



2015 Minerals Yearbook

FLUORSPAR [ADVANCE RELEASE]

FLUORSPAR

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In 2015, the bulk of fluor spar consumed in the United States was from imports and small amounts of byproduct synthetic fluor spar produced from industrial waste streams. Although not included in fluor spar production or consumption calculations, byproduct fluorosilicic acid (FSA) production from some phosphoric acid producers supplemented fluor spar as a domestic source of fluorine. Apparent consumption of fluor spar decreased by 21%, from 518,000 metric tons (t) at yearend 2014 to 411,000 t at yearend 2015 (table 1). Estimated world production decreased slightly to an estimated 6.67 million metric tons (Mt).

Fluor spar is the commercial name that refers to crude or beneficiated material that is mined and (or) milled from the mineral fluorite (calcium fluoride, CaF_2). Most of the fluor spar consumed and traded is either acid grade (also called acid spar), which is more than 97% CaF_2 , or subacid grade (including ceramic and metallurgical grade), which is less than or equal to 97% CaF_2 and is commonly called metspar.

Globally, there are three leading fluor spar-consuming industries. The manufacture of hydrofluoric acid (HF), the leading source of fluorine in industrial applications and a precursor to the production of most other fluorine-containing chemicals, accounts for approximately 40% of annual global fluor spar consumption. The manufacture of aluminum fluoride (AlF_3) and cryolite (Na_3AlF_6), essential for primary aluminum smelting, accounts for approximately 18% of annual global fluor spar consumption. Both of these applications typically require acid-grade fluor spar, although FSA can also be used to produce AlF_3 . Fluor spar used as a steelmaking flux accounts for approximately 30% of global consumption. Metallurgical-grade fluor spar is primarily used in this application, although acid-grade material may also be used. Other applications of fluor spar include use in the manufacture of cement, ceramics, enamel, glass, and welding rod coatings.

Legislation and Government Programs

The U.S. Department of Health and Human Services, U.S. Public Health Service revised the recommendations for fluoride concentration in community drinking water systems. The original guidelines, issued in 1962, recommended that fluoride levels of 0.8 to 1.2 milligrams per liter (mg/L) were optimal for the prevention of dental caries. The new recommendation of 0.7 mg/L is based on a number of factors including scientific evidence of the effectiveness of water fluoridation in the prevention of dental caries across all age groups; the increase in the availability of fluoride from sources other than drinking water such as toothpastes, mouth rinses, dietary supplements, and so forth; trends in the prevalence and severity of dental fluorosis; and differing fluid intake by children

across differing climates (U.S. Department of Health and Human Services, 2015). In 2015, almost all FSA produced in the United States was sold for fluoridation of drinking water.

Mexichem S.A.B. de C.V. appealed the U.S. International Trade Commission's (U.S. ITC's) ruling that imports of 1,1,1,2 Tetrafluoroethane (HFC-134a) from China do not materially harm U.S. companies. The decision, made in November 2014, eliminated countervailing and dumping duties instituted by the U.S. Department of Commerce. Mexichem expects the appeal to be resolved in approximately 1 year (Mexichem S.A.B. de C.V., 2015).

A coalition of U.S. hydrofluorocarbon (HFC) producers filed a petition with the U.S. ITC alleging that certain HFC blends and components from China were being sold at less than fair value. A preliminary determination by the U.S. ITC concluded that there was a reasonable indication that U.S. industry had been materially harmed and will therefore continue its investigation (U.S. International Trade Commission, 2015).

The U.S. Environmental Protection Agency (EPA) issued its final ruling regarding the status of certain HFCs under the Significant New Alternatives Policy Program. The new rule will phase out or limit the use of many HFC and HFC-blend substances used in a wide variety of applications such as foam-blowing agents, propellants, and refrigerants because of their high global-warming potential (GWP) (U.S. Environmental Protection Agency, 2015).

The European Union's revised regulation on fluorinated gases (f-gases) took effect on January 1, 2015, superseding the original regulation passed in 2006. The measure's intent is to reduce the European Union's f-gas emissions by two-thirds by 2030 compared to 2014 levels. The measure instituted a more aggressive phase down schedule, increased restrictions on manufacture and use, and stringent reporting requirements for many higher GWP f-gases including foam-blowing agents, propellants, and refrigerants. The measure also seeks to reduce f-gas emissions by improving equipment servicing and maintenance, and recovering f-gases at the end of the equipment's lifecycle (European Commission, undated).

Production

In 2015, small amounts of fluor spar may have been produced in Illinois by Hastie Mining & Trucking as a byproduct of limestone mining operations, but no data were collected on quantities produced. Synthetic fluor spar may have been produced as a byproduct of petroleum alkylation, stainless steel pickling, and uranium processing. However, the U.S. Geological Survey (USGS) has no data survey for synthetic fluor spar produced in the United States.

FSA was produced as a byproduct from the processing of phosphate rock into phosphoric acid. Domestic production

¹Deceased.

data for FSA were developed by the USGS from a voluntary canvass of U.S. phosphoric acid operations known to recover FSA. Of the five active FSA operations surveyed, responses were received from all, representing 100% of the total sold or used by producers. In 2015, three companies—J.R. Simplot Co., Mosaic Fertilizer LLC (a subsidiary of The Mosaic Co.), and PCS Phosphate Co., Inc.—produced marketable byproduct FSA at five phosphoric acid plants (part of phosphate fertilizer operations) in Florida, Louisiana, North Carolina, and Wyoming. In 2015, production of FSA decreased by 8% to 64,500 t (equivalent to about 105,000 t of fluorspar grading 100% CaF₂).

Hastie Mining & Trucking, Core Metals Group (Aurora, IN), and Seaforth Mineral & Ore Co., Inc. (East Liverpool, OH) marketed screened and dried imported acid- and metallurgical-grade fluorspar. Hastie Mining & Trucking also continued development of the Klondike II fluorspar mine in Livingston, KY.

