



# 2016 Minerals Yearbook

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**FLUORSPAR [ADVANCE RELEASE]**

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# FLUORSPAR

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In 2016, the bulk of fluor spar consumed in the United States was from imports. Although not included in fluor spar production or consumption calculations, byproduct fluorosilicic acid (FSA) from some phosphoric acid producers, byproduct hydrofluoric acid (HF) from the U.S. Department of Energy's (DOE's) conversion of depleted uranium hexafluoride ( $\text{DUF}_6$ ), and small amounts of byproduct synthetic fluor spar produced from industrial waste streams supplemented fluor spar as a domestic source of fluorine. Apparent consumption was 371,000 metric tons (t), a decrease of 10% from 411,000 t in 2015 (table 1). Estimated world production decreased by 3% to 5.93 million metric tons (Mt).

Fluor spar is the commercial name that refers to crude or beneficiated material mined and (or) milled from the mineral fluorite (calcium fluoride,  $\text{CaF}_2$ ). Most of the fluor spar consumed and traded is either acid grade (also called acid spar), which is more than 97%  $\text{CaF}_2$ , or subacid grade (including ceramic and metallurgical grade), which is less than or equal to 97%  $\text{CaF}_2$  and is commonly called metspar.

Globally, there are three leading fluor spar-consuming industries. The manufacture of HF, the leading source of fluorine in industrial applications and a precursor in the production of most other fluorine-containing chemicals, accounts for approximately 40% of global annual fluor spar consumption. The manufacture of aluminum fluoride ( $\text{AlF}_3$ ) and cryolite ( $\text{Na}_3\text{AlF}_6$ ), essential for primary aluminum smelting, accounts for approximately 18% of global annual fluor spar consumption. Both of these applications typically require acid-grade fluor spar, although FSA can also be used to produce  $\text{AlF}_3$ . Fluor spar used as a steelmaking flux accounts for approximately 34% of global consumption. Metallurgical-grade fluor spar is primarily used in this application, although acid-grade material can also be used (Roskill Information Services Ltd., 2013, p. 151). Other applications of fluor spar include use in the manufacture of cement, ceramics, enamel, glass, and welding rod coatings.

## Legislation and Government Programs

The Frank R. Lautenberg Chemical Safety for the 21st Century Act was signed into law on June 22, 2016. The law amends The Toxic Substances Control Act of 1976, the Nation's primary chemicals management law. By law, all new and existing chemicals are subject to a safety review by the U.S. Environmental Protection Agency (EPA). Following this preliminary review, the EPA may further prioritize potentially harmful chemicals for a full, risk-based assessment. The law empowers the EPA to require the development of information necessary to support these evaluations, seeks to make that information more transparent and publicly available while preserving the confidentiality of business information, establishes clear and enforceable timelines for the review of chemicals and action on identified risks, and provides

mechanisms for funding the EPA's activities under the new law. Existing State laws remain in effect, but States are precluded from placing new restrictions on chemicals regulated by the EPA (Grace, 2016; U.S. Environmental Protection Agency, undated d).

A new amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in Kigali, Rwanda, on October 15, 2016. The goal of the amendment is to reduce the production and consumption of hydrofluorocarbon gases (HFCs) by 80% over the next 30 years to reduce greenhouse gas emissions. Hydrofluorocarbon gases have a global warming potential (GWP) that is typically hundreds to thousands of times more potent than carbon dioxide and are commonly used as aerosols, refrigerant gases, and solvents, and in fire protection systems and foam insulation products. Hydrofluorocarbon gases are the fastest growing greenhouse gases, increasing approximately 10% each year, driven largely by demand for air-conditioning and refrigeration in developing countries. Developed countries are slated to begin phasing down consumption by 2019 with an eventual consumption freeze in 2024. Developing countries and certain countries with hotter climates are subject to a less aggressive schedule. Initiatives under the amendment are expected to reduce projected global warming by as much as 0.5 degree Celsius by the end of the century (United Nations Environment Programme, 2016; U.S. Environmental Protection Agency, undated c).

The EPA issued Final Rule 21 under the Clean Air Act's (CAA's) section 612, the Significant New Alternatives Policy Program. The rule lists as unacceptable, or narrows the use of, numerous commonly used HFCs in new centrifugal and displacement chillers, new cold storage warehouses, household freezers and refrigerators, and retail food refrigeration. The use of HFCs in many foam-blowing applications were listed as unacceptable or limited, including a prohibition on the import of materials such as foam insulation boards or foam appliance panels manufactured using HFCs listed as unacceptable. The rule approved the use of a hydrofluoroolefin (HFO), HFO-1234yf, for use in refrigeration systems in newly manufactured medium-duty passenger vehicles, heavy-duty pickup trucks, and complete heavy-duty vans, and in the use of 2-bromo-3,3,3-trifluoropropene in total flooding and streaming fire suppression systems in aircraft. The EPA also approved the use of propane in refrigeration for applications including new self-contained commercial ice machines, new water coolers, and new, very low temperature refrigeration equipment. Propane in these end uses was excluded from venting prohibitions under section 608 of the CAA (U.S. Environmental Protection Agency, 2016d).

Per- and polyfluoroalkyl substances (PFAS) are a class of fluorinated chemicals with a wide range of uses. Per- and polyfluoroalkyl substances are commonly used to make products resistant to grease, oil, and water and have been used in firefighting foams and as a processing aid in the manufacture

of fluoropolymers. The substances, particularly long-chain PFAS (PFAS molecules containing eight or more carbon atoms, which are sometimes referred to as C-8), have come under scrutiny in the past 10 to 15 years, owing to their environmental persistence, widespread geographic distribution, and prevalence in the bloodstream of 99% of the U.S. population. Per- and polyfluoroalkyl substances can enter the environment directly or through the degradation of other fluorinated telomers.

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are two PFAS that have received the most attention. Human studies examined possible links between elevated blood levels of PFOA and PFOS and numerous adverse health conditions. Perfluorooctane sulfonate was voluntarily phased out of production by 2002, and the EPA's voluntary 2010/2015 PFOA Stewardship Program has likely reduced or eliminated the manufacture and import of PFOA and other long-chain PFAS. Although the presence of PFOA and PFOS in blood levels remained widespread, the levels are thought to have decreased (U.S. Environmental Protection Agency, undated a, b). However, numerous communities and States across the Nation have identified localized areas with PFOA and PFOS contamination, particularly those near industrial sites where the chemicals were manufactured or used at airfields in firefighting foams (Morrison, 2016).

