FLUORSPAR

By M. Michael Miller

Traditionally, fluorspar has been considered vital to the Nation for national security and economic reasons. It is used directly or indirectly to manufacture products such as aluminum, gasoline, insulating foams, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involves either acid grade, which is greater than 97% calcium fluoride (CaF₂) or metallurgical grade, which is 97% or less CaF₂.

The domestic output of fluorspar is now entirely dependent on sales of material from the National Defense Stockpile (NDS), which entered the U.S. supply through sales to consumers or distributors, as did a small amount of synthetic fluorspar produced from industrial waste streams. Supplementing fluorspar as a domestic source of fluorine, but not included in fluorspar production or consumption calculations, was byproduct fluorosilicic acid production from some phosphoric acid producers. According to the Bureau of the Census and the U.S. Geological Survey (USGS), imports of fluorspar increased by nearly 4% compared with the 1996 figures. Hydrofluoric acid (HF) imports were 32% higher than those reported in the previous year.

Legislation and Government Programs

The Defense Logistics Agency, Defense National Stockpile Center (DLA-DNSC) was authorized to sell about 45,000 metric tons (50,000 short dry tons) of metallurgical grade and about 163,000 tons (180,000 short dry tons) of acid grade during fiscal year 1997 (October 1, 1996 to September 30, 1997). During the 1997 calendar year DLA-DNSC sold about 45,000 tons (50,000 short dry tons) of metallurgical grade and about 94,000 tons (104,000 short dry tons) of acid grade. The DLA-DNSC sold an additional 32,700 tons (36,000 short dry tons) of acid grade during the fourth quarter of 1996, which falls under fiscal year 1997. Cumulative sales of fluorspar from the NDS, for calendar years 1992 through 1996, were about 134,000 tons (148,000 short dry tons) of metallurgical grade and about 584,000 tons (644,000 short dry tons) of acid grade. According to the DLA-DNSC's fiscal year 1998 Annual Materials Plan, total sales of about 45,400 tons (50,000 short dry tons) of metallurgical grade and about 163,000 tons (180,000 short dry tons) of acid grade were authorized for fiscal year 1998. In one December 1997 sale the DLA-DNSC met its entire fiscal year 1998 sales goal for metallurgical grade by selling approximately 45,400 tons (50,100 short dry tons). Under current sales levels, the DLA-DNSC projects that the remaining acid-grade stockpiles will be sold during fiscal year 1999 and that the final sale of the remaining metallurgical-grade stockpiles will be accomplished by 2002 or 2003.

Production

There is currently no domestic mine production of 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, representing 100% of the quantity reported.

In 1997, Hastie/Sogem Minerals continued to operate the former Ozark-Mahoning facility at Rosiclare, IL, under a lease agreement. They washed, screened, and dried metallurgical- 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.

Six companies operating 10 plants processing phosphate rock for the production of phosphoric acid produced 67,600 tons of byproduct fluorosilicic acid and sold or used 68,500 tons of byproduct fluorosilicic acid at a value of about \$8.40 million. This was equivalent to approximately 121,000 tons of 92% fluorspar. The level of fluorosilicic acid output was essentially unchanged compared to that of 1996. Since 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.

There was some recovery of synthetic fluorspar as a byproduct of uranium processing, petroleum alkylation, and stainless steel pickling. Currently it is estimated that the majority of the marketable product comes from uranium processing. Greater restrictions on the disposal of industrial wastes and improvements in recovery processes may lead to greater recovery from the various sources. At present, an estimated 10,000 tons of synthetic fluorspar is being produced annually in the United States.

Environment

At the United Nations Framework Convention on Climate Change held in Kyoto, Japan, representatives from more than 150 countries agreed on measures that would obligate industrial countries to cut emissions of greenhouse gases. Carbon dioxide, methane, and nitrous oxide account for the bulk of worldwide greenhouse gas (GHG) emissions caused by human activities, but it was decided also to include hydrofluorocarbons (HFC's), perfluorocarbons, and sulfur hexafluoride in the list of gases to be controlled. The accord, known as the Kyoto Protocol, would require the United States to reduce GHG emissions 7% below 1990 or 1995 levels, depending on the gas, by the year 2012. The protocol does not include an emissions trading system and major developing countries such as China, India, and Mexico did not

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sign the accord. These two factors make it unlikely that Congress will ratify the treaty in its present form. The protocol is generally seen as an early step in the continuing attempt to deal with the causes of climate change, and that any attempt will ultimately require the involvement of all countries.

