FLUORSPAR

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Traditionally, fluorspar has been considered to be vital to the Nation's national security and economy. It is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involve either acid grade, which is greater than 97% calcium fluoride (CaF₂), or subacid grade, which is 97% or less CaF₂. The latter includes metallurgical and ceramic grades and is commonly called metallurgical grade.

All domestic sources of fluorspar are derived from sales of material from the National Defense Stockpile (NDS) and from a small amount of synthetic fluorspar produced from industrial waste streams. Byproduct fluorosilicic acid production from some phosphoric acid producers supplements fluorspar as a domestic source of fluorine, but is not included in fluorspar production or consumption calculations. According to the U.S. Census Bureau and the U.S. Geological Survey (USGS), imports of fluorspar decreased by 5% compared with those of 1998. Hydrofluoric acid (HF) imports decreased by 3% when compared with those of 1998.

Legislation and Government Programs

In accordance with the Strategic and Critical Materials Stock Piling Act as amended (50 U.S.C. section 98h-2), the Defense Logistics Agency, Defense National Stockpile Center (DLA-DNSC), was authorized to sell about 45,400 metric tons (t) (50,000 short dry tons) of metallurgical grade and about 109,000 t (120,000 short dry tons) of acid grade during fiscal year 1999 (October 1, 1998 to September 30, 1999). During calendar year 1999, DLA-DNSC sold about 75,300 t (specifically, 82,966 short dry tons) of acid grade and only about 1,230 t (specifically, 1,356 short dry tons) of metallurgical grade. The sale of acid-grade material exhausted the last remaining NDS inventory.

According to the DLA-DNSCs' revised fiscal year 2000 (October 1, 1999 to September 30, 2000) Annual Materials Plan, total sales of about 54,400 t (60,000 short dry tons) of metallurgical grade were authorized. At the current rate of sales, the metallurgical-grade NDS will be exhausted in a couple of years.

Production

In 1999, there was no domestic mine production of fluorspar, and there is no data survey for byproduct fluorspar. Domestic production data for fluorosilicic acid were developed by the USGS from voluntary surveys of U.S. operations. Of the 11

fluorosilicic acid operations surveyed, 10 respondents reported production, and 1 respondent reported zero production, representing 100% of the quantity reported.

Hastie Mining Co. washed, screened, and dried metallurgicaland acid-grade fluorspar imported or purchased from the NDS. Seaforth Mineral & Ore Co., Inc., dried and screened imported or NDS fluorspar at its facilities at Cave-In-Rock, IL, and East Liverpool, OH, as did Applied Industrial Materials Corp. at its facility at Aurora, IN.

In 1999, 5 companies operated 10 plants that processed phosphate rock for the production of phosphoric acid and produced 69,200 t of byproduct fluorosilicic acid and sold or used 69,100 t of byproduct fluorosilicic acid at a value of about \$9.47 million. This was equivalent to approximately 122,000 t of fluorspar (grading 92% CaF₂) sold or used. This was a nearly 3% increase in the level of fluorosilicic acid output compared with that of 1998. Because fluorosilicic acid is a byproduct of the phosphate fertilizer industry and is not manufactured for itself alone, shortages may occur when phosphate fertilizer production goes down.

Some synthetic fluorspar was recovered as a byproduct of uranium processing, petroleum alkylation, and stainless steel pickling. The majority of the marketable product was estimated to come from uranium processing. Greater restrictions on the disposal of industrial wastes and improvements in recovery processes may lead to greater recovery from nonuranium sources. At present, an estimated 10,000 t of synthetic fluorspar is produced annually in the United States.

Environment

As part of the Montreal Protocol, officials from 129 nations agreed on a 3-year funding package to enable developing countries to continue their efforts to phase out chlorofluorocarbons (CFC's) and other ozone-depleting chemicals. The funds will be used to support the adoption of more ozone-friendly technologies for consumer products and industrial processes. In 1999, the fund's executive committee approved major agreements with China and India to finance the shutdown of the CFC production facilities in the two countries during the next 10 years (Hess, 1999).

According the United Nations Environment Program, an international agreement to curtail illegal trade in CFC's and other ozone-depleting chemicals went into effect on November 10, 1999. The agreement, which was authorized through an amendment to the Montreal Protocol in 1997, requires nations to create licensing systems for international sales of ozone-depleting chemicals. The licensing systems will regulate

exports of CFC's, carbon tetrachloride, halons, hydrobromofluorocarbons, hydrochlorofluorocarbons (HCFC's), methyl bromide, and methyl chloride (Chemical Market Reporter, 1999b). The illegal trade in these chemicals has slowed the introduction and use of ozone-friendly replacement chemicals.

Consumption

Domestic consumption data for fluorspar were developed by the USGS from voluntary surveys of U.S. operations (table 2). The consumption survey was sent to 42 operations quarterly and to 3 small operations annually. In 1999, on average, 37 operations responded to the consumption surveys, representing 82% of those operations surveyed. These respondents accounted for 98% of the reported U.S. consumption. Estimates for nonrespondents were based on past consumption levels, trends, and nonsurvey sources. Owing to the existence of additional consumers that are not surveyed, the reported consumption figures are estimated to constitute about 89% of the actual U.S. annual consumption.

Traditionally, there have been three grades of fluorspar: acid grade, containing more than 97% CaF₂; ceramic grade, containing 85% to 95% CaF₂; and metallurgical grade, containing 60% to 85% or more CaF₂. During the last several decades, there has been a general movement toward the use of higher quality fluorspar by many of the consuming industries. For example, welding rod manufacturers may use acid-grade fluorspar rather than ceramic grade, and some steel mills use ceramic or acid grade rather than metallurgical grade. The following is a discussion of the general uses of fluorspar by grade, and, in the case of acid grade, the uses of some of its important downstream products.

Acid-grade fluorspar was used primarily as a feedstock in the manufacture of HF and in the production of aluminum fluoride (AlF₃). Two companies reported fluorspar consumption for the production of HF, E.I. du Pont de Nemours and Company, Inc., and Honeywell International Inc. Honeywell is a new name in the global fluorochemicals business. In late 1999, AlliedSignal Corp. and Honeywell Inc. completed a merger that launched a global technology company. Although the merger was made because of complementary technology businesses, the new company retained AlliedSignal's specialty chemicals, performance fibers, plastics, and advanced materials businesses. The fluorochemicals business is now part of Honeywell Specialty Chemicals (Honeywell Inc., December 1, 1999, AlliedSignal-Honeywell Merger Receives Clearance From European Commission, press release, accessed December 7, 1999, via URL http://www.honeywell.com/).

