands	66,730	158,880	11,638	94,904
Sweden	135,828	314,471	--	--
United Kingdom	242,734	2,771,311	198,558	2,646,492
Other	14,868	96,383	6,545	115,868
Total	726,302	5,655,481	364,014	4,585,037

Table 9.—U.S. exports of zirconium oxide, by country

Country	1979		1980	
	Pounds	Value	Pounds	Value
Argentina	69,071	$82,576	2,047	$3,207
Belgium-Luxembourg	77,682	71,346	59,108	24,894
Brazil	23,160	47,525	17,033	53,793
Canada	701,170	1,465,656	3,355,702	1,031,755
France	34,654	79,105	298,357	1,034,908
Germany, Federal Republic of	960,925	301,174	60,063	175,331
Hungary	--	--	36,000	39,192
Italy	18,500	54,378	66,405	70,519
Japan	727,490	758,232	347,803	406,311
Mexico	73,293	92,838	91,794	73,592
Netherlands	45,683	56,483	140,087	266,959
Sweden	35,103	56,792	26,845	38,161
Switzerland	3,070	5,969	2,004	47,169
United Kingdom	155,955	181,742	223,775	315,970
Other	55,031	130,590	51,149	95,924
Total	2,980,787	3,384,406	4,778,172	3,677,685

Table 10.—U.S. imports for consumption of zirconium ores, by country

Country	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	86,642	$14,731	101,144	$15,605	97,968	$8,888
Austria[1]	22	3	124	15	20	3
Canada[1]	377	76	2,312	564	1,082	165
South Africa, Republic of[2]	3,928	396	7,262	779	14,714	1,539
Sweden[1]	40	3	--	--	--	--
Total	91,009	15,209	110,842	16,963	113,784	10,595

[1]Believed to be country of shipment rather than country of origin.
[2]In addition, imports of baddeleyite were estimated as follows: 1978—1,600 tons; 1979—1,600 tons; 1980—1,700 tons.

Table 11.—U.S. imports for consumption of zirconium and hafnium, 1980

Class and country	Pounds	Value
Zirconium, wrought:		
Belgium-Luxembourg	72	$4,063
Canada	8,819	148,323
France	1,090,048	19,655,284
Germany, Federal Republic of	20	6,152
Italy	99	3,600
Japan	160	2,443
Sweden	485	22,579
United Kingdom	266	7,391
Total	1,099,969	19,849,835
Zirconium, unwrought and waste and scrap:		
Canada	42,935	109,010
France	2,248	14,741
Germany, Federal Republic of	220	2,151
Japan	284,086	2,378,944
Netherlands	6,250	20,866
Switzerland	2,471	4,067
United Kingdom	3	1,041
Total	338,213	2,530,820
Zirconium alloys, unwrought:		
France	14	1,352
United Kingdom	6,005	22,254
Total	6,019	23,606
Zirconium oxide:		
France	264	3,470
Germany, Federal Republic of	1,950	67,075
Japan	3,526	26,829
Switzerland	417	3,833
United Kingdom	591,096	1,244,100
U.S.S.R	19,800	47,383
Total	617,053	1,392,690
Zirconium compounds:		
Canada	7,252	9,543
France	68,343	62,620
Germany, Federal Republic of	73,964	256,283
Netherlands	269	2,637
Panama	7	1,154
South Africa, Republic of	1,365,043	486,567
United Kingdom	292,278	410,175
Total	1,807,156	1,228,979
Hafnium, unwrought and waste and scrap:		
Germany, Federal Republic of	333	8,372
United Kingdom	267	23,455
Total	600	31,827
Hafnium, wrought: Germany, Federal Republic of	14	300

WORLD REVIEW

Australia leads the world in the production of zircon and produced a record 506,003 short tons in 1980. Australian zircon is recovered as a coproduct of titanium concentrates from sand mining operations along the eastern coast (44%) and in Western Australia (56%). The impact of the mineral sands operation at Richards Bay in the Republic of South Africa has been less than expected by other zircon producers and huge producer stocks of Australian zircon have been considerably reduced because of the firmer zircon market.

Zircon sand is also produced in Brazil, mainland China, India, Malaysia, the Republic of South Africa, Sri Lanka, Thailand, and the U.S.S.R.

Baddeleyite is produced in the Republic of South Africa and Brazil and also is found in east Africa, Sri Lanka, and the U.S.S.R.

Australia.—Production of zircon from mineral sand operations in Western Australia decreased slightly in 1980. However, the decrease was more than matched by increased production on the east coast where output exceeded 220,000 tons for the first time since 1977.[9] Despite record shipments of 550,000 tons of zircon concentrates in 1980, prices were well maintained and had risen by yearend. The three largest

Table 12.—Zirconium concentrate: World production, by country[1]

(Short tons)

Country	1976	1977	1978	1979p	1980e
Australia	463,174	438,972	431,671	492,711	[2]506,003
Brazil	3,371	5,125	4,741	3,678	5,000
India	e11,400	e11,800	r12,309	[3]13,700	14,800
Malaysia[4]	3,449	r1,995	1,022	1,401	440
South Africa, Republic of	12,403	18,546	e40,000	90,000	88,000
Sri Lanka	11	e11	3,634	1,664	2,000
Thailand	61	60	28	95	77
United States	W	W	W	W	W
Total	493,869	r476,509	493,405	603,249	616,320

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data, excluded from total.

[1]No data are available on production, if any, within the centrally planned economy nations, nor is there any basis for the formulation of reliable estimates of output levels. Includes data available through May 15, 1981.

[2]Reported figure.

[3]Data are for fiscal year beginning April 1 of that stated.

[4]Exports (production not officially reported; exports believed to closely approximate total output).

customers, Japan, the United States, and Italy, received 186,000 tons, 98,000 tons, and 87,000 tons of zircon, respectively.

In 1980, the Australian Bureau of Mineral Resources, Geology, and Geophysics reassessed identified resources of zircon at 19 million tons, of which about 14 million tons were considered to be economical at 1980 prices of zircon and related minerals, rutile, ilmenite, and monazite.[10] About 20% of identified economic resources were not available for mining because of environmental considerations.

The mineral sands mining industry has had severe constraints placed on it because of environmental considerations. The mineral sands deposits are generally at or near population centers, major resorts, or natural scenic spots, and as a result of ecological concerns and the creation of State or National parks and natural preserves, many potential mineral sands deposits on Australia's eastern coast were unavailable for mining.

Allied Eneabba Pty. Ltd. announced plans to significantly expand its facilities at Narngulu, Western Australia.[11] A new zircon circuit, designed to produce 11,000 tons per year of a new, very coarse-grained zircon suitable for the refractory and foundry industries, was to have been in operation by the end of the year.

D. M. Minerals (a partnership between Murphyores Holdings Ltd. and a U.S. firm, Dillingham Corp.) was effectively prevented from mining zircon and other heavy minerals of Fraser Island, Queensland, through a continuing Federal export ban.[12] The firm still had hopes of renewed mining on Fraser Island and reportedly was planning to develop heavy mineral reserves it held in the Gladstone area of Queensland.

Consolidated Rutile, Ltd., the Brisbane-based mineral sand producer, increased its zircon production for the year ending June 30, 1980, by 66% over the previous year.[13]

Mineral Deposits Ltd., a subsidiary of Utah Mining Australia, Ltd., was granted the necessary development leases from the New South Wales Government to commence mining zircon and other heavy minerals at Middle Head, near Macksville, but was forced to suspend operations in March following objection from a local action group.[14]

France.—Cie. Européenne du Zirconium Ugine Sandvik (CEZUS), a Péchiney Ugine Kuhlmann (PUK) subsidiary, was at or near full production of zirconium metal in 1980, supported by the strong French nuclear power program.[15] CEZUS was building a new plant capable of producing 1,600 tons of zirconium sponge per year. The plant was to use a solvent-free process.[16]

India.—Further slippage occurred in the construction of Indian Rare Earths Ltd.'s (IREL) Orissa Mineral Sands Complex, which was being set up to exploit the mineral deposits at Chatrapur on the east coast of Orissa. The project was designed to produce, primarily for export, 2,200 tons per year of zircon as well as quantities of other heavy minerals; the production capacity may be doubled later. The second phase development called for a zirconium alloy plant. The quality and quantity of the mineral sands at Manavalakurichi, Tamil Nadu, and Chavara, Kerala have declined over the years; as a consequence, IREL was considering mechanizing some of its manual mining operations at Manavalakurichi, and at Chavara, a wet concentrator plant was being set up.

Japan.—Nippon Mining Co., Ltd., was to have started producing nuclear-grade zirconium sponge in August 1980.[17] Sumitomo Metal Mining Co., Ltd., and Kobe Steel, Ltd., reportedly have committed themselves to using the domestically produced sponge.[18] The other domestic nuclear grade manufacturer, Mitsubishi Metal Corp., has strong ties to the U.S. firm Western Zirconium, and has made no such commitment relative to zirconium sponge. It was reported that Mitsubishi was to increase production capacity of its Zircalloy-4 alloy tube from 55 to 66 tons per year in June 1981.[19]

Japan continued to receive more than one-third of Australian zircon exports in 1980.[20] The higher pouring temperatures used by the Japanese steel industry require zircon ladle linings, which have technical advantages over other materials.

Mitsui & Co. and Ishizuka Research Institute Ltd. were building a 130- to 200-ton-per-year zirconium sponge plant at Hiratsuka with startup slated for December.[21] The feasibility of a 1,300-ton-per-year plant was being studied.

China, Mainland.—The China Metallurgical Import and Export Corporation was offering atomic-grade zirconium sponge and other zirconium products.

South Africa, Republic of.—The projected capacity of the mineral sands operation at Richards Bay was 127,000 tons of zircon per year.[22] This meant a new producer was entering the market with the potential of supplying some 20% of world zircon demand.

United Kingdom.—Magnesium Elektron Ltd. (MEL) of Twickenham was increasing zirconium chemicals production at its Manchester plant by about 25% in 1980 and had plans for further increases there and at its U.S. subsidiary, Magnesium Elektron Inc., Flemington, N.J.[23] The production increases were a result of increased demand for zirconium chemicals such as zirconium oxide and zirconium carbonate.

Consumption of zircon for foundry use, normally 13,000 to 16,000 tons per year, was substantially down because of a reduced level of activity in the industry.[24]

TECHNOLOGY

Zirconium alloys, used extensively as cladding for fuel rods in commercial nuclear power reactors, reportedly are subject to failure from stress-corrosion cracking. This cracking is thought to be a result of reactions between zirconium and iodine, a fission product. The Bureau of Mines made studies on zirconium tetraiodide to better understand the zirconium-iodine system.[25]

The use of zircon in rammed-sand and shell molds as a less expensive method for shape-casting titanium was investigated.[26] The method developed was less expensive and generated none of the noxious fumes produced by the currently used commercial process.

Ishizuka Research Institute Ltd., of Hiratsuka, Japan, developed a new method of producing zirconium sponge that substitutes a single fractional distillation step for the extraction, precipitation, calcination, and chlorination steps used in current processes.[27] In the Ishizuka process, zirconium chloride ($ZrCl_4$) is separated from contaminating hafnium chloride ($HfCl_4$) and other impurities by fractional distillation at temperatures of 400° to 500° C and pressures of 20 to 25 atmospheres. Mitsui & Co., of Tokyo, which funded Ishizuka's research, said that the overall production cost of zirconium sponge, using the new method, would be about 50% of the cost of conventional methods.

A solvent-free process to produce zirconium sponge was developed by a French firm, PUK.[28] Zirconium sponge, in conventional processes, is separated from hafnium by using methylisobutyl ketone, a solvent which is volatile and corrosive, and generates effluents that must be treated. The PUK process is based on mixing molten chlorinated zirconium and hafnium with molten aluminum and potassium chlorides at 350° to 400° C and distilling the mixture at 1 atmosphere. The resulting zirconium-containing stream has less than 50 parts per million (ppm) of hafnium.