The Kyoto Protocol adds uncertainty to the future demand for fluorspar. Just as the Montreal Protocol had a major impact on fluorspar consumption resulting from the phaseout of chlorofluorocarbons, the Kyoto Protocol may affect fluorspar demand in the future.

Consumption

Domestic consumption data for fluorspar were developed by the USGS from voluntary surveys of U.S. operations. The consumption survey was sent to 60 operations quarterly and to 4 additional operations annually. Of the operations surveyed quarterly, 92% responded. Of the operations surveyed on an annual basis, 100% responded. Estimates were made for some of the operations surveyed quarterly. (See table 1.)

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

Acid-grade fluorspar was used primarily as a feedstock in the manufacture of HF and to produce aluminum fluoride (AlF₃). Two companies reported fluorspar consumption for the production of HF. The largest use of HF was for the production of a wide range of fluorocarbon chemicals, including HFC's, hydrochlorofluorocarbons (HCFC's), and fluoropolymers. HCFC's and HFC's were produced by seven companies: Allied Signal Corp., Ausimont USA Inc., E.I. du Pont de Nemours & Co. Inc. (DuPont), Elf Atochem North America Inc., ICI Americas Inc., La Roche Chemicals Inc., and MDA Manufacturing Ltd. The latter is a joint venture between Daikin America Inc. and 3M Corp. producing HCFC 22 and hexafluoropropane for captive use in fluoropolymer manufacturing. Some of the fluorocarbon replacements for the banned chlorofluorocarbons (CFC's) will be HCFC's 22, 123, 124, 141b, 142b, and 225. These HCFC substitutes have ozone-depletion potentials much lower than that of CFC 11, CFC 12, and CFC 113, which in total have accounted for more than 90% of CFC consumption. HCFC 22 has been used for home air conditioning for years and HCFC 141b and HCFC 142b have replaced most of the CFC 11 and CFC 12 used in foam blowing. HCFC 141b, HCFC 225, perfluorocarbons, and hydrofluoroethers have been introduced as replacements for CFC solvents. Unfortunately, because of the current phaseout schedule for HCFC's and the possibility that the schedule will be accelerated, the market for HCFCs will exist for only a relatively short time, and perfluorocarbons are on the list of gases that contribute to global warming.

The HFC replacements have no ozone-depletion potential because they contain no chlorine atoms. The most successful HFC replacement compound is HFC 134a, which is the main replacement for CFC 12 in auto air conditioners and in mediumtemperature-range refrigeration systems. Demand for HFC 134a is growing, but will never achieve the market size that CFC 12 did because of markets lost to not-in-kind replacements, and at present HFC 134a production capacity continues to far exceed demand. HFCs 32, 125, 143a, and 152a also are being produced domestically, but in much smaller quantities. These four HFC's hold potential for use by themselves or more likely as blends for specific uses, such as the azeotropic mixture of HFC 32 and HFC 125 that is emerging as the replacement of choice for HCFC 22. HFC 134a and HFC 227 are being evaluated for use in medical aerosols. HFC 245ca is being tested in low pressure centrifugal compressor chillers, and HFC 245 and HFC 356 are being tested as potential replacements for HCFC 141b in blowing agents for thermosets such as polyurethane. DuPont has developed its proprietary HFC 4310 as a replacement for CFC 113, HCFC's, and perfluorocarbon for use in drying fluids, cleaning and rinsing agents, defluxing agents, and in heat transfer media.

HF was consumed in the manufacture of uranium tetrafluoride that was used in the process of concentrating uranium isotope 235 for use as nuclear fuel and in fission explosives. It also was used to manufacture AlF₃, in stainless steel pickling, petroleum alkylation, glass etching, and in oil and gas well treatment. HF was used as a cleaner and etcher in the electronics industry.

HF was used as the feedstock in the manufacture of a host of fluorine chemicals used in dielectrics, metallurgy, wood preservatives, herbicides, mouthwashes, decay-preventing dentifrices, plastics, and water fluoridation.