In May, the EPA issued drinking water health advisories for both PFOA and PFOS. Although a separate advisory was issued for each chemical, the EPA established, to maximize protection of the most Americans over the course of an individual lifetime, that the combined level of PFOA and PFOS should be no more than 70 parts per trillion (ppt). If water sampling confirms that the combined level of PFOA and PFOS exceeds 70 ppt, the EPA recommends that water system operators undertake additional action to address the contamination, including additional sampling to determine the scope and source of contamination; notification of the primary State water safety agency; and notifying water consumers on the level of contamination, possible health effects, and information on the actions being taken to address the contamination. The EPA's health advisories are non-regulatory, non-enforceable, and primarily intended to provide State agencies, public health officials, and local water operators technical information on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination (U.S. Environmental Protection Agency, 2016a, b, c).

In December, the Vermont Legislative Committee on Administrative Rules permanently set a limit of 20 ppt on PFOA and PFOS concentrations in drinking water (Weiss-Tisman, 2016). The State used an emergency rule to enact a temporary limit after several wells in Bennington County tested positive for contaminants in February.

The U.S. Air Force awarded a contract to replace the firefighting foam known as aqueous film forming foam (AFFF) in fire vehicles. Aqueous film forming foam is particularly effective at extinguishing highly flammable liquid fuel fires and is commonly used at industrial, commercial, and military aviation facilities. Aqueous film forming foam used by the military and in most civilian applications contains fluorinated surfactants. To reduce possible environmental contamination,

the new generation of AFFF contains fluorinated surfactants with a six carbon chain structure. A second contract was awarded to retrofit all aircraft rescue and firefighting vehicles with specialized equipment that allows firefighters to conduct fire vehicle operational checks and required annual foam tests without discharging any AFFF into the environment. Future use of AFFF is to be restricted to emergency use. Foam residue is to be treated as hazardous waste and removed and destroyed (U.S. Air Force, 2016). In 2016, the U.S. Department of Defense was in the process of conducting environmental sampling at over 600 sites nationwide where the military had conducted fire or crash training (McDermott, 2016).

The U.S. Food and Drug Administration (FDA) revoked two food additive regulations that permitted the use of five long-chain PFASs in grease-repellent food packaging. The substances had been used in the coatings on paper food-packaging such as microwavable popcorn bags, pet-food bags, pizza or other 'to-go' boxes, and other fast-food wrappers to prevent grease and oil leakage. Following a safety review, food-paper manufacturers voluntarily agreed to discontinue distribution of products containing these chemicals in 2011; however, existing supplies were allowed to be used. Although food-paper manufacturers had likely discontinued use of the long-chain PFAS, the FDA, in response to a petition filed by numerous environmental groups, decided at yearend 2015 to revoke the food additive regulation pertaining to three long-chain PFAS. Any return to the use of these substances would require initiation of the FDA's Food Contact Notification process. A second rule covering the use of two other long-chain PFASs was revoked later in 2016, in response to a petition from the 3M Company, which stated that, as the sole domestic and international manufacturer, the company had completely abandoned use of the chemicals in the U.S. market (U.S. Food and Drug Administration, 2015, 2016, undated).

## Production

In 2016, small amounts of fluorspar 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 fluorspar 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 fluorspar produced in the United States.

Fluorosilicic acid was produced as a byproduct of the processing of phosphate rock into phosphoric acid. The USGS developed domestic production data for FSA 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 2016, 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 2016, production of FSA decreased by 31% to 44,400 t (equivalent to about 72,100 t of fluorspar grading 100%

CaF<sub>2</sub>) (table 1). Reduced production was primarily attributed to the suspension of operations at one location.

Hastie Mining & Trucking, Core Metals Group LLC (Aurora, IN), and Seaforth Mineral & Ore Company, 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 County, KY.

The DOE's DUF<sub>6</sub> conversion project restarted two process lines at its facility in Paducah, KY. The goal of the project, which started production in 2011, is to convert the Government's inventory of DUF<sub>6</sub> into more stable forms, including uranium oxide and aqueous HF. The HF is sold into the commercial market. Operations were suspended in early 2015 owing to the failure of HF condensers. New condensers were installed in two of the four operating process lines. Condensers in the other two lines were slated for replacement in 2017. The project operates three additional lines at a second facility at the Portsmouth Site in Piketon, OH, which were also shut down. Condensers in one line were replaced, and the facility was awaiting delivery of condensers for the other two lines. Production at Portsmouth was expected to restart by September 2017. Through January 2017, the combined HF production of the Paducah and Portsmouth facilities totaled 33.5 million liters (Edwards, 2017; U.S. Department of Energy, undated).

## Consumption

The USGS developed domestic consumption data 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). Because industry participation in the survey declined in recent years, it is estimated that only 28% of total fluorspar consumption was reported in 2016. Owing to decreased survey participation, 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 at 371,000 t, a 10% decrease from 411,000 t in 2015 (table 1).

Two companies used fluorspar for the production of HF in 2016: The Chemours Co. and Honeywell International Inc. The leading use for HF is in the manufacture of fluorocarbon chemicals [hydrochlorofluorocarbons (HCFCs), HFCs, and HFOs] used as aerosols, refrigerants, and solvents, and in the production of high-performance plastics and rubbers (fluoropolymers and fluoroelastomers). These substances are found in dozens of familiar products used daily in the United States. Examples include the antifingerprint 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 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 AlF<sub>3</sub> and cryolite, which are essential in primary aluminum smelting. Alumina (Al<sub>2</sub>O<sub>3</sub>) is dissolved in a bath that consists primarily of molten cryolite and small amounts of AlF<sub>3</sub> and fluorspar to allow the 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 AlF<sub>3</sub>, 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, in addition to other terms. In the aluminum smelting process, AlF<sub>3</sub> is also used to replace fluorine losses (either absorbed by the bath walls or captured as emissions). Most AlF<sub>3</sub> is produced directly from acid-grade fluorspar or byproduct FSA. The AlF<sub>3</sub> requirements of the U.S. aluminum industry were met through imports in 2016 (table 8) as there were no active AlF<sub>3</sub> producers in the United States.