The kinetics of the chlorination of zirconium dioxide and carbon were studied.[29]

An all-zirconia combustion chamber for testing fuels reportedly prevented flashback, the accidental extension of the flame into the fuel supply line.[30] The zirconia device operates at higher temperatures and lasts longer than materials previously used.

An X-ray fluorescence method was developed to determine zirconium and hafnium in solution simultaneously at levels ranging from 0.5 to 200 ppm.[31]

The advantages of zirconium as a corrosion-resistant material for industrial applications were reviewed.[32] According to the review, it has oxidation resistance up to 400° C against air, steam, carbon dioxide, sulfur dioxide, nitrogen, and oxygen, and is resistant to strong basic and acid solutions.

A study was carried out in which zirconium was systematically replaced by hafnium as the major constituent in a series of fluoride glasses.[33] Hafnium-based materials appear to have better glass formation tendencies than their zirconium-based counterparts.

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Minor Metals

By Staff, Section of Nonferrous Metals

CONTENTS

ARSENIC[1]

Demand for arsenic exceeded supply in 1980, and the major domestic and foreign producers allocated available supplies to customers. Major demand was about evenly divided between industrial chemicals and agricultural chemicals.

Legislation and Government Programs.—In June 1980, the Environmental Protection Agency (EPA) listed inorganic arsenic as a hazardous air pollutant.[2] Proposed regulations on arsenic emissions were to be announced on an industry-by-industry basis at a future date, and public comment on the listing and on specific regulations was to be heard.

The Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as "superfund" legislation, became law on December 11, 1980 (Public Law 96-510).[3] The law provides for the establishment of a hazardous substance response fund to cover the costs of abandoned disposal sites and the cleanup of spills of hazardous substances. The fund will be raised by taxes levied on producers and importers, to be collected between April 1, 1981, and September 30, 1985, on 42 chemicals and petroleum products designated as hazardous. At the expected rates of production, the fund should build up to about $1.6 billion. As hazardous chemicals, arsenic metal and arsenic trioxide will be taxed at the rates of $4.45 and $3.41 per short ton, respectively.

DOMESTIC PRODUCTION

Arsenic trioxide and arsenic metal were produced only at the Tacoma, Wash., copper smelter of ASARCO Incorporated. Asarco processed arsenic residues and high-arsenic copper concentrates from both imported and domestic resources. Production data cannot be published.

CONSUMPTION AND USES

Of the arsenic consumed in 1980, 3% was used as metal, mainly as an alloying agent in nonferrous alloys (lead- and copper-based) and in electronic applications; 97% was used in compounds, of which arsenic trioxide containing 76% arsenic by weight was the most important commercially. Arsenic trioxide was used as an intermediate chemical in the manufacture of other arsenic compounds. About 45% of the arsenic in compound form was used in the manufacture of industrial chemicals (wood preservatives and mineral flotation reagents), another 45% in agricultural chemicals (herbicides and plant desiccants), 5% in glass and glassware, and the remaining 2% in other uses (for example, animal feed additives and pharmaceuticals).

Arsenical wood preservatives include chromated copper arsenate (CCA) and fluor chrome arsenate phenol (FCAP). According to the American Wood-Preservers' Association, usage of CCA increased from 12,494 tons in 1978 to 16,882 tons in 1979, the latest year for which data are available.[4] Usage of FCAP was 112 tons in 1978; usage in 1979 was withheld from publication. Usage of wood preservatives has grown at about a 20% annual rate over the past 3 years.

PRICES AND GRADES

Arsenic trioxide, minimum 95% As_2O_3 content, was sold in quantities ranging from 200 pounds (drums) to 130,000 pounds (bulk cars). In addition, arsenic metal, 99% minimum purity, was sold in drums.

Prices of arsenic trioxide and arsenic metal rose substantially in 1980, as shown below:

	Prices of arsenic (cents per pound, yearend)		
	1978	1979	1980
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, Wash	23	24	32
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, Tex	27	30	46
Trioxide, imports	28-32	32	35
Metal, domestic, 99% As	190	190	300

Table 1.—U.S. imports for consumption of arsenic trioxide (As_2O_3) content, by country

Country	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Belgium-Luxembourg	189	$48	184	$50	388	$142
Canada	136	34	277	80	486	110
France	5,077	1,844	3,242	1,376	2,780	1,597
Germany, Federal Republic of	1	6	6	15	116	92
Japan	(1)	1	--	--	58	79
Korea, Republic of	--	--	--	--	18	26
Mexico	2,603	1,064	3,125	1,799	3,720	2,681
Netherlands	--	--	--	--	57	26
Peru	--	--	477	148	--	--
Spain	--	--	--	--	135	170
Sweden	2,281	764	5,014	2,086	4,770	2,429
United Kingdom	19	9	(1)	8	(1)	(1)
Total	10,306	3,770	12,325	5,562	12,528	7,352

[1]Less than 1/2 unit.

Table 2.—U.S. imports for consumption of arsenicals, by class

Class	1978		1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Arsenic trioxide (As_2O_3)	10,306	$3,770	12,325	$5,562	12,528	$7,352
Metallic arsenic	369	1,622	405	1,881	266	1,524
Sulfide	(1)	1	39	112	11	2
Sodium arsenate	(1)	3	1	3	(1)	2
Arsenic acid	565	260	176	94	271	197
Arsenic compounds, n.e.c	473	262	1	76	1	113

[1]Less than 1/2 unit.

Table 3.—U.S. imports for consumption of arsenicals, by country[1]

(Short tons)

Country	Metal (TSUS 632.04)		Acid (TSUS 416.05)		Sulfide (TSUS 417.60)	
	1979	1980	1979	1980	1979	1980
Belgium-Luxembourg	--	--	--	--	17	--
Canada	11	13	--	--	22	11
Germany, Federal Republic of	--	--	--	--	--	--
Mexico	--	--	68	251	--	--
Sweden	394	252	--	--	--	--
United Kingdom	--	--	108	20	--	--
Total	405	[2]266	176	271	39	11

[1]Figures of less than 1/2 unit are not indicated in this table.
[2]Data do not add to total shown because of independent rounding.

FOREIGN TRADE

Imports of arsenic trioxide increased slightly in 1980. The main sources of trioxide imports were Sweden, Mexico, and France. Twenty tons of lead arsenate (TSUS 419.00) were received from Peru. Small quantities of sodium arsenate (TSUS 420.70) and other arsenic compounds were imported.

The scheduled changes in the U.S. tariff rates for arsenic are as follows:

Item	TSUS No.	Most Favored Nation (MFN) Jan. 1, 1980	Most Favored Nation (MFN) Jan. 1, 1981	Most Favored Nation (MFN) Jan. 1, 1987	Non-MFN, Jan. 1, 1981
Arsenic metal	632.04	1.8 cents per pound.	1.5 cents per pound.	Free	6.0 cents per pound.
Trioxide and sulfide	417.62, 417.60	Free	Free	do	Free.
Other compounds	417.64	4.8% ad valorem.	4.7% ad valorem.	3.7% ad valorem.	25% ad valorem.

Table 4.—White arsenic (arsenic trioxide):[1] World production, by country[2]

(Short tons)

Country[3]	1976	1977	1978	1979[p]	1980[e]
France	[r]8,023	6,661	[r] [e]6,500	[r] [e]6,100	5,800
Germany, Federal Republic of[e]	400	400	400	400	400
Japan	66	NA	NA	NA	NA
Korea, Republic of	[r]1,028	[r]713	604	[e]650	NA
Mexico	6,062	6,332	6,884	7,206	7,200
Namibia[4]	5,646	2,882	2,647	2,448	2,200
Peru	879	1,507	1,386	2,690	2,800
Portugal	306	245	220	[e]240	220
Sweden[5]	7,411	7,443	7,372	[r] [e]5,600	4,500
U.S.S.R.[e]	8,200	8,300	8,400	8,500	8,500
United States	W	W	W	W	W
Total	[r]38,021	[r]34,483	34,413	33,834	31,620

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic and arsenic compounds other than white arsenic, where inclusion of such materials would not duplicate reported white arsenic production.
[2]Table includes data available through May 15, 1981.
[3]In addition to the countries listed, Austria, Belgium, mainland China, Czechoslovakia, the German Democratic Republic, Finland, Hungary, Zimbabwe, the United Kingdom, and Yugoslavia have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make reliable estimates of output levels.
[4]Output of Tsumeb Corp. Ltd. only.
[5]Output of white arsenic for sale plus the white arsenic equivalent of the output of metallic arsenic for sale.

WORLD REVIEW

Demand for arsenic trioxide exceeded supply in 1980, and the United States, Sweden, and Mexico allocated available supplies to customers. Mexico was the largest of the market economy producers.

TECHNOLOGY

The Bureau of Mines conducted research on the removal of arsenic from copper smelter feed during roasting.[5] For nearly complete arsenic removal, a temperature of 650° to 700° C, a reducing atmosphere of carbon monoxide, and a source of sulfur were found to be essential.

U.S. Department of Agriculture scientists have developed an analytical method by which they can separate and determine arsenic compounds quantitatively.[6]

A high-pressure liquid chromatograph and a graphite furnace atomic absorption detector are employed in the method to separate arsenite, methane arsonic acid, cacodylic acid, and arsenate. The procedure has the advantage of allowing closer monitoring of arsenic in the environment.

CESIUM AND RUBIDIUM[7]

DOMESTIC PRODUCTION

There was no known domestic production of cesium- or rubidium-bearing minerals during 1980. Cesium compounds and small quantities of cesium metal were produced from imported cesium ore (pollucite). Rubidium compounds and metal were produced from imported lepidolite ores and possibly Alkarb, a residual material stockpiled when lithium was produced from African lepidolite. Production of both cesium and rubidium compounds declined slightly in 1980 from that of 1979, but production of cesium metal rose moderately.

Cabot Berylco Inc. was the major producer of cesium and rubidium products from its plant at Revere, Pa.; other possible suppliers included Callery Chemical Co., Callery Pa., and Kerr-McGee Chemical Corp., Trona, Calif.

CONSUMPTION AND USES

Data concerning specific end use and consumption patterns for cesium and rubidium and their compounds were not available. Cesium and rubidium and their respective compounds were interchangeable in most applications, although cesium compounds were the most widely accepted because of their availability and price advantage. Commercial consumption included uses for high-voltage rectifying tubes, which change alternating current to direct current, and for infrared lighting where cesium vapor emits light with a wavelength that is invisible. In photoelectric cells, cesium chloride was used since its color sensitivity is higher than that of other alkali salts. Construction was begun by the Sandia Corp. of Albuquerque, N. Mex., on a pilot plant which will use cesium 137, produced as a byproduct of atomic generating plants, to sanitize sewage and other objectionable sludges to a level where they are compatible with the general environment.

PRICES

The yearend 1980 market quotation for cesium metal, 99+% purity, was unchanged at $225 per pound, according to industry sources. The quotation for pollucite concentrates remained unchanged from 1979 and was published in the Metal Bulletin at $12.40 to $13.00 per metric ton unit (22.046 pounds), f.o.b. source, minimum basis 24% Cs_2O contained. Rubidium metal was priced at $661.40 per kilogram for technical grade, and $826.75 per kilogram for high-purity grade, an increase over that of 1979. The prices for rubidium compounds also increased about 20% over those of the previous year. The increases in the prices for rubidium and its compounds were attributed to increased costs of manufacturing.

Table 5.—Prices of selected cesium and rubidium compounds in 1980

Item	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$29	$67
Cesium carbonate	29	67
Cesium chloride	31	70
Cesium fluoride	37	77
Cesium hydroxide	35	75
Rubidium carbonate	65	104
Rubidium chloride	66	105
Rubidium fluoride	71	110
Rubidium hydroxide	71	110

[1]Price is for quantities of less than 100 pounds, f.o.b. Revere, Pa., excluding packaging costs.

Source: Cabot Berylco Corp.

FOREIGN TRADE

Imports of cesium compounds during 1980 declined almost 50% from those of 1979. Trade data on raw materials and metal were not available. Changes in the tariff schedules as a result of the Tokyo Round of negotiations are shown below.