Most of the AlF₃ manufactured for use in aluminum reduction cells was produced directly from acid-grade fluorspar. In the Hall-Héroult process, alumina is dissolved in a bath of molten cryolite, AlF₃, and fluorspar to allow electrolytic recovery of aluminum. On average, worldwide the aluminum industry consumes about 21 kilograms of fluorides for each metric ton of aluminum produced. This ranges from 10 to 12 kilograms per ton in a modern prebaked aluminum smelter to 40 kilograms per ton in an older Soderberg smelter without scrubbers. AlF₃ was used by the ceramic industry for some body and glaze mixtures and in the production of specialty refractory products. It was used in the manufacture of aluminum silicates and in the glass industry as a filler.

Ceramic-grade fluorspar, containing 85% to 95% CaF_2 , was used by the ceramic industry as a flux and as 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. It increases the fluidity of the slag (by reducing its melting point) and thus increases 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.

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Fluorspar of different grades was used in the manufacture of aluminum, brick, cement, and glass fibers, and also was used in the melt shop by the foundry industry.

The level of total reported fluorspar consumption decreased by nearly 7% in 1997. Declines in consumption by the domestic HF and AlF3 industries accounted for all of the decrease. A factor in the decrease was the inability of Texas consumers to move fluorspar by railcar because of the major rail freight logiam that resulted from Union Pacific Railroad's takeover of Southern Pacific Railroad in 1996. The reported consumption of fluorspar for non-HF/AlF₃ uses was essentially unchanged compared to that of 1996. The data collected for these non-HF/AlF₃ markets do not accurately reflect the true size of these markets, which are believed to be larger than reported. About 31,500 tons of byproduct fluorosilicic acid valued at \$3.04 million was sold for water fluoridation, about 16,200 tons of fluorosilicic acid valued at \$3.12 million was sold to make AlF₃ for the aluminum industry, and about 20,800 tons valued at \$2.24 million was sold or used for other uses such as sodium silicofluoride production. (See table 2.)

Stocks

Consumer stocks at yearend were 137,000 tons, an increase of nearly 17% from the level reported in 1996. Consumer and distributor stocks contained a total of 375,000 tons, which included 238,000 tons purchased from the NDS but still located at NDS depots. As of December 31, 1997, the NDS fluorspar inventory classified as excess (excluding material sold pending shipment) contained about 254,000 tons (280,000 short dry tons) of acid-grade material and about 194,000 tons (214,000 short dry tons) of metallurgical-grade material. About one-half of the remaining metallurgical-grade material is classified as nonstockpile grade.

Transportation

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

Most acid grade imports come from China and South Africa. Fluorspar is shipped by ocean freight utilizing the "Tramp" market for ships. Bulk carriers of 10,000 to 50,000 tons deadweight normally are utilized. Participants negotiate freight levels, terms, and conditions. The main participants are *charterers*—generally the buyers or sellers, *ship owners*—who either own vessels or have them time chartered, *operators*—traders normally taking positions on either cargo or ships, and *brokers*—generally represent ship owners or charterers and act as go-betweens. Ships are primarily owned by the following: privately held shipping companies, publicly held shipping companies, government-controlled companies, and groups of

professionally managed fleets under varying ownership (R.C. Diamond, Mid-Ship Marine, Inc., written commun., 1993). Until recently, the rate of new ship construction in the range of 10,000 to 50,000 tons had been very low, but during the 1996-97 period more than 300 new ships were to be built. These ships would drop the average age of the fleet to about 10 years.

This expansion of the smaller bulk carrier fleet resulted in overcapacity and caused a decrease in shipping prices during the latter part of 1997. The new ships will make competition difficult for the older ships, which already may be burdened with the overage insurance frequently required on ships over 15 years in age. In addition, the new International Safety Management Code goes into effect on July 1, 1998. Burdened by competition from newer ships, the overage insurance, and the new safety code, an estimated 30% of the older ships will be scrapped or pushed off main routes into niche markets (Steven Rzehak, Mid-Ship Marine, Inc., oral commun., 1997 and 1998).

Prices

Industrial Minerals (Metal Bulletin PLC) published yearend price ranges for Mexican fluorspar were \$110 to \$130 per ton for acid grade and \$80 to \$105 per ton for metallurgical grade. South African prices for acid grade, f.o.b. Durban, were unchanged at \$125 to \$135 per ton. No specific f.o.b. China or c.i.f. Gulf of Mexico prices were available for Chinese fluorspar.