Chemours announced its intention to construct a new manufacturing facility to produce HFO-1234yf at its Corpus Christi site in Ingleside, TX. The facility allows Chemours to triple production capacity of the chemical, a low-GWP refrigerant used in automotive air-conditioning and other applications. The plant is expected to begin production in the third quarter of 2018 (Chemours Co., The, 2016).

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 was combined with other uses in table 2 to avoid disclosing 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 use in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

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. Fluorosilicic acid also can be used in the processing of animal hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2016, the amount of FSA sold or used by producers was 42,300 t (table 1) (equivalent to about 68,800 t of fluorspar grading 100% CaF<sub>2</sub>), a 33% decrease compared with that of 2015.

## 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). The substantial decrease in imports in 2014 and 2015 has been partially attributed to a drawdown in consumer and distributor stocks. By yearend 2016, stocks were estimated to be approximately 147,000 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 treatment 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 2016, acidspars prices from China declined for the fifth consecutive year, and those from South Africa declined for the third. Acidspars prices from Mexico remained stable. According to Industrial Minerals magazine, the yearend 2016 price range for acidspars filtercake from China—dry basis, cost, insurance, and freight Gulf port—decreased to \$260 to \$270 per metric ton at yearend 2016 from \$270 to \$300 per metric ton at yearend 2015. The price range for Mexican high-arsenic acidspars filtercake, free on board (f.o.b.) Tampico, was \$260 to \$280 per metric ton, and Mexican low-arsenic acidspars (less than 5 parts per million arsenic), f.o.b. Tampico, was \$280 to \$310 per metric ton (table 3, fig. 2).

## Foreign Trade

In 2016, U.S. exports of fluorspar decreased by 13% to 11,900 t compared with those of 2015 (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 re-exports of imported material. Approximately 90% of exports went to Canada.

In 2016, combined acid- and metallurgical-grade fluorspar imports for consumption were 383,000 t, a 2% increase compared with those of 2015 (table 5). Acid-grade imports were unchanged from 2015. Metallurgical-grade imports increased by 16% to 55,200 t. The leading suppliers of fluorspar to the United States were Mexico (70%), China (12%), South Africa (8%), Vietnam (6%), and Spain (3%).

The following imports are compared with those of 2015. Imports of HF increased by 4% to 126,000 t (table 6); the majority

of HF imports were from Mexico (90%) and China (6%). Imports of cryolite decreased by 17% to 15,700 t (table 7). Aluminum fluoride imports decreased by 37% to 20,500 t (table 8), with almost all coming from two countries: China (59%) and Mexico (35%). Mexico was previously the leading source of imported  $\text{AlF}_3$ , but imports from Mexico decreased much more (61%) than those from China (11%). Aluminum fluoride imports decreased each year for the past 4 years, which reflects a similar trend in the domestic production of primary aluminum.

On August 5, 2016, the U.S. International Trade Commission determined that United States industry was materially harmed by certain HFC blends from China being sold at less than fair value. As a consequence, antidumping duties were to be imposed. The investigation excluded blends that include products other than HFCs, patented HFC blends, and any blend or semifinished blend that includes an HFC other than R-32, R-125, R-143a, and R-134a. Individual HFC components from China were not found to have materially harmed United States industry (U.S. International Trade Administration, 2016).

## World Review

**Bulgaria.**—In January, 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.**—In April, Canada Fluorspar Inc. (CFI) began development at its site near St. Lawrence on Newfoundland’s Burin Peninsula. CFI’s resources include the AGS, Blue Beach North, Director, and Tarefare veins, which total 8.8 Mt of resources with an average grade of 39% fluorspar. The company expects to begin operations in late 2017, with the 200,000-metric-ton-per-year capacity mill processing material from the open pit mining operations at the AGS vein (Gorrill, 2016).

**Kenya.**—Citing weak demand and low prices, Kenya Fluorspar Company Ltd. suspended operations at its facilities in western Kenya on April 30, 2016. The company sustained financial losses for the past 3 years and had previously suspended operations for approximately 2 months in 2015. All employees were to be terminated but would receive preferential treatment in rehiring should the company resume operations (Kenya Fluorspar Company Ltd., 2016).

## 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 stable and versatile, and new applications continue to be developed. However, numerous environmental, health, and safety issues constrain the use of fluorine, HF, and 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 for aluminum smelting, are estimated to account for approximately

18% of global fluorspar consumption (Roskill Information Services Ltd., 2013, p. 151). Because aluminum produced from scrap does not require either  $\text{AlF}_3$  or cryolite, demand for fluorspar is expected to increase with primary aluminum production only. Aluminum fluoride produced from FSA may displace some  $\text{AlF}_3$  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 55% of HF annually, well over one-half of which are used as refrigerant and air-conditioning gases (Roskill Information Services Ltd., 2013, p. 151). Other uses include foam-blowing agents, propellants, solvents, and precursory use in the manufacture of a wide range of fluoropolymers and fluoroelastomers.

Because of the ozone-depleting potential of early generations of fluorocarbon gases [chlorofluorocarbons (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, which was adopted in 1987. Chlorofluorocarbons 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. The adoption of the Kigali Amendment in 2016 effectively expanded the scope of the Montreal Protocol to reduce the use of many higher GWP HFCs 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, which could temper 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 34% of annual global fluorspar production is estimated to be used as a flux in steelmaking (Roskill Information Services Ltd., 2013, p. 151). However, this use varies significantly by geographic region. Metspar consumption in Europe and North America decreased dramatically in the 1990s with the 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.

