

FLUORSPAR

By M. Michael Miller

Domestic survey data and tables were prepared by Barbara J. McNair, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.

Fluorspar is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, plastics, 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 . Subacid grade includes metallurgical and ceramic grades, and is commonly called metallurgical grade or metspar. The bulk of U.S. demand is supplied by imports, although supply is supplemented by sales of material from the National Defense Stockpile (NDS) and by small amounts of byproduct 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, U.S. imports of fluorspar increased by nearly 15%, imports of hydrofluoric acid (HF) decreased by 3%, and exports of fluorspar increased by more than 26% when compared with those in 2002.

Legislation and Government Programs

The section 201 (Trade Act of 1974) tariffs on imported steel, which went into effect on March 20, 2002, were repealed by the President in early December 2003 (White House, 2003¹). The tariffs ranged from 8% to 30%, excluding imports from free-trade partners, and were to be in effect for 3 years. Pressure from steel importers and foreign trading partners resulted in their early repeal. A significant increase in low-cost steel imports could result in a reduction in domestic steel production. This would adversely affect merchant sales of fluorspar to this sector.

During calendar year 2003, there were no sales of fluorspar from the NDS. According to the Defense National Stockpile Center's (DNSC) fiscal year 2004 (October 1, 2003, to September 30, 2004) Annual Materials Plan, total sales of about 54,400 metric tons (t) (60,000 short dry tons) of metallurgical grade and 10,900 t (12,000 short dry tons) of acid grade have been authorized. Actual quantities sold will be limited to remaining sales authority or inventory. Unsold quantities remaining in the NDS are documented in the "Stocks" section of this report.

Production

In 2003, there was no reported mine production of fluorspar in the United States. There is no U.S. Geological Survey (USGS) data survey for synthetic fluorspar. Domestic production data for fluorosilicic acid were developed by the USGS from a

voluntary canvass of U.S. operations. Of the nine fluorosilicic acid operations surveyed, eight respondents reported production, and one respondent reported zero production, representing 100% of the quantity reported.

Fluorosilicic acid is produced as a byproduct from the processing of phosphate rock into phosphoric acid. In 2003, five phosphoric acid companies operated eight plants and reported production of 53,400 t of byproduct fluorosilicic acid. They sold or used 53,200 t of byproduct fluorosilicic acid (equivalent to approximately 93,600 t of fluorspar grading 92% CaF_2). This material was valued at about \$7.92 million. 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 decreases.

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, but the actual amount of synthetic fluorspar recovered is unknown.

Applied Industrial Materials Corp. (AIMCOR) in Aurora, IN; Hastie Mining Co. in Cave-In-Rock, IL; and Seaforth Mineral & Ore Co., Inc., in East Liverpool, OH, screened and dried metallurgical- and acid-grade fluorspar imported or purchased from the NDS.

AIMCOR was acquired by Oxbow Carbon and Minerals LLC (OCM) in December 2003 and is now part of OCM. The acquisition also included the 49% share AIMCOR held in Mexican fluorspar producer Fluorita de Mexico S.A. de C.V. (Industrial Minerals, 2004).

Environment

The U.S. Environmental Protection Agency (EPA) announced it will be conducting a scientific assessment of perfluorooctanoic acid (PFOA) and its salts. The most commonly used PFOA is ammonium perfluorooctanoate, which is a surfactant that aids in polymerization of fluoropolymer resins such as Teflon[®]. Laboratory studies have shown that exposure to PFOA causes developmental toxicity in rats, and a preliminary assessment by the EPA indicated that the U.S. public was exposed to the chemical at very low levels. Since PFOA is only manufactured at one site in the United States and used at only a small number of fluorochemical plants, it is postulated that there may be additional sources of PFOA in the environment. The EPA is looking at fluorinated telomers (short polymers), which may biodegrade into PFOA, as possible sources. Products made with these telomers include fire-fighting foams, personal care and cleaning products, and stain-repellent coatings on carpets, fabrics, and paper (Hogue, 2003).

As a result of new research on the health effects of fluorides, the EPA has requested the National Research Council (NRC) of

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

the National Academies of Science to perform another review of the potential problems associated with water fluoridation. The specific task for the new NRC review is to examine the toxicological, epidemiological, clinical, and exposure data published on fluoride since 1993. In the United States, beginning with regional studies in 1945, fluoride has been added to drinking water in many localities in order to reduce dental caries (cavities). In 1986, the EPA set a maximum contaminant level (MCL) of fluoride at 4 milligrams per liter (mg/l) in drinking water and set a secondary MCL at 2 mg/l. The secondary MCL is a goal that water systems should try to reach, but they cannot be fined if they fail to do so. There is recent evidence from both human and animal studies that excessive levels of fluoride presents risks to bones and other organs. The review is being performed by NRC's Board on Environmental Studies and Toxicology; the board plans to complete its review by November 2004 (Hileman, 2003).

Consumption

Domestic consumption data for fluorspar were developed by the USGS from a quarterly consumption survey of three large consumers that provide data on HF and aluminum fluoride (AlF₃) consumption and five distributors that provide data on the merchant market (metallurgical and other uses). Quarterly data were received from all eight respondents, and these responses made up 100% of the reported consumption in table 2.

Industry practice has established three grades of fluorspar—acid grade, containing more than 97% CaF₂; ceramic grade, containing 85% to 95% CaF₂; and metallurgical grade, normally containing 60% to 85% CaF₂. Fluorspar grades are defined by the intended use, but these grades are essentially just averages. During the past several decades, there has been a general movement in the United States 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.

Total reported U.S. fluorspar consumption increased by about 5% in 2003 compared with that of 2002. Consumption of acid grade for HF and AlF₃ increased by more than 9% to 523,000 t, but consumption of fluorspar for metallurgical and other uses decreased by 16% (table 2).

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 & Co. Inc. (DuPont) and Honeywell International Inc. To analyze demand for acid-grade fluorspar it is necessary to describe and analyze the markets for HF. In 2003, production of HF for use in manufacturing fluorocarbons accounted for the bulk of the increased consumption of acid-grade fluorspar.