According to Industrial Minerals, the average U.S. Gulf port price, dry basis, for acid grade decreased to \$130 to \$137 per ton. This would be the average delivered price of Chinese, Mexican, and South African acid grade at Gulf ports. (See table 3.)

The drop in prices in 1997 appears to have been caused by a mixture of factors involving Chinese fluorspar exports. These included unused export licenses carried over from 1996, lower 1997 export license fees, lower shipping costs during latter part of the year, and unauthorized exports that avoided payment of the export license fees. Since China dominates the world market for fluorspar, producers in other exporting countries were forced to lower prices to remain competitive.

The yearend price quotation from Chemical Market Reporter (CMR) for anhydrous HF was unchanged at \$0.70 per pound (\$1.55 per kilogram). The CMR quotation for aqueous HF, 70%, in drums, f.o.b., freight allowed, was unchanged at \$62.00 per 100 pounds (\$137.70 per 100 kilograms). The CMR yearend price quotation for hydrofluosilicic acid (fluorosilicic acid), 23% basis, in tanks, Midwest and East Coast terminals, was unchanged at \$165 per short ton (about \$182 per metric ton).

Foreign Trade

According to the Bureau of the Census, U.S. exports of fluorspar were essentially unchanged at about 62,100 tons. All U.S. exports were believed to be reexports of material imported into the United States or exports of material purchased from the NDS. (See table 4.)

In 1997, imports for consumption of fluorspar increased by more than 4% when compared with those of 1996, according to Bureau of the Census and USGS data. In descending order,

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China, South Africa, and Mexico were the largest suppliers of fluorspar to the United States.

China accounted for more than 65% of U.S. fluorspar imports. The average c.i.f. unit value of all imports, in dollars per metric ton, was \$134 for acid grade and \$91 for subacid grade. (See table 5.)

There is now no tariff on subacid-grade (metallurgical-grade) fluorspar from most-favored nation (MFN) countries, and the tariff on acid grade from MFN countries is now \$0.41 per ton. The North American Free Trade Agreement eliminates all tariffs on any fluorspar imported from Mexico or Canada.

Imports of HF, excluding material from DuPont's foreign trade zone, increased by 32% to a quantity equivalent to approximately 164,000 tons of fluorspar. Imports of synthetic and natural cryolite increased 45% to a quantity equivalent to approximately 11,100 tons of fluorspar. Imports of AlF_3 decreased by 30% to a quantity equivalent to 19,200 tons of fluorspar. (See tables 6, 7, and 8.)

World Review

The industry experienced the first major capacity increases at non-Chinese mining operations in years. Capacity increases were reported in Africa and Mexico, with additional increases planned for the near future. In order of rank, China, Mexico, Mongolia, Russia, and South Africa were the major producers. (See table 9.)

Canada.—Efforts to reopen fluorspar mining operations at St. Lawrence, Newfoundland continued, albeit slowly, in 1997. Burin Minerals Ltd. has been working on development plans for nearly 3 years. Engineering studies were completed on the Blue Beach and Tarefare #2 deposits, and it was determined that it only would be feasible to develop both deposits under a single business plan and that the best scenario called for increasing the capacity of the flotation mill to 180,000 tons per year. The company commissioned a study on the feasibility of constructing a deep water port in the outer St. Lawrence harbor, which would provide the capability of making 20,000-ton shipments (Burin Minerals Ltd., 1997).

China.—China continues to dominate the world market for fluorspar. Its fluorspar industry is made up of more than 1,000 mines, most of which are private or township owned, and probably in excess of 120 flotation mills. It is estimated that China has over 23 million tons of reserves (100% contained CaF_2) and a reserve base in excess of 94 million tons (100% contained CaF_2). There are three major fluorspar districts: East China Coastal Region, Mid-south China Region, and the Inner Mongolia Region. There are over 20 provinces and autonomous regions that produce fluorspar, but Zhejiang Province (East China Coastal Region) alone currently produces one-third to one-half of the country's total output (Aijun, 1997). Currently domestic consumption is estimated at more than 1.1 million tons per year and 1997 exports were about 1.3 million tons.