Environment

Environmental Health Perspectives, a peer-reviewed journal of the National Institute of Environmental Health Sciences, highlighted opposing scientific viewpoints regarding the use of poly- and perfluoroalkyl substances (PFASs). The Madrid Statement on Poly- and Perfluoroalkyl Substances, originally presented at the 34th International Symposium on Halogenated Persistent Organic Pollutants in Madrid, Spain, was signed by more than 200 scientists and other professionals from 40 countries. The statement opposed the use of all classes of PFASs owing to environmental persistence, bioaccumulation, and potential toxicity. The FluoroCouncil, a global consortium of fluorochemical producers, in its statement, agreed that industry should seek to eliminate long-chain PFASs, but argued that the Madrid Statement was too broad in its condemnation of all classes of PFASs, ignored their criticality, and failed to recognize governmental and industry efforts to replace long-chain PFASs with less harmful substances, specifically short-chain PFASs (Birnbaum and Grandjean, 2015).

Consumption

Domestic consumption data were developed by the USGS from a quarterly survey of two large consumers that provide data on HF consumption and four distributors that provide data on the merchant market (metallurgical and other uses). Responses were received by two of the six companies, accounting for approximately 51% of estimated fluorspar consumption. Estimates were made for the four nonrespondents based on prior years' data and industry sources where available. These combined data constitute 100% of the reported consumption in table 2.

Beginning in 2014, total reported U.S. fluorspar consumption and data on quarterly consumer stocks were withheld to avoid disclosing company proprietary data (table 2). However, estimates of yearend consumer stocks were made to facilitate calculation of apparent consumption which is defined as production plus imports minus exports plus adjustments for changes in stocks. Apparent consumption of fluorspar was

estimated to have decreased by 21% from 518,000 t at yearend 2014 to 411,000 t at yearend 2015 (table 1). Most of the decrease in apparent consumption was attributed to a decrease in metallurgical-grade imports, which decreased by 61% (75,000 t) in 2015 (table 5).

Two companies used fluorspar for the production of HF in 2015—The Chemours Co. and Honeywell International Inc. The leading use for HF is in the manufacture of fluorocarbon chemicals (hydrochlorofluorocarbons or HCFCs, HFCs, and hydrofluoroolefins or HFOs) that are used as aerosols, refrigerants, and solvents and in the production of high-performance plastics and rubbers (fluoropolymers and fluoroelastomers). These substances are used in dozens of familiar products used in daily life. Examples include the anti-fingerprint coatings of touch-screen devices; nonstick coatings on cookware; refrigerant gases used in household and commercial refrigeration and automotive, home, and industrial air-conditioning systems; and water- and stain-resistant clothing and textiles. Major U.S. producers were Arkema Inc., Chemours, Daikin America, Inc. (formerly MDA Manufacturing Ltd.), Honeywell, Mexichem Fluor, Inc., and Solvay Solexis Inc. HF is also crucial in many manufacturing processes such as in the cleaning and etching of semiconductors and circuit boards, the enrichment of uranium, the production of low octane fuels (petroleum alkylation), and the removal of impurities from metals (pickling).

Internationally, acid-grade fluorspar was used in the production of AlF₃ and cryolite, which are essential in primary aluminum smelting. Alumina (Al₂O₃) is dissolved in a bath that consists primarily of molten cryolite and small amounts of AlF₃ and fluorspar to allow electrolytic recovery of aluminum. During the aluminum smelting process, the amount of excess sodium in the bath (a result of impurities in the alumina) is controlled by the addition of AlF₃, which reacts with the sodium to form cryolite. This reaction results in excess bath material, which is drawn off in a liquid form, allowed to cool and solidify, and can then be crushed and reused to start up new pots or to compensate for electrolyte losses. This excess material is variously called crushed tapped bath, secondary cryolite, or bath cryolite, as well as other terms. In the aluminum smelting process, AlF₃ is also used to replace fluorine losses (either absorbed by the bath walls or captured as emissions). Most AlF₃ is produced directly from acid-grade fluorspar or from byproduct FSA. The AlF₃ requirements of the U.S. aluminum industry were met through imports in 2015 (table 8) as there are no active AlF₃ producers in the United States.

E.I. du Pont de Nemours & Co. (DuPont) sold the global marketing, sales, and distribution rights for its pharmaceutical-grade HFC propellants, which are important in metered-dose inhalers as well as other applications. DuPont sold the distribution and sales license for its HFC-227ea/P pharmaceutical-grade propellant to Mexichem. The product will be marketed under Mexichem's own medical propellant brand, ZEPHEX® (Bailey, 2015). SRF Ltd., a specialty chemicals company based in India, acquired DuPont's Dymel® brand. DuPont planned to assist SRF in setting up a manufacturing facility for pharmaceutical-grade HFC-134a and will supply SRF with product until SRF's facility is approved (SRF Ltd., 2015).

DuPont finalized the separation of its Performance Chemicals division into Chemours, an independent, publicly traded company focused on chemical solutions, fluoroproducts, and titanium. Chemours's growth in the fluoroproducts sector will continue to focus on the development and acceptance of HFO products, which DuPont and Honeywell collaborated to develop in response to the European Union's Mobile Air Conditioning (MAC) directive. The directive requires automakers to reduce fluorinated greenhouse gas emissions by banning the use of any automotive air-conditioning refrigerant with a GWP of greater than 150 in all new model vehicles sold after January 1, 2013, and all cars sold after 2017. Chemours announced that it had increased HFO production capacity at its manufacturing facility in Zhonghao, China, and introduced HFO products for other applications including foam-blowing agents and commercial and stationary refrigeration (RAC, 2015; Westervelt, 2015).