Item	TSUS No.	Most Favored Nation (MFN) Jan. 1, 1981	Most Favored Nation (MFN) Jan. 1, 1987	Non-MFN, Jan. 1, 1981
Ore and concentrate	601.66	Free	Free	Free.
Cesium	415.10	7.7% ad valorem	5.3% ad valorem	25% ad valorem.
Cesium chloride	418.50	5.5% ad valorem	4% ad valorem	Do.
Other cesium compounds	418.52	4.8% ad valorem	do	Do.
Rubidium	415.40	4.7% ad valorem	3.7% ad valorem	Do.
Rubidium compounds	423.00	do	do	Do.

Table 6.—U.S. imports for consumption of cesium compounds, by country

Country	1979				1980			
	Cesium chloride		Cesium compounds, n.s.p.f.		Cesium chloride		Cesium compounds, n.s.p.f.	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Canada	45	$1,853	--	--	--	--	--	--
Germany, Federal Republic of	4,071	243,171	18,030	$648,447	5,303	$274,716	5,383	$291,579
United Kingdom	999	33,353	37	1,564	1,134	52,473	2	699
Total	5,115	278,377	18,067	650,011	6,437	327,189	5,385	292,278

WORLD REVIEW

The Tantalum Mining Corp. of Canada Ltd. (Tanco), owned jointly by Cabot Berlyco Inc., 37.5%; Hudson Bay Mining & Smelting Co. Ltd., 37.5%; and the Manitoba Government, 25%, announced expansion of the mill at its Bernic Lake property near Lac du Bonnet in Manitoba. Tanco is one of two large commercial producers of pollucite and lepidolite in the Western Hemisphere.

Bikita Minerals (Pvt.) Ltd., which operates mines in the Victoria district of Zimbabwe, has the second largest known deposit of pollucite in the Western World. Early in 1980, sanctions which had been imposed by the United Nations were lifted and the company announced plans to reactivate production.

TECHNOLOGY

Plans were announced by Argonne National Laboratory to design a magnetohydrodynamic (MHD) electrical generator which would be simpler and less difficult to build than the initial model constructed by Westinghouse Electric Corp. The Space Systems Division of General Electric Co. was awarded the design contract. The new design was to incorporate certain MHD advances developed in the U.S.S.R., which were not available to the United States in 1980.

GERMANIUM[8]

Consumption of germanium in infrared systems for both military and nonmilitary applications continued to increase during 1980. The other major use for germanium, semiconductor electronics, resumed the downward trend which began in the 1960's. Germanium consumption in fiber optics increased in 1980 and is expected to show continued growth during the next few years.

DOMESTIC PRODUCTION

Eagle-Picher Industries, Inc., at Quapaw, Okla., was the sole domestic producer of primary germanium. Refined germanium was produced from stockpiles of old smelter residues from the zinc-mining operations in the Kansas-Missouri-Oklahoma district, supplemented occasionally with purchased germanium-rich residues. New scrap generated during the manufacture of electronic devices and electro-optical components was recycled.

Kawecki Berylco Industries, Inc., Revere, Pa., and Atomergic Chemetals Co., Plainview, N.Y., produced germanium from domestic secondary materials as well as imported metal, oxide, and scrap.

An estimated 27,000 kilograms of germanium was produced from domestic primary and secondary sources in 1980. Based on the U.S. producer price for refined germanium, the approximate value of production in 1980 was $17 million.

CONSUMPTION AND USES

Germanium usage in infrared optical systems increased sharply during 1980. The ability of infrared sensing systems to "see" in the dark, or through fog or smoke, has led to their widespread use by the military for guidance and weapon sighting. Nonmilitary applications, especially in security surveillance and fire alarms, also increased.

During 1980, the demand for germanium as a substrate upon which gallium arsenide phosphide (GaAsP) is deposited to form an essential part of light-emitting-diodes (LED) decreased, since it was again less costly to use gallium arsenide (GaAs) substrates. The use of germanium in semiconductor electronics also decreased owing to increased use of the less expensive, more versatile silicon devices.

In the manufacture of fiber optics, germanium tetrachloride is oxidized to the dioxide during the fiber-forming process to provide a high-refractive-index fiber core. The fiber optic system, which replaces conventional wire conductors for telecommunications, provides a very compact, inexpensive, short-circuit-free transmission medium that is not susceptible to distortion by an electromagnetic field and that cannot be tapped using currently available technology. Germanium was also used in highly sensitive single-crystal gamma-radiation detectors, glass microscope lenses, petroleum and petrochemical catalysts, fluorescent lamp phosphors, and special-purpose alloys.

The estimated consumption pattern for various end uses of germanium during 1980 was about 40% in infrared systems, 25% in semiconductors, 20% in fiber optics, 10% in detectors, and 5% for other uses.

PRICES

During 1980, the continued increase in demand for germanium for infrared and fiber optic applications, the necessity to recover germanium from increasingly lower grade raw materials, higher production costs, and fluctuations in international currency exchange rates resulted in numerous price adjustments. The U.S. producer price for germanium metal started the year at $521.20 per kilogram and closed at $784 per kilogram. The U.S. producer price for germanium dioxide rose from $307.25 to $491.50 per kilogram. The New York dealer price for germanium metal started the year at $557.50, reached a high of $834 from July to October, and closed at $753.50 per kilogram. The New York dealer price for germanium dioxide started at $305 per kilogram, peaked at $491.50, and closed the year at $444.

FOREIGN TRADE

As a result of the Tokyo Round of multilateral trade negotiations completed in 1979, the tariff rates for germanium metal and germanium dioxide were scheduled to be reduced in gradual stages through January 1, 1987.

Item	TSUS No.	Most Favored Nation (MFN)		Non-MFN, Jan. 1, 1980-Jan. 1, 1981
		Jan. 1, 1980	Jan. 1, 1981	
Germanium dioxide	423.00	4.8% ad valorem	4.7% ad valorem	25% ad valorem.
Metal, unwrought and waste and scrap[1]	628.25	do	do	Do.
Metal, wrought	628.30	8.6% ad valorem	8.1% ad valorem	45% ad valorem.

[1]Duty on waste and scrap suspended until June 30, 1981, as provided by Public Law 95-508.

Table 7.—U.S. imports for consumption of germanium in 1980, by country

Country	Quantity (kilograms)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	247	$1,041,094
China, mainland	61	44,840
Germany, Federal Republic of	89	38,072
Japan	299	154,425
Switzerland	(1)	377
United Kingdom	832	258,412
Total	1,528	1,537,220
Wrought:		
Belgium-Luxembourg	1,801	1,464,838
Japan	(1)	1,738
Total	1,801	1,466,576

[1]Less than 1/2 unit.

WORLD REVIEW

As a byproduct of base-metal refining, mainly zinc, primary germanium supplies were dependent upon the rate of production and recovery of the host metal. The largest reserves of germanium were located in the Shaba Province of Zaire. La Générale des Carrières et des Mines du Zaire (Gécamines) operated the Kipushi Mine and mill in Zaire and historically, the germanium-bearing residues were sent to Metallurgie Hoboken-Overpelt, S.A. (MHO), in Belgium. However, no shipments have been reported over the past several years. MHO produced germanium oxide and metal at its plant in Olen, Belgium, from stockpiled residues from Zaire and from materials derived from mines in France, Italy, and other European countries.

In France, Société Minière et Métallurgique de Peñarroya produced germanium concentrates and crude germanium dioxide at its Noyelles-Godault refinery. In Italy, the Crotone refinery, operated by Societá Mineraria e Metallurgica di Pertusola, is believed to produce an upgraded germanium cake. Other germanium producers were Bleibergerbergwerksunion AG in Austria and Preussag AG Metall and Otavi in the Federal Republic of Germany. Germanium refineries were also located in Japan, the U.S.S.R., mainland China, and the United States.

World production of refined germanium in 1980 was estimated to be 116,000 kilograms. France and Italy combined produced over 23,000 kilograms in 1980.

TECHNOLOGY

A method to produce rodstock for optical fibers was developed and patented by Bell Telephone Laboratories, Inc. Silicon chlorides or hydrides as vapors were passed through a fused quartz tube together with oxygen and doping agents to form glass layers of graded refractive index which minimized contamination by light-absorbing water and reduced impurities to the parts-per-billion level. Doping agents controlled the refractive index of each layer. Boron compounds lowered the index, and compounds of germanium, titanium, aluminum, or phosphorus raised it.[9]

INDIUM[10]

DOMESTIC PRODUCTION

Indium was produced by Indium Corp. of America in Utica, N.Y., and by NJZ Alloys, Inc., a joint venture of The New Jersey Zinc Co. and Indium Corp. NJZ Alloys, Inc., produced indium at the Palmerton, Pa., plant of New Jersey Zinc, with further refining and marketing provided by Indium Corp. Asarco, a company with a long history of indium production, temporarily ceased production in 1980 owing to reduced content of indium in its feed stocks. Data on domestic production, which declined slightly, were withheld to avoid disclosing company proprietary information. Small quantities of secondary indium were available from specialty-metal-recycling firms.

CONSUMPTION AND USES

Indium consumption declined slightly in 1980. Most usage categories remained steady, but consumption for nuclear control rods fell sharply as new activity in the nuclear energy field declined. The lower prices toward yearend helped solidify the competitive position of indium in its traditional markets. Research studies continued on a variety of possible new uses, particularly for solar cells. Estimated consumption patterns for indium metal were electrical and electronic components, 40%; solders, alloys, and coatings, 40%; and research and other uses, 20%.

PRICES

The price of indium generally declined during 1980. The price was $18.50 per troy ounce at the start of the year, was raised to $20 per troy ounce in February, and was lowered steadily in several stages in the second half of the year to $10.75 per troy ounce at yearend. The price decreases were attributed to lower demand, the need to be competitive with European prices, and a general worldwide oversupply situation.

FOREIGN TRADE

Imports of indium rose slightly but remained well below the high levels of the 1970-74 period. Belgium-Luxembourg remained the primary source, followed by Peru. The 1980 value of indium imports, at $5 million, was the highest in recent years, primarily reflecting higher indium prices in the first half of the year.

The duty on unwrought waste and scrap indium was 2% ad valorem for the most favored nations (MFN) and 25% ad valorem for the non-MFN; duties on waste and scrap were suspended until June 30, 1981, by Public Law 95-508. The duty on wrought indium was 8.3% ad valorem for MFN and 45% for non-MFN. For compounds, the duty was 4.4% ad valorem for MFN and 25% ad valorem for non-MFN.

Table 8.—U.S. imports for consumption of indium, by country

(Thousand troy ounces and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	33	432	124	1,504	148	2,349
Canada	25	196	36	458	36	690
Germany, Federal Republic of	23	222	16	176	3	50
Japan	24	268	3	24	10	167
Mexico	--	--	3	4	--	--
Netherlands	3	39	3	36	(1)	8
Peru	71	589	90	1,172	84	1,318
Switzerland	--	--	--	--	(1)	(1)
United Kingdom	25	303	7	219	14	404
Total	204	2,049	282	3,593	295	4,986
Wrought:						
Belgium-Luxembourg	--	--	1	13	--	--
Canada	--	--	(1)	6	(1)	1
Germany, Federal Republic of	(1)	2	1	7	--	--
Netherlands	(1)	1	(1)	1	(1)	4
Peru	2	15	9	137	4	80
United Kingdom	(1)	18	1	22	(1)	32
Total	2	36	12	186	4	117

[1]Less than 1/2 unit.

WORLD REVIEW

In response to substantially higher indium prices, world production increased in 1980. Major refiners included Metallurgie Hoboken-Overpelt AS/NV in Belgium, Preussag AG in the Federal Republic of Germany, Mining and Chemical Products Ltd. in the United Kingdom, and Cominco Ltd. in Canada. Industry sources reported that increased supplies of indium from mainland China, the U.S.S.R., and Japan in 1980 contributed to the world oversupply situation and weakened prices during the last half of the year.