Mexico.—Cia. Minera Las Cuevas, S.A. de C.V., already the world's largest fluorspar producer, completed modernization and expansion of its mining operations, raising ore production capacity to 1.2 million tons per year. The company also installed a second metspar plant that raises its total metspar capacity to

400,000 tons per year, and completed a new flotation mill that raises its acidspar capacity to 340,000 tons per year. During 1998-99, Las Cuevas expects to further expand the flotation mill, bringing capacity up to 500,000 tons per year, and build a fluorspar refinery to produce high-purity (low arsenic) acidspar (North American Mineral News, 1997).

Namibia.—Namibia's sole fluorspar producer, Okorusu Fluorspar (Pty) Ltd. was acquired by Solvay S.A. of Belgium. Solvay's HF and fluorochemicals division has long been Okorusu's major customer. The purchase may allow Okorusu to streamline production and to upgrade its analytical facilities. In addition, a debottlenecking plan is being considered that could gradually increase production capacity to 80,000 tons per year. Current nameplate capacity is 55,000 tons per year, although in recent years the company has been unable to produce more than 30,000 to 40,000 tons per year (Kendall, 1997).

South Africa.—Vergenoeg Mining Company, a subsidiary of Bayer AG of Germany, was involved in a project to expand its acid-grade capacity by upgrading and expanding its flotation circuit. Previous practical capacity was about 110,000 tons per year, and the expansion will bring capacity up to about 135,000 tons per year. This expansion project was expected to be complete by late 1997 or early 1998. This follows improvements made in the last couple of years, which included construction of a larger primary mill and new magnetic separation stages (Kendall, 1997).

Outlook

Consumption of acidspar by the chemical industry for the production of HF is the largest market for fluorspar. There are a number of major issues affecting the future worldwide demand for HF. Positive factors generating growth in demand include the growth in fluoropolymer and solvent applications, rising demand from fluoroethers and other new fluorochemicals, rising demand for aluminum production, and rising demand in developing countries. Negative factors that might slow or cut demand include phaseout of HCFC's and foam blowing alternatives, global warming potential of HFC's, increasing use of hydrocarbons in refrigerators, and increasing use of ammonia in industrial refrigeration (Will, 1998). In the North American market, the positives outweigh the negatives and the demand for HF is expected to increase.

In North America, the largest use of HF is in the manufacture of fluorocarbons and fluoropolymers, which together account for about 65% to 70% of HF demand. It appears that demand for replacement fluorocarbons is slowly increasing, although a cool summer in 1997 reduced demand in the automotive and home air conditioning markets. The fluoropolymer market has grown strongly in recent years and now accounts for about 23% of North American HF demand. The North American fluoropolymer markets are expected to grow at 4% to 5% per year. The next largest market for HF is chemical derivatives, which consist of applications where fluorine is required in the production of other chemicals such as herbicides, pharmaceuticals, fluorochemicals, and specialty chemical intermediates. This market sector has grown an aggregate of more than 30% in the last 5 years, and industry expects continued growth in this sector.

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Since AlF₃ demand mirrors aluminum demand, the outlook for aluminum production is important. Domestically, output of aluminum has been increasing in recent years as world markets recovered from the effects of large-scale Russian exports. This trend is expected to continue, as was indicated by Reynolds Metals' announced plans to gradually bring 200,000 tons of idle aluminum smelter capacity back on-line over the course of 1998 (Reynolds Metals Company, 1997 and 1998). Additional idle capacity is expected back on-stream in the next few years as demand increases and prices strengthen. It is expected that fluorspar consumption in North America for AlF₃ production will increase as aluminum output increases.