The largest use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), and fluoroelastomers or fluoropolymers. HCFCs and HFCs were produced by the following companies: ATOFINA Chemicals Inc., DuPont, Great Lakes Chemical Corp., Honeywell, INEOS Fluor Americas LLC, MDA Manufacturing Ltd., and Solvay Solexis Inc.

Some of the existing or potential fluorocarbon replacements for 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 prior to their phaseout. Specific HCFCs individually or in mixtures are being used in home air conditioning systems, in chillers, as foam blowing agents, as solvents (in addition to perfluorocarbons and hydrofluoroethers), and as a diluent in sterilizing gas.

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, 152a, 227ea, 236fa, 245fa, and 4310 also are being produced domestically but in much smaller quantities. These HFCs are being used individually or in blends as replacements for CFCs and HCFCs.

The largest use for HCFC 141b was as a foam blowing agent; however, on January 1, 2003, a ban on the production and importation of HCFC 141b went into effect. In response to this ban, HFCs 134a, 152a, 236ea, 245fa, 356, and 365mfc have been tested as potential replacements as blowing agents for polystyrene and polyurethane foams. For blowing polyurethane, it appears that the fluorocarbon blowing agents of choice are HFCs 134a, 245fa, and 365mfc. Honeywell is manufacturing and marketing HFC 245fa for this market from its plant in Louisiana. HFC 245fa is also being marketed as a replacement for HCFCs 22 and 123 in low-pressure centrifugal chillers. HFC 365mfc is not approved for foam blowing in the United States as yet, but Solvay Fluor (a business unit of Solvay S.A.) is manufacturing it at its plant in France for the European market. HFC 152a has been approved for use in several types of foams but primarily is used for blowing polystyrene and polyolefin foams.

HCFCs 22, 123, and 124; HFCs 23, 125, 134a, and 227ea; and a number of other fluorine compounds have been approved by the EPA 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, the conversion of systems to the use of alternatives is progressing slowly. The alternatives compare unfavorably (based on cost, space, and weight) when compared with halons, and there are sufficient supplies of recycled halons 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§). Although the production of halons has been banned in the United States since 1993, the use of recycled halon material is allowed.

The use of HF for the manufacture of fluoroelastomers and fluoropolymers continued to display strong growth. CFC 113, HCFCs 22 and 142b, and HFC 152a were produced as chemical intermediates in the production of fluoroelastomers and fluoropolymers. These compounds have desirable physical and chemical properties that allow them to be used in products from pipes, valves, and seals to architectural coatings and 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 petroleum alkylation, stainless steel pickling, 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, stannous fluoride, sulfur hexafluoride, tungsten hexafluoride, and others that are used in decay-preventing dentifrices, dielectrics, metallurgy, mouthwashes, water fluoridation, and wood preservatives. It is used as the feedstock for producing potassium fluoride, which is the preferred fluorine source in a number of insecticides and herbicides, as well as in some proprietary analgesic preparations, antibiotics, and antidepressants.

Acid-grade fluorspar was used in the production of AlF_3 and cryolite (Na_3AlF_6), which are the main fluorine compounds used in aluminum smelting. In the Hall-Héroult aluminum process, alumina is dissolved in a bath consisting primarily of molten Na_3AlF_6 , AlF_3 , and fluorspar to allow electrolytic recovery of aluminum. In countries with strong environmental regulations, a modern aluminum smelter operating prebaked anode technology will contain high-efficiency scrubbers that will recover 96% to 99% of fluorine emissions. Fluorine losses are made up entirely by the addition AlF_3 , the majority of which will react with excess sodium from the alumina to form Na_3AlF_6 . This type of smelter will consume about 20 kilograms (kg) of AlF_3 for each metric ton of aluminum produced. Plants using the older Soderburg technology with minimal recovery of fluorine emissions will have significant losses of fluorine and sodium, which will be replaced by adding a combined 40 to 50 kg of AlF_3 and Na_3AlF_6 per metric ton of aluminum produced.

Minor uses of AlF_3 included its use by the ceramics industry for some body and glaze mixtures, in the production of specialty refractory products, in the manufacture of aluminum silicates, in the glass industry as a filler, as a catalyst for organic synthesis, and as an inhibitor of fermentation.

Most AlF_3 is produced directly from acid-grade fluorspar or from byproduct fluorosilicic acid. In 2003, Alcoa World Alumina LLC (a business unit of Alcoa Inc.) produced AlF_3 from fluorspar at Point Comfort, TX.

The merchant fluorspar market in the United States includes metallurgical- and acid-grade sales to steel mills, foundries, glass and ceramics plants, cement plants, welding rod manufacturers, and other small markets in rail car, truckload, and less than truckload quantities. In 2003, this merchant market totaled 92,600 t, which included 49,500 t of acid-grade sales (53% of the merchant market) and 43,100 t of metallurgical-grade sales (47% of the merchant market). During the past 20 to 30 years, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

Acid- or 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. These grades also were used in welding fluxes and as a flux in the steel industry. In welding, fluxes are commercially termed welding consumables and are manufactured as a flux coating to electrodes, as a flux core in a wire electrode, or as powdered flux product. These products are broadly categorized as acid, basic, rutile, and cellulosic. Fluorspar is used in basic compositions where it can make up 30% to 40% of the flux composition (O'Driscoll, 2002).

Consumption of fluorspar in metallurgical markets (mainly steel) decreased by more than 17% compared with 2002. 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- or submetallurgical-grade fluorspar is used in cement production where it acts mainly 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. Its use can, however, damage the refractory lining in the cement kiln and this factor has limited its use in the cement industry.

About 38,300 t of byproduct fluorosilicic acid valued at \$5.61 million was sold for water fluoridation, and about 14,800 t valued at \$2.31 million was sold or used for other uses. There were no sales for AlF_3 production in 2003.

Stocks

Data for stocks were available from distributors and HF and AlF_3 producers. Known consumer and distributor stocks totaled 206,000 t, which included 126,000 t at consumer or distributor facilities and 80,000 t purchased from the NDS but still located at NDS depots. As of December 31, 2003, the NDS fluorspar inventory classified as excess (excluding material sold pending shipment) contained about 95,000 t (105,000 short dry tons) of fluorspar (table 1). This total included about 6,880 t of acid grade (7,580 short dry tons), 68,200 t of metallurgical grade (75,100 short dry tons), and 20,000 t (22,000 short dry tons) of metallurgical grade that did not meet NDS specifications. These numbers, particularly in the breakdown between metallurgical grade and subspecification metallurgical grade, differ from those reported in 2002, and it is assumed that the DNSC's records were updated or reassessed.

