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 (also called acidspar), which is greater than 97% calcium fluoride (CaF_2), or subacid grade, which is 97% or less CaF_2. The latter includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

All domestic sources of fluorspar are derived, in descending order of quantity supplied, from sales of material from the National Defense Stockpile (NDS), small amounts of synthetic fluorspar produced from industrial waste streams, and a small amount from the single fluorspar mine operating in Utah. 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 data released by the U.S. Census Bureau and the U.S. Geological Survey (USGS), imports of fluorspar were essentially unchanged compared with those of 2000. Hydrofluoric acid (HF) imports decreased by nearly 15% when compared with those of 2000.

Legislation and Government Programs

In accordance with the Strategic and Critical Materials Stock Piling Act, as amended (50 U.S.C. sec. 98h-2), the Defense National Stockpile Center (DLA-DNSC) of the Defense Logistics Agency was authorized to sell about 54,400 metric tons (t) (60,000 short dry tons) of metallurgical-grade fluorspar during fiscal year 2001 (October 1, 2000, to September 30, 2001). During calendar year 2001, the DLA-DNSC made no sales of fluorspar. According to the DLA-DNSC's fiscal year 2002 (October 1, 2001, to September 30, 2002) Annual Materials Plan, total sales of about 54,400 t (60,000 short dry tons) of metallurgical grade and 10,900 t (12,000 short dry tons) were authorized. Unsold quantities remaining in the NDS are documented in the stocks section below.

Production

In 2001, there was a small amount of unreported mine production from Milford Mining Co. LLC in Utah. 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 metallurgical-grade and 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 2001, 6 companies operated 10 plants that processed phosphate rock for the production of phosphoric acid, which generated 65,200 t of byproduct fluorosilicic acid. They sold or used 59,100 t of byproduct fluorosilicic acid at a value of about $9.38 million. This was equivalent to approximately 104,000 t of fluorspar (grading 92% CaF_2) sold or used. This was a decrease from the level of fluorosilicic acid output reported in 2000. 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. At present (2001), an estimated 5,000 to 8,000 metric tons per year (t/yr) of synthetic fluorspar is produced in the United States.

Consumption

Domestic consumption data for fluorspar were developed by the USGS from a quarterly consumption survey of three large consumers, five distributors, and one mining company. Of these nine respondents, six responded every quarter, one provided partial data, and two did not respond at all. Those companies that responded make up 100% of the reported consumption in table 2.

Traditionally, there have been three grades of fluorspar—acid grade, containing more than 97% CaF_2; ceramic grade, containing 85% to 95% CaF_2; and metallurgical grade, containing 60% to 85% or more CaF_2. During the past 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. Two companies reported fluorspar consumption for the production of HF—E.I. du Pont de Nemours and Co. (DuPont) and Honeywell International Inc. In 2001, the HF market experienced weak demand because of the poor economy and concerns about the looming U.S. phaseout of hydrochlorofluorocarbon (HCFC) 141b, a key HF derivative. Electronic uses were down sharply, and demand for fluorocarbons and fluoropolymers slumped with the economy. The petroleum alkylation market was strong, driven by high refinery operating rates, but alkylation only accounts for about 3% of the HF market.

The largest use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs), HCFCs, and fluoropolymers. HCFCs and HFCs were produced by the following seven companies: ATOFINA Chemicals, Inc.; Ausimont USA, Inc. (now part of Solvay S.A.); DuPont; Great Lakes Chemical Corp.; Honeywell; INEOS Fluor Americas LLC; and MDA Manufacturing Ltd. MDA 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 existing or potential fluorocarbon replacements for the banned chlorofluorocarbons (CFCs) are HCFCs 22, 123, 124, 141b, 142b, and 225. These HCFC substitutes have ozone-depletion potentials that are much lower than those of CFCs 11, 12, and 113, which together had 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 for CFC 12 as a diluent in sterilizing gas, and HCFCs 141b and 142b have replaced most of the CFCs 11 and 12 used in foam blowing. HCFCs 141b and 225, perfluorocarbons, and hydrofluoroethers have been introduced as replacements for CFC solvents. However, because of the current phaseout schedule for HCFCs, the market for HCFCs 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 is scheduled to go into effect 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. HFCs 23, 32, 125, 143a, and 152a also are being produced domestically but in much smaller quantities. These HFCs hold potential for use individually or, more likely, in blends for specific uses, such as the azeotropic mixture of HFCs 32 and 125 that is emerging as the replacement of choice for HCFC 22. HFCs 134a and 227ea are being introduced as propellants in medical aerosols. HFC 227 also is an alternative to CFC 114, while HFC 245ca and HFC 356 are identified as possible long-term replacements for CFC 11 in chillers and for CFC 114 in high-temperature heat pumps. HFC 245fa may be a candidate for use as a low-pressure refrigerant to replace HCFC 123.