The largest use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFC's), HCFC's, and fluoropolymers. HCFC's and HFC's were produced by the following eight companies: Ausimont USA, Inc.; DuPont; Elf Atochem North America, Inc.; Great Lakes Chemical Corp.; Honeywell; I.C.I. Americas, Inc.; La Roche Chemicals, Inc.; and MDA Manufacturing Ltd. The latter is a joint venture between Daikin America Inc. and 3M Corp. to produce HCFC 22 and hexafluoropropane for captive

use in fluoropolymer manufacturing.

Some of the current or potential fluorocarbon replacements for the banned CFC's are HCFC's 22, 123, 124, 141b, 142b, and 225. These HCFC substitutes have ozone-depletion potentials that are much lower than those of CFC's 11, 12, and 113, which together have accounted for more than 90% of CFC consumption. HCFC 22 has been used as a high-pressure refrigerant (e.g., in home air conditioning) for years, HCFC 123 is being used as a replacement for CFC 11 in low-pressure centrifugal chillers, HCFC 124 is a potential replacement for CFC 114 in medium-pressure centrifugal chillers and may replace CFC 12 as a diluent in sterilizing gas, and HCFC's 141b and 142b have replaced most of the CFC's 11 and 12 used in foam blowing. HCFC's 141b and 225, perfluorocarbons, and hydrofluoroethers have been introduced as replacements for CFC solvents. However, because of the current phaseout schedule for HCFC's, the market for HCFC's will exist for only a short time, and perfluorocarbons are on the list of gases that contribute to global warming. Of most immediate concern is the ban on production and importation of HCFC 141b, which goes into effect on January 1, 2003.

The HFC replacements have no ozone-depletion potential because they contain no chlorine atoms. The most successful HFC replacement compound is HFC 134a. It is the main replacement for CFC 12 in automobile air conditioners and is being used as the refrigerant in new commercial chillers and refrigerators and as the propellant in aerosols and tire inflators. HFC's 23, 32, 125, 143a, and 152a also are being produced domestically but in much smaller quantities. These HFC's hold potential for use by themselves or more likely as blends for specific uses, such as the azeotropic mixture of HFC's 32 and 125 that is emerging as the replacement of choice for HCFC 22. HFC's 134a and 227ea are being evaluated for use in medical aerosols. HFC 245fa may be a candidate for use as a lowpressure refrigerant to replace HCFC 123. HFC's 245fa and 356 are being tested as potential replacements for HCFC 141b in blowing agents for thermosets, such as polyurethane. HFC 4310 has been developed as a replacement for CFC 113, HCFC's, and perfluorocarbons for use in drying fluids, cleaning and rinsing agents, defluxing agents, and heat-transfer media. HCFC's 22, 123, and 124; HFC's 23, 125, 134a, and 227ea; and a number of other fluorine compounds have been approved by the U.S. Environmental Protection Agency as acceptable substitutes (some subject to use restrictions) for halon streaming agents for fire suppression.

CFC 113, HCFC's 22 and 142b, and HFC 152a were produced as chemical intermediates in the production of fluoropolymers. Fluoropolymers have desirable physical and chemical properties that allow them to be used in products from pipes and valves to architectural coatings to cookware. These intermediate uses of CFC 113 and HCFC's 22 and 142b will not be subject to the production phaseouts mandated by the Montreal Protocol and the Clean Air Act Amendments of 1990 because these products are consumed in the manufacturing process.

HF was consumed in the manufacture of uranium tetrafluoride, which was used in the process of concentrating uranium isotope 235 for use as nuclear fuel and in fission explo-

sives. It also was used in stainless steel pickling, petroleum alkylation, glass etching, treatment of oil and gas wells, and as a cleaner and etcher in the electronics industry. HF was used as the feedstock in the manufacture of a group of inorganic fluorine chemicals that include chlorine trifluoride, lithium fluoride, sodium fluoride, sulfur hexafluoride, tungsten hexafluoride, and others that are used in dielectrics, metallurgy, wood preservatives, herbicides, mouthwashes, decay-preventing dentifrices, and water fluoridation.

Currently the AlF₃ manufactured for use in aluminum reduction cells is produced directly from acid-grade fluorspar or byproduct fluorosilicic acid. In the Hall-Héroult process, alumina is dissolved in a bath of molten cryolite, AlF₃, and fluorspar to allow electrolytic recovery of aluminum. On average worldwide, the aluminum industry consumes about 21 kilograms of fluorides for each metric ton of aluminum produced; this ranges from 10 to 12 kilograms per metric ton (kg/t) in a modern prebaked aluminum smelter to 40 kg/t in an older Soderberg smelter without scrubbers. AlF₃ was added to the electrolyte in reduction cells to improve the cells' electrical efficiency. AlF₃ was used by the ceramic industry for some body and glaze mixtures and in the production of specialty refractory products. It was used in the manufacture of aluminum silicates and in the glass industry as a filler.

Ceramic-grade fluorspar was used by the ceramic industry as a flux and an opacifier in the production of flint glass, white or opal glass, and enamels. Ceramic grade was also used to make welding rod coatings and as a flux in the steel industry.

Metallurgical-grade fluorspar was used primarily as a fluxing agent by the steel industry. Fluorspar is added to the slag to make it more reactive by increasing its fluidity (by reducing its melting point) and thus increasing the chemical reactivity of the slag. Reducing the melting point of the slag brings lime and other fluxes into solution to allow the absorption of impurities. Fluorspar of different grades was used in the manufacture of aluminum, brick, cement, and glass fibers and by the foundry industry in the melt shop.

Any ill effects experienced by the metallurgical-grade market as a result of the dramatic increases in steel imports in 1998 and 1999 should have passed. In 1998, the United States imported 33% more steel than in 1997, but imports decreased by 14% in 1999 compared with those of 1998 (although this quantity was still 14% higher than that of 1997). Total steel shipments increased by 2.6% in 1999, but production actually decreased by 1.4%. This apparent contradiction is explained by the decrease in imports and the drawdown of excess inventories that had accumulated in 1998. A better indication of the recovery is evident when comparing the rate of capacity utilization. In the first three quarters of 1999, the utilization rate averaged only 79.7%, but in the fourth quarter, the utilization rate had risen to an average of 88.6%, and by the first quarter of 2000, it had risen to 90.4%.

The merchant-fluorspar market includes metallurgical-grade and acid-grade sales to steel mills, foundries, glass plants, welding rod manufacturers, and other small markets in rail car, truckload, and less than truckload quantities. This merchant market is mature and in the United States amounts to about 110,000 metric tons per year (t/yr), equally divided between

acid-grade and metallurgical-grade sales. Over the years, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices. The merchant market has been replaced by less expensive or more effective substitutes in industries such as steel and glass.