SELENIUM[11]

An industrywide copper strike that lasted 5 months adversely affected production of selenium in 1980. Despite a sharply curtailed production rate, high producer stock levels remained essentially unchanged over those of the previous year.

Legislation and Government Programs.—Controversy continued on toxic effects versus beneficial effects of selenium. The Occupational Safety and Health Administration included selenium sulfide on its candidate list of potential chemical carcinogens.[12]

Table 9.—Salient selenium statistics

(Pounds of contained selenium)

	1976	1977	1978	1979	1980
United States:					
Production, primary	400,609	499,475	508,636	587,118	310,588
Shipments to consumers	369,588	353,098	324,378	467,338	310,764
Imports for consumption	811,257	585,673	799,853	683,903	625,472
Exports, metal, waste and scrap	193,484	67,610	227,449	333,282	180,269
Shipments from Government stocks	2,470	--	--	--	--
Apparent consumption	989,831	871,161	896,782	817,959	755,967
Stocks, yearend, producer	176,742	323,119	507,377	627,157	626,981
Producers' price, average per pound, commercial and high-purity grades	\$18-\$22	\$17.12-\$20.86	\$15-\$18	\$13.65-\$15.31	\$10.95-\$12.66
World: Refinery production	r2,455,738	r3,051,815	r3,132,987	r3,527,930	2,935,875

rRevised.

DOMESTIC PRODUCTION

During 1980, primary selenium was recovered at three copper refineries: AMAX Copper Inc., at Carteret N.J.; Asarco at Amarillo, Tex.; and Kennecott Corp. at Magna, Utah. The selenium was recovered from copper refinery anode slimes along with gold, silver, and tellurium, and from residues of pollution abatement plants at domestic and foreign nonferrous smelters and refineries. Two domestic companies that shipped selenium-containing materials to these refineries were the Phelps Dodge Refining Corp. and the Anaconda Company. High-purity selenium metal and various selenium compounds were produced from commercial-grade metal by the three copper refineries and other processors.

Secondary selenium was recovered from used xerographic drums by the Xerox Corp. in Webster, N.Y., and by Selenium Inc. (a division of Refinemet International) in Mapleville, R.I. Selenium Inc. also recovered selenium from used selenium rectifiers. The two U.S. companies are estimated to recover a total of about 100,000 pounds, and Noranda Mines Ltd. in Canada is estimated to recover 100,000 to 200,000 pounds of selenium per year from secondary sources, primarily from xerographic scrap imported from the United States, Europe, and Japan.

CONSUMPTION AND USES

The following are estimates of selenium consumption by end-use categories in 1980: Electronic and photocopier components, 35%; glass manufacturing, 30%; chemicals and pigments, 25%; and other, 10%. Consumption of selenium decreased in 1980 as a result of depressed conditions in the construction and automobile industries. Glass manufacturers have learned to conserve selenium, used in decolorizing glass containers, by using sintered pellets instead of powder.[13]

STOCKS

U.S. producer stocks in 1980 were essentially unchanged from those of 1979 and represented about 10 months' supply at the 1980 rate of apparent consumption.

PRICES AND GRADES

Selenium is usually sold as a commercial-grade (99.5% minimum) and high-purity grade (99.9% minimum) powder available in several mesh sizes. Pellets and sticks are also sold.

Domestic producer prices for commercial-grade and high-purity selenium declined in 1980 for the fourth consecutive year. The producer price for commercial-grade metal began the year at $10 to $15 per pound, decreased to $10 to $12 per pound in late January, and in early October decreased again to $8.50 to $12.00 per pound. In October, the U.S. producer price of high-purity selenium dropped from $13 per pound to $11.50 per pound. Dealer prices for commercial-grade selenium began the year at $9.15 to $9.75 per pound and ended the year at $5.50 to $6.50 per pound.

FOREIGN TRADE

Exports of selenium dropped sharply as a result of lower production, while imports declined slightly. In 1980, a new tariff category was established for sodium selenite, TSUS 421.625.

Table 10.—U.S. exports of selenium metal, waste, and scrap in 1980, by country

Country	Quantity (pounds)	Value
Argentina	500	$5,000
Australia	4,834	1,209
Canada	14,562	108,501
France	1,480	15,683
Japan	15,626	73,450
Mozambique	440	3,000
Netherlands	19,200	189,223
Philippines	66	1,300
Singapore	140	4,572
Spain	4,000	29,045
United Kingdom	118,365	1,245,486
Venezuela	1,056	12,144
Total	180,269	1,688,613

The U.S. tariff rates for selenium were changed as follows:

Item	TSUS No.	Most Favored Nation (MFN)			Non-MFN, Jan. 1, 1981
		Jan. 1, 1980	Jan. 1, 1981	Jan. 1, 1987	
Selenium metal	632.40	Free	Free	Free	Free.
Selenium dioxide and salts	420.50, 420.52	do	do	do	Do.
Sodium selenite and other selenium compounds.	421.625, 420.54	4.8% ad valorem.	4.7% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

The Second International Symposium on Industrial Uses of Selenium and Tellurium was held in Toronto, Canada, October 21-23, 1980, the first having been held in New York City in 1965. Representatives of 140 producers, consumers, dealers, trade organizations, universities, and governments participated. One major purpose of the symposium was to stimulate interest and research on new uses of these two metals. The Selenium-Tellurium Development Association, Inc. (STDA), composed of eight member companies (four American, two Canadian, one Swedish, and one Japanese), sponsored the symposium. The proceedings of the symposium were to be published and distributed at some future date.

The Second International Symposium on Selenium in Biology and Medicine was held May 13-16, 1980, at Texas Tech University in Lubbock, Tex. Medical experts discussed the role of selenium in the treatment and prevention of disease and its biological significance in the life cycle.

TECHNOLOGY

Research personnel from the Boeing Corp. of Seattle, Wash., under contract to the Solar Energy Research Institute (SERI) of Golden, Colo., developed an improved solar photovoltaic cell. They achieved a record high efficiency rate of 9.4% with a thin-film copper indium selenide-cadmium sulfide cell.[14]

A lead-salt light-emitting diode that can operate at room temperature was developed at General Motors Research Laboratories in Warren, Mich. The diode, made from lead sulfide selenide, can be used in fiber optic communication systems.[15]

Table 11.—U.S. imports for consumption of selenium in 1980, by country

Country	Quantity (pounds of contained selenium)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	38,918	$775,752
Canada	266,305	3,536,909
Chile	47,620	351,766
Germany, Federal Republic of	15,433	149,370
Japan	60,005	1,149,235
Peru	4,400	40,618
Sweden	15,973	396,856
United Kingdom	77,314	715,486
U.S.S.R	1,047	9,111
Yugoslavia	30,855	247,574
Total	557,870	7,372,677
Selenium dioxide:		
Germany, Federal Republic of	15,400	129,812
Japan	143	9,752
Total	15,543	139,564
Selenium salts: Japan	899	17,421
Sodium selenite:		
Canada	11,200	107,346
Germany, Federal Republic of	18,911	140,560
Italy	2,205	17,531
Spain	4,409	37,200
Switzerland	635	2,870
United Kingdom	9,914	79,947
Total	47,274	385,454
Other selenium compounds:		
Germany, Federal Republic of	220	3,290
Japan	2	528
United Kingdom	3,664	46,980
Total	3,886	50,798
Total, all forms	625,472	7,965,914

Table 12.—Selenium: World refinery production, by country[1]

(Pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Belgium[e]	130,000	130,000	130,000	130,000	130,000
Canada[3]	499,168	905,111	865,924	1,128,111	[4]831,591
Chile	33,160	18,291	18,001	[e]18,000	18,100
Finland	21,894	25,693	37,104	38,671	38,600
Japan	1,014,125	1,005,306	1,060,422	1,124,356	1,050,000
Mexico	127,868	110,231	176,369	165,346	180,000
Peru	19,299	35,097	28,499	40,387	42,000
Sweden	[r]110,231	[r]176,370	123,459	149,914	150,000
United States	400,609	499,475	508,636	587,118	[4]310,584
Yugoslavia	99,384	111,024	116,492	101,979	119,000
Zambia	--	35,217	68,081	44,048	66,000
Total	[r]2,455,738	[r]3,051,815	3,132,987	3,527,930	2,935,875

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Insofar as possible, data relate to refinery output only; thus, countries that produce selenium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but do not recover refined selenium from these materials indigenously, are excluded to avoid double counting. Table includes data available through May 15, 1981.

[2]In addition to the countries listed, Australia, the Federal Republic of Germany, and the U.S.S.R. produce refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products (Peko Wallsend Ltd. at June and Warrego Mines, Tennant Creek) and has facilities to produce elemental selenium (Port Kembla refinery of the Electrolytic Refining and Smelting Co. of Australia Pty Ltd.); output by Peko Wallsend is not reported in order to avoid double counting, and output, if any, by the Port Kembla refinery is unreported.

[3]Refinery output from all sources, including imported materials and secondary sources.

[4]Reported figure.

TELLURIUM[16]

An industrywide copper strike that lasted 5 months adversely affected production of tellurium. Apparent consumption was also down sharply.

Most tellurium figures, with the exception of imports and apparent consumption, have been withheld in this publication to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

Tellurium and tellurium dioxide were recovered domestically as byproducts of electrolytic copper refining by AMAX Copper Inc. at Carteret, N.J., and by Asarco at Amarillo, Tex. At least one domestic company that shipped tellurium-containing materials to AMAX was the Phelps Dodge Corp. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide.

CONSUMPTION AND USES

Comsumption of tellurium declined in 1980 to its lowest level since 1965. The closure of Oxirane Corp.'s ethylene glycol plant late in 1979 sharply reduced the quantity of tellurium catalysts used, and the decline in automobile sales caused less tellurium-alloyed steel to be used. Tellurium consumption by end use in 1980 was estimated as follows: Iron and steel products, 65%; nonferrous metals, 20%; chemicals, 10%; other uses, including rubber manufacturing, 5%.

PRICES AND GRADES

The producer price of tellurium metal quoted by Metals Week was $20 per pound until early October when the price range widened to $18 to $20 per pound. Tellurium metal is usually marketed in the form of minus 200-mesh powder, or as slabs, tablets, or sticks. Normal commercial grades contain a minimum 99% or 99.5% tellurium. Tellurium dioxide is sold in the form of minus 40- to minus 200-mesh powder containing a minimum 75% tellurium.

FOREIGN TRADE

Imports of tellurium declined sharply in 1980 to their lowest level since 1971. Hong Kong was the leading supplier. Imports from Canada were down substantially, and no imports at all were received from Fiji. There are no data on tellurium exports.

U.S. tariff rates for tellurium in 1980 are shown below, with scheduled changes.

Item	TSUS No.	Most Favored Nation (MFN)			Non-MFN, Jan. 1, 1981
		Jan. 1, 1980	Jan. 1, 1981	Jan. 1, 1987	
Tellurium metal	632.48	3.5% ad valorem	3.0% ad valorem	Free	25% ad valorem.
Compounds	421.90	4.8% ad valorem	4.7% ad valorem	3.7% ad valorem	Do.

Table 13.—Salient tellurium statistics

(Pounds of contained tellurium)

	1976	1977	1978	1979	1980
United States:					
Refinery production	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Imports for consumption	203,534	171,291	173,989	167,760	64,860
Apparent consumption	390,503	393,479	402,232	494,010	177,880
Stocks, yearend, producer	W	W	W	W	W
Producers' price, average per pound, commercial grade	$10.33	$17.15	$20	$20	$19.77
World: Refinery production[1]	(2)	(2)	(2)	(2)	(2)

W Withheld to avoid disclosing company proprietary data.
[1]Excludes U.S. production.
[2]See World Production table.