## References Cited

- Boday, D.J., 2012, The state of fluoropolymers, chap. 1 of Smith, D.W., Jr., Iacono, S.T., Boday, D.J., and Kettwich, S.C., eds., *Advances in fluorine-containing polymers*: Washington, DC, American Chemical Society Symposium Series, v. 1106, p. 1–7. (Accessed August 16, 2016, at <https://doi.org/10.1021/bk-2012-1106.ch001>.)
- Chemours Co., The, 2016, Chemours announces major investments in new U.S. HFO-1234yf plant: Wilmington, DE, The Chemours Co., May 2. (Accessed September 20, 2016, at [https://chemours.com/Refrigerants/en\\_US/assets/downloads/20160502-HFO-1234yf-plant-triple-opteon-product-supply.pdf](https://chemours.com/Refrigerants/en_US/assets/downloads/20160502-HFO-1234yf-plant-triple-opteon-product-supply.pdf).)
- Edwards, R.E., III, 2017, Portsmouth/Paducah Project Office: U.S. Department of Energy presentation at Waste Management Symposia, March 9, 126 p.
- Gorrill, Lindsay, 2016, St. Lawrence fluorspar resource overview: St. Lawrence, Newfoundland and Labrador, Canada, Canada Fluorspar Inc., October 25, 29 p.
- Grace, L.M., 2016, TSCA reform bill signed into law—Frank R. Lautenberg Chemical Safety for the 21st Century Act: Western Springs, IL, The National Law Review, June 30. (Accessed September 20, 2016, at <https://www.natlawreview.com/article/tsca-reform-bill-signed-law-frank-r-lautenberg-chemical-safety-21st-century-act>.)
- Kenya Fluorspar Company, Ltd., 2016, Kenya Fluorspar Limited to suspend operations: Eldoret, Kenya, Kenya Fluorspar Company, Ltd. press release, February 18. (Accessed May 27, 2016, at <http://www.kenyafluorspar.com/wp-content/uploads/2016/03/Press-release-18Feb16.pdf>.)
- McDermott, Jennifer, 2016, Military to check for water contamination at 664 sites: Providence, RI, Military Times, March 10. (Accessed March 14, 2017, at <http://www.militarytimes.com/story/military/2016/03/10/military-check-water-contamination-664-sites/81623162/>.)
- Mihaylov, Ivaylo, 2016, Solvay-owned Bulgaria Fluorite ceases operations in Chiprovtsi mine: SeeNews [Sofia, Bulgaria], January 31. (Accessed May 27, 2016, at <http://wire.seenews.com/news/solvay-owned-bulgaria-fluoriteceases-operations-in-chiprovtsi-mine-511155#>.)
- Morrison, Jessica, 2016, Perfluorinated chemicals taint drinking water: American Chemical Society Chemical & Engineering News, v. 94, no. 20, May 16, p. 20–22. (Accessed March 14, 2017, at <https://cen.acs.org/articles/94/i20/Perfluorinated-chemicals-taint-drinking-water.html>.)
- Roskill Information Services Ltd., 2013, Fluorspar—Global industry markets and outlook (11th ed.): London, United Kingdom, Roskill Information Services Ltd., 262 p.
- United Nations Environment Programme, 2016, Countries agree to curb powerful greenhouse gases in largest climate breakthrough since Paris: Kigali, Rwanda, United Nations Environment Programme, October 15. (Accessed November 18, 2016, at <http://www.unep.org/newscentre/countries-agree-curb-powerful-greenhouse-gases-largest-climate-breakthrough-paris>.)
- U.S. Air Force, 2016, AF awards replacement firefighting foam contract: U.S. Air Force Civil Engineer Center Public Affairs, August 15. (Accessed February 28, 2017, at <http://www.af.mil/News/ArticleDisplay/tabid/223/Article/915057/af-awards-replacement-firefighting-foam-contract.aspx>.)

- U.S. Department of Energy, [undated], Portsmouth/Paducah project office: U.S. Department of Energy Portsmouth/Paducah Project Office website. (Accessed March 28, 2017, via <https://energy.gov/pppo/portsmouthpaducah-project-office>.)
- U.S. Environmental Protection Agency, 2016a, Drinking water health advisory for perfluorooctane sulfonate (PFOS): U.S. Environmental Protection Agency, EPA 822-R-16-004, May, 88 p. (Accessed February 28, 2017, at [https://www.epa.gov/sites/production/files/2016-05/documents/pfos\\_health\\_advisory\\_final-plain.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/pfos_health_advisory_final-plain.pdf).)
- U.S. Environmental Protection Agency, 2016b, Drinking water health advisory for perfluorooctanoic acid (PFOA): U.S. Environmental Protection Agency, EPA 822-R-16-005, May, 103 p. (Accessed February 28, 2017, at [https://www.epa.gov/sites/production/files/2016-05/documents/pfoa\\_health\\_advisory\\_final\\_508.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/pfoa_health_advisory_final_508.pdf).)
- U.S. Environmental Protection Agency, 2016c, Fact sheet PFOA & PFOS drinking water health advisories: U.S. Environmental Protection Agency, EPA 800-F-16-003, November, 5 p. (Accessed March 1, 2017, at [https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories\\_pfoa\\_pfos\\_updated\\_5.31.16.pdf](https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf).)
- U.S. Environmental Protection Agency, 2016d, Final Rule 21—Protection of stratospheric ozone—Significant New Alternatives Policy program new and changed listings: U.S. Environmental Protection Agency Fact Sheet, December 1, 5 p. (Accessed March 14, 2017, at [https://www.epa.gov/sites/production/files/2016-12/documents/snap\\_action\\_scr2\\_factsheet.pdf](https://www.epa.gov/sites/production/files/2016-12/documents/snap_action_scr2_factsheet.pdf).)
- U.S. Environmental Protection Agency, [undated]a, Assessing and managing chemicals under TSCA—Per- and polyfluoroalkyl substances (PFASs) under TSCA: U.S. Environmental Protection Agency website. (Accessed March 14, 2017, at <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/and-polyfluoroalkyl-substances-pfass-under-tsca>.)
- U.S. Environmental Protection Agency, [undated]b, Fact sheet—2010/2015 PFOA Stewardship Program: U.S. Environmental Protection Agency website. (Accessed February 28, 2017, at <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program>.)
- U.S. Environmental Protection Agency, [undated]c, Recent international developments under the Montreal Protocol: U.S. Environmental Protection Agency website. (Accessed November 18, 2016, at <https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol>.)
- U.S. Environmental Protection Agency, [undated]d, The Frank R. Lautenberg Chemical Safety for the 21st Century Act—Frequent questions: U.S. Environmental Protection Agency website. (Accessed September 20, 2016, at <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/frank-r-lautenberg-chemical-safety-21st-century-act-0>.)
- U.S. Food and Drug Administration, 2015, FDA revokes food additive approval for the use of long-chain perfluorinated compounds as oil and water repellents for paper used in food packaging: U.S. Food and Drug Administration website, December 31. (Accessed March 15, 2017, at <http://wayback.archive-it.org/7993/20171114120118/https://www.fda.gov/Food/NewsEvents/ConstituentUpdates/ucm479465.htm>.)
- U.S. Food and Drug Administration, 2016, FDA removes approval for the use of PFCs in food packaging based on the abandonment: U.S. Food and Drug Administration website, November 21. (Accessed March 10, 2017, at <https://www.fda.gov/Food/NewsEvents/ConstituentUpdates/ucm528911.htm>.)
- U.S. Food and Drug Administration, [undated], Update on perfluorinated grease-proofing agents: U.S. Food and Drug Administration website. (Accessed March 15, 2017, at <https://www.fda.gov/food/ingredientspackaginglabeling/packagingfcs/notifications/ucm308462.htm>.)
- U.S. International Trade Administration, 2016, Hydrofluorocarbon blends from the People's Republic of China—Antidumping duty order: Federal Register, v. 81, no. 161, August 19, p. 55436–55438. (Accessed August 11, 2017, at <https://www.gpo.gov/fdsys/pkg/FR-2016-08-19/pdf/2016-19873.pdf>.)
- Weiss-Tisman, Howard, 2016, Vermont sets a permanent drinking water standard for PFOA: VPR [Vermont Public Radio] News website, December 15. (Accessed March 10, 2017, at <http://digital.vpr.net/post/vermont-sets-permanent-drinking-water-standard-pfoa#stream/0>.)