The level of total reported fluorspar consumption decreased by more than 4% in 1999. A decrease of more than 5% in acid-grade consumption for HF and AlF $_3$ accounted for the overall decrease. Other uses actually increased by nearly 10%, although the data collected for non-HF/AlF $_3$ markets are believed to be underreported and may not accurately reflect the true size of these markets.

About 34,900 t of byproduct fluorosilicic acid valued at \$5.01 million was sold for water fluoridation, about 19,000 t of fluorosilicic acid valued at \$2.12 million was sold to make AlF_3 for the aluminum industry, and about 15,300 t valued at \$2.35 million was sold or used for other uses, such as sodium silicofluoride production.

Stocks

Consumer stocks at yearend totaled 90,500 t, which was a decrease of 32% from 1998 levels. Consumer and distributor stocks totaled of 373,000 t, which included 282,000 t purchased from the NDS but still located at NDS depots. As of December 31, 1999, the NDS fluorspar inventory classified as excess (excluding material sold pending shipment) contained only about 146,000 t (161,000 short dry tons) of metallurgical-grade material. About 40% of the remaining metallurgical-grade material was classified as nonstockpile grade.

Transportation

The United States is import dependent for the majority of its fluorspar supply. Fluorspar is transported to customers by truck, rail, barge, and ship. Metallurgical grade is shipped routinely as lump or gravel, with the gravel passing a 75-millimeter (mm) sieve and not more than 10% by weight passing a 9.5-mm sieve. Acid grade is shipped routinely in the form of damp filtercake containing 7% to 10% moisture to facilitate handling and to reduce dust.

Most acid-grade imports come from China and South Africa. Fluorspar is shipped by ocean freight using the "Tramp" market for ships. Bulk carriers of 10,000 to 50,000 tons deadweight normally are used. Participants negotiate freight levels, terms, and conditions. The main participants are (1) charterers, who are generally the buyers or sellers; (2) ship owners, who either own vessels or have them time chartered; (3) operators, who are traders normally taking positions on either cargo or ships; and (4) brokers, who generally represent ship owners or charterers and act as go betweens. Ships are primarily owned by the following: privately held shipping companies, publicly held shipping companies, government-controlled companies, and groups of professionally managed fleets under varying ownership (R.C. Diamond, Mid-Ship Marine, Inc., written commun., 1993).

From 1997 through most of 1999, Asian economies were

experiencing major difficulties. This resulted in reduced shipments of goods and materials to Asia. Construction of new ships outpaced the scrapping of old ships, despite the adoption of the new International Safety Management Code (ISMC), which went into effect on July 1, 1998. The Asian economies are rebounding, and the ISMC is slowly starting to result in the scrapping of older ships. Freight prices have increased as a result (George Kachmar, President, Mid-Ship Logistics, oral commun., March 23, 2000).

Prices

According to Industrial Minerals, yearend price ranges for Mexican fluorspar, f.o.b. Tampico, were unchanged at \$110 to \$130 per metric ton for acid grade, \$130 to \$140 per ton for low-arsenic acid grade, and \$85 to \$105 per ton for metallurgical grade (table 3). The range of South African prices for acid grade, f.o.b. Durban, changed only slightly to \$105 to \$125 per ton. No specific f.o.b. China or c.i.f. Gulf of Mexico prices were available for Chinese fluorspar. According to Industrial Minerals, the average U.S. Gulf port price, dry basis, for acid grade increased to \$127 to \$138 per ton. This would be the average delivered price of Chinese, Mexican, and South African acid grade at Gulf port.

Prices of imported acid-grade fluorspar during the past 10 years have exhibited a roller-coaster pattern of highs and lows (figure 1). Prices have been affected by major factors, such as the severe drop in demand caused by the CFC phaseout, major increases in Chinese exports and the resulting cutthroat competition between Chinese exporters, and the introduction of Chinese export quotas and license fees. Lesser factors that affected prices were sales from the NDS, variations in shipping rates, and changes in import tariffs. The latter is not included in price data derived from trade statistics, which include only the additional costs of insurance and freight.

According to Chemical Market Reporter, the yearend price quotation for anhydrous hydrogen fluoride, tank cars, carload, f.o.b., freight equalized was unchanged at \$0.70 per pound. The quoted price for chemically pure (99.0 weight percent) anhydrous HF, 1,300 pounds, f.o.b., was also unchanged at \$2.96 per pound. The quotation for aqueous HF, 70%, in drums, f.o.b., freight allowed, was unchanged at \$0.65 per pound. The yearend price quotation for hydrofluosilicic acid (fluorosilicic acid), 23% basis, in tanks, Midwest and East Coast terminals, was unchanged at \$165 per short ton. Quoted yearend prices for AlF₃ ranged from \$825 to \$1,408 per metric ton.

Foreign Trade

According to the U.S. Census Bureau, U.S. exports of fluorspar increased by 135% to 55,400 t from the revised 1998 figure (table 4). The 1998 export data were reduced by about 20,000 t, which had been incorrectly reported as fluorspar by the exporter. All U.S. exports were believed to be reexports of material imported into the United States or exports of material purchased from the NDS.

In 1999, imports for consumption of fluorspar decreased by

5% when compared with those of 1998, according to the U.S. Census Bureau and USGS data (table 5). The largest suppliers of fluorspar to the United States were, in descending order, China, South Africa, and Mexico. China accounted for nearly 64% of U.S. fluorspar imports. The average c.i.f. unit value, in dollars per metric ton, was \$124 for acid grade and \$88 for metallurgical grade.

There is no tariff on subacid-grade (metallurgical-grade) fluorspar from normal-trade-relations (NTR) countries, and the tariff on acid grade from NTR countries was eliminated effective January 1, 1999. There are no tariffs on other major fluoride minerals and chemicals, such as natural or synthetic cryolite, hydrofluoric acid, and aluminum fluoride.

Imports of HF decreased by about 3%, to 120,000 t, or a quantity equivalent to approximately 188,000 t of fluorspar (table 6). Imports of synthetic and natural cryolite decreased by 38% to 9,560 t, or a quantity equivalent to approximately 11,500 t of fluorspar (table 7). Imports of AlF_3 decreased by nearly 14% to 19,300 t, or a quantity equivalent to about 29,000 t of fluorspar (table 8).