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. This moisture is removed by heating in rotary kilns, or other kinds of dryers, before treating with sulfuric acid to produce HF. Most acid-grade imports come from China and South Africa and are usually shipped by ocean freight using bulk carriers of 10,000 to 50,000 t deadweight. Participants negotiate freight levels, terms, and conditions. Some acid grade and ceramic grade is marketed in bags for small users and shipped by truck.

Prices

At yearend, the average range of U.S. Gulf port prices, including cost, insurance, and freight (c.i.f.), dry basis, for Chinese acid grade increased to a range of \$165 per metric ton to \$170 per ton (table 3). The South African price range for acid grade [free on board (f.o.b.) Durban] was unchanged, and price ranges for Mexican acid-grade fluorspar (f.o.b. Tampico) also were unchanged compared with those of 2002 (Industrial Minerals, 2003b). Industrial Minerals no longer lists a price for metallurgical-grade fluorspar, so the prices listed in table 3 were calculated from fourth-quarter statistics from the U.S. Census Bureau.

Foreign Trade

U.S. exports of fluorspar increased by more than 26% to 30,700 t from the 2002 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 2003, imports for consumption of fluorspar increased by nearly 15% when compared with those of 2002 (table 5). The largest suppliers of fluorspar to the United States, in descending order, were China (59%), South Africa (21%), Mexico (16%), and Spain (3%). The average unit value including c.i.f. was \$138 per ton for acid grade and \$85 per ton for metallurgical grade (table 1).

Imports of HF decreased by 3% to 111,000 t, or a quantity equivalent to about 166,000 t of fluorspar (table 6). Imports of synthetic and natural Na_3AlF_6 increased slightly to 8,120 t, or a quantity equivalent to 9,740 t of fluorspar (table 7). Imports of AlF_3 decreased by about 41% to 10,100 t, or a quantity equivalent to about 15,200 t of fluorspar (table 8).

There are no tariffs on fluorspar from normal-trade-relations countries. There are no tariffs on other major fluoride minerals and chemicals, such as natural or synthetic Na_3AlF_6 , HF, and AlF_3 .

World Review

Estimated world production increased by 7% compared with the revised 2002 data (table 9). China, Mexico, South Africa, Mongolia, and Russia, in decreasing order, were the largest producers.

Europe.—Fluorspar consumers and producers are facing pressures from a couple of pieces of proposed legislation—Registration, Evaluation, and Authorization of Chemicals

(REACH) and regulations intended to reduce emissions of fluorinated gases.

Existing chemicals legislation in Europe and the United States, passed in the 1970s, instituted testing and review requirements for chemicals placed on the market after 1980, but chemicals already on the market were “grandfathered” with few regulatory requirements. These chemicals, representing 99% by volume of chemicals on the market in 2003, were presumed by law to be safe until proven dangerous. In October 2003, the European Commission (EC) of the European Union officially adopted the REACH legislative proposal. REACH will require that chemical producers (including foreign firms wishing to sell their products in Europe) provide basic toxicity and exposure information on all chemicals in commerce, and it institutes a presumption that certain chemicals are potentially dangerous and should be replaced unless it is shown that they are necessary or can be used safely (Lowell Center for Sustainable Production, 2003a§, b§). Large production chemicals will have to be registered within the first 2 years, but chemicals for which a risk assessment is already available will likely not have to undergo further evaluation. Most of the new fluorocarbon compounds have undergone extensive safety and toxicology testing during their development, but REACH will affect any newly developed fluorochemicals (Crossley, 2004).

The fluorinated gases legislation is part of proposed measures to reduce emissions of fluorinated greenhouse gases comprising HFCs, perfluorocarbons, and sulfur hexafluoride. The greatest impact on fluorocarbon producers and fluorspar suppliers would be from plans to phase out HFC 134a in new vehicle automobile air-conditioning systems between 2009 and 2013. The proposal may be amended during the review process by the Council of Ministers and the European Parliament (Chemical Week, 2003).

In November, the EC concluded its review of the antidumping measures on Chinese fluorspar and decided to keep the existing measures in place. There was concern that the current measures allowed potential price manipulation to circumvent the minimum import price (€113.50 per ton), so an ad valorem duty of 37.8% had been proposed. Since the effective price of Chinese fluorspar was well above the minimum import price, the ad valorem duty would have meant a 37.8% price increase, making Chinese imports uncompetitive (Crossley, 2004).

Australia.—Mineral Securities Ltd. (MSL), which acquired the Speewah fluorite project in the East Kimberley region of northern Western Australia in 2002, entered into a A\$3.75 million agreement with Doral Mineral Industries Ltd. to complete a bankable feasibility study. The agreement would allow Doral to earn up to 75% interest in the project, while making Doral responsible for management of the project including an expanded drilling program and delivery of the bankable feasibility study. Prior to the onset of the wet season, the drilling program completed approximately 7,000 meters (m) of reverse circulation drilling and 1,000 m of diamond core drilling that intersected broad zones of fluorite mineralization consistent with previous drilling. Additional drilling will be undertaken beginning at the start of the 2004 dry season. Completion of sample work is expected to give an approximate run of mine ore grade of 25% to 26% CaF_2 . Data from the drilling program will be used in the bankable

feasibility study scheduled for completion by August 2004. Various environmental, ethnographic, hydrologic, road, and metallurgical studies have been commissioned with pit design and engineering studies to follow (Mineral Securities Ltd., 2003, 2004).

China.—Determining China's actual production of fluor spar 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. In particular, quantifying the production and consumption of metallurgical-grade fluor spar is extremely difficult. In addition, domestic consumption may include significant amounts of sub-metallurgical-grade fluor spar for cement and other uses. Based on comments from the Chinese steel industry, estimates of metallurgical-grade fluor spar production have been increased (P.K. Tse, country specialist, U.S. Geological Survey, oral commun., June 2004), but other sources also have reported that safety issues have forced the closure of some fluor spar mines, inventories have been drawn down, and reserves have become depleted at several operations (Crossley, 2004). Chinese exports decreased for the third straight year to 951,000 t, which included 837,000 t of acid grade and 114,000 t of metallurgical grade.