Table 14.—U.S. imports for consumption of tellurium in 1980, by country

Country	Quantity (pounds)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	3,932	$34,602
Canada	7,380	487,547
Germany, Federal Republic of	692	134,936
Hong Kong	10,030	207,136
Japan	6,646	115,016
Peru	4,375	78,012
United Kingdom	8,863	178,239
Total	41,918	1,235,488
Compounds:		
Germany, Federal Republic of	22	2,673
Hong Kong	22,818	386,700
Japan	100	3,271
United Kingdom	2	738
Total	22,942	393,382
Grand total	64,860	1,628,870

WORLD REVIEW

The Second International Symposium on Industrial Uses of Selenium and Tellurium was held in Toronto, Canada, October 21-23, 1980, the first having been held in New York City in 1965. Representatives of 140 producers, consumers, dealers, trade organizations, universities, and governments participated. One major purpose of the symposium was to stimulate interest and research on new uses of these two metals. The Selenium-Tellurium Development Association, Inc. (STDA), composed of eight member companies (four American, two Canadian, one Swedish, and one Japanese), sponsored the symposium. The proceedings of the symposium were to be published and distributed at some future date.

India.—India produced 440 pounds of crude tellurium from copper tankhouse slimes for the first time in 1980. The tellurium was produced from a pilot plant operation by Hindustan Copper Ltd.'s unit at Ghatsia, Bihar. The company plans to eventually open a production plant with a capacity of 3,300 pounds per year of crude and/or high-purity tellurium for export.

TECHNOLOGY

The Inland Steel Co. of Chicago began marketing a free-machining steel that contains bismuth, as a substitute for free-machining steel containing lead and tellurium.[17] The company will continue selling its lead-tellurium steel but planned eventually to replace it with the bismuth steel.

Table 15.—Tellurium: World refinery production, by country[1]

(Pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Canada[3]	117,156	81,617	99,867	104,067	100,000
Fiji	2,446	[e]27,000	[e]50,000	[e]50,000	25,000
Hong Kong	--	--	NA	[e]100,000	100,000
India	--	--	--	--	[4]440
Japan	73,634	143,521	163,142	169,756	176,400
Peru	27,130	40,499	33,911	46,811	48,500
United States	W	W	W	W	W

[e]Estimated. [p]Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Insofar as possible, data relate to refinery output only; thus, countries that produce tellurium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but do not recover refined tellurium, are excluded to avoid double counting. Table is not totaled because of the exclusion of data from major world producers, notably the United States and the U.S.S.R. Table includes data available through May 22, 1981.

[2]In addition to the countries listed, Australia, Belgium, the Federal Republic of Germany, and the U.S.S.R. are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Moreover, other major copper refining nations such as Chile, Zaire, and Zambia may produce refined tellurium, but output in these nations is conjectural.

[3]Refinery output from all sources, including imports and secondary sources.

[4]Pilot plant production.

THALLIUM[18]

DOMESTIC PRODUCTION

Trace amounts of thallium are contained in certain zinc-bearing ores and are concentrated in smelter flue dusts and residues which provide the commercial source for production of thallium. The Globe plant of Asarco at Denver, Colo., was the only domestic producer of thallium and thallium compounds.

USES

The current uses of thallium include electronic components, gamma radiation detection equipment, additives for changing the refractive index and density of glass, low-temperature mercury switches, and photosensitive devices. The radioisotope thallium-201 is used in studies of the heart to evaluate the arterial blood supply and to diagnose myocardial infarction.

PRICES

The price of thallium in 25-pound lots was $7.50 per pound throughout 1980.

FOREIGN TRADE

The duty on waste and scrap was suspended until June 30, 1981, as provided by Public Law 95-508.

Item	TSUS No.	Most Favored Nation (MFN) Jan. 1, 1980	Most Favored Nation (MFN) Jan. 1, 1981	Non-MFN, Jan. 1, 1980- Jan. 1, 1981
Unwrought metal, and waste and scrap	632.50	4.4% ad valorem	3.8% ad valorem	25% ad valorem.
Compounds	422.00	4.8% ad valorem	4.7% ad valorem	Do.

Table 16.—U.S. imports for consumption of thallium in 1980, by country

Country of origin	Compounds			Unwrought, and waste and scrap	
	Gross weight (pounds)	Content[e] (pounds)	Value	Gross weight (pounds)	Value
Belgium-Luxembourg	--	--	--	50	$1,176
Canada	--	--	--	3	1,311
Germany, Federal Republic of	123	98	$11,637	--	--
Total	123	98	11,637	53	2,487

[e]Estimated.

WORLD REVIEW

World mine production data for thallium were not available. The U.S. reserves in zinc ores were estimated at 75,000 pounds. Rest-of-world reserves were estimated to be 725,000 pounds of thallium.

[1]Prepared by J. Roger Loebenstein, physical scientist.

[2]Federal Register. National Emmission Standards for Hazardous Air Pollutants; Addition of Inorganic Arsenic to List of Hazardous Air Pollutants. V. 45, No. 110, June 5, 1980, pp. 37886-37888.

[3]U.S. Congress. Comprehensive Environmental Response, Compensation, and Liability Act. Public Law 96-510, Dec. 11, 1980, 94 Stat. 2767.

[4]Maloney, J. P., and L. J. Pagliai. Wood Preservation Statistics, American Wood-Preservers' Association, Washington, D.C., 1979, table 2, p. 329.

[5]Landsberg, A., J. E. Mauser, and J. L. Henry. Behavior of Arsenic in a Static Bed During Roasting of Copper Smelter Feed. BuMines RI 8493, 1980, 18 pp.

[6]Woolson, E. A., and N. Aharonson. Separation and Detection of Arsenical Pesticide Residues and Some of Their Metabolites by High Pressure Liquid Chromatography-Graphite Furnace Atomic Absorption Spectrometry. J. Assoc. Official Analytical Chemists (U.S. Dept. of Agriculture, Beltsville, Md.), v. 63, No. 3, May 1980, pp. 523-528.

Iadevaia, R., N. Aharonson, and E. A. Woolson. Extraction and Cleanup of Soil Arsenical Residues for Analysis by High Pressure Liquid Chromatographic-Graphite Furnace Atomic Absorption. J. Assoc. Official Analytical Chemists (U.S. Dept. of Agriculture, Beltsville, Md.), v. 63, No. 4, July 1980, pp.742-746.

[7]Prepared by John A. Rathjen, mineral specialist.

[8]Prepared by Patricia A. Plunkert, physical scientist.

[9]MacChesney, J. B., and P. B. O'Connor (Bell Telephone Laboratories, Inc., Murray Hill, N.J.) Optical Fiber Fabrication and Resulting Product. U.S. Pat. 4,217,027, Aug. 12, 1980.

[10]Prepared by James F. Carlin, Jr., physical scientist.

[11]Prepared by J. Roger Loebenstein, physical scientist.

[12]Chemical and Engineering News. OSHA's Candidate List: A Variety of Targets. Aug. 25, 1980, pp. 24-25.

[13]Crown, J. Process Cuts Glass Use of Selenium. Am. Metal Market, Oct. 24, 1980, p. 10.

[14]Chemical and Engineering News. Innovative Solar Cell Has High Efficiency. Aug. 11, 1980, p. 30.

[15]Hinden, H. J. Lead-Salt Diode Operates at Room Temperature. Electronics, Mar. 13, 1980, p. 39.

[16]Prepared by J. Roger Loebenstein, physical scientist.

[17]American Metal Market. Inland Now Markets Steel With Bismuth. Dec. 2, 1980, p. 12.

[18]Prepared by Patricia A. Plunkert, physical scientist.

Minor Nonmetals

By Staff, Section of Nonmetallic Minerals

CONTENTS

ASPHALT (NATIVE)[1]

Native asphalt was produced in 1980 by six companies in four States. Leading States were Texas and Utah. Output decreased 22% in 1980 to 1.25 million tons while value decreased 2% to $25.0 million.

Bituminous limestone was produced by Whites Uvalde Mines and by Uvalde Rock Asphalt Co. in Uvalde County, Tex.; by Southern Stone Co. in Colbert, Ala.; and by Barton County Rock Asphalt Co. in Barton County, Mo. The product was used mainly in street and road repair.

Gilsonite was produced by American Gilsonite Co. in Uinta County, Utah, and by Ziegler Chemical and Mineral Corp. in Weber County, Utah. This material was used for purposes other than road repair.

GREENSAND[2]

Greensand (glauconite) was produced in 1980 only by the Inversand Co., a subsidiary of Hungerford and Terry Inc., near Clayton, N.J. Production and sales information is withheld to avoid disclosing company proprietary data.

Raw greensand produced by the company was sold for agricultural use as a soil conditioner. It contains both potassium and phosphorus. Processed greensand was sold as a filter media for the removal of manganese, iron, sulfide, and other elements from water.

IODINE[3]

U.S. apparent consumption of crude iodine during 1980 remained at 1979 levels although the price of iodine rose by 50%. The two U.S. producers of crude iodine decreased total production during 1980. Total U.S. production capacity was less than 30% of domestic requirements. The major sources of U.S. iodine were imports from Japan and Chile.

Legislation and Government Programs.—The U.S. Government strategic stockpile contained 8,009,811 pounds of crude iodine at yearend 1980. The stockpile goal remained at 5,800,000 pounds, although no disposals were authorized for the 2,210,000 pounds in excess of the stockpile goal.

The depletion allowance for iodine remained at 14% of gross income and may not exceed 50% of net income without the depletion deduction.

The Dow Chemical Co. continued to protest an aerial photograph team, which was commissioned by the Environmental Protection Agency (EPA) and took detailed photographs of the Midland, Mich., plant. The Midland plant is one of two domestic producers of iodine.[4]

Methyl iodide was one of a number of chemicals that the EPA proposed to carry a cancer hazard warning.[5]

DOMESTIC PRODUCTION

Two companies continued to supply approximately 30% of U.S. consumption during 1980. The companies, which are located in Michigan and Oklahoma, produce iodine from subsurface brines.

Woodward Iodine Operations of Woodward, Okla., decreased output. Woodward Iodine is a joint venture between Amoco Production Co. (49%) and PPG Industries, Inc. (51%). Iodine of greater than 99.9% purity is recovered by a conventional process with proprietary refinements from brine associated with natural gas. Production was less than the 2-million-pound design capacity because of maintenance problems.

The Oklahoma Supreme Court ruled November 12, 1980, that salt water is a mineral. Brine water and any oil, gas, or other mineral were ruled to belong to the owner of the mineral rights. Amoco Production Co., which extracts natural gas in Woodward and Harper Counties and iodine in Woodward County, was the company most affected by the decision.

The Dow Chemical Co. recovered iodine from mineral-rich brines at Midland, Mich. Dow's iodine production was reported to have increased during 1980 because of the strong demand for iodine compounds. Most of the Dow product was retained for captive use. Dow announced during 1980 plans to build a world-scale (1 to 2 million pounds per year) iodine plant. The plant was planned to be onstream by 1982 and to be located in southern California.

Calabrian International Co., the largest U.S. importer of iodine, announced that it would build a 3-million-pound-per-year iodine facility. No further information was available until a firm brine source could be located.

CONSUMPTION AND USES

The Bureau of Mines consumption canvass for iodine received responses from 31 plants in 14 States. The 1980 canvass indicated a 21% decline in gross weight of crude iodine consumed. The decline was primarily a result of increases in the price of crude iodine and of the inflationary state of the U.S. economy.

The major downstream uses of iodine for 1980 were estimated as follows: Animal feed supplements (mainly for cattle), 22%; pharmaceuticals, 22%; catalyst (for synthetic rubber, stabilized rosin, tall oil, and other uses), 22%; stabilizers (as in nylon precursors), 13%; inks and colorants, 10%; photographic equipment, 6%; sanitary and industrial disinfectants, 2%; and other uses, 3%. Other uses include the making of high-purity metals, motor fuels, iodized salt, smog inhibitors, and lubricants. Iodine also has application in cloud seeding and radiopaque diagnosis in medicine. The major changes in demand were decreases in usage as a catalyst and in sanitary preparations.

Establishing an accurate pattern of demand by end use is difficult because iodine is frequently converted into intermediate compounds and marketed as such before reaching its ultimate end use. Moreover, iodine and iodides used in catalytic and other dissipative processes are not well covered. This situation has been revealed consistently in recent years by import figures that exceeded reported consumption figures.