World Review

It was an interesting and busy year in the fluorspar industry in 1999 that included mine ownership changes, threatened mine closures, production capacity increases, drilling programs, two international fluorspar conferences (in Mexico and the United States), and a major price scare on Chinese exports. World production was essentially unchanged compared with the revised 1998 data (table 9).

Canada.—In 1999, Canada imported 20,100 t of metallurgical-grade fluorspar and 150,000 t of acid-grade fluorspar. Total fluorspar imports were nearly 9% lower than those of 1998. The major sources of supply were, in descending order, Mexico, China, and Morocco (Jane Currie, Minerals and Mining Statistics Division, Natural Resources Canada, written commun., 2000). The two major fluorspar consumers in Canada are the Honeywell HF plant at Amherstburg, Ontario, and Alcan Aluminium Ltd., which produces AlF₃ at its Vaudreuil refinery at Jonquière, Québec.

Burin Minerals Ltd.'s drilling programs on the Blue Beach North and Tarefare deposits at its St. Lawrence, Newfoundland, fluorspar mining project continued through the early part of December and totaled 14,000 meters (m). For the year, the company reported drilling 27 holes on the Blue Beach North deposit and 16 on the Tarefare deposit. Drilling was expected to resume in April 2000, with plans to drill an additional 15,000 m (Burin Minerals Ltd., 1999b).

In August 1999, Burin Fluorspar Ltd., Burin Minerals' parent company, announced a proposed merger with Blue Desert Mining Inc. of Vancouver, British Columbia. The merger was to be a reverse takeover, in that the shareholders of Burin would hold a controlling interest in the new company. The merger was designed to obtain market liquidity for existing shareholders and to provide access to public equity markets for financing additional development work on the fluorspar mining product at St. Lawrence, Newfoundland (Burin Minerals Ltd., 1999a). The merger, which formed the new company Canada

Fluorspar Inc., was not finalized until March 2000.

China.—Determining China's actual production data for acid- and metallurgical-grade fluorspar has always been difficult owing to the lack of official Government data and the complex nature of the network of producers, processors, exporters, and consumers in China. Problems range from an unreliable breakdown of export data by grade to the lack of reliable information on domestic consumption levels, which may include more than 400,000 t/yr of submetallurgical-grade fluorspar for cement and glass manufacturing.

After revising the export license system, the Chinese Ministry of Foreign Trade and Economic Cooperation (MOFTEC) held the first round of bidding in early February 1999 with a second round held in March. The results were export license fees in the \$56-to-\$60-per-metric-ton range. This was an increase of about \$30 to \$34 per metric ton over the previous licenses. Consumers around the world balked at this dramatic price increase, and after a period of extremely low export volumes, MOFTEC held another round of bidding and authorized the export of 500,000 t at about \$39 per ton (S.A. Humphrey, Sourcing Manager, DuPont Fluoroproducts, written commun., May 18, 1999). Apparently MOFTEC authorized additional exports later in the year also at \$39 per ton. This is supported by the import prices, as calculated from the monthly trade statistics, for Chinese acid grade into the U.S. Gulf of Mexico during the third quarter (\$134 per ton) and fourth quarter (\$132 per ton) of 1999 and the first quarter (\$130 per ton) of 2000.

Japan.—In 1999, Japan imported a total of 535,000 t of fluorspar of which 247,000 t was metallurgical grade and 288,000 tons was acid grade. China (51%) and Mexico (46%) were the major suppliers of metallurgical grade, with Thailand, Vietnam, and Iran, in descending order, supplying the remainder. China supplied 97% of the acid-grade imports, and the remainder was supplied by Kenya and Mongolia (Ministry of Finance, 1999).

Namibia.—Okorusu Fluorspar (Pty.) Ltd. completed a geologic exploration program on its "B" ore body at the summit of Okorusu Hill. The program effectively doubled the company's proven reserves for that ore body and with better than expected grades. The company continued the waste pushback at it's a pit and reached the A ore body in May 2000 after 2½ years of stripping. Current life of the mine is estimated to be 15 years, with the potential to extend this as other lesser known ore bodies are explored. In 1999, Okorusu also began construction of a new milling plant that will double the mine's milling capacity to 40 metric tons per hour. This plant, which consists of a rod mill and ball mill in series, was expected to be completed August 2001. The company's 1999 production reached nearly 58,000 t, and it shipped almost 55,000 t, all to Solvay S.A., its parent company (Mark Dawe, General Manager, Okorusu Fluorspar (Pty.) Ltd., written commun., June 5, 2000).

Russia.—Prior to the breakup of the former Soviet Union, the Russian fluorspar industry consisted of the Kalanguy Fluorspar Concentrating Plant, the Khyahtinsky Mine, the Usugly Mine, and the Yaroslavsky Mining and Dressing Complex (YMDC). During the 1990's, however, the

Khyahtinsky Mine ceased production and the Kalanguy plant was reduced to producing only about 4,000 t/yr. The Usugly Mine is in a difficult situation because the upper strippable ore beds are mined out, and the operation lacks the means to strip the lower ore bodies. The YMDC currently supplies most of the domestic market, producing flotation concentrates with about 90% to 92% CaF₂. This is much too low for the international acid-grade markets, but in the near future the YMDC hopes to install briquetting equipment that would dramatically improve the company's chances to supply international metallurgical markets (Levman, 2000). In 1999, the YMDC produced about 150,000 t of concentrates (Y.I. Sivachenko, Marketing and Foreign Economic Relations Director, Yaroslavsky Mining and Dressing Complex, written commun., June 9, 2000).

South Africa.—In 1999, Metorex (Pty.) Ltd. of South Africa purchased Vergenoeg Mining Co. (Pty.) Ltd. from Bayer (Pty.) Ltd. for about \$6.8 million. Bayer is the South African subsidiary of Bayer AG of Germany, which has an offtake agreement with Metorex for the supply of 60,000 t/yr to Bayer's HF plant in Leverkusen, Germany. The Vergenoeg Mine processes about 500,000 t/yr of ore, producing 100,000 t/yr of acid-grade fluorspar and 10,000 t/yr of metallurgical grade (Industrial Minerals, 1999a). In a followup development, Minerales y Productos Derivados S.A. (Minersa) of Spain purchased a 30% stake in the Vergenoeg Mine from Metorex. Minersa has been involved with Metorex in evaluating current operations with the aim of improving the quality and recovery of fluorspar from the mine since its acquisition of Vergenoeg. Minersa provides additional technical and marketing expertise, which is expected to improve product quality, marketing, and profitability (African Mining Bulletin, 1999).