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Fluorine. Ch. in *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*, Professional Paper 1802, 2017.
- Fluorspar. Ch. in *Mineral Commodity Summaries*, annual.
- Fluorspar. *Mineral Industry Surveys*, quarterly.
- Geology and Resources of Fluorine in the United States*. Professional Paper 933, 1976.
- Historical Statistics for Mineral and Material Commodities in the United States*. Data Series 140.

### Other

- Fluorocarbons. *Chemical Economics Handbook Marketing Research Report*, IHS Chemical, 2011.
- Fluorspar. Ch. in *Industrial Minerals and Rocks* (7th ed.), Society for Mining, Metallurgy, and Exploration, Inc., 2006.
- Fluorspar. Ch. in *Mineral Facts and Problems*, U.S. Bureau of Mines Bulletin 675, 1985.
- Fluorspar and Inorganic Fluorine Compounds. *Chemical Economics Handbook Marketing Research Report*, IHS Chemical, 2012.
- Fluorspar—*Global Industry Markets & Outlook*, 11th edition. Roskill Information Services Ltd., 2013.
- ICIS Chemical Business Americas.
- Industrial Minerals.
- United Nations Commodity Trade Statistics Database.
- United States International Trade Commission, *Interactive Tariff and Trade DataWeb*.
- World Fluorochemicals to 2016. The Freedonia Group, 2012.

TABLE 1  
SALIENT FLUORSPAR STATISTICS<sup>1,2</sup>

		2012	2013	2014	2015	2016
United States:						
Exports: <sup>3</sup>						
Quantity	metric tons	23,800	16,000	13,400	13,700	11,900
Value <sup>4</sup>	thousands	\$3,640	\$2,520	\$2,200	\$2,210	\$1,900
Imports for consumption: <sup>3</sup>						
Quantity	metric tons	620,000	643,000	414,000	376,000	383,000
Value <sup>5</sup>	thousands	\$157,000	\$147,000	\$105,000	\$107,000	\$102,000
Consumption:						
Reported	metric tons	416,000	441,000	W	W	W
Apparent <sup>6</sup>	do.	525,000	548,000	518,000	411,000	371,000
Fluorosilicic acid:						
Production	metric tons	73,600	74,300	70,100	64,500	44,400
Sold and used	do.	73,600	73,900	70,600	63,500	42,300
Value	thousands	\$12,100	\$21,800	\$19,800	\$15,500	\$14,100
Stocks, consumer and distributor, December 31	metric tons	234,000	313,000	195,000	146,000 <sup>c</sup>	147,000 <sup>c</sup>
World, production	do.	7,930,000 <sup>r</sup>	7,110,000 <sup>r</sup>	6,780,000 <sup>r</sup>	6,090,000 <sup>r</sup>	5,930,000

<sup>c</sup>Estimated. <sup>r</sup>Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits.

<sup>2</sup>Does not include byproduct or synthetic fluorspar production.

<sup>3</sup>Source: U.S. Census Bureau; data may be adjusted by the U.S. Geological Survey.

<sup>4</sup>Free alongside ship values at U.S. ports.

<sup>5</sup>Cost, insurance, and freight values at U.S. ports.

<sup>6</sup>Imports minus exports plus adjustments for changes in stocks.

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

(Metric tons)

End use or product	Containing more than 97% calcium fluoride		Containing not more than 97% calcium fluoride		Total	
	2015	2016	2015	2016	2015	2016
Hydrofluoric acid	W	W	--	--	W	W
Metallurgical	W	W	29,700	30,700	W	W
Other <sup>2</sup>	W	W	--	--	W	W
Total	W	W	29,700	30,700	W	W
Stocks, consumer and distributor, December 31	W	W	21,200	18,200	146,000 <sup>c</sup>	147,000 <sup>c</sup>

<sup>c</sup>Estimated. W Withheld to avoid disclosing company proprietary data. -- Zero.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

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

TABLE 3  
PRICES OF IMPORTED FLUORSPAR<sup>1</sup>

(Dollars per metric ton)

Source and grade	2015	2016
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	270–300	260–270
Chinese, free on board (f.o.b.) China, wet filtercake	260–280	250–270
Mexican, f.o.b. Tampico, filtercake	260–280	260–280
Mexican, f.o.b. Tampico, arsenic <5 parts per million	280–310	280–310
South African, f.o.b. Durban, filtercake	260–280	200–220
Metspar, Mexican, f.o.b. Tampico	230–270	230–250

<sup>1</sup>Table includes data available through May 3, 2018.

Source: Industrial Minerals magazine (London).