The merchant fluorspar market in the United States included sales of metallurgical- and acid-grade material mainly to steel mills, where it was used as a fluxing agent to increase the fluidity of the slag. Sales were also made to smaller markets such as cement plants, foundries, glass and ceramics plants, and welding rod manufacturers in railcar, truckload, and less-than-truckload quantities. Complete data on merchant fluorspar sales cannot be shown because consumption of acid-grade fluorspar for HF production has been combined with other uses in table 2 to prevent disclosure of company proprietary data. In the late 1970s, the United States annually used upwards of 500,000 t for these applications. During the past 20 to 30 years, however, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

The 75,000-t decrease in metallurgical-grade imports suggests a significant decrease in apparent consumption of metspar in 2015 as compared with 2014. Whether this represents a real decrease in metallurgical fluorspar usage is difficult to verify because of incomplete reporting by fluorspar distributors and uncertainty regarding the accuracy of import data. According to U.S. trade statistics, imports of metspar from Mexico increased substantially beginning in 2010. Because imports of metspar were much lower than Mexico's reported fluorspar exports to the United States, previous USGS reports posited that fluorspar moving through ports in the United States for reexport had not been properly reported in the U.S. trade statistics. However, the American Iron and Steel Institute estimated that the amount of fluorspar used as a flux in steelmaking has been approximately 100,000 t in recent years, as follows: 80,000 t (2010), 95,000 t (2011), 110,000 t (2012), 100,000 t (2013), 100,000 t (2014), and 100,000 t (2015) (American Iron and Steel Institute, 2015, p. 77; 2016, p. 77). In 2015, Mexichem, the leading U.S. metspar supplier, reported weak demand for metspar as one reason for a 5% decrease in its Fluor business group (Mexichem S.A.B. de C.V., 2016, p. 21).

In the United States, FSA is used primarily for water fluoridation, but it also is used as a metal surface treatment and cleaner and for pH adjustment in industrial textile processing or laundries. It also can be used in the processing of animal hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2015, the amount of FSA sold or used

by producers was 63,500 t (equivalent to about 103,000 t of fluorspar grading 100% CaF₂), a 10% decrease compared with that of 2014 (table 1).

Stocks

Beginning in the fourth quarter of 2014, quarterly stock data on consumer and distributor stocks were withheld to avoid disclosing company proprietary data. Known consumer and distributor stocks at the end of 2013 totaled 313,000 t, the highest in the past 10 years (table 1, fig. 1). Stock data for the first three-quarters of 2014 progressively decreased. The substantial decrease in imports in 2014 and 2015 has been partially attributed to a drawdown in company stocks. By yearend 2015, stocks were estimated to have decreased to approximately 146,000 t, closer to the levels typical of the past 10 years.

U.S. Government stocks of fluorspar are currently zero. Government stocks of fluorspar were, however, maintained from 1943 until 2006.

Transportation

The United States depends on imports for most of its fluorspar supply. Metallurgical-grade fluorspar 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 fluorspar is shipped in the form of damp filtercake that contains 7% to 10% moisture to facilitate handling and to reduce dust. This moisture is removed by heating the filtercake in rotary kilns or other dryers before treating with sulfuric acid to produce HF. Acid-grade imports from China and South Africa are usually shipped by ocean freight using bulk carriers of 10,000- to 50,000-t deadweight capacity; ships in this size range are termed "handymax." Participants negotiate freight levels, terms, and conditions. Some of the acid-grade and ceramic-grade fluorspar is marketed in bags for small users and shipped by truck.

Prices

In 2015, acidspare prices declined for the fourth consecutive year. According to Industrial Minerals magazine, the yearend 2015 price range for acidspare filtercake from China, dry basis, cost, insurance, and freight Gulf port, decreased to \$270 to \$300 per metric ton at yearend 2015 from \$340 to \$370 per metric ton at yearend 2014. The price range for Mexican high-arsenic acidspare filtercake, free-on-board (f.o.b.) Tampico, also decreased to \$260 to \$280 per metric ton, and low-arsenic (less than 5 parts per million) acidspare from Mexico, f.o.b. Tampico, decreased to \$280 to \$310 per metric ton (table 3, fig. 2).

Foreign Trade

In 2015, U.S. exports of fluorspar increased slightly to 13,700 t compared with those of 2014 (table 4). With the absence of fluorspar stocks in the National Defense Stockpile and only a small amount of mined or byproduct fluorspar, exports are likely reexports of imported material. Approximately 92% of exports went to Canada.

In 2015, combined acid- and metallurgical-grade fluorspar imports for consumption were 376,000 t, a 9% decrease

compared with those of 2014 (table 5). Although this followed a 36% decrease of total imports in 2014, the composition of the decrease differed significantly. In 2015, acid-grade imports increased by 13%, but metallurgical-grade imports decreased by 61%. In 2014, acid- and metallurgical-grade imports decreased by 40% and 6%, respectively (fig. 1). The leading suppliers of fluorspar to the United States were Mexico (59%), Vietnam (15%), South Africa (8%), China (7%), Spain (6%), and Mongolia (4%).

The following imports are compared with those of 2014. Imports of HF decreased by about 4% to 120,000 t (table 6); the majority of HF imports were from Mexico (90%) and China (6%). Imports of cryolite increased by 17% to 18,900 t (table 7). AlF_3 imports decreased by 16% to 32,400 t (table 8), with almost all coming from two countries—Mexico (57%) and China (42%).

World Review

Bulgaria.—Solvay S.A. announced its intention to cease operations at its fluorspar mine in Chiprovtsi. The company cited reduced demand for fluorspar and depletion of quality ore. All 116 employees were scheduled to be laid off by March 2016 except for 9 who would maintain the mine until its permanent closure (Mihaylov, 2016).

Canada.—The government of Newfoundland and Labrador, Department of Environment and Conservation, released the St. Lawrence AGS Vein fluorspar project from further environmental review. The project, proposed by Canada Fluorspar Inc., would include four open pits and underground mine operations, a tailings management facility capable of storing 2.8 Mt of flotation tailings, a mill facility capable of processing 200,000 metric tons per year (t/yr) of fluorspar flotation concentrate, and a marine terminal facility capable of handling vessels of 10,000 to 65,000 deadweight tons (Canada Fluorspar Inc., 2015). Prior to construction, the company will still be required to submit an Environmental Protection Plan and Environmental Effects Monitoring Program, a Development Plan, and a Mine Rehabilitation and Closure Plan (Department of Environment and Conservation, Environmental Assessment Division, 2015).