France.—Société Industrielle du Centre, which ceased production from its Rossignol Mine in 1997, made its last fluor spar shipments in early 2004. This leaves Société Generale de Recherches et d'Exploitation Minières (SOGEREM) as the only French fluor spar producer (Olivier Jullin, product manager fluor spar, SOGEREM, written commun., March 12, 2004).

India.—Although the reason is unknown, the Indian Bureau of Mines significantly reduced the reported quantities of fluor spar produced from 2000 to 2002. It is possible the previous numbers may have been run-of-mine production instead of finished product.

Kenya.—Kenya Fluor spar Co. Ltd. undertook a limited expansion program, which will increase capacity by 20%. The company has already upgraded its mining equipment and has begun debottlenecking and installing additional milling and flotation capacity (Crossley, 2004).

Mexico.—Atlas Minerals Inc., through its wholly owned Mexican subsidiary Minerales Atlas S.A. de C.V., executed a 6-month option to purchase the La Barra fluor spar property in the State of Sonora, Mexico. The property is comprised of three claims covering 300 hectares (741 acres) and two underground mines that were reportedly last mined in early 1974. The property is located 80 kilometers (50 miles) south of Douglas, AZ, near the town of Esqueda. During the 6-month term of the purchase option, Atlas evaluated the mining claims and existing underground mines, as well as aspects of possible future mine development, milling, product transportation, and end-use markets (Atlas Minerals Inc., 2003). Upon conclusion of its evaluation, however, Atlas opted not to renew or extend its option to purchase the La Barra property (Atlas Minerals, Inc., written commun., December 16, 2003).

Mongolia.—Mongolia's largest fluor spar producer, Mongolrostsvetmet Corp., announced it was preparing a long-term business plan that includes technology improvements, better product quality, and product diversification. It installed new lines for the production of fluor spar briquettes and high-quality flotation concentrates for welding electrodes. In recent

years, the majority of sales have been to Russia and Ukraine, plus small amounts to Belarus and Moldavia. The company has been attempting to expand its export business to include customers in Europe, Japan, the Republic of Korea, and the United States (Crossley, 2004).

Mongolian Minerals, a fluor spar mining and milling joint venture between Mongolian mining company Ayrag Mining Corp. and U.S. trading company One-O-One Inc. that was formed in early in 2003, announced plans to build an AlF_3 plant in order to create value-added export products. The company hopes to export metallurgical- and acid-grade fluor spar to customers in Asia, Europe, and North America (Industrial Minerals, 2003a). At present, the company is only producing metallurgical-grade fluor spar, but it does sell acid-grade fluor spar sourced from Mongolrostsvetmet, and it is working on setting up its own acid-grade fluor spar production to supply the AlF_3 plant (Penny Crossley, senior assistant editor, Industrial Minerals, written commun., December 9, 2003).

Russia.—There are four fluor spar producers in Russia—JSC Kalanguisky PShK, JSC Zabaikalsky GOK, Suran Cooperative Quartz, and Yaroslavsky Mining & Ore Dressing Complex. Yaroslavsky, which is located in the Primorsky region of the Russian Far East, is the leading producer and accounted for an estimated 70% to 80% of Russia's total production in 2003. The company operates two mines, the newest of which opened in 2000. Yaroslavsky is part of Energoprom Group, a financial and industrial group of companies that also owns one of Yaroslavsky's main customers JSC South Ural Cryolite Plant. Another major customer is JSC Cryolite Production Plant at Polevskoy in the Sverdlovsk region. These two plants consume about 90% to 95% of Yaroslavsky's annual production, which, in 2003, was about 120,000 t. In 2004, its production is expected to increase by 50% to about 180,000 t, which would boost total Russian production to about 220,000 t (Crossley, 2004).

South Africa.—South African Land and Exploration Co.'s Witkop Fluor spar (Pty.) Ltd. continued work on the turnaround strategy initiated in the latter part of 2002. As part of the strategy, the company took its opencast mining operations back in-house and acquired new mining equipment. These two factors are expected to allow greater efficiencies and to present the opportunity to reduce costs. The flotation plant was improved in 2002, and the company is in the process of adding more milling capacity. Some of ore processed at the mill is a weathered altered dolomite that contains high quantities of silica, tremolite, and talc that caused problems in the flotation process. After 2 years of testing, the company developed a combination of collectors and depressants that increased the recovery rates to more than 90% from between 75% and 80%. This resulted in an 18% increase in concentrate production.

Finally, the company investigated the ore body thoroughly through an extensive drilling program. This allowed the establishment of best mining practice to efficiently mine Witkop's irregular ore body and maintain the target ore grade to the plant. The company changed the size of the benches mined and reduced the size of explosive charges to provide more even fragmentation and better ore clearing. The goal of these improvements is to increase Witkop's production to 180,000 t/yr from its current output of about 110,000 t/yr (Lanham, 2004§).

Vietnam.—Tiberon Minerals Ltd. continued development work on its Nui Phao tungsten-fluorite deposit north of Hanoi. In early 2003, results of its prefeasibility study were released proposing a 16-year mine life, with production of 6,000 t/yr of tungsten trioxide, 196,000 t/yr of fluor spar (mostly acid grade), and lesser amounts of bismuth, copper, and gold. Fluor spar recovery would be as a byproduct of the tungsten recovery. Previous preliminary metallurgical test work confirmed recoveries for the prefeasibility study of 80% of the tungsten, 75% of the copper, 70% of the fluorite, 20% of the gold, and 10% of the bismuth using conventional gravity and flotation processing techniques (Tiberon Minerals Ltd., 2003b).

Tiberon drilled an additional 54 holes in 2003, which, with the 110 holes drilled previously, were used to establish a final mineral resource estimate for the deposit. The company reported, at an average fluor spar grade of about 8.35% CaF₂, an estimate of 25.1 million metric tons (Mt) of measured reserves and 35.4 Mt of indicated reserves. Tiberon awarded contracts for a bankable feasibility study and submitted its application to the Vietnamese Government for an investment license. The investment license was approved by the Government in February 2004 (Tiberon Minerals Ltd., 2003a, 2003c, 2004).