HFCs 134a, 245fa, 356, and 365mfc are being tested as potential replacements for HCFC 141b in blowing agents for thermosets, such as polyurethane. The timing of this research has become critical owing to the looming phaseout of HCFC 141b, which goes into effect January 2003, and some companies are moving into the product development and distribution phase. To this end, Honeywell is building a plant to manufacture HFC 245fa in the United States, and Solvay is building a plant to manufacture HFC 365mfc in France for the European market; both plants are expected to be operational by the end of 2002. Because none of these compounds are suitable for all foam applications, they will likely also be used as blends with each other, with HFC 134a, or even with pentanes to provide improved properties.

HFC 4310 and a blend of HFC 4310 and HFC 365 have been developed as a replacement for CFC 113, HCFCs, and perfluorocarbons for use in drying fluids, cleaning and rinsing agents, defluxing agents, and heat-transfer media. The blends are stable, nonflammable, and have lower global warming potential than many previously existing products.

HCFCs 22, 123, and 124; HFCs 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 1211 as a streaming agent and for halon 1301 as a total flooding agent for fire suppression. With the exception of the U.S. Department of Defense, however, there has not been a significant concerted effort anywhere in the United States to remove halon 1211 and 1301 systems from service and replace them with products using alternatives. The low market penetration levels of the alternatives are due to end user resistance predominantly focused on one or more of these undesirable (when compared to the halons) characteristics—cost, space, and weight. In addition, there are sufficient supplies of recycled 1211 and 1301 available at prices reasonable enough to make it more cost effective to recharge these systems than to replace them with alternatives (Wickham, 2002§[1]).

CFC 113, HCFCs 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 HCFCs 22 and 142b will not be subject to the production phaseouts mandated by the Montreal Protocol on Substances that Deplete the Ozone Layer 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 explosives. 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.

Acid-grade fluorspar was used in the production of aluminum fluoride (AlF_3), which is the main fluorine compound used in

[1]References that include a section twist (§) are found in the Internet References Cited section.

aluminum smelting. In the Hall-Héroult aluminum process, alumina is dissolved in a bath of molten cryolite, AlF_3, and fluorspar to allow electrolytic recovery of aluminum. On average worldwide, the aluminum industry consumes about 23 kilograms of fluorides (measured as AlF_3 equivalent) for each metric ton of aluminum produced, ranging 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. AlF_3 was added to the electrolyte in reduction cells to improve the cells' electrical efficiency. It was used by the ceramics industry for some body and glaze mixtures, in the production of specialty refractory products, in the manufacture of aluminum silicates, and in the glass industry as a filler. The AlF_3 manufactured for use in aluminum reduction cells is produced directly from acid-grade fluorspar or from byproduct fluorosilicic acid. About 82% of AlF_3 is produced from fluorspar, and 18%, from fluorosilicic acid [excluding China and the Commonwealth of Independent States (CIS) for which specific data are unavailable]. In 2001, Alcoa World Chemicals, a business unit of Alcoa Inc., produced AlF_3 from fluorspar at Point Comfort, TX.

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, and glass fibers and by the foundry industry in the melt shop.

Metallurgical-grade or submetallurgical-grade fluorspar is used in cement production where it mainly acts as a flux. It is added to the mix of cement raw materials before introduction to the rotary kiln. The addition of fluorspar provides a savings in thermal energy by allowing the kiln to operate at a lower temperature thus saving fuel. It also increases the amount of tricalcium silicate produced. More tricalcium silicate results in a softer clinker product, which requires less grinding time thus saving electrical energy.

Because of a slowing economy, increased steel imports, low prices, and large legacy burdens (pension and retirement benefits owed to retirees), the U.S. steel industry was under a great deal of economic stress. For the year, raw steel production was down by 11.5% compared with 2000, and a number of companies had declared bankruptcy, including Bethlehem Steel Corp. and LTV Steel Corp.

In response to a spate of steel company bankruptcies (18 in the past 3 years) and complaints by steel companies of unfair trade practices, the U.S. International Trade Commission (ITC) initiated a section 201 investigation in 2001. Under section 201 of the Trade Act of 1974, domestic industries seriously injured or threatened with serious injury by increased imports may petition the ITC for import relief. The ITC determines whether an article is being imported in such increased quantities that it is a substantial cause of serious injury or threat thereof to the U.S. industry. If the ITC makes an affirmative determination, it recommends to the President relief that would prevent or remedy the injury and facilitate industry adjustment to import competition. On December 7, 2001, the ITC announced recommendations that included tariffs on various types of steel for a period of 4 years that ranged from 20% to 40%; these recommendations were forwarded to the President.