China.—For 2014, China reported fluorspar reserves of 39 Mt, significantly higher than the most recent USGS estimate of 24 Mt. A graph of the changes in China's reported reserves from 2005 to 2014 is shown in figure 3. The trend of reported reserves suggests ongoing exploration and development of China's fluorspar resources. However, industry analysts have reported that as previously mined deposits are depleted, the grade of China's resources have decreased, and are increasingly located farther from ports.

Germany.—To comply with regulatory timelines established by the MAC directive, automobile manufacturer Daimler AG (Daimler) announced that it will introduce carbon dioxide (CO_2)-based air-conditioning systems in all 2017 model year Mercedes-Benz E- and S-Class passenger cars, but all other 2017 Daimler models will use HFO-1234yf. Despite validation of HFO-1234yf's safety by the Society of Automotive Engineers and the European Commission's Joint Research Centre, Daimler objected to its use, owing to its mild flammability, and announced its intention to pursue development of a CO_2 -based

air-conditioning system. The company, however, was unable to implement the CO_2 -based technology in all of its passenger cars and still meet MAC directive requirements (Daimler AG, 2015). If successfully deployed, the CO_2 -based system would represent the first viable alternative to fluorinated MAC refrigerants.

Kenya.—Kenya Fluorspar Company suspended operations at its processing plant in western Kenya for 2 months beginning in June, citing quality issues, reduced global demand, and competition from new producers. The company intended to sell 30,000 t of accumulated fluorspar stock prior to resuming operations. Operations restarted in August, but the company expected to record another net loss in 2015 (Andae, 2015; KTN News Kenya, 2015).

United Arab Emirates.—Gulf Fluor LLC opened a new fluorine industrial complex in Abu Dhabi. Production facilities include a 60,000-t/yr AlF_3 plant, a 54,000-t/yr anhydrous HF plant, and a 140,000-t/yr sulfuric acid plant. The complex is expected to consume 125,000 t of fluorspar annually and supply AlF_3 to major aluminum producers in the Persian Gulf (Musleh, 2015; Zawya, 2015).

United Kingdom.—Mexichem closed its HF production plant in Runcorn and withdrew financial support of Fenix Fluor Ltd., a company that produced chlorodifluoromethane (R-22), an HCFC used as both a refrigerant and an intermediate in the production of fluoropolymers. Mexichem cited the price decline of HF in Europe resulting from oversupply in China and the shutdown of numerous operations of its main clients as reasons for the closure (Mexichem, S.A.B. de C.V., 2016, p. 37).

Outlook

Because of fluorspar's role as the basic material for almost all other fluorochemicals, fluorspar consumption is primarily driven by factors affecting the downstream industries. Fluorochemicals, particularly those containing carbon, are very stable and versatile, and new applications continue to be developed. However, numerous environmental, health, and safety issues constrain the use of fluorine, HF, and many other fluorinated substances. These conflicting factors complicate an assessment of the outlook for fluorspar. The following discussion examines fluorspar consumption within three leading industrial sectors.

Aluminum.—Aluminum fluoride and cryolite, essential in aluminum smelting, are estimated to account for approximately 18% of global fluorspar consumption. Because aluminum produced from scrap does not require either AlF_3 or cryolite, demand for fluorspar is expected to increase with primary aluminum production only. Aluminum fluoride produced from FSA may displace some AlF_3 produced from fluorspar. However, because of differing physical properties, the two products are not readily interchangeable.

Chemicals.—Approximately 40% of global annual fluorspar production is used to produce HF, which is the precursor for almost all other fluorochemicals. Of total HF production, organic fluorine compounds have been estimated to consume over 60% of HF annually, as much as one-half of which are used as refrigerant and air-conditioning gases. Other uses include foam-blowing agents, propellants, solvents, and as the precursor in the manufacture of a wide range of fluoropolymers and fluoroelastomers.

Because of the ozone-depleting potential of early generations of fluorocarbon gases, (chlorofluorocarbons or CFCs and later HCFCs), many fluorinated substances used as foam-blowing agents, propellants, refrigerants, and solvents have been a major target for reduction and eventual phase out under the Montreal Protocol on Substances that Deplete the Ozone Layer, which was adopted in 1987. CFCs and HCFCs have been replaced by HFCs, which, although not ozone depleting, in many cases are potent greenhouse gases owing to high GWP and long atmospheric lifecycles. Europe and the United States have already adopted regulations to decrease reliance on higher GWP HFCs and have proposed expanding the scope of the Montreal Protocol to phase down the use of higher GWP substances as well.

Fluorinated foam-blowing agents and propellants are still in use but have been replaced in many applications by nonfluorinated alternatives. The use of fluorinated refrigerants has persisted, and increased global demand for refrigeration and air-conditioning, particularly in developing countries, is expected to drive increased consumption of fluorspar. Further, subsequent generations of fluorinated refrigerants often contained more fluorine than previous generations, which increased the amount of fluorspar required for their manufacture. Although low-GWP fluorinated refrigerants have been developed and are gaining acceptance, a portion of the refrigerant market is expected to transition to nonfluorinated alternatives, tempering increased consumption of fluorspar in this sector.