Current Research and Technology

Emulsified perfluorochemicals, organic compounds in which all hydrogen atoms have been replaced by fluorine, are undergoing investigation as synthetic blood substitutes and therapeutic oxygen carriers. They transport oxygen and may be useful in surgery and trauma patients. Such blood substitutes would carry no risk of disease transmission, would have a shelf life of up to 2 years, and could be used in patients regardless of their blood type (Robinson, 2003).

Outlook

The dramatic runup in acid-grade fluor spar prices that took place in 2003 has improved the prospects of fluor spar projects in the development stage and has caused companies to “dust off” files on dormant fluor spar properties with an eye to preparing new evaluations based on the changed economic circumstances. The earliest any new fluor spar production projects are expected to be in operation is 2007, although some incremental increases in capacity at existing mines will be available earlier.

The rapid growth of China’s domestic markets (aluminum, fluorochemicals, and steel) and an announced desire to conserve national resources likely will cause the Government to continue to decrease the annual fluor spar export quotas. China’s export quota for 2004 has tentatively been announced to be 750,000 t, with the first round of bidding assigning a total of 375,000 t that included 225,000 t assigned with an export license fee equivalent to about \$37 per ton and 150,000 t assigned at about \$82 per ton. For the full first round amount, this works out to an average license fee of about \$55 per ton. This reduction in exports and the continued policy of requiring export license fees will cause prices to remain at elevated levels or even continue to increase. The price of Chinese acid spar continued to increase in early 2004 reaching, according to Industrial Minerals magazine,

a range of \$195 to \$205 per ton, c.i.f., U.S. Gulf ports. Prices appeared to have stabilized in that range by spring of 2004.

For the past decade, China has been the world’s largest fluor spar exporter, but consumed a relatively small amount of fluor spar (mostly metallurgical and submetallurgical grades) for domestic use. This now has changed, and China is exporting less fluor spar and is actually exporting HF and lesser amounts of downstream fluorochemicals (such as AlF₃, Na₃AlF₆, and fluorocarbons). Fluorochemical exports are expected to increase dramatically in the next few years. The only factor that may slow these exports is the growing demand for the same chemicals by the domestic market in China. China’s aluminum industry has been growing at a rapid pace, and this requires increasing amounts of AlF₃ and Na₃AlF₆. Fluorocarbon demand in China has increased to the extent that it may already be the largest air-conditioning market in the world. In the near term, these changes mean that other fluor spar-producing countries may find greater demand (and be able to charge higher prices) for their product as China continues to reduce its exports. In the longer term, HF and fluorochemicals plants outside of China may be unable to compete with Chinese exports and may be forced to close as Chinese exports increase. Recognizing this possible future, some Western companies have entered into joint-venture agreements with Chinese companies to build HF and fluorocarbon production facilities in China.

References Cited

- Atlas Minerals Inc., 2003, Atlas acquires option to purchase fluorite property in Mexico: Lakewood, CO, Atlas Minerals Inc. news release, June 18, 1 p.
- Chemical Week, 2003, Europe to slash fluorinated gas emissions: Chemical Week, v. 165, no. 29, August 20, p. 12.
- Crossley, Penny, 2004, Fluor spar in focus—Light at the end of the tunnel: Industrial Minerals, no. 436, January, p. 26-37.
- Hileman, Bette, 2003, Fluoride concerns surface once again: Chemical & Engineering News, v. 81, no. 34, August 25, p. 22-23.
- Hogue, Cheryl, 2003, Focus on perfluoros—EPA boosts scrutiny of chemicals due to concern of possible health effects: Chemical and Engineering News, v. 81, no. 17, April, p. 9.
- Industrial Minerals, 2003a, Mongolian fluor spar j-v moves into AlF₃: Industrial Minerals, no. 434, November, p. 9.
- Industrial Minerals, 2003b, Prices: Industrial Minerals, no. 435, December, p. 74.
- Industrial Minerals, 2004, Fluorite de Mexico share changes hands: Industrial Minerals, no. 436, January, p. 16.
- Mineral Securities Ltd., 2003, Fluor spar project progress report—No. 1: Perth, Australia, Mineral Securities Ltd. progress report, November, 2 p.
- Mineral Securities Ltd., 2004, Fluor spar project progress report—No. 2: Perth, Australia, Mineral Securities Ltd. progress report, March, 3 p.
- O’Driscoll, Mike, 2002, The state of flux: Industrial Minerals, no. 423, December, p. 40-43.
- Robinson, Alicia, 2003, Fake blood passes early tests—A Cosa Mesa-based company is developing Oxybyte, a synthetic blood for use in surgery: Los Angeles Times Costa Mesa Daily Pilot, November 13, [unpaginated].
- Tiberon Minerals Ltd., 2003a, Increased resource estimate for Nui Phao & award of key contracts for bankable feasibility study: Calgary, Alberta, Canada, Tiberon Minerals Ltd. press release #03-17, October 9, 2 p.
- Tiberon Minerals Ltd., 2003b, Tiberon releases Nui Phao prefeasibility study results: Calgary, Alberta, Canada, Tiberon Minerals Ltd. press release #03-02, January 15, 5 p.
- Tiberon Minerals Ltd., 2003c, Tiberon submits Nui Phao investment license application: Calgary, Alberta, Canada, Tiberon Minerals Ltd. press release #03-18, October 20, 2 p.
- Tiberon Minerals Ltd., 2004, Tiberon receives Nui Phao investment license: Calgary, Alberta, Canada, Tiberon Minerals Ltd. press release #04-03, February 25, 2 p.