The President makes the final decision whether to provide relief and the amount of relief. On March 5, 2002, the President imposed tariffs for 3 years ranging from 8% to 30% on various types of imported steel, excluding imports from free-trade partners. Effective March 20, 2002, in the first year slab steel imports in excess of 4.9 million metric tons (Mt) would get a 30% tariff; finished flat products, hot-rolled and cold-finished bar, and tin mill products, a 30% tariff; and six other categories, 8% to 15% tariffs. The tariffs will decrease in each of the 3 subsequent years (Thelen Reid & Priest LLP, 2002§).

The merchant fluorspar market includes metallurgical-grade and acid-grade sales to steel mills, foundries, glass and ceramics plants, welding rod manufacturers, and other small markets in rail car, truckload, and less than truckload quantities. This merchant market is mature in the United States and in 2001 amounted to more than 106,000 t 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 level of total reported fluorspar consumption increased by about 5% in 2001 compared with that of 2000, but this increase was entirely the result of more complete data collection in the merchant market sector (metallurgical and other uses). Consumption of acid grade for HF and AlF_3 actually decreased by 9%.

About 41,200 t of byproduct fluorosilicic acid valued at $6.01 million was sold for water fluoridation, about 4,700 t of fluorosilicic acid valued at $495,000 was sold to make AlF_3 for the aluminum industry, and about 13,200 t valued at $2.88 million was sold or used for other uses, such as sodium silicofluoride production. Sales for AlF_3 production decreased by nearly 75% because Alcoa World Alumina announced that it was temporarily curtailing production (effective March 31, 2001) of aluminum fluoride at its Fort Meade, FL, facility because of reduced demand for the product. The Fort Meade plant was only operating at about two-thirds of rated capacity prior to the shutdown (Alcoa Inc., 2001§).

Stocks

Consumer stocks at yearend were in excess of 71,100 t. Because of a change in survey methodology, stocks data were only available from HF and AlF_3 producers, although this is a significant increase compared with the 48,300 t of acid-grade stocks held at the end of 2000. Known consumer and distributor stocks totaled 221,000 t, which included 150,000 t purchased from the NDS but still located at NDS depots. As of December 31, 2001, the NDS fluorspar inventory classified as excess (excluding material sold pending shipment) contained only about 112,000 t (124,000 short dry tons) of fluorspar (table 1). This total included 9,500 t of acid grade (10,400 short dry tons), 46,000 t of metallurgical grade (50,600 short dry tons), and 57,000 t (62,800 short dry tons) of nonstockpile-grade metallurgical 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 t deadweight normally are used. Participants negotiate freight levels, terms, and conditions. Ocean freight rates declined throughout most of 2001. The lagging world economy resulted in excess capacity and a buyers market.

Prices

According to Industrial Minerals, yearend price ranges for Mexican fluorspar increased or decreased (depending on the grade) compared with those of 2000. The range of South African prices for acid grade was unchanged. The average U.S. Gulf port price, including cost, insurance and freight (c.i.f.), dry basis, for Chinese acid grade was $136 to $141 per metric ton (table 3).

According to Chemical Market Reporter, the yearend 2001 price quotation for aqueous HF, 70%, in drums, free on board (f.o.b)., freight allowed, was unchanged at $0.65 per pound. The quotation for chemically pure (99.0 weight percent) anhydrous HF, 1,300 pounds, f.o.b., was unchanged at $2.96 per pound. Quoted yearend prices for AlF_3 were unchanged and ranged from $825 to $1,408 per metric ton. Quoted prices for sodium fluoride, white, 97%, in 50- or 100-pound bags, drums, carloads, were unchanged at $0.60 per pound, f.o.b. Tampa, and $0.63 per pound, f.o.b. El Paso. A price quote for fluorosilicic acid was unavailable.

Foreign Trade

According to the U.S. Census Bureau, U.S. exports of fluorspar decreased by 47% to 21,200 t from the 2000 figure (table 4). 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 2001, imports for consumption of fluorspar were essentially unchanged when compared with those of 2000, according to the U.S. Census Bureau and USGS data (table 5). The largest suppliers of fluorspar to the United States, in descending order, were China, South Africa, and Mexico. China accounted for nearly 68% of U.S. fluorspar imports. The average c.i.f. unit value was $135 per ton for acid grade and $80 per ton for metallurgical grade (table 1).