Demand is expected to increase for use as a catalyst in converting synthesis gas produced from coal into ammonia, urea, and methanol. Of the 35 methanol projects being studied in the United States, 15 planned to use coal as a feed.[6] Tennessee Eastman Co. announced construction of a plant for converting coal to synthesis gas to acetic anhydride using an iodine catalyst.[7]

A lithium-iodide solid electrolyte cell for medical and commercial applications was in use. More than 80% of the pacemakers manufactured in 1978 used lithium-iodide cells.[8]

Table 1.—Crude iodine consumed in the United States

Products	1979 Number of plants	1979 Consumption Thousand pounds	1979 Consumption Percent of total	1980 Number of plants	1980 Consumption Thousand pounds	1980 Consumption Percent of total
Reported consumption:						
Resublimed iodine	12	635	11	9	427	9
Potassium iodide	9	1,155	19	9	976	21
Sodium iodide	4	113	2	4	414	9
Other inorganic compounds	18	1,791	30	10	933	20
Organic compounds	15	2,235	38	16	1,935	41
Total	[1]31	5,929	100	[1]31	4,685	100
Apparent consumption	XX	8,100	XX	XX	8,700	XX

XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.

PRICES

The quoted price at the beginning of 1980 was $4.54 per pound of crude iodine. By yearend, the price had risen to $6.80 per pound. Discounted sales prices for quantity purchases continued at the beginning of 1980, but price discounts were withdrawn during July. List prices of compounds rose approximately 33% during 1980.

The quoted U.S. prices for iodine and its primary compounds at yearend were as follows:

	Per pound [1]
Iodine, crude, drums	$6.80
Resublimed iodine, U.S.P., granular, 100-pound drums, works	12.16
Calcium iodate, drums, delivered	6.23
Calcium iodide, 35-pound drums, works	5.98
Potassium iodide, U.S.P., granular, crystals, drums, 1,000-pound lots, delivered	9.17
Sodium iodide, U.S.P., crystals, 300- to 500-pound lots, drums, freight equalized	11.85
Iodoform, N.F., 300-pound drums, f.o.b. works	21.75

[1]Conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.

Source: Chemical Marketing Reporter, v. 218, No. 26, Dec. 29, 1980, pp. 26-37.

FOREIGN TRADE

The quantity of U.S. imports of crude iodine for consumption during 1980 remained at approximately 1979 levels. The declared value for U.S. Customs increased from $2.98 per pound in 1979 to $4.63 per pound in 1980, a value growth rate of 55% during 1980. Imports of Japanese iodine increased, whereas imports of Chilean iodine decreased.

Table 2.—U.S. imports for consumption of resublimed iodine in 1980, by country

Country	Thousand pounds	Value (thousands)
Canada	([1])	$2
Germany, Federal Republic of	16	101
Japan	29	176
Sweden	1	9
Total	46	288

[1]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

Imports of potassium iodide for U.S. consumption totaled 93,000 pounds valued at $470,000. Japan supplied 95% of the total amount.

Table 3.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1978		1979		1980	
	Quantity	Value	Quantity	Value	Quantity	Value
Chile	1,102	2,425	1,342	4,314	1,124	5,669
Germany, Federal Republic of	--	--	--	--	(1)	(1)
Indonesia	--	--	13	40	--	--
Japan	5,734	12,208	4,838	14,073	5,062	22,894
Korea, Republic of	--	--	--	--	42	253
Mexico	--	--	1	2	--	--
United Kingdom	--	--	7	25	6	31
Total[2]	6,837	14,633	6,201	18,454	6,234	28,848

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Bureau of the Census.

WORLD REVIEW

Iodine-producing nations include Japan, Chile, the United States, the U.S.S.R., mainland China, and Indonesia.

Chile.—Production of iodine associated with nitrates was marketed through Chilean Nitrate Sales Corp. Production levels in Chile are tied to the output of nitrates. Iodine production was expected to increase because of better recovery techniques.

Indonesia.—The Japanese firm Ise Chemical Industries, Ltd., continued to be involved in the production of small amounts of iodine in Indonesia. Technical problems caused the quality of the material to be low in iodine content.

Italy.—Antiparassitaria per Agricoltura S.p.A. (APA), at Rovigo, near Venice, was acquired 51% by Kemagard, a subsidiary of Kema Nobel. The acquisition involved APA's fungicide and insecticide market.

Japan.—Japan continued to be the world's largest supplier of crude iodine during 1980. Environmental problems with the subsidence of land have lowered Japan's capacity from 14 million pounds to 13 million pounds per year.

Table 4.—Crude iodine: World production, by country[1]

(Thousand pounds)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Chile	3,137	4,092	4,237	5,313	4,900
China, mainland[e]	800	800	1,000	1,000	1,000
Indonesia	60	[r]26	16	56	55
Japan	15,331	13,448	13,228	13,800	14,300
U.S.S.R.[e]	5,000	5,000	5,000	5,000	5,000
United States	W	W	W	W	W
Total	[r]24,328	[r]23,366	23,481	25,169	25,255

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 22, 1981.
[2]In addition to the countries listed, the Federal Republic of Germany is known to have produced elemental iodine in 1976 and may have continued to do so during 1977-80, but output is not officially reported and available information is inadequate for formulations of reliable estimates of output levels.

TECHNOLOGY

Tennessee Eastman Co. announced construction of a plant that would produce synthesis gas from coal using a rhodium and methyl iodine catalyst.[9] Synthesis gas, which is a mixture of carbon monoxide and hydrogen, will be used to produce acetic acid from methanol. Plans called for esterification and subsequent carbonylation to anhydride by 1983.[10] The U.S. Department of Energy announced feasibility studies for 15 coal-to-methanol ventures.[11] It has been estimated that the rhodium-iodine catalyst will produce nearly one-third of all the acetic acid manufactured by 1985.

A study designed to find substitutes for chlorine in disinfecting water and wastewater named iodine as a reliable substitute. Chlorine produces hydrocarbons that are suspected to be carcinogenic to human beings and free residuals that may adversely affect aquatic organisms. Elemental iodine tablets have been used by the military to disinfect individual water supplies in emergency situations. Iodine is especially effective in use against outbreaks of cholera caused by water contamination. Potassium iodide was found to be a reliable alternative to chlorination.[12]

Iodine was introduced in facial tissues to control the spreading of colds in Antarctica. Facial tissues impregnated with iodine were used to interrupt the transmission of cold viruses.[13]

Medical uses of iodine continued to grow. Radioactive iodine continued to be used to trace the progress of a substance as the substance passes through the body or plant. Radioactive iodine, found to be delivered by antibodies directed against proteins on tumor cells, has shown positive results. Patients do not exhibit the usual side effects of conventional radiotherapy.[14]

Radioactive iodine emissions from an accident at Three Mile Island nuclear power plant in Pennsylvania were feared to be absorbed into the thyroid gland. However, studies of animal thyroids showed no increments of iodine absorbed from June 1979 to June 1980.[15]

The National Alcoholic Fuels Commission completed an 18-month study on alcohol-based fuels. Methanol produced from coal, using an iodine catalyst, could be competitive with methanol made from natural gas when price controls on natural gas are lifted.[16]

Other new uses of iodine included a patent in which iodine was used to treat sulfur-containing lubricating oil to increase resistance to oxidation.[17] A sulfur-iodine cycle for the production of hydrogen by solar energy produced at approximately 50% efficiency.[18]

A technique for recovery of silver from chloride leach solutions by iodine precipitation was developed by the U.S. Bureau of Mines. The silver is first precipitated as silver iodide and treated with sodium sulfate to form silver sulfate. Recovery of 100% silver can be achieved, although a 90% to 92% recovery represents a practical economic balance.[19]

A report on the handling of organic heavy liquids, which included methyl iodide, was compiled by the U.S. Geological Survey. The physical properties of handling, proper storage facilities, and adequate protective clothing were discussed. Toxicity data and suggested first aid treatments are included.[20]

A new iodine chapter of the Bureau of Mines publication, Mineral Facts and Problems, was written in 1980; the publication covers such aspects as industrial structure and supply. Demand for iodine is predicted to the year 2000.[21]

MEERSCHAUM[22]

Imports of crude or block meerschaum in 1980, all from the United Kingdom, totaled 3,793 pounds with a customs declared value of $17,720. The unit value of this imported material was $4.67 per pound. No meerschaum was imported in 1979. Somalia and the Federal Republic of Germany have been the previous major suppliers to the United States; their 1978 imports of 14,055 pounds of block meerschaum was valued at $35,405 or $2.52 per pound.

Although Turkey is a major producer of crude or block meerschaum, State laws have prohibited export of uncarved materials since 1975. The block material was used by companies in New York and Ohio for manufacturing of smokers' pipes.

QUARTZ CRYSTAL[23]

U.S. consumption of lasca (feedstock for cultured crystal production) in 1980 was 1,026,000 pounds, a 26% increase over that in 1979. Cultured quartz crystal production in 1980 was 757,000 pounds compared with 575,000 pounds in 1979, a 32% increase. Consumption of both natural and cultured electronic- and/or optical-grade quartz crystal increased significantly in 1980 and totaled 418,000 pounds, compared with 284,000 pounds in 1979. Natural quartz crystal consumption was 25,000 pounds in 1980, all reportedly in the electronics industry. The average reported sales value for cultured quartz crystal in 1980 was $28.60 per pound for "as grown" crystal and $37.08 per pound for "lumbered" crystal. Brazil continued to be the principal U.S. source for lasca in 1980. U.S. exports of both natural and cultured electronic- and/or optical-grade quartz crystal totaled 310,000 pounds; Japan and the Federal Republic of Germany were the principal recipients. Imports of natural quartz crystal (including lasca) totaled 816,000 pounds in 1980, a 91% increase over that of the previous year.

Legislation and Government Programs.—At yearend 1980, the total Defense Materials Inventory of natural quartz crystal was 2.42 million pounds, of which 1.82 million pounds was classified as excess stockpile grade. During the latter part of 1979 and through 1980, the General Services Administration suspended sales of quartz crystal from the stockpile pending reevaluation of the provisional inventory goal of 600,000 pounds established in September 1979. Currently, no provision has been made for a stockpile of cultured quartz crystal.

Table 5.—Salient electronic- and optical-grade quartz crystal statistics

(Thousand pounds and thousand dollars unless otherwise noted)

	1976	1977	1978	1979	1980
Production:					
Mine[1]	513	606	317	314	e400
Cultured quartz	849	583	329	575	757
Imports of natural quartz crystal:[2]					
Quantity	187	265	165	428	816
Value	$183	$394	$459	$216	$402
Exports of electronic- and optical-grade quartz crystal:					
Natural:					
Quantity	188	370	NA	NA	91
Value	$1,626	$1,371	NA	NA	$366
Cultured:					
Quantity	457	133	NA	NA	219
Value	$9,282	$2,634	NA	NA	$3,209
Total:					
Quantity	645	502	NA	NA	310
Value	$10,908	$4,005	NA	NA	$3,575
Consumption of quartz crystal	349	280	261	284	418
Natural (electronic and optical grade)	159	56	24	15	25
Cultured	190	224	237	269	393

eEstimated. NA Not available.

[1]Includes lasca and some specimen and jewelry material.

[2]Includes electronic grade, optical grade, and lasca (a feedstock for growing cultured quartz).

DOMESTIC PRODUCTION

In 1980, various grades of natural quartz were produced in Arkansas by Ocus Stanley, Mount Ida, Ark.; Terry Mining Co., Midwest, Okla.; and Coleman Crystal, Inc., Jessieville, Ark. Total production was estimated to be 400,000 pounds. In 1980, U.S. production of cultured quartz crystal, for use in the quartz-cutting industry, totaled 757,000 pounds from seven companies in five States, an increase of 32% compared with 575,000 pounds produced by eight companies in 1979. The producers were Motorola, Inc., Chicago, Ill.; Electro Dynamics Corp., and Thermo Dynamics Corp., both in Shawnee-Mission, Kans.; Western Electric Co., Inc., North Andover, Mass.; Sawyer Research Products, Inc., Eastlake, Ohio; Bliley Electric Co., Cortland, Ohio (plant in Pennsylvania); and P. R. Hoffman Co., Carlisle, Pa.