The South African Land and Exploration Co. Ltd. (SALEC) outbid four competitors and acquired the Witkop Mine from Phelps Dodge Mining (Pty.) Ltd. for \$12.3 million. The Witkop Mine produces about 100,000 to 110,000 t/yr of acidgrade fluorspar, most of which is exported to the United States. The acid-grade product from the Witkop Mine is reportedly lower in arsenic and phosphate than that of the other South African producer. The company owns and has drilled another high-grade ore body nearby, which may be developed in the future (Industrial Minerals, 1999b). Later in the year, SALEC reported the completion of a construction project to introduce several metallurgical techniques designed to eliminate minor bottlenecks at the Witkop mill. The project increased production by 20,000 t/yr, and the facility is now operating at full capacity (120,000 t/yr). The company also initiated an extensive market evaluation of end uses and potential clients to determine the size of the market. Sufficient reserves exist to allow an increase in production of 50,000 t/yr, but any additional capacity increases were to await completion of the market study (Graulich, 1999).

United Kingdom.—Following the loss of a major customer contract for fluorspar, Laporte plc announced its intention to close Laporte Minerals, its minerals operation located in Derbyshire, England. Laporte Minerals was a trading unit of Laporte Industries Ltd., a wholly owned subsidiary of Laporte plc. Despite efforts made to secure an ongoing supply contract through competitive pricing and a radical restructuring of the

operation, the customer decided to secure alternative supplies from China. Because the problems at Laporte Minerals were commercial rather than technical, management was optimistic that a buyer could be found that would be able to maintain the fluorspar producer as a going concern (Laporte Minerals, July 28, 1999, Closure of Laporte Minerals, press release, accessed October 1, 1999, via URL http://www.laporte-minerals.co.uk/). A buyer was found, and the closure was averted with the sale to Land Regeneration Management Ltd. (LRM). LRM specializes in the regeneration of brownfield industrial lands, with a background in mining-related environmental work. The new operation will resurrect the name Glebe Mining Ltd., which was the name of the operation prior to its acquisition by Laporte in 1959. The new company will continue production, but with a greatly reduced labor force and a much reduced production output. Restarting production from the underground mines, Milldam and Sallet Hole, was not in the company's immediate plans (P.L. Huxtable, General Manager, Laporte Minerals, written commun., November 18, 1999).

Current Research and Technology

Kvaerner Process Technology AG of Switzerland (formerly Buss AG) has developed a process to produce high-purity HF from fluorosilicic acid, which is a byproduct of the phosphoric acid industry. Concentrated fluorosilicic acid is reacted with sulfuric acid according to the following reaction:

 $H_2SiF_6\cdot SiF_4(aq.) + H_2SO_4 \rightarrow 2SiF_4 + 2HF + H_2SO_4(aq.)$. Concentrated fluorosilicic acid is heated and mixed with sulfuric acid, and most of the resulting HF is absorbed by sulfuric acid. The liquid containing sulfuric acid and HF is distilled to produce crude HF gas. Additional HF is recovered by stripping, and sulfuric acid at 70% to 75% concentration is recovered. The crude HF gas is cooled and impurities with high boiling points are removed. Then the gas passes through two condensers where the HF is liquified, and impurities with low boiling points, mainly sulfur dioxide and silicon tetrafluoride, are removed. Gaseous HF streams are passed through an absorption column and reacted with sulfuric acid; this mixture is then pumped back through the original process system. Gases containing silicon tetrafluoride leaving the absorption column are mixed in counter-current flow with fluorosilicic acid; this results in a strong solution of fluorosilicic acid that contains precipitated silica. The process produces a final HF product of 99.98% purity with byproducts of sulfuric acid and silica. An offgas containing 10 to 25 milligrams per cubic meter of fluorine after scrubbing with water is expected, which may require further treatment depending on local environmental regulations (Dieter Böse, Manager Marketing and Sales, Kvaerner Process Technology AG, written commun., May 15, 1999).

Research was conducted by North American Minerals Corp. and National Briquette Corp. in the use of synthetic fluorspar in the making and treating of steel. Currently, the uses of synthetic fluorspar are limited by difficulties in the handling and processing the material (excessive flowability and baghouse dust losses). The synthetic fluorspar, which is recovered by reacting lime (CaO) with a fluorine waste stream, contains 88%

to 92% CaF₂ and 8% to 10% CaO, and when dry it will pass 97% through a 45-micron (325-mesh) screen. The synthetic product normally contains 8% to 10% moisture. The solution was to add an additional 10% water to the synthetic fluorspar and to process through a pin mixer. The CaO acts as a binder, and the end product is a small prill the size of a "BB." The chemistry remains the same, but the process increases the size, density, and moisture. The resulting prills can be blended with other materials and briquetted for use in steel mills or simply dried and blended with CaO and other materials for use as desulfurizers (Barker and Berger, 2000).

Outlook

Fluorocarbon production from HF is the single largest market that drives fluorspar demand. Between 1998 and 2002, fluorocarbon demand is expected to increase by 3% to 5% per year. In particular, the demand for HFC 134 is benefitting from steady auto sales, retrofits, and an emerging aftermarket. Demand for fluorocarbons used as fluoropolymer precursors has grown at an even faster rate. These market strengths, however, are balanced by market losses to not-in-kind replacements in solvents, tighter recycling requirements in air-conditioning systems that will reduce aftermarket sales, the ban on the foamblowing agent HCFC 141b in 2003, and potential future restrictions owing to the global warming potential of fluorocarbons (Chemical Market Reporter, 1999a).

Because AlF₃ demand mirrors aluminum demand, the outlook for aluminum production is important. In recent years, increased domestic output of aluminum has been fueled by the strong U.S. economy and the recovery of world markets from the effects of the large quantities of Russian exports. Despite some short-term idling of capacity in the first half of 2000, this trend is expected to continue, with idle capacity expected to be back on-stream in the next few years as demand increases and prices strengthen. It is expected that fluorspar consumption for AlF₃ production will increase as aluminum output increases in North America.

There is little sales growth expected in the merchant market, although the steel markets should rebound from problems caused by the high import levels. A possible exception is for metallurgical-grade sales to the cement industry. Some cement manufacturers are starting to use fluorspar in clinker production. Fluorspar can be added to limestone in the cement kiln as a fluxing agent, where it reduces the residence time and increases production capacity. This use, which is common is some countries, but not in the United States, has been expanding in Mexico through the cooperative activities of the Mexican fluorspar producer Cia. Minera Las Cuevas, S.A. de C.V. and local cement manufacturers. The size of the potential Mexican market is estimated to be more than 80,000 t/yr, and U.S. clinker production is more than double that of Mexico.