There are no tariffs on acid-grade or subacid-grade (metallurgical-grade) fluorspar from normal-trade-relations countries. There are no tariffs on other major fluoride minerals and chemicals, such as natural or synthetic cryolite, HF, and AlF_3.

Imports of HF decreased by nearly 15% to 112,000 t, or a quantity equivalent to about 168,000 t of fluorspar (table 6). Imports of synthetic and natural cryolite decreased by nearly 27% to 6,750 t, or a quantity equivalent to approximately 8,100 t of fluorspar (table 7). Imports of AlF_3 decreased by nearly 19% to 17,400 t, or a quantity equivalent to about 26,100 t of fluorspar (table 8).

World Review

World production increased by nearly 100,000 t compared with the revised 2000 data (table 9). China, Mexico, South Africa, Mongolia, and Russia, in decreasing order, were the largest producers.

Belgium.— Solvay S.A. announced that it had agreed to acquire Italian fluorinated specialties producer Ausimont S.p.A. from Montedison Group and Longside International. The acquisition, which is expected to be finalized during the first half of 2002, will cost $1.16 billion and include 100% of Ausimont’s capital and 100% of Agora, Ausimont’s holding company. Ausimont is a major producer of fluoroelastomers and fluoropolymers (Industrial Minerals, 2002). Following approval by the European Commission and the U.S. Federal Trade Commission, Solvay completed the acquisition from Edison S.p.A. (formerly Montedison Group) and Longside International on May 7, 2002. Among other things, the approval was subject to Solvay divesting its 50% share in a polyvinylidene fluoride operation in Decatur, AL (Solvay S.A., 2002§).

Canada.—In 2001, Canada imported 14,800 t of metallurgical-grade fluorspar and 149,000 t of acid-grade fluorspar. Total fluorspar imports decreased by nearly 9% compared to those of 2000. The major sources of supply, in descending order, were Mexico, China, Morocco, and Spain (Wayne Wagner, International and Domestic Policy Division, Natural Resources Canada, written commun., 2002). The two major fluorspar consumers in Canada are the Honeywell HF plant at Amherstburg, Ontario, and Alcan Aluminium Ltd., which produces AlF_3 at its Vaudreuil refinery at Jonquière, Québec.

China.—Determining China’s actual production data for acid-grade 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. Domestic consumption for 2001 was estimated to be 1.4 Mt.

The Chinese Government launched a National Program of Mineral Resources in June. The program stipulates that mining (including fluorspar) can be conducted only by the enterprises equipped with sufficient resources and the approval of the Government. This is an attempt to curtail the small-scale irregular mining that is damaging to the environment, wasteful of resources, and dangerous for the miners. In addition, the program indicates that fluorspar production shall be restricted to a certain total quantity because of its scarcity. It is believed that these restrictions and China's export quota system are in compliance with World Trade Organization regulations (WTO) (Hong, 2002). China officially joined the WTO on December 11.

In December, the Chinese Ministry of Foreign Trade and Economic Cooperation held bidding for about 500,000 t of an expected 1 Mt of fluorspar authorized for export in 2002. Bids by potential Chinese exporters were for 325,000 t under invitational tenders at an average value of \$39 to \$41 per ton and for 175,000 t under public tenders at values that ranged from \$74 to \$83 per ton.

Morocco.—Société Anonyme d'Enterprises Minières (SAMINE) has embarked on a quality improvement program at its El Hammam fluorspar mine. The first phase of the program involved a detailed mineralogical analysis of the ore and flotation products. The primary conclusions were that there were no mineralogical reasons to prevent the quality improvement objectives being met through optimization of the flotation circuit. The second phase involved installation of a sulfide flotation circuit ahead of fluorspar flotation using old fluorspar cleaner cells no longer in use. The success of this circuit convinced SAMINE to replace these old inefficient cells with three new 8-cubic-meter cells with sufficient retention time to remove all sulfides. The third phase under investigation in the laboratory involves a review of flotation reagents and performance testing of substitute reagents for the sulfide and fluorspar circuits. After completion of these changes, a final phase will be undertaken to review the grinding circuit (Sennaji, 2002).

Namibia.—In January, an exploration contract was awarded by Okorusu Fluorspar (Pty) Ltd. for 6,500 meters (m) of diamond drilling to define the full extent of the A ore body, which is located half way up the slope of Okorusu Mountain. By the end of the year, about 90% of the drilling had been completed, proving significant extensions of the ore body to the west and downdip. Drilling will continue in the first quarter of 2002 to delineate the geometry of the ore body. Future drilling is planned to explore the nearby B and C ore bodies, and other outlying prospects on the mining license and surrounding area will be investigated. A cause of concern is that there is a possibility that mining of the existing A ore body will be restricted in the future because the pit configuration is constricted to areas where a compensation agreement exists with the land owner.