TABLE 4  
U.S. EXPORTS OF FLUORSPAR, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>2</sup>	Quantity (metric tons)	Value <sup>2</sup>
Australia	759	\$110,000	--	--
Canada	12,500	2,050,000	10,700	\$1,730,000
Chile	--	--	214	28,300
Colombia	97	10,800	--	--
Dominican Republic	--	--	199	28,800
France	--	--	5	3,820
Indonesia	5	2,800	4	2,800
Italy	--	--	44	6,000
Malaysia	--	--	10	9,930
Mexico	210	15,000	672	85,100
Netherlands	47	6,840	--	--
Nicaragua	20	2,880	30	4,350
Taiwan	21	2,990	--	--
Trinidad and Tobago	--	--	44	6,350
Total	13,700	2,210,000	11,900	1,900,000

-- Zero.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Free 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 DISTRICT<sup>1</sup>

Country and customs district	2015		2016	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
<b>Containing more than 97% calcium fluoride (CaF<sub>2</sub>):</b>				
China:				
Houston, TX	18,700	\$6,600	35,900	\$11,000
New Orleans, LA	7,050	1,970	10,200	3,000
Total	25,700	8,580	46,100	14,000
France, Houston, TX	--	--	285	150
Germany:				
Baltimore, MD	19	8	--	--
Houston, TX	38	21	270	150
New York, NY	203	104	171	86
Total	260	133	441	235
Israel, New Orleans, LA	--	--	1	7
Mexico:				
Baltimore, MD	1,070 <sup>r</sup>	748 <sup>r</sup>	57	35
Laredo, TX	4,410	1,380	16,200	4,970
New Orleans, LA	170,000	48,100	197,000	53,400
Philadelphia, PA	--	--	19	8
Total	176,000	50,300	213,000	58,400
Mongolia:				
Baltimore, MD	10	10	247	129
Houston, TX	14,800	6,200	--	--
Total	14,800	6,210	247	129
Netherlands, Houston, TX	4	16	--	--
Russia, Chicago, IL	--	--	1	6
South Africa, Houston, TX	31,400	7,090	31,300	6,260
Spain, Houston, TX	21,700	5,240	10,900	2,680
United Kingdom:				
Chicago, IL	19	12	--	--
Cleveland, OH	2,000	1,090	2,060	991
Houston, TX	10	34	25	24
Los Angeles, CA	291	150	146	75
Total	2,320	1,280	2,230	1,090
Vietnam:				
Houston, TX	30,600	9,950	17,700	5,360
New Orleans, LA	25,600	6,180	5,600	1,130
Total	56,200	16,100	23,300	6,490
Grand total	328,000	95,000	328,000	89,500
<b>Containing not more than 97% CaF<sub>2</sub>:</b>				
China:				
Houston, TX	--	--	27	9
Los Angeles, CA	--	--	9	6
New Orleans, LA	500	282	--	--
New York, NY	182 <sup>r</sup>	97 <sup>r</sup>	--	--
Seattle, WA	--	--	25	8
Total	682 <sup>r</sup>	379 <sup>r</sup>	61	23
Mexico:				
Laredo, TX	2,940	472	3,750	631
New Orleans, LA	43,500	10,700	50,700	11,800
Total	46,400	11,200	54,500	12,400
Mongolia, New Orleans, LA	--	--	700	406
Spain, New York, NY	11	13	--	--
Switzerland, San Francisco, CA	1	2	--	--
United Kingdom, Cleveland, OH	508	252	--	--
Grand total	47,600 <sup>r</sup>	11,900	55,200	12,900
Grand total, all grades	376,000	107,000	383,000	102,000

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 6  
U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Belgium	(3)	\$3	1	\$4
Canada	597	1,090	594	986
China	7,170	7,580	7,570	6,920
Germany	1,470	3,690	1,100	2,260
Hong Kong	1	9	--	--
India	37	42	72	75
Japan	1,470	2,400	1,560	2,020
Korea, Republic of	508	1,320	89	334
Mexico	108,000	178,000	114,000	175,000
Singapore	243	660	274	750
Spain	113	337	149	424
Taiwan	385	1,010	532	1,140
Total	120,000	196,000	126,000	190,000

-- Zero.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Cost, insurance, and freight values at U.S. ports.

<sup>3</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7  
U.S. IMPORTS FOR CONSUMPTION OF CRYOLITE, BY COUNTRY OR LOCALITY<sup>1,2</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>3</sup> (thousands)	Quantity (metric tons)	Value <sup>3</sup> (thousands)
Canada	9,070	\$4,160	7,830	\$2,720
China	964	644	261	178
Denmark	--	--	19	40
Germany	1,150	1,900	1,930	2,640
Hungary	221	321	228	348
Iceland	173	143	--	--
India	--	--	1	3
Italy	322	371	10	15
Japan	5,110	5,730	4,510	5,580
Mexico	--	--	1	4
Spain	1,440	569	236	72
United Arab Emirates	--	--	50	51
United Kingdom	494	841	628	1100
Total	18,900	14,700	15,700	12,800

-- Zero.

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes natural and synthetic cryolite.

<sup>3</sup>Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 8  
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM FLUORIDE, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Canada	420	\$634	1,130	\$1,540
China	13,600	18,100	12,100	13,600
Mexico	18,400	22,800	7,200	7,880
Other <sup>3</sup>	37	82	96	96
Total	32,400	41,600	20,500	23,100

<sup>1</sup>Table includes data available through May 3, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Cost, insurance, and freight values at U.S. ports.

<sup>3</sup>Includes all countries and (or) localities with quantities less than 1,000 metric tons.

Source: U.S. Census Bureau.