CONSUMPTION AND USES

U.S. consumption of lasca (a grade of nonelectronic natural quartz primarily used as feedstock for growing cultured quartz crystal) by seven crystal growers in 1980 was 1,026,000 pounds, a 26% increase over the 815,000 pounds reported in 1979.

U.S. consumption of both natural and cultured electronic- and/or optical-grade quartz crystal in 1980 totaled 418,000 pounds, a 47% increase over that reported in the previous year. Of the 1980 total, natural quartz crystal used in the electronic industry was 25,000 pounds compared with 15,000 pounds in 1979, and cultured quartz crystal consumption was 393,000 pounds compared with 269,000 pounds in 1979.

In 1980, 37 companies in 14 States reported consumption of quartz crystal, compared with 36 companies in 14 States in 1979. Of the 1980 total, 27 companies consumed only cultured quartz crystal, 2 consumed natural quartz crystal only, and 8 consumed both natural and cultured material.

In 1980, the Bureau of Mines revised the survey form for quartz crystal to improve the data collection. Companies that only manufacture finished crystal units from purchased blanks were not canvassed because these data are collected by the Bureau of the Census and also by the Electronics Industry Association (EIA) on a voluntary basis to members.

STOCKS

Reported industry stocks of quartz crystal (cultured and natural electronic- and/or optical-grade) totaled approximately 142,000 pounds at yearend 1980. Of this total, 62,000 pounds was natural and 82,000 pounds was cultured. Compared to yearend 1979 stocks, natural quartz crystal stocks had decreased by 26,000 pounds and cultured had decreased by 136,000 pounds.

PRICES

The average reported value for lasca consumed for the production of cultured quartz crystal in 1980 was $0.60 per pound, a 9% increase over the $0.55 per pound reported in 1979. The average value for cultured quartz crystal, based on reported sales of 251,700 pounds in 1980, was $35.32 per pound. Of the total 1980 sales, the value of "as grown" crystal was $28.60 per pound, and that for "lumbered" crystal was $37.08 per pound.

FOREIGN TRADE

U.S. exports of cultured (electronic- and/or optical-grade) quartz crystal in 1980 totaled 219,000 pounds, valued at $3.2 million. Exports of high-quality cultured quartz crystal, at an average value of $27.36 per pound, totaled 84,100 pounds. Of this total, 70,500 pounds was exported to Japan (53,600 pounds) and the Federal Republic of Germany (16,900 pounds). Approximately 45,000 pounds at an average value of $3.30 per pound was also exported in 1980 under the cultured crystal classification.

U.S. exports of natural quartz crystal in 1980 totaled 91,400 pounds valued at $366,000 ($4.02 per pound). Approximately 33,000 pounds of this was valued at an average of $5.47 per pound. Countries that received natural quartz crystal at an average value of over $4.00 per pound in 1980 were Hong Kong, Japan, Poland, Switzerland, and the Federal Republic of Germany. In addition to that shown in table 5, approximately 465,000 pounds was exported in 1980 at an average U.S. Customs value of less than $2.50 per pound under the classification of natural quartz crystal.

U.S. imports of natural quartz, all of which was designated as "Crude Brazilian Pebble" in 1980, totaled 816,000 pounds, an increase of 91% (428,000 pounds) over that of 1979. U.S. Customs value of the 1980 imports was $402,000 or $0.49 per pound. Of the total quantity imported, Brazil supplied 692,000 pounds valued at $325,400. The low average value per pound ($0.47) indicated that all monthly shipments of quartz crystal from Brazil constituted lasca. Other principal sources of imported natural quartz crystal in 1980 were Argentina (75,000 pounds), Japan (45,000 pounds), and the United Kingdom (3,750 pounds). Imports from the United Kingdom were valued from $0.66 per pound to $25.00 per pound. A small quantity (29 pounds valued at $780) was also imported from Canada during the year.

STAUROLITE[24]

Staurolite is a naturally occurring, complex, hydrated aluminosilicate of iron having a variable but uncertain composition. Its formula can be generalized as $Fe_2Al_9Si_4O_{22}(OH)_2$. The mineral most commonly occurs as opaque reddish-brown to black crystals with specific gravity ranging from 3.74 to 3.83 and Mohs' hardness between 7 and 8.

A limited rock-shop trade in cruciform twinned staurolite crystals ("fairy crosses") exists, notably from deposits in Georgia, North Carolina, and Virginia. Staurolite in the United States was produced commercially in 1980 by E. I. du Pont de Nemours & Co. and by Associated Minerals (U.S.A.) Ltd., Inc. The plant of the latter was not in operation for much of 1980. The plant also changed ownership; Associated Minerals Consolidated Ltd., a member of the Gold Fields group, bought the plant for $11.7 million from Titanium Enterprises, Inc., to strengthen its position in the U.S. rutile market and to supplement its dwindling Australian rutile output. An additional $6 million is planned to be invested in various improvements, mostly related to the titanium minerals.[25] This staurolite is a byproduct of heavy-mineral concentrates recovered from a glacial age beach sand in Clay County, north-central Florida. The staurolite is removed by means of electrical and magnetic separation after the concentrates have been scrubbed and chemically washed with caustic, rinsed, and dried. The resulting fraction produced is comprised of about 77% clean, rounded, and uniformly sized grains of staurolite, with minor proportions of tourmaline, ilmenite and other titanium minerals, kyanite, zircon, and quartz. A nominal composition of this staurolite sand is 45% Al_2O_3 (minimum), 18% Fe_2O_3 (maximum), 3% ZrO_2 (maximum), 5% TiO_2 (maximum), and 5% SiO_2.

Although originally marketed only as an ingredient in some portland cement formulations, staurolite is now marketed as a specialty sand under the trade name "Biasill" for use as a molding material in iron and nonferrous foundries, owing to its low rate of thermal expansion, high rate of thermal conductivity, and high melting point. It is also used as an abrasive for impact finishing metals and sandblasting buildings under the trade names "Starblast" (80 mesh) and "Biasill" (90 mesh), as well as a coarse grade (55 mesh).

Quantitative production data are not released for publication, but the 1980 output of staurolite decreased 20% from that of 1979; shipments decreased 41% in tonnage and increased 49% in price per ton from 1979. Domestic productive capacity is 135,000 tons to 160,000 tons per year.

Staurolite is also produced in India in small quantities and sometimes by other nations as well.

STRONTIUM[26]

Domestic consumption of primary strontium on a carbonate basis in 1980, 23,940 short tons, was unchanged from that of 1979. Imports of strontium minerals were 38,646 tons in 1980 and 43,956 tons in 1979. Imports of various strontium compounds were 2,932 tons in 1980 and 5,861 tons in 1979.

Legislation and Government Programs.—Government stockpiles contained 13,415 tons of nonstockpile-grade celestite (strontium sulfate) at yearend 1980, almost unchanged from that of 1979. This material was available for disposal throughout the year, but no sales were made.

DOMESTIC PRODUCTION

Strontium minerals have not been produced commercially in the United States since 1959. However, a number of firms produced strontium compounds from imported celestite.

Table 6.—Major producers of strontium compounds in 1980

Company	Location	Compounds
Baker, J. T. Chemical Co	Phillipsburg, N.J	Various.
Barium and Chemicals, Inc	Steubenville, Ohio	Do.
C-E Minerals (Div. of Combustion Engineering, Inc.)	King of Prussia, Pa	Sulfate.
Chemical Products Corp	Cartersville, Ga	Carbonate.
FMC Corp	Modesto, Calif	Carbonate and nitrate.
M & T Chemicals, Inc	Baltimore, Md	Various.
Mallinckrodt Chemical Works	St. Louis, Mo	Do.
Milwhite Co., Inc	Houston, Tex	Sulfate.
Mineral Pigments Corp	Beltsville, Md	Other.

CONSUMPTION AND USES

Domestic consumption of strontium in the manufacture of various primary strontium compounds remained steady at 23,940 tons in 1980 on a strontium carbonate basis, of which 78% was consumed as strontium carbonate, 14% as strontium nitrate, and the balance mostly as strontium sulfate or processed celestite. In terms of end use in 1980, 67% of the total was consumed in television picture tubes, 12% in pyrotechnics, 5% each in ferrites and purifying electrolytic zinc, and the balance in other uses. Domestic consumption of primary strontium was 23,940 tons in 1979 and 23,770 tons in 1978; the distribution by end use is shown in table 7. Additional amounts were consumed directly as crude celestite in all 3 years, usually in pigments (white filler) or in purifying electrolytic zinc. Although quantitative information concerning consumption is incomplete, sales of domestically produced strontium carbonate to manufacturers of glass for color television picture tube faceplates appeared to have increased significantly in 1980 over that of 1979. Consumption of strontium carbonate in the manufacture of ferrite ceramic permanent magnets decreased in 1980, as did strontium nitrate in the manufacture of pyrotechnics and signals. Miscellaneous uses included plastics, toothpaste, pharmaceuticals, paint, electronic components, drilling mud, welding fluxes, and the making of electrolytic zinc metal. Small quantities of strontium metal were produced by research companies.

Table 7.—Distribution of primary strontium compounds

(Percent)

	1978	1979	1980
Ferrite ceramic magnets	8	10	5
Pigments and fillers	2	4	4
Purifying electrolytic zinc	4	7	5
Pyrotechnics and signals	19	16	12
Television picture tube faceplates	57	57	67
Other	10	6	7
Total	100	100	100

PRICES

At yearend, prices quoted in the Chemical Marketing Reporter[27] were as follows: Strontium carbonate—glass grade, bags, truckloads, works, 28 to 28.75 cents per pound in 1980; strontium nitrate—bags, carlots, works, $24 per 100 pounds in 1980. Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published. The average value of imported strontium minerals at foreign ports was $55.56 per ton in 1980, up $2.44 from 1979.

FOREIGN TRADE

Imports of strontium minerals in 1980 decreased from 43,956 tons in 1979 to 38,646 tons in 1980. Almost all of the material was imported from Mexico in both years. Imports of various strontium compounds decreased to 2,932 tons in 1980 from 5,861 tons in 1979. The Federal Republic of Germany was again the principal source of compounds, providing 2,100 tons to the United States in 1980, compared with 3,927 tons in 1979. Quantitative data on U.S. exports of strontium compounds were not available. On October 21, 1980, the U.S. International Trade Commission made a preliminary determination that strontium nitrate from Italy was being sold at less than fair value (dumped). It also determined that strontium carbonate from the Federal Republic of Germany was not being dumped, thus terminating the case.

Table 8.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1979		1980	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Canada	183	$8	--	--
Mexico	43,406	2,304	37,817	$2,086
Spain	--	--	829	60
Turkey	367	22	--	--
U.S.S.R	--	--	(2)	1
Total	43,956	[3]2,335	38,646	2,147

[1]Strontianite (strontium carbonate) and celestite (strontium sulfate).
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Table 9.—U.S. imports for consumption of strontium compounds, by country

Country	1979		1980	
	Pounds	Value	Pounds	Value
Strontium carbonate, not precipitated:				
Canada	1,500	$500	--	--
Germany, Federal Republic of	79,366	14,765	--	--
Total	80,866	15,265	--	--
Strontium carbonate, precipitated:				
Canada	14,294	7,147	317,462	$70,560
China, mainland	2,205	565	--	--
Germany, Federal Republic of	7,682,615	1,498,128	4,118,201	920,465
United Kingdom	1	399	2	364
Total	7,699,115	1,506,239	4,435,665	991,389
Strontium chromate:[1]				
Canada	420,370	435,630	483,525	525,411
Germany, Federal Republic of	39,683	7,485	--	--
Total	460,053	443,115	483,525	525,411
Strontium nitrate:				
Canada	425	391	--	--
France	220	533	--	--
Germany, Federal Republic of	1,872	4,326	--	--
Ireland	--	--	29	628
Italy	3,085,558	792,467	816,363	269,100
Total	3,088,075	797,717	816,392	269,728
Strontium compounds, n.s.p.f.:				
Canada	22,121	1,480	--	--
Germany, Federal Republic of	50,484	69,915	82,460	66,421
Italy	276,899	65,419	--	--
Japan	44,489	28,544	45,205	32,922
United Kingdom	3	540	577	1,783
Total	393,996	165,898	128,242	101,126
Grand total	11,722,105	2,928,234	5,863,824	1,887,654

[1]Imported as strontium chromate pigment (TSUS 473.19).