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

TABLE 1 SALIENT FLUORSPAR STATISTICS 1/2/

		1993	1994	1995	1996	1997
United States:						
Production:						
Finished (shipments) e/ 3/	metric tons	60,000	49,000	51,000	8,200	
Value, f.o.b. mine	thousands	W	W	W	W	
Exports 4/	metric tons	12,700	23,500	41,800	61,600	62,100
Value 5/	thousands	\$2,130	\$3,690	\$5,550	\$8,110	\$8,330
Imports 6/	metric tons	497,000	492,000	558,000	513,000	536,000
Value 7/	thousands	\$47,000	\$47,600	\$67,400	\$71,000	\$69,500
Value per ton, acid grade 7/		\$97.60	\$97.70	\$126.00	\$142.00	\$134.00
Value per ton, metallurgical grade 7/		\$73.40	\$74.90	\$94.40	\$103.00	\$90.70
Consumption (reported)	metric tons	447,000	486,000	534,000	527,000	491,000
Consumption (apparent) 8/	do.	556,000	311,000	446,000	630,000 r/	330,000
Stocks, December 31:						
Consumer and distributor 9/	do.	78,000	284,000	405,000	234,000	375,000
Government stockpile	do.	1,160,000	909,000	756,000	667,000	448,000
World: Production	do.	4,180,000 r/	3,810,000 r/	4,280,000 r/	4,320,000 r/	4,620,000 e/

- e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.
- 1/ Data are rounded to three significant digits.
- 2/ Does not include fluorosilicic acid (H2SiF6) or imports of hydrofluoric acid (HF) and cryolite.
- 3/ May include fluorspar from the National Defense Stockpile beneficiated by Ozark-Mahoning Co., Illinois.
- 4/ Source: Bureau of the Census and the U.S. Geological Survey.
- 5/ F.a.s. values at U.S. ports.
- 6/ Source: Bureau of the Census as modified by the U.S. Geological Survey.
- 7/ C.i.f. values at U.S. ports.
- 8/ U.S. primary and secondary production plus imports minus exports plus adjustments for Government and industry stock changes.
- 9/Includes fluorspar purchased from the National Defense Stockpile, but still located at National Defense Stockpile depots.

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

(Metric tons)

	Containir than 9 calcium t	97%	Containing not more than 97% calcium fluoride		Tota	Total	
End use or product	1996	1997	1996	1997	1996	1997	
Hydrofluoric acid and aluminum fluoride	477,000	442,000			477,000	442,000	
Basic oxygen furnaces			11,900	7,830	11,900	7,830	
Electric furnaces	W	W	19,200	21,700	19,200	21,700	
Other 2/	W	W	W	W	18,800	19,100	
Total	W	W	W	W	527,000	491,000	
Stocks (consumer), December 31	106,000	120,000	11,100	16,800	117,000 r/	137,000	

r/ Revised. W Withheld to avoid disclosing company proprietary data.

^{1/} Data are rounded to three significant digits; may not add to totals shown.

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

TABLE 3 PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source-grade	1996	1997
Mexican, f.o.b., Tampico:		
Acidspar filtercake	115-135	110-130
Metallurgical grade	80-105	80-105
South African, acidspar dry basis, F.o.b. Durban	125-135	125-135
U.S. Gulf port, dry basis, acidspar	142-152	130-137

Source: Industrial Minerals (Metal Bulletin PLC), no. 351, p. 72, December 1996 and no. 363, p. 78, December 1997.

 $\label{eq:table 4} \textbf{U.S. EXPORTS OF FLUORSPAR, BY COUNTRY } 1/$

	1996		1997		
	Quantity	Quantit		У	
Country	(metric tons)	Value 2/	(metric tons)	Value 2/	
Canada	37,400	\$5,480,000	19,200	\$3,410,000	
Dominican Republic	4,340	595,000	19,700	2,860,000	
Italy	10,300	851,000			
Korea, Republic of	540	84,800	5,190	739,000	
Mexico	6,000	669,000	9,600	1,070,000	
Taiwan	2,340	298,000	7,680	120,000	
United Kingdom	54	12,700	303	51,500	
Venezuela	336	59,100	40	15,000	
Other 3/	310 r/	58,300 r/	350	58,600	
Total	61,600	8,110,000	62,100	8,330,000	

r/ Revised.

Source: Bureau of the Census.

 $^{1/\,\}mbox{Data}$ are rounded to three significant digits; may not add to totals shown.

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

^{3/} Includes Australia, Bolivia, Chile, France, Germany, Japan, and Malaysia.