Okorusu Fluorspar completed a desktop study on the Omburu fluorspar prospect near Omaruru, which justifies an exploration drilling program. An agreement with the land owner was not reached in 2001, and plans have been deferred to the latter half of 2002, with a bankable feasibility study targeted for completion in early 2003 (Chamber of Mines of Namibia, 2002, p. 12, 17, 19).

South Africa.—Vergenoeg Mining Co. (Pty.) Ltd., completed two capital projects to improve acid grade recovery and quality. The first project involved the construction and commissioning of two 22-m-diameter thickeners for use in the milling circuit. Mechanisms for the thickener were purchased and refurbished by Baker Process (a division of Baker Hughes Inc.), which also constructed the thickener tanks and rakes. Personnel from the Vergenoeg Mine completed all the process engineering, civil and electrical work as well as the piping, ancillary tanks, and access platforms. The second project, which was completed in October, involved the extension of the present concentrator building and construction of two new banks of cleaner cells. Once again, all the process engineering, construction, and commissioning was undertaken by Vergenoeg Mine staff, with the assistance of Minerales y Productos Derivados S.A. (Vergenoeg Mining Co. [Pty.] Ltd., [undated]§). The quality of the fluorspar at the Vergenoeg Mine was identified some time ago as a deterrent to supplying the North American markets. The plant upgrade program was initiated to address the problems and to allow Vergenoeg to expand its markets.

Vietnam.—Tiberon Minerals Ltd. has been conducting an exploration drilling program for tungsten on the Nui Phao exploration license and discovered that the prospect contained significant fluorspar mineralization. The company drilled more than 100 holes in 2001 and, in its updated resource estimate released in March 2002, classified 5.73 Mt as measured containing 11.0% CaF_2 and 11.47 Mt as indicated containing 10.0% CaF_2 (Tiberon Minerals Ltd., 2002b§). The company also announced the results from a metallurgical study of fluorspar recovery performed on a head sample containing 12.4% CaF_2. The test results indicated that overall fluorspar recovery as flotation concentrates expected in a continuous operation would be approximately 70%, with 75% to 80% of this recovered as acid grade and the remaining as subacid grade grading 92% to 97% CaF_2. Potential fluorspar production is in excess of 120,000 t/yr based on a plant design throughput of 1.5 to 2.3 million metric tons per year grading 8% to 11% CaF_2 (Tiberon Minerals Ltd., 2002a§).

Current Research and Technology

When producing HF from the reaction of fluorspar and sulfuric acid, the process produces significant quantities of byproduct gypsum. The gypsum is in anhydrous form and, because it contains 1% to 2% unreacted fluorspar, is called fluorgyp. Alcoa World Chemicals, which produces HF as part of its AlF_3 manufacturing process at Point Comfort, TX, investigated the use of the byproduct fluorgyp as a set retarding agent in cement. Because the material also contains 0.1% to 4% unreacted sulfuric acid, it was necessary to neutralize it with calcium carbonate before it could be tested for use in cement. A prominent national laboratory was hired to test the fluorgyp against a control of commercial dihydrate gypsum to determine if it was suitable. Results of the tests met the ASTM C150 standard for setting times and compressive strength, and the differences in test results between the cement made with natural cement and fluorgyp were insignificant. Alcoa built a pilot plant and produced several trial lots of fluorgyp for testing by the cement industry with excellent results. Advantages of fluorgyp compared to natural gypsum include greater sulfate availability because it is in anhydrous form and energy savings because it does not require grinding (the average particle size of the Alcoa material is 6 micrometers). Alcoa has applied for a patent on the process (Eisele, 2002).

Outlook

Fluorocarbon production from HF is the single largest market that drives acid-grade fluorspar demand. In 2001, the effects of the poor economy could be seen in the decrease in acidspar consumption in the United States and in the decrease in HF imports. Any really visible upturn in the economy is not expected until 2003. In 2003, the ban on production and importation of the widely used blowing agent HCFC 141b will go into effect. The expected loss of market share to nonfluorocarbon replacements will be significant. Some sources estimate that fluorocarbons will lose half this market to not-in-kind replacements, such as carbon dioxide, water, and pentane isomers. Growth potential in the refrigerant market looks fairly positive for the next few years, and the fluoropolymer precursors market will continue to display solid growth. It is difficult to forecast how these mixed factors will affect fluorspar consumption. A factor to remember is that many of the replacement HFCs use more fluorspar than the CFCs or HCFCs they are replacing. In the United States, it is expected that consumption of acid-grade fluorspar for HF and AlF_3 will return to 2000 levels by 2003. In recent years, the U.S. HF plants have been operating at high capacity rates so that there is little room for increased fluorspar consumption. Any increase will occur in Canada and Mexico, which possess excess capacity that could supply the HF feedstock if U.S. fluorocarbon production increases.