The use of some fluorocarbons, particularly those used to manufacture fluoropolymers and fluoroelastomers, has not been restricted by the provisions of the Montreal Protocol because chemicals used entirely as feedstock in the manufacture of other chemicals are excluded from production and consumption calculations. Fluoropolymers and fluoroelastomers possess a wide range of advantageous properties including low adhesion; low index of refraction; low gas permeability; and chemical, electrical, oil, temperature, and water resistance, which make them invaluable in a wide range of applications in harsh and demanding environments. Some examples include gaskets, o-rings, and seals in automotive and aviation applications; fittings, liners, and seals in the chemical industry; cable, insulation, and protective coatings used in electronics, photovoltaics, and semiconductors; architectural fabrics and coatings; and medical applications such as cardiovascular grafts and ligament replacements. In 2012, fluoropolymer industry revenue was estimated to be \$5.8 billion with an estimated 6.5% compound annual growth rate (Boday, 2012).

Fluxes in Steelmaking.—Approximately 30% of annual global fluorspar production is estimated to be used as a flux in steelmaking. However, this use varies significantly by geographic region. Metspar consumption in Europe and North America decreased dramatically in the 1990s with decreasing use of open-hearth steelmaking furnaces that used large quantities of fluorspar as a flux. Improvements in steelmaking technology have also reduced the unit consumption of fluorspar per unit ton of steel produced. In less developed countries, the quantity of fluorspar used as a flux in steelmaking continues to be much higher, but further efficiency improvements are expected to moderate growth.

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TABLE 1
SALIENT FLUORSPAR STATISTICS^{1,2}

		2011	2012	2013	2014	2015
United States:						
Exports:³						
Quantity	metric tons	24,100	23,800	16,000	13,400	13,700
Value ⁴	thousands	\$3,780	\$3,640	\$2,520	\$2,200	\$2,210
Imports for consumption:³						
Quantity	metric tons	727,000	620,000	643,000	414,000	376,000
Value ⁵	thousands	\$154,000	\$157,000	\$147,000	\$105,000	\$107,000
Consumption:						
Reported	metric tons	456,000	416,000	441,000	W	W
Apparent ⁶	do.	672,000	525,000	548,000	518,000 ^e	411,000 ^e
Fluorosilicic acid:						
Production	metric tons	70,300	73,600	74,300	70,100	64,500
Sold or used	do.	70,200	73,600	73,900	70,600	63,500
Value ⁵	thousands	\$13,400	\$12,100	\$21,800	\$19,800	\$15,500
Stocks, December 31:						
Consumer and distributor	metric tons	162,000	234,000	313,000	195,000 ^e	146,000 ^e
World, production ^e	do.	9,080,000	6,870,000 ^r	6,330,000 ^r	6,720,000 ^r	6,670,000

^eEstimated. ^rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

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

²Does not include byproduct or synthetic fluorspar production.

³Source: U.S. Census Bureau; data 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 changes in stocks.

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	
	2014	2015	2014	2015	2014	2015
Hydrofluoric acid	W	W	--	--	W	W
Metallurgical	W	W	30,600	29,700	W	W
Other ²	W	W	--	--	W	W
Total	W	W	30,600	29,700	W	W
Stocks, consumer and distributor, December 31	W	W	20,000	21,200	195,000 ^e	146,000 ^e

^eEstimated. W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

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

²May include cement, enamel, glass and fiberglass, hydrofluoric acid, steel castings, and welding rod coatings.

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source and grade	2014	2015
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	340–370	270–300
Chinese, free on board (f.o.b.) China, wet filtercake	290–310	260–280
Mexican, f.o.b. Tampico, filtercake	290–330	260–280
Mexican, f.o.b. Tampico, arsenic <5 parts per million	370–420	280–310
South African, f.o.b. Durban, filtercake	300–330	260–280
Metspar, Mexican, f.o.b. Tampico	230–270	230–270

Source: Industrial Minerals magazine (London).

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

Country	2014		2015	
	Quantity (metric tons)	Value ²	Quantity (metric tons)	Value ²
Australia	88	\$12,800	759	\$110,000
Brazil	170	24,700	--	--
Canada	13,000	2,150,000	12,500	2,050,000
China	128	14,300	--	--
Colombia	--	--	97	10,800
Indonesia	--	--	5	2,800
Mexico	--	--	210	15,000
Netherlands	--	--	47	6,840
Nicaragua	--	--	20	2,880
Taiwan	--	--	21	2,990
Total	13,400	2,200,000	13,700	2,210,000

-- Zero.

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

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

Source: U.S. Census Bureau.

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

Country and customs district	2014		2015	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Containing more than 97% calcium fluoride (CaF₂):				
China:				
Houston, TX	--	--	18,700	\$6,600
Mobile, AL	801	\$520	--	--
New Orleans, LA	--	--	7,050	1,970
Total	801	520	25,700	8,580
Germany:				
Baltimore, MD	--	--	19	8
Cleveland, OH	27	18	--	--
Houston, TX	--	--	38	21
New York, NY	--	--	203	104
Savannah, GA	20	16	--	--
Total	47	35	260	133
Mexico:				
Baltimore, MD	1,050	692	1,100	774
Laredo, TX	22,500	8,100	4,410	1,380
New Orleans, LA	187,000	45,500	170,000	48,100
Total	210,000	54,300	176,000	50,300
Mongolia:				
Baltimore, MD	--	--	10	10
Houston, TX	8,880	3,510	14,800	6,200
New Orleans, LA	5,280	1,820	--	--
Total	14,200	5,330	14,800	6,210
Netherlands, Houston, TX	5	4	4	16
South Africa, Houston, TX	38,000	11,700	31,400	7,090
Spain, Houston, TX	9,950	3,540	21,700	5,240
Sweden, New York, NY	1	2	--	--
United Kingdom:				
Chicago, IL	--	--	19	12
Cleveland, OH	--	--	2,000	1,090
Houston, TX	8,310	2,650	10	34
Los Angeles, CA	184	95	291	150
Total	8,490	2,740	2,320	1,280
Vietnam:				
Houston, TX	8,460	3,770	30,600	9,950
New Orleans, LA	649	630	25,600	6,180
Total	9,110	4,400	56,200	16,100
Total, containing more than 97% CaF ₂	291,000	82,600	328,000	95,000
Containing not more than 97% CaF₂:				
China:				
Mobile, AL	295	172	--	--
New Orleans, LA	--	--	500	282
New York, NY	412	111	200	109
Total	707	283	700	391
Mexico:				
Baltimore, MD	91	39	--	--
Laredo, TX	3,520	606	2,940	472
New Orleans, LA	106,000	19,600	43,500	10,700
Total	110,000	20,300	46,400	11,200
Mongolia:				
Cleveland, OH	6,620	903	--	--
New Orleans, LA	300	192	--	--
Total	6,920	1,100	--	--
Spain, New York, NY	--	--	11	13
Switzerland, San Francisco, CA	--	--	1	2
United Kingdom, Cleveland, OH	--	--	508	252
Vietnam, New Orleans, LA	5,470	745	--	--
Total, containing not more than 97% CaF ₂	123,000	22,400	47,700	11,900
Grand total	414,000	105,000	376,000	107,000
-- 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.