Internet References Cited

- Lanham, Andrew, 2004 (January 30), Clear strategy—Sustainable future, accessed March 7, 2004, at URL <http://www.engineeringnews.co.za/min/news/today/?show=45743#>.
- Lowell Center for Sustainable Production, 2003a (October 10), Chemicals policies in Europe set new worldwide standard registration, evaluation and authorization of chemicals (REACH), accessed May 20, 2004, at URL http://www.chemicalspolicy.org/downloads/chemicals_policy_reach.doc.
- Lowell Center for Sustainable Production, 2003b (November 25), Update on the European Commission's REACH proposal—Registration, evaluation, and authorization of chemicals, accessed May 20, 2004, at URL <http://www.chemicalspolicy.org/downloads/Update%20on%20the%20European%20Commission%20final.doc>.
- White House, The, 2003 (December 4), President's statement on steel, accessed April 29, 2004, at URL <http://www.whitehouse.gov/news/releases/2003/12/20031204-5.html>.
- Wickham, R.T., 2002 (March 16), Status of industry efforts to replace halon fire extinguishing agents, accessed June 12, 2002, at URL <http://www.epa.gov/docs/ozone/snap/fire/status.pdf>.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Fluorspar. Ch. in Mineral Commodity Summaries, annual.
- Fluorine. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

- Fluorspar. Mineral Industry Surveys, quarterly.
- Geology and Resources of Fluorine in the United States. Professional Paper 933, 1976.

Other

- Chemical and Engineering News.
- Chemical Market Reporter.
- Chemical Week.
- Economics of Fluorspar, The. Roskill Information Services Ltd., 1993.
- European Chemical News.
- Fluorochemicals. The Freedonia Group, 2002.
- Fluorsight. Brennan Research Group.
- Fluorspar. Ch. in Industrial Minerals and Rocks (6th ed.), Society for Mining, Metallurgy, and Exploration, Inc., 1994.
- Fluorspar. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675.
- Fluorspar and Inorganic Fluorine Compounds, Chemical Economics Handbook Marketing Research Report. SRI International, 2002.
- Industrial Minerals.
- Industrial Specialties News.

TABLE 1
SALIENT FLUORSPAR STATISTICS^{1,2}

| | | 1999 | 2000 | 2001 | 2002 | 2003 |
|---------------------------------------|-----------------|----------------------|------------------------|------------------------|------------------------|------------------------|
| United States: | | | | | | |
| Exports: ³ | | | | | | |
| Quantity | metric tons | 55,400 | 39,800 | 21,200 | 24,300 | 30,700 |
| Value ⁴ | thousands | \$6,980 | \$5,330 | \$3,250 | \$3,540 | \$4,610 |
| Imports: ³ | | | | | | |
| Quantity | metric tons | 478,000 | 523,000 | 522,000 | 494,000 | 567,000 |
| Value ⁵ | thousands | \$56,900 | \$65,200 | \$69,000 | \$62,000 | \$76,300 |
| Average value: ⁵ | | | | | | |
| Acid grade | dollars per ton | \$124 | \$128 | \$135 | \$128 | \$138 |
| Metallurgical grade | do. | \$88 | \$84 | \$80 | \$89 | \$85 |
| Consumption: | | | | | | |
| Reported | metric tons | 514,000 | 512,000 | 536,000 | 588,000 | 616,000 |
| Apparent | do. | 615,000 ⁶ | 601,000 ⁶ | 543,000 ⁷ | 477,000 ⁷ | 589,000 ⁸ |
| Stocks, December 31: | | | | | | |
| Consumer and distributor ⁹ | do. | 373,000 | 289,000 | 221,000 | 245,000 | 206,000 |
| Government stockpile | do. | 146,000 | 112,000 | 112,000 | 109,000 | 95,000 |
| World, production | do. | 4,300,000 | 4,440,000 ^r | 4,580,000 ^r | 4,430,000 ^r | 4,740,000 ^e |

^eEstimated. ^rRevised.

¹Data are rounded to no more than three significant digits.

²Does not include fluorosilicic acid production or imports of hydrofluoric acid and cryolite.

³Source: U.S. Census Bureau; may be adjusted by the U.S. Geological Survey.

⁴Free alongside ship values at U.S. ports.

⁵Cost, insurance, and freight values at U.S. ports.

⁶Imports minus exports plus adjustments for Government and industry stock changes.

⁷Imports minus exports plus adjustments for changes in stocks held by Government and three leading consumers.

⁸Imports minus exports plus adjustments for changes in stocks held by distributors, Government, and leading consumers.

⁹Includes 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 USE¹

(Metric tons)

| End use or product | Containing more than 97% calcium fluoride | | Containing not more than 97% calcium fluoride | | Total | |
|--|--|---------|--|--------|---------|---------|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Hydrofluoric acid and aluminum fluoride | 478,000 | 523,000 | 406 | -- | 478,000 | 523,000 |
| Metallurgical | 22,500 | 20,400 | 54,400 | 43,100 | 76,900 | 63,500 |
| Other ² | 33,300 | 29,100 | -- | -- | 33,300 | 29,100 |
| Total | 533,000 | 573,000 | 54,800 | 43,100 | 588,000 | 616,000 |
| Stocks, consumer, December 31 ³ | 91,600 | 99,200 | 30,900 | 26,800 | 122,000 | 126,000 |

-- Zero.

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

²Includes acid grade used in enamel, glass and fiberglass, steel castings, and welding rod coatings.

³Stocks are from hydrofluoric acid and aluminum fluoride producers and major distributors.

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

| Source and grade | 2002 | 2003 |
|--|---------|---------|
| Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, acidspar filtercake | 128-135 | 165-170 |
| Mexican, free on board (f.o.b.) Tampico, acidspar filtercake | 105-125 | 105-125 |
| Mexican, f.o.b. U.S. Gulf port, arsenic <5 parts per million | 141-150 | 141-150 |
| Mexican, c.i.f. port of U.S. entry, metspar ¹ | 87 | 85 |
| South African, f.o.b. Durban, acidspar | 105-125 | 105-125 |

¹Metspar prices are the average value per metric ton of imported Mexican metspar for the fourth quarter calculated from the U.S. Census Bureau statistics.

Sources: Industrial Minerals, no. 411, p. 82, December 2002, and no. 435, p. 79, December 2003.