In 1997-98, the International Fertilizer Industry Association's (IFA) Technical Subcommittee set up the Fluorine Forum to further the studies on the liberation and control of fluorine derived from the manufacture of phosphate fertilizers. To promote the aims of the Forum, a paper titled "History of Fluorine Recovery Processes" was presented at the

IFA Technical Subcommittee Meeting in Novgorod, Russia, in September 1999. This paper provides a foundation for future research on the recovery of fluorine and more importantly what can be done with it. This is of particular concern if future environmental regulations call for the total control of fluorine emissions from the processing of phosphate rock (Sinden, 2000). In the United States alone, the fertilizer industry could be looking at what to do with 550,000 to 700,000 t/yr of 100%basis fluorosilicic acid. These calculations depend on the amount of phosphate rock consumed annually, the fluorine content of the rock, the average percentage of fluorine released, and scrubber efficiency. According to data collected by the USGS, only 69,200 t of fluorosilicic acid was recovered for sale or use by phosphoric acid plants in 1999. At present, the most significant chemical use worldwide of fluorosilicic acid is for the manufacture of aluminum fluoride. If the technology developed by Kvaerner Process Technology is widely adopted, it could have a dramatic impact on the supply and demand of fluorspar as the raw material for production of HF.

References Cited

African Mining Bulletin, 1999, Spanish fluorspar leader takes stake in Vergenoeg: African Mining Bulletin, no. 101, electronic issue, July 5, [unpaginated].

Barker, B.J., and Berger, J.H., 2000, The use of synthetic fluorspars in the making and treating of steel, in International Fluorspar Conference 2000, Denver, CO, 2000, Proceedings: Ann Arbor, MI, North American Minerals Corp., [unpaginated].

Burin Minerals Ltd., 1999a, Quarterly progress report: St. Lawrence, Newfoundland, Burin Minerals Ltd. press release, September 30, 2 p.

———1999b, Quarterly progress report: St. Lawrence, Newfoundland, Burin Minerals Ltd. press release, December 31, 1 p.

Chemical Market Reporter, 1999a, Chemical profile—Fluorocarbons: Chemical Market Reporter, v. 256, no. 15, October 11, p. 45.

Graulich, I., 1999, Mine completed ahead of schedule, R3 million under budget: Business Day, October 7, p. 23.

Hess, Glenn, 1999, World community moves ahead with efforts to protect the ozone layer: Chemical Market Reporter, v. 256, no. 24, December 13, p. 1,

Industrial Minerals, 1999a, Metorex buys Bayer's fluorspar mine: Industrial Minerals, no. 381, June, p. 14.

———1999b, Phelps Dodge fluorspar sold to S.A. Land & Exploration for \$12.3m.: Industrial Minerals, no. 382, July, p. 13.

Levman, A.K., 2000, The conference paper, in International Fluorspar Conference 2000, Denver, CO, March 22-24, 2000, Proceedings: Ann Arbor, MI, North American Minerals Corp., [unpaginated].

Ministry of Finance, 1999, Japan exports and imports, commodity by country: Tokyo, Ministry of Finance, December, p. 161.

Sinden, John, 2000, What's to become of all this fluosilicic acid?: Phosphorus and Potassium, no. 225, January-February, p. 45-49.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Fluorine. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Fluorspar. Ch. in Minerals Yearbook, annual.¹

Fluorspar. Ch. in Mineral Commodity Summaries, annual.¹

Fluorspar. Mineral Industry Surveys, quarterly.¹

Geology and Resources of Fluorine in the United States, Professional Paper 933, 1976.

Other

Chemical and Engineering News.

Chemical Market Reporter.

Chemical Week.

European Chemical News.

Fluorspar. Ch. in Industrial Minerals and Rocks (6th ed.), Society of Mining, Metallurgy, and Exploration, 1994.

Fluorspar. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675.

Industrial Minerals (London).

North American Minerals News.

Roskill—The Economics of Fluorspar 1993.

SRI International—Chemical Economics Handbook, Fluorine.

U.S. Department of Commerce Current Industrial Reports, Inorganic Chemicals, MQ325A.

¹Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1 SALIENT FLUORSPAR STATISTICS 1/2/

		1995	1996	1997	1998	1999
United States:						
Production:						
Finished (shipments) e/ 3/	metric tons	51,000	8,200			
Value, f.o.b. mine	thousands	W	W			
Exports 4/	metric tons	41,800	61,600	62,100	23,600 r/	55,400
Value 5/	thousands	\$5,550	\$8,110	\$8,330	\$3,890 r/	\$6,970
Imports 6/	metric tons	558,000	513,000	538,000 r/	503,000	478,000
Value 7/	thousands	\$67,400	\$71,000	\$69,500	\$62,700	\$56,900
Value per ton, acid grade 7/		\$126.00	\$142.00	\$134.00	\$128.00	\$124.00
Value per ton, metallurgical grade	7/	\$94.40	\$103.00	\$90.70	\$89.20	\$87.80
Consumption (reported)	metric tons	534,000	527,000	491,000	538,000	515,000
Consumption (apparent) 8/	do.	599,000	719,000	551,000	591,000 r/	615,000
Stocks, December 31:						
Consumer and distributor 9/	do.	405,000	234,000	375,000	468,000	373,000
Government stockpile	do.	756,000	667,000	448,000	243,000	146,000
World, production	do.	4,170,000	4,250,000 r/	4,410,000 r/	4,460,000 r/	4,510,000

- e/Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.
- 1/ Data are rounded to no more than three significant digits.
- 2/ Does not include fluorosilicic acid (H2SiF6) or imports of hydrofluoric acid (HF) and cryolite.
- 3/ May include fluorspar from the National Defense Stockpile beneficiated by Ozark-Mahoning Co., Illinois.
- 4/ Source: U.S. Census Bureau and the U.S. Geological Survey.
- 5/ F.a.s. values at U.S. ports.
- 6/ Source: U.S. Census Bureau as modified by the U.S. Geological Survey.
- 7/ C.i.f. values at U.S. ports.
- 8/ U.S. primary and secondary production plus imports minus exports plus adjustments for Government and industry stock changes.
- 9/ Includes fluorspar purchased from the National Defense Stockpile, but still located at National Defense Stockpile depots.

 ${\bf TABLE~2} \\ {\bf U.S.~REPORTED~CONSUMPTION~OF~FLUORSPAR,~BY~END~USE~}~1/$

(Metric tons)

	Containing than 9 calcium	97%	Containing not more than 97% calcium fluoride To		otal	
End use or product	1998	1999	1998	1999	1998	1999
Hydrofluoric acid and aluminum fluoride	497,000	469,000		1,220	497,000	470,000
Basic oxygen furnaces			7,330	9,590	7,330	9,590
Electric furnaces	W	W	19,700	8,780	19,700	8,780
Other 2/	6,640	14,300	6,630	11,600	13,300	25,900
Total	504,000	483,000	33,700	31,200	538,000	515,000
Stocks (consumer), December 31	114,000	65,400	20,200	25,200	134,000	90,500

W Withheld to avoid disclosing company proprietary data. -- Zero.