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

Country	2014		2015	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Belgium	(3)	\$7	(3)	\$3
Canada	2,620	10,700	597	1,090
China	5,280	5,850	7,170	7,580
Colombia	127	178	--	--
Germany	1,000	2,460	1,470	3,690
Hong Kong	--	--	1	9
India	18	22	37	42
Japan	1,610	2,880	1,470	2,400
Korea, Republic of	336	1,030	508	1,320
Mexico	113,000	188,000	108,000	178,000
Singapore	81	223	243	660
Spain	113	325	113	337
Taiwan	218	555	385	1,010
Total	125,000	213,000	120,000	196,000

-- 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.

³Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF CRYOLITE, BY COUNTRY^{1,2}

Country	2014		2015	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Canada	6,550	\$2,850	9,070	\$4,160
China	1,250	1,240	964	644
France	165	114	--	--
Germany	1,580	2,470	1,150	1,900
Hungary	340	593	221	321
Iceland	453	293	173	143
Italy	141	197	322	371
Japan	3,650	4,450	5,110	5,730
Spain	1,290	476	1,440	569
Switzerland	38	32	--	--
United Kingdom	761	1130	494	841
Total	16,200	13,800	18,900	14,700

-- Zero.

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

²Includes natural and synthetic cryolite.

³Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau.

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

Country	2014		2015	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Canada	581	\$794	420	\$634
China	13,900	18,900	13,600	18,100
Italy	3,000	3,730	--	--
Mexico	20,900	27,100	18,400	22,800
Other ³	85	129	37	82
Total	38,400	50,700	32,400	41,600

-- 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 all countries with quantities less than 1,000 metric tons.

Source: U.S. Census Bureau.

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

(Metric tons)

Country ^{3, 4}	2011	2012	2013	2014	2015 ^e
Afghanistan ^e	--	--	--	2,000	2,000
Argentina	25,099	35,874	37,967	37,000 ^e	35,000
Brazil, marketable:					
Acid grade	6,197	5,768	6,835	6,496 ^r	6,500
Metallurgical grade	18,843	18,380	20,886	17,353 ^r	17,000
Total	25,040	24,148	27,721	23,849 ^r	23,500
Bulgaria ^{e, 5}	--	12,000	12,000	20,000	20,000
China: ^e					
Acid grade	3,800,000	2,400,000	2,300,000	2,500,000 ^r	2,600,000
Metallurgical grade ⁶	2,750,000	1,800,000	1,700,000	1,800,000 ^r	1,800,000
Total	6,550,000 ⁷	4,200,000 ⁷	4,000,000	4,300,000 ^{r, 7}	4,400,000
Germany, acid grade	65,619	54,202	48,744	35,270 ^r	40,000
India ⁸	5,010	3,092 ^r	2,487 ^r	2,947 ^r	3,000
Iran ⁹	58,000	80,000 ^e	69,828 ^{r, 10}	78,736 ^{r, 10}	80,000
Kazakhstan ^e	65,000	65,000	108,000 ¹¹	110,000	110,000
Kenya, acid grade	117,420	91,000	71,987	70,000 ^e	63,000
Kyrgyzstan ^e	550	-- ^r	-- ^r	-- ^r	--
Mexico:					
Acid grade	731,456	749,608	707,514 ^r	631,590 ^r	625,000
Metallurgical grade	475,451	487,483	502,963 ^r	478,131 ^r	400,000
Total	1,206,907	1,237,091	1,210,477	1,109,721	1,025,000 ¹¹
Mongolia:					
Acid grade ¹²	116,400	157,200	76,400	71,900	47,300 ¹¹
Other grades	232,000	327,200	161,700	303,000	183,500 ¹¹
Total	348,400	484,400	238,100	374,900	230,800 ¹¹
Morocco, acid grade	79,207	79,300	81,250	79,840 ^r	79,000
Namibia, acid grade ^{13, 14}	84,484	68,966	60,774	65,485	--
Pakistan, metallurgical grade	5,456 ^r	7,840 ^r	11,292 ^r	8,961 ^r	13,000
Russia	119,800	129,000	56,200 ^r	8,200 ^r	8,000
South Africa:					
Acid grade	177,000 ^r	156,000 ^r	141,000 ^r	165,000 ^r	120,000
Metallurgical grade	19,000 ^r	14,000 ^r	17,000 ^r	15,000 ^r	15,000
Total	195,502 ⁷	170,338 ⁷	157,776 ⁷	180,000 ^r	135,000
Spain:					
Acid grade	106,294	98,374	94,467 ^r	90,000 ^e	90,000
Ceramic grade	1,599	6,699	5,200 ^r	5,000 ^e	5,000
Metallurgical grade	4,275	2,250	4,320 ^r	3,000 ^e	3,000
Total	112,168	107,323	103,987 ^r	98,000 ^e	98,000
Thailand ^{e, 5}	9,000 ^r	11,000 ^r	15,000 ^r	40,000 ^r	50,000
Turkey	4,524	5,197	3,874	4,271 ^r	4,000
United Kingdom	--	--	16,000 ^r	25,000 ^r	81,000 ^p
Vietnam ^{e, 5}	NA	NA	NA	50,000 ^r	168,000
Grand total ^e	9,080,000	6,870,000 ^r	6,330,000 ^r	6,720,000 ^r	6,670,000

^eEstimated. ^pPreliminary. ^rRevised. NA Not available. -- Zero.