Table 10.—Strontium minerals: World production, by country[1]

(Short tons)

Country[2]	1976	1977	1978	1979[p]	1980[e]
Algeria	7,147	[r]5,622	6,418	[e]6,000	6,000
Argentina	2,264	[r]925	1,317	134	[3]209
Canada[e]	13,200	--	--	--	--
Iran[e 4]	6,000	11,000	16,535	[r]11,000	5,500
Italy	[e]770	[e]770	402	1,866	1,300
Mexico	24,424	50,302	36,563	[r e]38,500	33,000
Pakistan	665	402	239	680	670
Spain	[r e]9,100	12,120	15,430	19,840	20,000
Turkey	[e]7,000	[e]18,300	16,038	9,058	10,000
United Kingdom	5,952	5,622	4,740	6,600	5,500
Total	[r]76,522	[r]105,063	97,682	93,678	82,179

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 22, 1981.
[2]In addition to the countries listed, mainland China, the Federal Republic of Germany, Poland, and the U.S.S.R. produce strontium minerals, but output is not reported quantitatively and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Year beginning March 21 of that stated.

WORLD REVIEW

Deposits of strontium minerals are numerous throughout the world, but over three-quarters of known world production is usually from five major producing countries. In the 1976-80 time period, Canada dropped from the ranks of major producers and Iran rose into the ranks. Mexico, Turkey, Spain, and Algeria have continued as major producers. World production of these minerals has dropped since 1977.

Spain.—Bruno S.A. is building a new strontium compounds plant near the port of Motril in the Province of Granada. The plant will initially produce 1,500 to 2,000 tons of strontium carbonate annually and was scheduled to come onstream in late 1980. The plant will use celestite from the Montevive Mine, which itself has undergone a major expansion and modernization in the last few years.[28]

TECHNOLOGY

A new tooth-filling material that is now the only commercially available substitute for silver amalgam is composed of a strontium glass and an acrylic resin. This material, containing strontium glass, does not disintegrate slowly, as do similar materials made with barium glass or quartz glass. Because the material is costly, it may or may not be able to displace the silver amalgam.[29]

WOLLASTONITE[30]

Wollastonite is a natural calcium metasilicate, usually white or light-colored, and has a theoretical composition of $CaO \cdot SiO_2$, equivalent to 48.3% lime combined with 51.7% silica. The largest single use for wollastonite has been in ceramic mixes for floor and wall tile. The mineral is also used for glazes and enamels; as a pigment and extender for paints; as a filler for plastics, rubber, and asphalt products; and in other applications.

Wollastonite output in the United States in 1980 was some 20% greater in quantity than in 1979. Output data are withheld to avoid disclosing company proprietary data. The two producers were NYCO, a division of Processed Minerals, Inc., Essex County, N.Y.; and R. T. Vanderbilt Co., Inc., Lewis County, N.Y.

NYCO announced plans to construct a 10,000-ton-per-year plant to meet a growing demand for surface-modified wollastonite. This material has been gaining favor as an enhancer of corrosion resistance in maintenance paints.[31] Another end use for the wollastonite is in engineering resins, phenolic molding compounds, urethanes, and epoxies. New markets that are said to have opened for wollastonite are in thermoset molding compounds, sealants, casting plaster, roofing compounds, and thermal insulation board. Measured wollastonite reserves at the NYCO operation at Willsboro, N.Y., were reported to be 12 million tons, with another 4 million tons of indicated reserves.[32]

A comprehensive journal article not only discussed the different types of plastics but also several mineral fillers, such as wollastonite.[33] Considerable attention was reportedly being given to wollastonite for use in latex paint formulations to eliminate the need for ammonium hydroxide or an amine to control pH. At the rate of 50 pounds of wollastonite per 100 gallons of latex paint, pH can reportedly be increased to desirable levels, and package stability and color acceptance can be improved.[34]

A paper by two German authors discussed background information and development work on synthetic wollastonite and other synthetic alkaline earth silicates made from readily available raw materials such as limestone, dolomite, and quartz flour. In the Federal Republic of Germany, natural wollastonite is too expensive for use as a basis material for ceramics, and hence the interest in doing development work. Included in the paper are descriptions of individual synthesis processes and also some comments on economics.[35]

Chemical Marketing Reporter, December 29, 1980, quoted the price of paint-grade wollastonite, 400-mesh, bagged, in carload lots, f.o.b. works, as $106 per ton; 325-mesh material, $90 per ton. The American Paint & Coatings Journal, December 29, 1980, quoted the price of paint-grade wollastonite, 400-mesh, in carload lots, f.o.b. plant, as $92 per ton; and 325-mesh material as $76 per ton.

ZEOLITES[36]

Production of natural zeolites in the United States in 1980 was, again, approximately 5,000 tons. The markets for sustained production have yet to emerge, but indications are that the large amount of applications research will open several markets in the near future.

The feature article in the February issue of *Industrial Minerals* was on zeolites.[37] The article, alluding to ". . .this, perhaps the most exciting of all industrial minerals, . . ." tells of the great potential for this family of minerals and suggests that, because zeolites are beginning to enter many major market areas, the period between 1980 and 2000 could be the major test and acceptance years for them.

Analysis of the world sales data for 1978 in the above-mentioned article reflects that the markets for natural zeolites are not yet really coming from the emerging technology. Europe, with 63% of the world market of 248,000 tons, uses the majority of its natural zeolites in markets that existed prior to the knowledge that the material used was zeolitic. These are building and dimension stone, cement production, and low-density insulating material. The next largest use, in the Far East, is as a filler in the paper industry. Japan's necessity to import the higher grades of kaolin suitable for paper use probably is a factor in this market. All the rest, a nominal 20% of the tonnage, can be assumed to come from emerging technology for such uses as gas absorption, waste water treatment, soil applications, livestock uses, a variety of consumer uses, and experimentation.

An interesting note on livestock, fish, and agricultural uses was found in another article, which stated that zeolite-fed pigs gained 120% to 130% of the weight on 85% to 90% of the food when compared with nonzeolite-fed pigs.[38] Salmon gained 116% in weight. Soil applications of zeolites gave apparent increases in yield over controls of 63% with carrots, 15% with wheat, 28% with apples, and 17% with rice.

Another interesting article on utilization data revealed that in Hungary, owing to the absence of zeolite synthesis capability, ammonium exchanged hydrogen forms of natural zeolites are used for catalytic cracking of hydrocarbons.[39] The ores, from the Tokaj Mountains, contain about 65% to 70% mordenite and clinoptilolite. The associated impurities apparently have no serious disadvantages.

Some economic estimates and forecasts from the above article and another are of interest.[40] World sales data are estimated for a few dates for the 15-year period from 1965 through 1979. Trend analysis of the data reveals a very satisfactory 4.6% average annual growth rate for sales quantity and 4.8% for value. The estimated average sales value of natural zeolites was $125 per ton. This, of course, included both the unprocessed and highly processed material. If the world potential envisioned were reached and the average value were the same, then annual sales of natural zeolites would be between 9.6 and 18.4 million tons.

There were no new data supporting the proposal that erionite may be a causative factor in the Turkish villages having high mesothelioma rates. There were new speculations on possible hazards where erionite could be encountered such as the MX missile sites proposed for Nevada and Utah. Objective data seem to agree with Dr. Frederick Mumpton. Dr. Mumpton states, "The findings. . .suggest that no relationship exists between the existence of zeolites in this region and the incidence of malignant disease."[41]

Mainland China has joined the group of nations claiming zeolite deposits. A deposit containing 10 million tons of unspecified zeolite was reported discovered near Changchum in Jilin Province.

A recent paper tells of finding uranium associated with natural zeolites in Nevada.[42] The clinoptilolite, analcime, and erionite were able to absorb and concentrate 0.7% of uranium from solution. Indications are that this might present a valid new uranium exploration model and also a method of recovery of uranium from leached ores.

A Japanese inventor expressed interest in a U.S. source or sources for very large amounts of zeolites (probably clinoptilolite). The zeolites were to be used with Japanese machinery and a patented process to make an odorless, efficient plant nutrient from chicken manure for the U.S. market. Both the domestic poultry and natural zeolite industries expressed interest in the process.

The synthetic zeolite industry continues its growth. Zeolitic cracking catalysts now have an estimated 92% of the world market and this produced something over $300 million for the manufacturers in 1978. One paper said that the use of the zeolite cracking catalysts "is currently saving the United States several hundred million barrels of crude oil per year."[43] Ashland Oil, Inc., announced a new fluid catalytic cracking process that reportedly yielded the same amount of gasoline from 20% less crude by more efficiently using the heavier crudes. The key proprietary catalyst, ostensibly a zeolite, is not affected by the poisoning heavy metals.

Mobil Oil Corp.'s ZSM-5 catalyst that produces high-octane gasoline from methanol in one step was receiving much attention. The process, methanol to gasoline, is referred to by the initials MTG.

In addition to the New Zealand Government plant that used natural gas for the methanol feed (mentioned in the 1978-79 chapter), a fluidized bed MTG plant with a 100-barrel-per-day methanol feed was being built in the Federal Republic of Germany, and two domestic plants using at least part of their medium-Btu coal gas for the MTG route to gasoline are planned. Economic studies of the New Zealand plan showed that the natural gas-fed MTG process had an overwhelming economic advantage over the Fischer-Tropsch technology used by SASOL (South African Coal, Oil, and Gas Corp., Ltd.).[44] MTG would produce gasoline at two-thirds the cost of the other technology but would produce no jet or diesel fuel directly and a very limited range of hydrocarbons. The MTG process is gaining favor as a route to coal liquefaction because it sidesteps the heavy demand for hydrogen in direct liquefaction processes.

The zeolites-for-detergents market appears to be booming with new production capacity being brought in in Europe and the United States. Akzo Chemie BV in the Netherlands has plans for extending its capacity to 40,000 metric tons per year if expected legislation favors the market. Union Carbide and Italy's ANIC (part of the ENI Group) are planning a 35,000-metric-ton-per-year zeolite plant for the detergent industry. Domestically, the PQ Corp. announced that it will build a 130-million-pound-per-year zeolite plant to serve the merchant detergent market.

W. R. Grace & Co. is reportedly about to start zeolitic fluid cracking catalyst production in Europe. This company, Engelhard Minerals & Chemicals Corp., and Filtrol Corp. have been accused by Akzo Chemie in a complaint to the European Economic Commission of "dumping" the catalysts in Europe at prices 40% below those charged U.S. customers.

United Catalysts, Inc. (UCI), dedicated the new plant of Zeochem Co. in Louisville, Ky. This plant, in partnership with the Swiss firm Chemische Fabrik Uetikon, will manufacture zeolites for the general molecular sieve market using the Swiss firm's technology.

Union Carbide Corp.'s Linde Div. has a new gas separation process that is reportedly a great improvement over its pressure-swing-absorption (PSA) process. The new process employs pressure-swing parametric pumping across a single absorbent bed. For air separation, it is possible to obtain from this single bed a continuous separation that consists of 90% to 95% (by mole) oxygen with the remainder nitrogen and argon. Water is also separated out. The company is now marketing a small version that can make up to 6 liters per minute of up to 90% oxygen for home and medical uses and also units for high tonnage.

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[1]Prepared by Richard H. Singleton, supervisory physical scientist.

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