TABLE 9  
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Metric tons)

Country or locality <sup>2</sup>	2012	2013	2014	2015	2016
Afghanistan	-- <sup>e</sup>	-- <sup>e</sup>	2,507 <sup>r</sup>	5,516 <sup>r</sup>	6,000 <sup>e</sup>
Argentina	35,874	37,967	39,520 <sup>r</sup>	39,000 <sup>r,e</sup>	39,000 <sup>e</sup>
Brazil:					
Acid grade	5,768	6,835	6,496	6,500 <sup>e</sup>	6,500 <sup>e</sup>
Metallurgical grade	18,380	20,886	17,353	17,000 <sup>e</sup>	17,000 <sup>e</sup>
Total	24,100	27,700	23,800	23,500	23,500
Bulgaria <sup>e,3</sup>	12,000	12,000	20,000	20,000	2,000
China <sup>4</sup>	5,200,000 <sup>r</sup>	4,800,000 <sup>r</sup>	4,310,000 <sup>r</sup>	3,820,000 <sup>r</sup>	3,800,000 <sup>e</sup>
Egypt	7,700 <sup>r</sup>	850 <sup>r</sup>	900 <sup>r</sup>	1,105 <sup>r</sup>	1,000 <sup>e</sup>
Germany, acid grade	54,202	48,744	58,100 <sup>r</sup>	49,801 <sup>r</sup>	50,000 <sup>e</sup>
India	2,549 <sup>r</sup>	3,094 <sup>r</sup>	2,439 <sup>r</sup>	2,270 <sup>r</sup>	1,920
Iran	80,000 <sup>e</sup>	69,828 <sup>s</sup>	78,736 <sup>s</sup>	39,286 <sup>r,s</sup>	40,000 <sup>e</sup>
Kazakhstan	100,000 <sup>r,e</sup>	108,000	110,000 <sup>e</sup>	110,000 <sup>e</sup>	110,000 <sup>e</sup>
Kenya, acid grade	110,000 <sup>r</sup>	48,500 <sup>r</sup>	74,000 <sup>r</sup>	64,395 <sup>r</sup>	42,656
Korea, North	NA	NA	NA	NA	NA
Mexico:					
Acid grade	749,608	707,514	631,590	623,740 <sup>r</sup>	593,000
Metallurgical grade	487,483	502,963	478,131	400,000 <sup>e</sup>	395,000 <sup>e</sup>
Total	1,240,000	1,210,000	1,110,000	1,020,000	988,000
Mongolia:					
Acid grade <sup>6</sup>	157,200	76,400	71,900	47,300	34,100
Submetallurgical and other grades <sup>7</sup>	327,200	161,700	303,000	183,500	167,700
Total	484,000	238,000	375,000	231,000	202,000
Morocco, acid grade	79,300	81,200 <sup>r</sup>	79,840	80,890 <sup>r</sup>	70,000 <sup>e</sup>
Namibia, acid grade <sup>8</sup>	68,966	60,774	65,485 <sup>r</sup>	--	1,495
Pakistan, metallurgical grade	7,840	11,292	8,961	7,692 <sup>r</sup>	6,625
Russia, concentrate	129,000	56,200	8,200	8,000 <sup>e</sup>	8,000 <sup>e</sup>
South Africa	170,338	157,776	164,056 <sup>r</sup>	165,000 <sup>r,3</sup>	165,000
Spain:					
Acid grade	98,374	94,467	118,000 <sup>r,e</sup>	120,000 <sup>r,e</sup>	120,000 <sup>e</sup>
Ceramic grade	6,699	5,200	5,000 <sup>e</sup>	5,000 <sup>r,e</sup>	5,000 <sup>e</sup>
Metallurgical grade	2,250	4,320	3,000 <sup>e</sup>	5,000 <sup>r,e</sup>	5,000 <sup>e</sup>
Total	107,000	104,000	126,000	130,000	130,000
Thailand	9,602 <sup>r</sup>	15,000 <sup>e,3</sup>	40,000 <sup>e,3</sup>	52,000 <sup>r,e,3</sup>	42,000 <sup>e</sup>
Turkey	5,197	3,874	4,271	6,238 <sup>r</sup>	6,000 <sup>e</sup>
United Kingdom	--	16,000	25,000	17,000 <sup>r</sup>	17,000 <sup>e</sup>
Vietnam <sup>e,3</sup>	--	--	50,000	190,000 <sup>r</sup>	175,000
Grand total	7,930,000 <sup>r</sup>	7,110,000 <sup>r</sup>	6,780,000 <sup>r</sup>	6,090,000 <sup>r</sup>	5,930,000
Of which:					
Acid grade	1,320,000	1,120,000	1,110,000	993,000	918,000
Metallurgical grade	516,000	539,000	507,000	430,000	424,000
Ceramic grade	6,700	5,200	5,000	5,000	5,000
Other and unspecified	6,080,000	5,440,000	5,160,000	4,660,000	4,580,000

<sup>e</sup>Estimated. <sup>r</sup>Revised. NA Not available. -- Zero.

<sup>1</sup>Table includes data available through May 2, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to three significant digits; may not add to totals shown.

<sup>2</sup>An 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.

<sup>3</sup>Estimate based on export data.

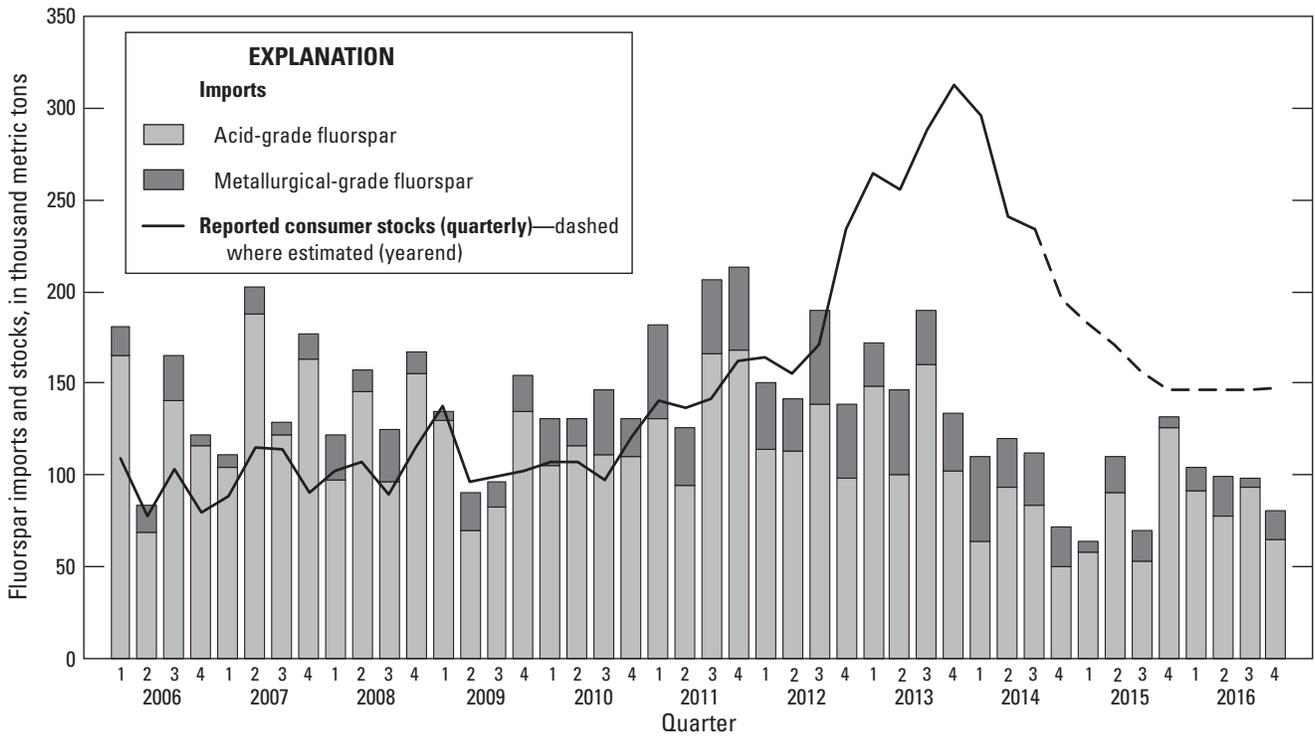
<sup>4</sup>As reported by China's Ministry of Land and Resources. Production may include a significant amount of submetallurgical-grade material.