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

²Includes data available through August 30, 2016.

³An effort has been made to subdivide production of all countries by grade (acid, ceramic, and metallurgical). Where this information is not available the data have been entered without qualifying notes.

⁴In addition to the countries listed, Egypt, North Korea, and some other nations may produce fluor spar. Output data are not reported and available general information is inadequate to formulate reliable estimates of output levels.

⁵Estimate based on export data.

⁶Includes submetallurgical-grade fluor spar used primarily in cement that may account for 33% to 50% of the quantity.

⁷Reported figure, quantities by grade are estimated.

⁸Year beginning April 1 of that stated.

⁹Year beginning March 21 of that stated.

¹⁰As reported by the International Organizing Committee for the World Mining Congress.

¹¹Reported figure.

¹²Flotation concentrate, includes some material less than 97%.

¹³Data were in wet tons, but have been converted to dry tons to agree with other data in the table.

¹⁴Prior to 2011 all production was acid grade, but beginning in 2011 data also included an unspecified amount of metallurgical grade.

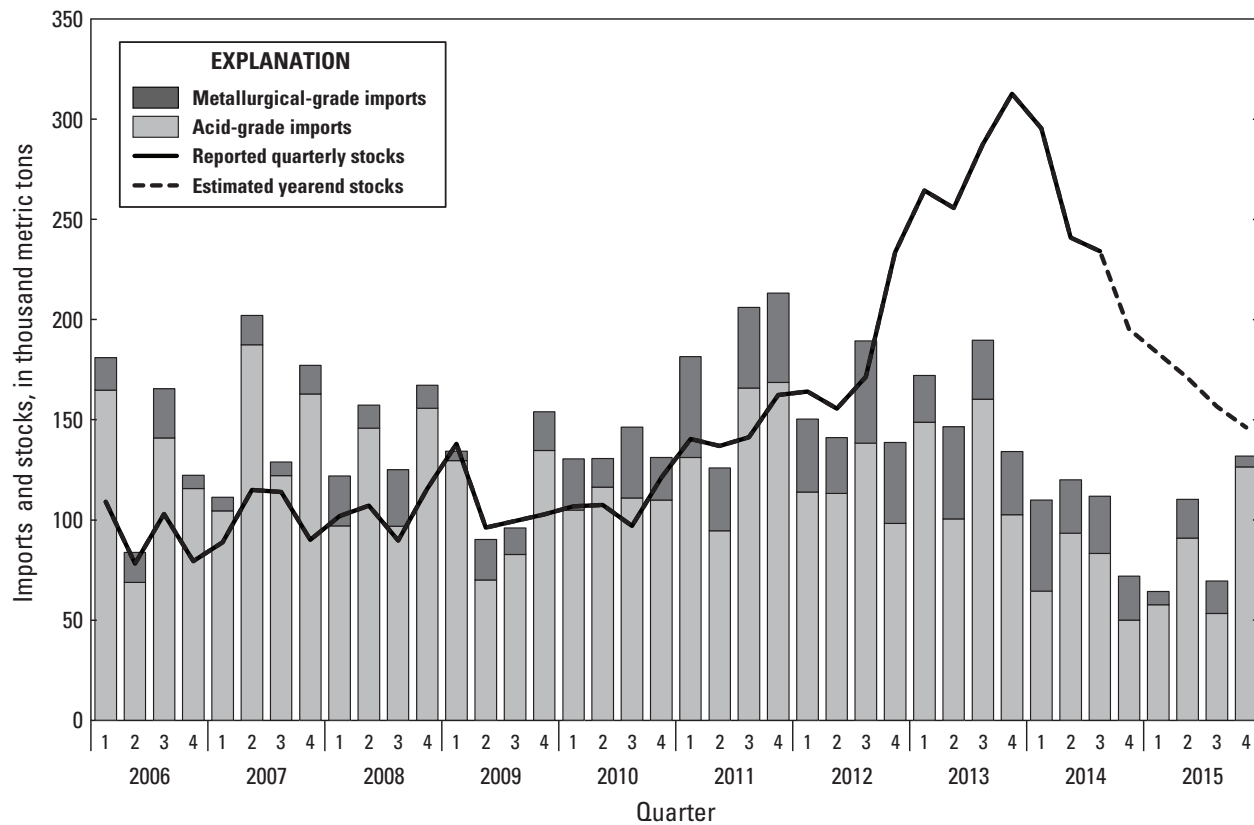


Figure 1. Acid- and metallurgical-grade imports for consumption compared to consumer stocks from the first quarter of 2006 to the fourth quarter of 2015. Reported quarterly stock data were withheld beginning in the fourth quarter of 2014. Sources: U.S. Geological Survey and U.S. Census Bureau.