Worldwide aluminum consumption is expected to increase by 1% to 3% per year during the next few years, and consumption of AlF_3 should mirror this forecast. The strongest growth is expected in China and the CIS where the largest increases in aluminum production are expected and where the highest usage rates occur because of the continued use of older smelters. The small increase in AlF_3 consumption is expected to be met by output from fluorspar rather than fluorosilicic acid.

Fluorspar sales to the steel industry should increase in 2002 with better prospects in 2003. Output by the domestic steel industry is expected to increase as the economy strengthens and import quotas are reached, triggering the import tariffs. Smaller markets, such as ceramics, glass, and stick metal arc welding electrodes, will improve with the economy. Growth is expected in the cement market. This market has been growing in Mexico, Central America, and South America, and metspar suppliers are hoping to duplicate such growth in Canada and the United States.

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TABLE 1
SALIENT FLUORSPAR STATISTICS 1/ 2/

		1997	1998	1999	2000	2001
United States:						
Production:						
Finished, shipments	metric tons	--	--	--	NA	NA
Value, free on board mine	thousands	--	--	--	NA	NA
Exports 3/	metric tons	62,100	23,600	55,400	39,800	21,200
Value 4/	thousands	$8,330	$3,890	$6,970	$5,330	$3,240
Imports 3/	metric tons	538,000	503,000	478,000	523,000	522,000
Value 5/	thousands	$69,500	$62,700	$56,900	$65,200	$69,000
Value per ton, acid grade 5/		$134.00	$128.00	$124.00	$128.00	$135.00
Value per ton, metallurgical grade 5/		$91.00 r/	$89.00 r/	$88.00 r/	$84.00 r/	$80.00
Consumption, reported	metric tons	491,000	538,000	514,000 r/	512,000	536,000
Consumption, apparent 6/	do.	551,000	591,000	615,000	601,000	543,000 7/
Stocks, December 31:						
Consumer and distributor 8/	do.	375,000	468,000	373,000	289,000	221,000 7/
Government stockpile	do.	448,000	243,000	146,000	112,000	112,000
World, production	do.	4,180,000 r/	4,410,000 r/	4,290,000 r/	4,430,000 r/	4,530,000 e/

e/ Estimated. r/ Revised. NA Not available. -- Zero.
1/ Data are rounded to no more than three significant digits.
2/ Does not include fluorosilicic acid (H_2SiF_6) or imports of hydrofluoric acid (HF) and cryolite.
3/ Source: U.S. Census Bureau, adjusted by the U.S. Geological Survey.
4/ Free alongisde ship values at U.S. ports.
5/ Cost, insurance, freight values at U.S. ports.
6/ Imports minus exports plus adjustments for Government and industry stock changes.
7/ Calculations made using only acid-grade stocks data from the three largest consumers.
8/ Includes fluorspar purchased from the National Defense Stockpile but still located at National Defense Stockpile depots.

TABLE 2
U.S. REPORTED CONSUMPTION OF FLUORSPAR, BY END USE 1/

(Metric tons)

End use or product	Containing more than 97% calcium fluoride 2000	Containing more than 97% calcium fluoride 2001	Containing not more than 97% calcium fluoride 2000	Containing not more than 97% calcium fluoride 2001	Total 2000	Total 2001
Hydrofluoric acid and aluminum fluoride	474,000	429,000	16	1,100	474,000	430,000
Metallurgical 2/	W	21,300	15,900	43,700	15,900	65,000
Other 3/	13,600	23,700	8,650	17,000	22,200	40,700
Total	487,000	474,000	24,500	61,800	512,000	536,000
Stocks (consumer), December 31 4/	48,300	71,100	25,700	NA	73,900	NA

NA Not available. W Withheld to avoid disclosing company proprietary data.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Data for 2000 include consumption for basic oxygen and electric arc furnaces; 2001 data include consumption for all metallurgical uses.
3/ Includes acid grade used in enamel, glass and fiberglass, steel castings, welding rod coatings, and data represented by symbol W.
4/ Because of a change in survey methodology, the 2001 stocks data are only available for hydrofluoric acid and aluminum fluoride.