TABLE 4
U.S. EXPORTS OF FLUORSPAR, BY COUNTRY¹

| Country | 2002 | | 2003 | |
|--------------------|---------------------------|--------------------|---------------------------|--------------------|
| | Quantity (metric tons) | Value ² | Quantity (metric tons) | Value ² |
| Canada | 18,600 | \$2,700,000 | 24,000 | \$3,610,000 |
| China | 174 | 25,200 | 100 | 28,800 |
| Dominican Republic | 175 | 19,300 | 468 | 70,500 |
| Mexico | 95 | 25,600 | 86 | 12,100 |
| Taiwan | 5,130 | 741,000 | 5,720 | 827,000 |
| Other ³ | 125 | 29,700 | 270 | 57,600 |
| Total | 24,300 | 3,540,000 | 30,700 | 4,610,000 |

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

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

³Includes Australia, The Bahamas, Trinidad and Tobago, and Venezuela.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF FLUORSPAR, BY COUNTRY AND CUSTOMS DISTRICT¹

| Country and customs district | 2002 | | 2003 | |
|--|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ² (thousands) | Quantity (metric tons) | Value ² (thousands) |
| Containing more than 97% calcium fluoride (CaF ₂): | | | | |
| China: | | | | |
| Houston, TX | 193,000 | \$25,600 | 227,000 | \$34,100 |
| New Orleans, LA | 152,000 | 18,800 | 109,000 | 14,900 |
| Total | 344,000 | 44,400 | 336,000 | 49,000 |
| France, Philadelphia, PA | 139 | 52 | 82 | 27 |
| Germany: | | | | |
| Philadelphia, PA | 1 | 3 | -- | -- |
| Savannah, GA | -- | -- | 17 | 11 |
| Total | 1 | 3 | 17 | 11 |
| Japan, New York, NY | 2,910 | 344 | -- | -- |
| Mexico: | | | | |
| Laredo, TX | 22,300 | 3,190 | 33,400 | 4,820 |
| New Orleans, LA | 12,600 | 1,150 | 23,000 | 2,070 |
| Total | 34,900 | 4,340 | 56,300 | 6,890 |
| Mongolia, Baltimore, MD | -- | -- | 20 | 3 |
| South Africa: | | | | |
| Houston, TX | -- | -- | 9,890 | 1,130 |
| New Orleans, LA | 83,100 | 10,300 | 111,000 | 13,700 |
| Total | 83,100 | 10,300 | 120,000 | 14,900 |
| Spain, New Orleans, LA | -- | -- | 19,100 | 2,540 |
| United Kingdom: | | | | |
| Cleveland, OH | -- | -- | 1 | 2 |
| Los Angeles, CA | 276 | 34 | 445 | 53 |
| New York, NY | 2 | 2 | 108 | 37 |
| Philadelphia, PA | -- | -- | 1 | 7 |
| Total | 278 | 36 | 555 | 99 |
| Grand total | 466,000 | 59,500 | 533,000 | 73,400 |
| Containing not more than 97% CaF ₂ : | | | | |
| Austria, Charleston, SC | 128 | 11 | -- | -- |
| Canada, Buffalo, NY | 147 | 48 | -- | -- |
| Mexico: | | | | |
| Buffalo, NY | 73 | 8 | -- | -- |
| Laredo, TX | 1,310 | 129 | 1,130 | 123 |
| New Orleans, LA | 21,800 | 1,830 | 32,700 | 2,750 |
| Total | 23,200 | 1,970 | 33,800 | 2,870 |
| South Africa, New Orleans, LA | 5,000 | 492 | -- | -- |
| United Kingdom, New York, NY | 74 | 9 | -- | -- |
| Grand total | 28,500 | 2,530 | 33,800 | 2,870 |
| Total imports all grades | 494,000 | 62,000 | 567,000 | 76,300 |

-- Zero.

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

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

Source: U.S. Census Bureau; may be adjusted by the U.S. Geological Survey.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID, BY COUNTRY¹

| Country | 2002 | | 2003 | |
|--------------------|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ² (thousands) | Quantity (metric tons) | Value ² (thousands) |
| Canada | 28,300 | \$34,200 | 33,900 | \$38,600 |
| China | 267 | 169 | 951 | 567 |
| France | 106 | 103 | 36 | 41 |
| Germany | 485 | 763 | 476 | 834 |
| Italy | 37 | 38 | 19 | 24 |
| Japan | 1,360 | 3,450 | 1,140 | 2,780 |
| Korea, Republic of | 84 | 319 | 70 | 261 |
| Mexico | 84,200 | 79,800 | 74,800 | 71,500 |
| Netherlands | 3 | 17 | 24 | 99 |
| United Kingdom | 96 | 91 | 2 | 8 |
| Other | -- | -- | 95 | 226 |
| Total | 115,000 | 119,000 | 111,000 | 115,000 |

-- Zero.

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

²Cost, insurance, and 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 COUNTRY¹

| Country | 2002 | | 2003 | |
|--------------------|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ² (thousands) | Quantity (metric tons) | Value ² (thousands) |
| Australia | 653 | \$329 | -- | -- |
| Canada | 1,000 | 250 | -- | -- |
| China | 429 | 327 | 510 | \$392 |
| Denmark | 394 | 674 | 239 | 417 |
| Germany | 1,680 | 1,310 | 1,710 | 1,350 |
| Hungary | 339 | 418 | 368 | 376 |
| Italy | 3,000 | 2,110 | 4,510 | 3,160 |
| Japan | 135 | 95 | 9 | 10 |
| United Kingdom | 111 | 162 | 16 | 28 |
| Other ³ | 202 | 136 | 759 | 376 |
| Total | 7,950 | 5,810 | 8,120 | 6,120 |

-- Zero.

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

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

³Includes Belgium, Hong Kong, Israel, the Republic of Korea, Russia, Turkey, and Ukraine.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM FLUORIDE, BY COUNTRY¹

| Country | 2002 | | 2003 | |
|--------------------|---------------------------|-----------------------------------|---------------------------|-----------------------------------|
| | Quantity (metric tons) | Value ² (thousands) | Quantity (metric tons) | Value ² (thousands) |
| Canada | 6,140 | \$4,880 | 2,700 | \$2,090 |
| Italy | 5,600 | 3,960 | 2,400 | 1,630 |
| Mexico | 4,960 | 3,860 | 4,830 | 3,790 |
| United Kingdom | -- | -- | 36 | 24 |
| Other ³ | 276 | 283 | 114 | 117 |
| Total | 17,000 | 13,000 | 10,100 | 7,640 |

-- Zero.