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

	1	996	1997	
	Quantity		Quantity	
	(metric	Value 2/	(metric	Value 2/
Country and customs district	tons)	(thousands)	tons)	(thousands)
Containing more than 97%	•			
calcium fluoride (CaF2):				
Austria: Charleston	348	\$97	84	\$71
China:				
Baltimore			301	63
Houston 3/	212,000	29,300	142,000	28,000
New Orleans	144,000	21,900	209,000	19,100
Total	356,000	51,200	351,000	47,200
France: Philadelphia	54	28	334	131
Germany:				
Charleston	1	9		
Savannah	10	16	34	18
Total	11	25	34	18
Mexico:				
Laredo	18,100	2,530	9,740	1,350
New Orleans			4,800	712
Total	18,100	2,530	14,500	2,060
South Africa:				
Houston	17,900	2,400	35,800	4,430
New Orleans	81,500	10,800	82,100	10,800
New York City	240	88	240	86
Total	99,600	13,300	118,000	15,300
Taiwan: Ogdensburg		·	9	4
United Kingdom: New York City	12	22	113	56
Grand total	474,000	67,100	485,000	64,800
Containing not more than 97%		•	•	-
calcium fluoride (CaF2):				
Canada:				
Buffalo	354	118	282	110
Ogdensburg	9	4		
Total	363	122	282	110
Germany: New Orleans	194	20	265	33
Mexico:				
Buffalo			239	29
El Paso	3,120	238	1,020	74
Laredo	6,180	494	6,300	484
New Orleans	29,000	2,930	43,200	3,920
Total	38,300	3,660	50,800	4,510
Grand total	38,900	3,810	51,300	4,650
r/ Revised	,	-,	,	.,020

r/ Revised.

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

 $^{1/\,\}mbox{Data}$ are rounded to three significant digits; may not add to totals shown.

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

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

	199	6	1997		
	Quantity	Value 2/ Quantity		Value 2/	
Country	(metric tons)	(thousands)	(metric tons)	(thousands)	
Canada	105	\$338	24,600	\$27,700	
France	272	304	281	321	
Germany	164	332	288	617	
Greece			19	20	
Japan	589	2,160	1,230	4,270	
Mexico	81,200	75,700	82,800	77,100	
United Kingdom			139	147	
Total	82,300	78,800	109,000	110,000	

^{1/} Data are rounded to three significant digits, may not add to totals shown.

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

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

	199	6	199	7
	Quantity	Value 2/	Quantity	Value 2/
Country	(metric tons)	(thousands)	(metric tons)	(thousands)
Australia			610	\$256
Austria			647	354
Bahrain	1,010	\$674		
Canada	594	155	3,450	919
China	77	67	200	168
Denmark	296	427	502	708
Germany	2,070	2,400	2,180	2,650
Hungary	565	833	1,060	1,350
India	1,020	1,030		
Italy	505	642		
Switzerland			549	666
Other 3/	270	283	75	80
Total	6,400	6,510	9,270	7,150

^{1/} Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

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

	199	6	1997		
	Quantity	Value 2/	Quantity	Value 2/	
Country	(metric tons)	(thousands)	(metric tons)	(thousands)	
Canada	2,510	\$2,410	2,140	\$2,050	
France	900	1,030			
India	309	312			
Indonesia	1,500	1,510			
Italy	129	96			
Mexico	8,520	7,890	7,910	7,390	
Norway	4,230	3,360	2,640	2,370	
Other 3/	242	250	99	185	
Total	18,300	16,800	12,800	12,000	

 $^{1/\,\}mbox{Data}$ are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

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

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

^{3/} Includes data for the Czech Republic, Japan, Russia, and the United Kingdom.

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

^{3/} Includes data for China, Germany, Japan, Sweden, and the United Kingdom.

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

(Metric tons)