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source-grade	2000	2001
Chinese, U.S. Gulf port, dry basis, acidspar	NA	136-141
Mexican, free on board (f.o.b.), Tampico:		
Acidspar filtercake	110-130	105-125
Metallurgical grade	85-105	95-115
Mexican, f.o.b., Mexico:		
Acidspar filtercake, As <5 ppm	132-145	138-150
South African, acidspar dry basis, f.o.b. Durban	105-125	105-125

NA Not available.

Sources: Industrial Minerals, no. 399, p. 74, December 2000, and no. 411, p. 82, December 2001.

TABLE 4

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

Country	2000 Quantity (metric tons)	2000 Value 2/	2001 Quantity (metric tons)	2001 Value 2/
Canada	18,100	$2,930,000	15,800	$2,410,000
Dominican Republic	62	9,090	--	--
Italy	13,200	1,210,000	--	--
Mexico	4,520	441,000	3	2,510
Taiwan	3,310	592,000	5,020	733,000
Other 3/	647	146,000	374	101,000
Total	39,800	5,330,000	21,200	3,240,000

-- Zero.

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

2/ Free alongside ship values at U.S. ports.

3/ Includes Australia, Belgium, France, India, Israel, Japan, the Netherlands, Saudi Arabia, Switzerland, and Venezuela.

Source: U.S. Census Bureau.

TABLE 5

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

Country and customs district	2000 Quantity (metric tons)	2000 Value 2/ (thousands)	2001 Quantity (metric tons)	2001 Value 2/ (thousands)
Containing more than 97% calcium fluoride (CaF_2):				
China:				
Houston	183,000	$23,200	174,000	$24,700
New Orleans	145,000	19,800	179,000	23,800
Total	328,000	43,000	353,000	48,500
France, Philadelphia	204	80	322	110
Germany:				
Boston	112	14	--	--
New Orleans	--	--	1	2
Philadelphia	172	20	--	--
Savannah	68	37	51	24
Total	352	71	52	26
Kenya, Laredo	18	3	--	--
Mexico:				
Detroit	71	12	--	--
Laredo	17,700	2,350	22,600	3,190
New Orleans	3,900	378	5,340	499
Total	21,700	2,740	27,900	3,690
South Africa:				
Houston	42,600	5,020	45,600	6,010
New Orleans	91,200	11,000	68,000	8,420
Total	134,000	16,000	114,000	14,400
United Kingdom:				
Houston	--	--	1	3
Los Angeles	182	23	172	22
New York City	15	28	--	--
Total	197	51	173	24
Grand total	484,000	62,000	495,000	66,800
Containing not more than 97% calcium fluoride (CaF_2):				
Canada, Buffalo	21	6	94	31
Japan, Cleveland	--	--	500	67
Mexico:				
Laredo	2,430	201	1,490	89
New Orleans	36,300	3,040	24,800	1,950
Total	38,700	3,240	26,300	2,040
United Kingdom, New York City 3/	6	17	9	17
Grand total	38,700	3,260	26,900	2,150
Total imports all grades	523,000	65,200	522,000	69,000

See footnotes at end of table.

TABLE 5--Continued

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

-- Zero.

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

2/ Cost, insurance, freight values at U.S. ports.

3/ In the 2000 publication of this chapter, New York City was erroneously reported as Philadelphia.

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

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID, BY COUNTRY 1/

	2000		2001	
Country	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Canada	36,000	$41,100	26,300	$31,000
China	144	99	114	84
France	212	209	111	108
Germany	150	285	342	543
India	--	--	14	4
Ireland	--	--	211	212
Japan	1,670	4,590	1,130	2,930
Korea, Republic of	80	329	63	248
Mexico	92,400	84,500	83,000	78,300
United Kingdom	163	189	147	146
Total	131,000	131,000	112,000	114,000

-- Zero.

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

2/ Cost, insurance, freight values at U.S. ports.

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

TABLE 7

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

	2000		2001	
Country	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Australia	2,140	$1,220	1,450	$841
Canada	2,840	1,090	1,770	759
China	398	323	153	128
Denmark	76	119	78	109
Germany	2,770	2,840	2,460	2,510
Hungary	439	495	415	431
Japan	20	19	70	52
United Kingdom	333	486	250	420
Other 3/	174	131	104	89
Total	9,190	6,730	6,750	5,340

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

2/ Cost, insurance, freight values at U.S. ports.

3/ Includes Austria, Belgium, Hong Kong, India, Italy, Russia, and Ukraine.

Source: U.S. Census Bureau.