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

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

³Includes Germany, Japan, Panama, Spain, and Sweden.

Source: U.S. Census Bureau.

TABLE 9
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

| Country and grade ^{3,4} | 1999 | 2000 | 2001 | 2002 | 2003 ⁵ |
|--|-----------|---------------------|---------------------|----------------------|--------------------|
| Argentina | 12,704 | 11,229 ^r | 9,075 | 5,168 ^r | 5,530 ^p |
| Brazil, marketable: | | | | | |
| Acid grade | 38,209 | 30,131 | 31,263 | 32,774 ^r | 31,300 |
| Metallurgical grade | 6,717 | 12,831 | 12,471 | 15,125 ^r | 12,500 |
| Total | 44,926 | 42,962 | 43,734 | 47,899 ^r | 43,800 |
| China: ^e | | | | | |
| Acid grade | 1,200,000 | 1,250,000 | 1,250,000 | 1,250,000 | 1,300,000 |
| Metallurgical grade ⁵ | 1,200,000 | 1,200,000 | 1,200,000 | 1,200,000 | 1,350,000 |
| Total | 2,400,000 | 2,450,000 | 2,450,000 | 2,450,000 | 2,650,000 |
| Egypt ^e | 500 | 500 | 500 | 500 | 500 |
| France: ^e | | | | | |
| Acid and ceramic grades | 82,000 | 80,000 | 90,000 | 90,000 | 90,000 |
| Metallurgical grade | 25,000 | 20,000 | 20,000 | 15,000 | 15,000 |
| Total | 107,000 | 100,000 | 110,000 | 105,000 | 105,000 |
| Germany ^e | 28,000 | 30,000 | 30,000 | 32,000 | 30,000 |
| India: ⁶ | | | | | |
| Acid grade | 48 | 3,253 ^r | 6,900 ^r | 4,198 ^r | 4,200 |
| Metallurgical grade | 4,025 | 3,782 ^r | 13,866 ^r | 6,296 ^r | 6,300 |
| Total | 4,073 | 7,035 ^r | 20,766 ^r | 10,494 ^r | 10,500 |
| Iran ⁷ | 18,387 | 20,000 ^e | 35,986 ^r | 32,006 ^r | 32,000 |
| Italy: ^e | | | | | |
| Acid grade | 95,000 | 50,000 | 30,000 | 30,000 | 30,000 |
| Metallurgical grade | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Total | 110,000 | 65,000 | 45,000 | 45,000 | 45,000 |
| Kenya, acid grade | 93,602 | 100,102 | 118,850 | 85,015 ^r | 100,000 |
| Korea, North, metallurgical grade ^e | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 |
| Kyrgyzstan | 2,997 | 3,000 ^e | 1,175 | 2,750 ^e | 3,973 ⁸ |
| Mexico: ⁹ | | | | | |
| Acid grade | 323,282 | 334,780 | 343,486 | 343,332 ^r | 390,000 |
| Metallurgical grade | 233,829 | 300,450 | 275,982 | 279,145 ^r | 340,000 |
| Total | 557,111 | 635,230 | 619,468 | 622,477 ^r | 730,000 |
| Mongolia: | | | | | |
| Acid grade | 100,000 | 111,443 | 127,000 | 86,000 ^r | 90,000 |
| Other grades ¹⁰ | 54,600 | 87,400 | 72,000 | 99,000 ^r | 100,000 |
| Total | 154,600 | 198,843 | 199,000 | 185,000 ^r | 190,000 |

See footnotes at end of table.

TABLE 9--Continued
 FLUORSPAR: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

| Country and grade ^{3,4} | 1999 | 2000 | 2001 | 2002 | 2003 ^e |
|---|-----------|------------------------|------------------------|------------------------|---------------------|
| Morocco, acid grade | 83,100 | 76,991 | 96,500 | 94,911 ^r | 75,000 |
| Namibia, acid grade ¹¹ | 71,011 | 66,128 | 81,245 | 81,084 | 79,281 ⁸ |
| Pakistan, metallurgical grade | 220 | 997 | 1,000 ^e | 1,000 | 1,000 |
| Romania, metallurgical grade ^e | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Russia | 153,800 | 187,600 | 200,000 ^r | 169,000 ^r | 170,000 |
| South Africa: ¹² | | | | | |
| Acid grade | 203,280 | 201,737 | 272,844 | 215,650 | 223,000 |
| Metallurgical grade | 14,000 | 10,618 | 13,156 | 11,350 | 12,000 |
| Total | 217,280 | 212,355 | 286,000 | 227,000 | 235,000 |
| Spain: ^e | | | | | |
| Acid grade | 123,000 | 120,000 | 115,000 | 115,000 | 115,000 |
| Metallurgical grade | 10,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Total | 133,000 | 135,000 | 130,000 | 130,000 | 130,000 |
| Tajikistan ^e | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 |
| Thailand, metallurgical grade | 13,005 | 4,745 | 3,020 | 2,271 ^r | 2,360 ⁸ |
| Tunisia | 520 | -- | -- | -- | -- |
| Turkey, metallurgical grade | 4,812 | 4,113 | 4,093 ^r | 5,344 ^r | 5,000 |
| United Kingdom ^e | 42,000 | 35,000 | 50,000 | 45,000 | 60,000 |
| Grand total | 4,300,000 | 4,440,000 ^r | 4,580,000 ^r | 4,430,000 ^r | 4,750,000 |

^eEstimated. ^pPreliminary. ^rRevised. -- Zero.

¹World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through June 6, 2004.

³In addition to the countries listed, Bulgaria is believed to have produced fluor spar in the past, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.

⁴An 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.

⁵Includes sub-metallurgical-grade fluor spar used primarily in cement that may account for 33% to 50% of the quantity.

⁶Year beginning April 1 of that stated.

⁷Year beginning March 21 of that stated.

⁸Reported figure.

⁹Data are reported by Consejo de Recursos Minerales, but the production of submetallurgical and acid grades has been redistributed on the basis of industry data.

¹⁰Principally submetallurgical-grade material.

¹¹Data are in wet tons.

¹²Based on data from the South African Minerals Bureau; data show estimated proportions of acid-, ceramic-, and metallurgical-grade fluor spar within the reported totals.