^{1/} Data are rounded to no more than three significant digits; may not add to totals shown.

^{2/} Includes enamel, glass and fiberglass, iron and steel foundries, primary aluminum, primary magnesium, and welding rod coatings.

TABLE 3 PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source-grade	1998	1999
Mexican, f.o.b., Tampico:		
Acidspar filtercake	110-130	110-130
Metallurgical grade	85-105	r/ 85-105
Mexican, f.o.b., Mexico:		
Acidspar filtercake, As <5 ppm	130-140	130-140
South African, acidspar dry basis, f.o.b. Durban	110-120	105-125
U.S. Gulf port, dry basis, acidspar	122-135	127-138
r/ Revised.		

Source: Industrial Minerals, no. 375, p. 78, December 1998, and no. 387, p. 70, December 1999.

TABLE 4 U.S. EXPORTS OF FLUORSPAR, BY COUNTRY 1/

	199	8	199	99
	Quantity		Quantity	
Country	(metric tons)	Value 2/	(metric tons)	Value 2/
Canada	18,400	\$3,130,000	24,400	\$3,900,000
Dominican Republic	r/	r/	104	18,900
Hong Kong	463	67,000		
Italy		14,300	27,800	2,540,000
Korea, Republic of	284	56,400	3	3,120
Mexico	633	71,200	136	40,800
Taiwan	3,420	493,000	1,990	278,000
United Kingdom		14,000	62	11,900
Other 3/		43,500 r/	845	178,000
Total	23,600 r/	3,890,000 r/	55,400	6,970,000

r/ Revised. -- Zero.

Source: U.S. Census Bureau.

 $^{1/\,\}textsc{Data}$ are rounded to no more than three significant digits; may not add to totals shown.

^{2/} F.a.s. values at U.S. ports.

^{3/} Includes Australia, Belgium, Brazil, China, Finland, France, Germany, Ireland, Japan, Netherlands, Panama, Papua New Guinea, Spain, Sweden, and Switzerland.

TABLE 5 U.S. IMPORTS FOR CONSUMPTION OF FLUORSPAR, BY COUNTRY AND CUSTOMS DISTRICT 1/

	19	98	1999		
	Quantity	Value 2/	Quantity	Value 2/	
Country and customs district	(metric tons)	(thousands)	(metric tons)	(thousands)	
Containing more than 97%					
calcium fluoride (CaF2):					
Austria:	-				
Charleston	2	\$4	107	\$63	
Savannah	- 6 r	/ 18 r/		_	
Total	8	22	107	63	
China:					
Baltimore	- 98	23			
Houston 3/	207,000	25,600	179,000	22,400	
New Orleans	134,000	17,800	108,000	13,400	
Total	341,000	43,400	287,000	35,900	
France: Philadelphia	508	188	163	67	
Germany: Savannah	10	10	291	53	
Mexico:	-				
Detroit	- 		204	38	
El Paso	221	42	1	3	
Laredo	3,080	438	17,300	2,130	
New Orleans	1,550	148	·	-	
Total	4,850	628	17,500	2,170	
Morocco: Houston	4,730	693	·	-	
South Africa:	-				
Houston	17,300	2,320	23,700	2,890	
New Orleans	93,900	11,800	90,000	10,600	
Total	111,000	14,100	114,000	13,500	
United Kingdom:					
New York City	- 8	16	13	21	
Los Angeles	- 		95	13	
Total	8	16	108	34	
Grand total	462,000	59,100	419,000	51,800	
Containing not more than 97%	-		•		
calcium fluoride (CaF2):					
Canada: Buffalo	174	50	97	29	
China:					
New Orleans	- 		16,700	1,500	
Ogdensburg	- 		9	4	
Total			16,700	1,500	
Mexico:	-		-7	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
Laredo	7,390	556	4,400	374	
New Orleans	33,200	3,030	37,500	3,250	
Total	40,600	3,580	41,900	3,620	
Grand total	40,700	3,630	58,700	5,150	
r/Revised Zero	.0,,,00	2,020	20,700	2,130	

r/ Revised. -- Zero.

Source: U.S. Census Bureau, adjusted by the U.S. Geological Survey.

^{1/} Data are rounded to no more than three significant digits; may not add to totals shown.

^{2/} C.i.f. values at U.S. ports.

^{3/} Includes data supplied by importer.

TABLE 6 U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID (HF), BY COUNTRY 1/

	1998		1999		
	Quantity	Value 2/	Quantity	Value 2/	
Country	(metric tons)	(thousands)	(metric tons)	(thousands)	
Canada	33,500	\$39,100	26,800	\$31,000	
China			17	\$14	
France	279	317	343	374	
Germany	141	301	147	349	
Japan	1,210	3,670	1,440	4,150	
Mexico	89,000	70,100	91,200	83,700	
United Kingdom	136	144	38	40	
Total	124,000	114,000	120,000	120,000	

⁻⁻ Zero.

Source: U.S. Census Bureau, adjusted by the U.S. Geological Survey.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION
OF CRYOLITE, BY COUNTRY 1/

	199	8	19	99
	Quantity	Value 2/	Quantity	Value 2/
Country	(metric tons)	(thousands)	(metric tons)	(thousands)
Australia	969	\$509	2,490	\$1,410
Canada	6,580	1,780	1,960	527
China	104	86	442	356
Denmark	324	497	222	355
Germany	3,310	3,580	2,700	2,810
Hungary	575	602	391	428
Japan	586	362	17	16
New Zealand	2,570	1,360	557	405
Spain	285	248	323	281
United Kingdom	162	249	294	419
Other 3/	58 r/	59 r/	172	143
Total	15,500 r/	9,320 r/	9,560	7,160

r/ Revised.

Source: U.S. Census Bureau.

TABLE 8 U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM FLUORIDE, BY COUNTRY 1/

	1998		19	99
	Quantity	Value 2/	Quantity	Value 2/
Country	(metric tons)	(thousands)	(metric tons)	(thousands)
Canada	5,930	\$5,490	5,330	\$4,500
Italy	4,290	3,110		
Mexico	8,870	7,440	11,100	9,340
Norway	3,020	2,920	2,800	2,620
Other 3/	268	382	151	248
Total	22,400	19,300	19,300	16,700

⁻⁻ Zero.