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

Country	2000 Quantity (metric tons)	2000 Value 2/ (thousands)	2001 Quantity (metric tons)	2001 Value 2/ (thousands)
Canada	3,610	$3,080	6,150	$4,940
Italy	2,880	2,000	5,280	3,900
Mexico	11,600	9,550	4,170	3,300
Norway	2,580	2,020	1,800	1,410
Other 3/	763	647	36	95
Total	21,500	17,300	17,400	13,600

1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Cost, insurance, freight values at U.S. ports.
3/ Includes China, Germany, Israel, Japan, and Sweden.

Source: U.S. Census Bureau.

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

(Metric tons)

Country and grade 3/ 4/	1997	1998	1999	2000	2001 e/
Argentina	12,172 r/	61,468 r/	12,704 r/	11,200 r/ e/	11,000
Brazil (marketable):					
Acid grade	66,858 r/	61,024	38,209 r/	30,131 r/	30,131 5/
Metallurgical grade	11,174	11,058	6,717 r/	12,381 r/	12,831 5/
Total	78,032 r/	72,082	44,926 r/	42,512 r/	42,962 5/
China: e/					
Acid grade	1,150,000	1,180,000	1,200,000	1,250,000	1,250,000
Metallurgical grade 6/	1,150,000	1,170,000	1,200,000	1,200,000	1,200,000
Total	2,300,000	2,350,000	2,400,000	2,450,000	2,450,000
Egypt e/	775	140	500	500	500
France: e/					
Acid and ceramic grades	80,000	80,000	82,000	80,000	90,000
Metallurgical grade	30,000	30,000	25,000	20,000	20,000
Total	110,000	110,000	107,000	100,000	110,000
Germany e/	24,000	25,000	28,000	30,000	30,000
India:					
Acid grade	6,937	-- e/	-- e/	--	--
Metallurgical grade	9,877	785	800 e/	850	900
Total	16,814	785	800 e/	850	900
Iran 7/	24,846 r/	25,904	18,387	20,000 e/	20,000
Italy: e/					
Acid grade	106,000 r/	92,000	95,000	50,000	30,000
Metallurgical grade	20,000 r/	15,000	15,000	15,000	15,000
Total	126,000	107,000	110,000	65,000	45,000
Kenya, acid grade	68,700	60,854	93,602 r/	100,102 r/	108,000
Korea, North, metallurgical grade e/	39,000	30,000	25,000	25,000	25,000
Korea, Republic of, metallurgical grade e/	617 5/	--	--	--	--
Kyrgyzstan	4,176	3,200 e/	2,997	3,000 e/	1,175 5/
Mexico: 8/					
Acid grade	290,580	330,711	323,282 r/	334,780 r/	335,000
Metallurgical grade	262,260	267,331	233,829 r/	300,450 r/	300,000
Total	552,840	598,042	557,111 r/	635,230 r/	635,000
Mongolia:					
Acid grade	130,000	122,000	100,000	111,443	110,000
Other grades 9/	41,000	45,900	54,600	87,400	90,000
Total	171,000	167,900	154,600	198,843	200,000
Morocco, acid grade	103,800	105,000 r/	83,100 r/	77,800 r/	75,000

See footnotes at end of table.

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

(Metric tons)

Country and grade 3/ 4/	1997	1998	1999	2000	2001 e/
Namibia, acid grade 10/	23,208	40,685	57,700	66,000 r/	83,000
Pakistan, metallurgical grade	1,050	1,000 e/	220	997 r/	1,000
Romania, metallurgical grade e/	15,000	15,000	15,000	15,000	15,000
Russia e/	6,200 r/	120,000	153,800 r/	187,600 r/	190,000
South Africa: 11/					
Acid grade	201,000 e/	222,000 e/	203,280	201,737 r/	272,000
Ceramic grade	4,000 e/	--	--	-- e/	--
Metallurgical grade e/	2,000	15,000	14,000	10,618 r/	14,300
Total	207,000	237,000	217,280	212,355	286,387 5/
Spain: e/					
Acid grade	110,000	110,000	123,000	120,000 r/	115,000
Metallurgical grade	10,000	10,000	10,000	15,000 r/	15,000
Total	120,000	120,000	133,000	135,000 r/	130,000
Tajikistan e/	9,000	9,000	9,000	9,000	9,000
Thailand, metallurgical grade	7,826	3,743	13,005	4,745	4,800
Tunisia	1,426	1,190 r/	520	--	--
Turkey, metallurgical grade	5,000 e/	5,000 e/	4,812 r/	4,113 r/	400
United Kingdom e/	64,000	65,000	42,000	35,000 r/	50,000
Uzbekistan e/	90,000	80,000	-- r/	-- r/	--
Grand total	4,180,000 r/	4,410,000 r/	4,290,000 r/	4,430,000 r/	4,530,000

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

1/ World totals, 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 6, 2002.

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 based on 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.