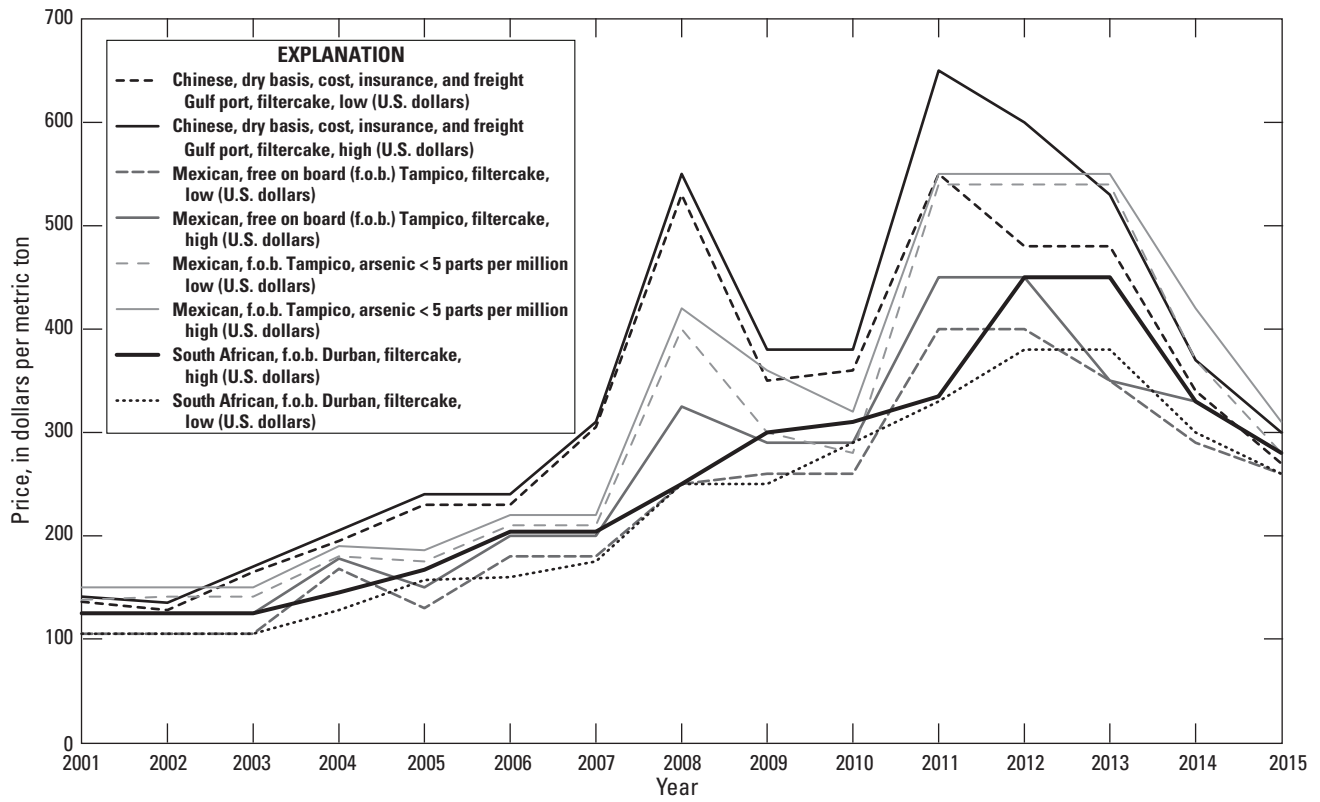


Figure 2. Prices of acid-grade fluorspar from leading exporting countries. Source: Industrial Minerals.

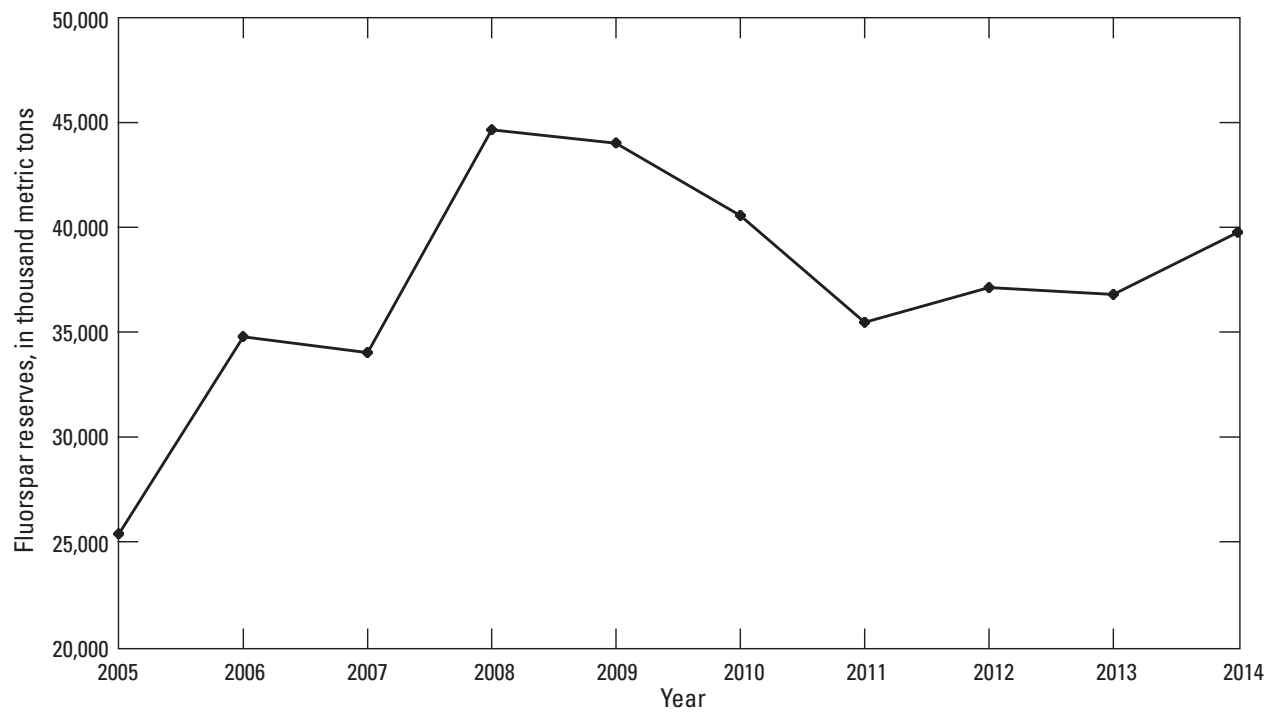


Figure 3. China's reported fluorspar reserves from 2005 to 2014. Source: National Bureau of Statistics of China.