Source: U.S. Census Bureau.

 $^{1/\,\}textsc{Data}$ are rounded to no more than three significant digits, may not add to totals shown.

^{2/} C.i.f. values at U.S. ports.

 $^{1/\}operatorname{Data}$ are rounded to no more than three significant digits; may not add to totals shown.

^{2/} C.i.f. values at U.S. ports.

^{3/} Includes data for the Czech Republic, Hong Kong, India and Italy.

 $^{1/\,\}text{Data}$ are rounded to no more than three significant digits; may not add to totals shown.

^{2/} C.i.f. values at U.S. ports.

³/ Includes data for Brazil, China, Finland, Germany, India, Japan, Sweden, and the United Kingdom.

TABLE 9 FLUORSPAR: WORLD PRODUCTION, BY COUNTRY 1/2/

(Metric tons)

Country and grade 3/4/	1995	1996	1997	1998 e/	1999 e/
Argentina	5,105	5,666	7,168 r/	7,200 r/	7,000
Brazil (marketable):					
Acid grade	72,498	46,706	66,859 r/	61,024 r/ 5/	61,000
Metallurgical grade	16,760	12,334 r/	11,174 r/	11,058 r/ 5/	11,000
Total	89,258	59,040 r/	78,033 r/	72,082 r/ 5/	72,000
China: e/					
Acid grade	1,200,000	1,250,000	1,150,000 r/	1,180,000 r/	1,200,000
Metallurgical grade 6/	800,000	900,000	1,150,000 r/	1,170,000 r/	1,200,000
Total	2,000,000	2,150,000	2,300,000 r/	2,350,000 r/	2,400,000
Egypt e/	551 5/	700	700	700	700
France: e/					
Acid and ceramic grades	102,000	78,000 5/	80,000	80,000	82,000
Metallurgical grade	28,000	33,000 5/	30,000	30,000	25,000
Total	130,000	111,000 5/	110,000	110,000	107,000
Germany	39,081	32,448	24,000 e/	25,000	28,000
India:				·	
Acid grade	6,359	5,115	6,937 r/	r/	
Metallurgical grade	17,887	14,263	9,877 r/	785 r/ 5/	800
Total	24,246	19,378	16,814 r/	785 r/ 5/	800
Iran 7/	20,163	20,000	20,000 e/	20,000	20,000
Italy:	20,103	20,000	20,000 0	20,000	20,000
Acid grade	91,529	103.527	106,000 r/e/	92,000 r/	95,000
Metallurgical grade	33,140	23,000	20,000 e/	15,000 r/	15,000
Total	124,669	126,527	126.000 e/	107,000 r/	110,000
Kenya: Acid grade	80,230		-,	,	
		83,000	68,700 r/	60,854 r/ 5/	98,000
Korea, North: Metallurgical grade e/	40,000	39,000	39,000	30,000	25,000
Korea, Republic of: Metallurgical grade	r/	e/	617	r/	2.007
Kyrgyzstan	2,500 e/	2,767	4,176	3,200 5/	2,997
Mexico: 8/					
Acid grade	270,000	279,033	290,580	330,711 r/5/	327,000
Metallurgical grade	252,000	244,938	262,260	267,331 r/ 5/	237,000
Total	522,000	523,971	552,840	598,042 5/	564,000
Mongolia:					
Acid grade	120,300	130,000 r/	130,000	122,000 r/	108,000
Other grades 9/	13,000	37,000	41,000	46,000 r/	46,000
Total	133,300	167,000 r/	171,000	168,000 r/	154,000
Morocco: Acid grade	105,800	95,900	103,800	110,000	110,000
Namibia: Acid grade 10/	36,889	32,285	23,208	40,685 5/	57,600
Pakistan: Metallurgical grade	2,753	363	1,050 r/	1,000 r/	220
Romania: Metallurgical grade e/	15,000	15,000	15,000	15,000	15,000
Russia e/	250,000	250,000	250,000	220,000	250,000
South Africa: 11/	200,000	200,000	200,000	220,000	200,000
Acid grade e/	177,000	191,018 5/	201,000	222,000 r/	203,000
Ceramic grade			4,000 e/	222,000 1/	203,000
Metallurgical grade e/	19,000	12,000	2,000	15,000 r/	14,000
	195,866	203,018	207,000 5/	237,000 r/ 5/	
Total	193,800	203,018	207,000 3/	257,000 1/ 3/	217,280 5/
Spain:	100 205	100.005	110.000 -/	110.000	122 000
Acid grade	108,205	109,085	110,000 e/	110,000	123,000
Metallurgical grade	10,206	7,441	10,000 e/	10,000	10,000
Total	118,411	116,526	120,000 e/	120,000	133,000
Tajikistan e/	9,000	9,000	9,000	9,000	9,000
Thailand: Metallurgical grade	24,114	17,247	7,826	3,743 5/	7,000
Turkey: Metallurgical grade	8,873	4,828	5,000 e/	5,000	5,000
			C 1 000 /	65,000	42,000
United Kingdom e/	55,000	65,000	64,000 e/	65,000	42,000
	51,000	65,000 8,200	64,000 e/ 	63,000	42,000
United Kingdom e/				80,000 80,000	42,000 80,000

See footnotes at end of table.

TABLE 9--Continued FLUORSPAR: WORLD PRODUCTION, BY COUNTRY 1/2/

e/ Estimated. r/ Revised. -- Zero.

- 1/ World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
- 2/ Table includes data available through June 2, 2000.
- 3/ In addition to the countries listed, Bulgaria is believed to have produced fluorspar in the past, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.
- 4/ An effort has been made to subdivide production of all countries by grade (acid, ceramic, and metallurgical). Where this information is not available in official reports of the subject country, the data have been entered without qualifying notes.
- 5/ Reported figure.
- 6/ Includes submetallurgical-grade fluorspar used primarily in cement that may account for 33% to 50% of the quantity.
- 7/ Year beginning March 21 of that stated.
- 8/ Data are reported by Consejo de Recursos Minerales; but the production of submetallurgical and acid grades has been redistributed on the basis of industry data.
- 9/ Principally submetallurgical-grade material.
- 10/ Data are in wet tons.
- 11/ Based on data from the South African Minerals Bureau, data show estimated proportions of acid-, ceramic-, and metallurgical-grade fluorspar within the reported totals.

FIGURE 1
ACID-GRADE FLUORSPAR IMPORT PRICES BY QUARTER
(Dollars per metric ton, c.i.f. port of entry, quarter = Q)