<sup>5</sup>As reported by the International Organizing Committee for the World Mining Congress.

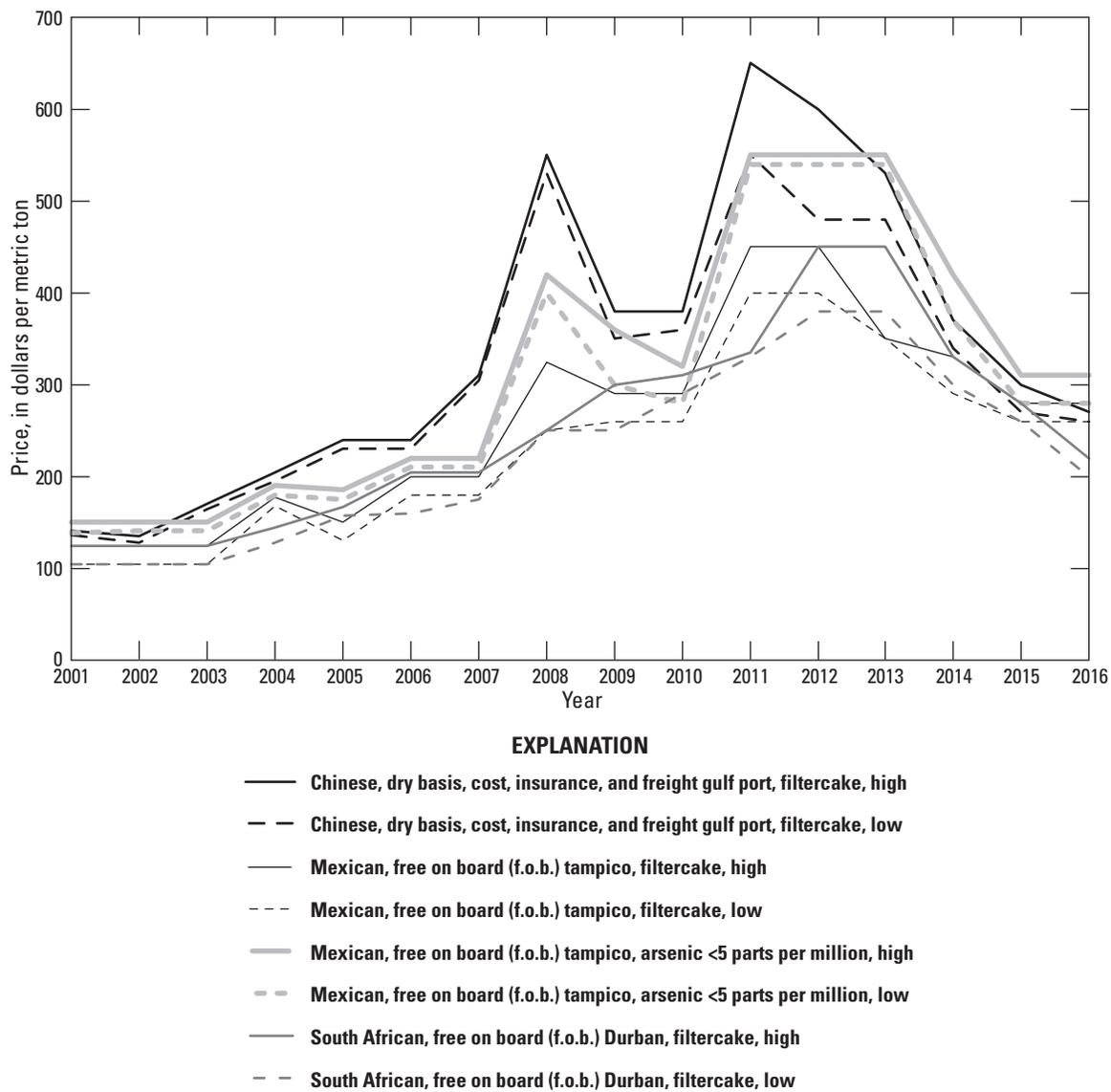
<sup>6</sup>Flotation concentrate, includes some material less than 97%.

<sup>7</sup>May include some submetallurgical-grade fluor spar.

<sup>8</sup>Data were reported in wet tons, but have been converted to dry tons to be consistent with other data in the table.



**Figure 1.** Quarterly acid- and metallurgical-grade imports for consumption and consumer stocks of fluorspar from 2006 through 2016. Reported quarterly stock data were withheld beginning in the fourth quarter of 2014; yearend stocks for 2014 through 2016 are estimated. Sources: U.S. Geological Survey and U.S. Census Bureau.



**Figure 2.** Prices of acid-grade fluorspar from leading exporting countries from 2001 through 2016. Source: Industrial Minerals.