Country 3/ and grade 4/	1993	1994	1995	1996	1997 e/
Argentina	4,611	3,585	5,105 r/	5,666 r/	5,000
Brazil (marketable):	_				
Acid grade	_ 68,325	68,890	72,498	46,706 r/	48,000
Metallurgical grade	24,566	21,041	16,760 r/	12,068 r/	12,100
Total	92,891	89,931	89,258 r/	58,774 r/	60,100
China: e/	_				
Acid grade	800,000	1,200,000	1,200,000	1,250,000	1,300,000
Metallurgical grade	1,300,000	800,000	800,000	900,000	1,100,000
Total	2,100,000	2,000,000	2,000,000	2,150,000	2,400,000
Czech Republic	22,100	10,000 e/	r/	r/	
Egypt	773	514 r/	551 r/	700 e/	700
France: e/	= -				
Acid and ceramic grades	96,000	105,000	102,000	78,000 r/5/	80,000
Metallurgical grade	20,000	26,000	28,000	33,000 r/5/	30,000
Total	116,000	131,000	130,000	111,000 r/ 5/	110,000
Germany e/	40,000	37,000	38,000 r/	31,000 r/	32,000
India:					
Acid grade	7,798	6,231	6,359 r/	5,115 r/	5,100
Metallurgical grade	13,846	16,360	17,887 r/	14,263 r/	14,000
Total	21,644	22,591	24,246 r/	19,378 r/	19,100
Iran e/ 6/	10,000	10,000	10,000	10,000	10,000
Italy:	- = 10,000	10,000	10,000	10,000	10,000
Acid grade	35,000 e/	52,630	105,000 r/	93,700 r/	100,000
Metallurgical grade	25,000 e/	15,312	33,140 r/	23,000 r/	25,000
Total	60,000 e/	67.942	138,140 r/	116,700 r/	125,000
Kazakstan	_ 00,000 e/ r/	- r/	r/	r/	123,000
Kenya: Acid grade	78,725	53,488	80,230	83,000 r/	90,000
Korea, North: Metallurgical grade e/	41,000	40,000	40,000	39,000 r/	39,000
Korea, Republic of: Metallurgical grade	_				
	50	50 e/	50 e/	r/	617 5/
Mexico: 7/	107.000	120,000	270.000	070.022 /	200 500 5/
Acid grade	187,000	129,000	270,000	279,033 r/	290,580 5/
Metallurgical grade	93,000	103,000	252,000	244,938 r/	262,260 5/
Submetallurgical grade	3,000 e/	3,000 e/			
Total	283,000 e/	235,000	522,000	523,971 r/	552,840 5/
Mongolia:					
Acid grade	77,000	88,000	120,300	130,000	130,000 5/
Other grades 8/	276,000	85,000	119,000 e/	124,000 e/	120,000
Total	353,000	173,000	239,000 e/	254,000 e/	250,000
Morocco: Acid grade	70,050	85,000	105,800	95,900 r/	103,800 5/
Namibia: Acid grade 9/	43,466	52,226	36,889 r/	32,285 r/	35,000
Pakistan: Metallurgical grade	5,100 e/	13,351	2,753	363 r/	500
Romania: Metallurgical grade e/	_ 15,000	15,000	15,000	15,000	15,000
Russia e/	236,300 r/5/	250,000 r/ 5/	250,000 r/	250,000 r/	250,000
South Africa: 10/					
Acid grade	195,000 e/	166,761	177,000 e/	191,018 r/	207,000
Ceramic grade	3,800 e/				
Metallurgical grade e/	19,000	7,497 5/	19,000	12,000 r/	10,000
Total	217,778	174,258	195,866	203,018 r/	217,000
Spain:	-				
Acid grade	82,000	97,000 e/	108,205 r/	109,085 r/	110,000
Metallurgical grade	5,000 e/	10,000 e/	10,206 r/	7,441 r/	10,000
Total	87,000 e/	107,000 e/	118,411 r/	116,526 r/	120,000
Tajikistan e/	8,000 5/	10,000 5/	9,000	9,000	9,000
Thailand: Metallurgical grade	48,387	23,705	24,114	17,247 r/	7,826
Turkey: Metallurgical grade	4,000 e/	6,671	8,873 r/	8,900 r/e/	8,900
United Kingdom	70,285	58,000 e/	55,000 e/	65,000 r/	67,000
United States (shipments) e/	60,000	49,000	51,000	8,200	07,000
Uzbekistan e/	90,000 5/	90,000 r/ 5/	90,000 r/	90,000 r/	90,000
	_				· ·
Grand total	4,180,000 r/	3,810,000 r/	4,280,000 r/	4,320,000 r/	4,620,000

See footnotes at end of table.

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

e/ Estimated. r/ Revised.

- 1/World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.
- 2/ Table includes data available through April 21, 1998.
- 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/ Year beginning March 21 of that stated.
- 7/ Data are reported by Consejo de Recursos Minerales; but the production of submetallurgical grade and acid grade have been redistributed by the author based on industry data.
- 8/ Principally submetallurgical grade material.
- 9/ Data are in wet tons.
- 10/ Data show estimated proportions of acid grade, ceramic grade, and metallurgical grade fluorspar within the reported totals.