FLUORSPAR

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In 2011, there was no primary fluorspar production in the United States, although a small amount of fluorspar may have been recovered as a byproduct of limestone quarrying in Illinois and then screened and sold as metallurgical grade. The bulk of U.S. consumption was supplied by imports and by small amounts of byproduct synthetic fluorspar produced from industrial waste streams. Byproduct fluorosilicic acid (FSA) production from some phosphoric acid producers supplemented fluorspar as a domestic source of fluorine but was not included in fluorspar production or consumption calculations.

Fluorspar is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, plastics, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involve either acid grade (also called acidspar), which is greater than 97% calcium fluoride (CaF_2), or subacid grade, which is 97% or less CaF_2. Subacid grade includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

World fluorspar production increased in 2011 by more than 300,000 metric tons (t) to 7.52 million metric tons (Mt) compared with the revised figures for 2010. Production estimates for China were revised retroactively to 2008 based on new data. In descending order, Mexico, China, South Africa, and Kenya recorded the largest production increases in 2011 and accounted for most of the increase.

Production

In 2011, small amounts of byproduct fluorspar may have been produced in Illinois by a single company, but there was no attempt to collect data on quantities produced. There is no U.S. Geological Survey (USGS) data survey for synthetic fluorspar produced in the United States. FSA was produced as a byproduct from the processing of phosphate rock into phosphoric acid. Domestic production 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 FSA operations surveyed, responses were received from four plants, representing 98% of the total sold or used by producers. Production and sales data for the one nonrespondent were estimated based on prior year company data.

In 2011, three companies produced marketable byproduct FSA at phosphoric acid plants (part of phosphate fertilizer operations). J.R. Simplot Co., Mosaic Fertilizer (a subsidiary of The Mosaic Co.), and PCS Phosphate Co. Inc. operated five plants in Florida, Louisiana, North Carolina, and Wyoming that produced marketable FSA. Production of byproduct FSA was slightly less than that in 2010 at 70,300 t (100% basis H_2SiF_6), and quantities sold or used totaled 70,200 t (equivalent to about 124,000 t of fluorspar grading 92% CaF_2) valued at $13.4 million. @25% HFSA basis = 281,200t

Some synthetic fluorspar was recovered as a byproduct of petroleum alkylation, stainless steel pickling, and uranium processing. The majority of the marketable product was estimated to come from uranium processing, but the actual amount of synthetic fluorspar recovered is unknown.

Hastie Mining and Trucking Co. (Cave-In-Rock, IL), 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 also screened and sold small amounts of byproduct fluorspar from the company's limestone quarry operation.

Hastie Mining continued work on the development of its Klondike II underground fluorspar mine in Livingston County, KY. Site preparation work continued, and work started on excavating the incline that would provide access to the vein deposit. At yearend 2011, excavation work was well underway, and the company anticipated reaching the orebody and beginning to mine ore by yearend 2012. In 2011, the company drilled an additional 10 exploration holes on the deposit, which more than doubled the reserves from the first phase of drilling to about 4 Mt (Don Hastie, Hastie Mining & Trucking Co., oral commun., February 24, 2012). Hastie Mining has been working with Arkema Inc. (Colombes, France), which operates a fluorochemicals plant in nearby Calvert City, KY. The Calvert City plant formerly operated a hydrofluoric acid (HF) plant, but it was shut down in the mid-1990s, and since then the plant has relied on imports of HF for its feedstock. Arkema has considered constructing a new HF plant at Calvert City to take advantage of the expected acid-grade production from the Klondike II Mine; no official decision had been made by yearend.

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). Complete quarterly data were received from the two HF producers, while partial data were received from the four distributors, with estimates made for nonrespondents. These responses and estimates accounted for 100% of the reported consumption in table 2.

Industry practice has established three grades of fluorspar—acid grade, containing more than 97% CaF_2; ceramic grade, containing 85% to 95% CaF_2; and metallurgical grade, normally containing 60% to 85% CaF_2. Fluorspar grades are defined by the intended use, but these grades are essentially just ranges derived from customer and supplier specifications. For reasons ranging from availability to economics to process changes, U.S. consumers have been moving toward the use of higher-grade fluorspar. For example, welding rod manufacturers may use acid-grade fluorspar rather than ceramic grade, and some steel mills use ceramic or acid grade rather than metallurgical grade.

Total reported U.S. fluorspar consumption was 454,000 t, a slight increase compared with that of 2010 (table 2). Because of the closure of the single aluminum fluoride (AlF_3) producer in 2008, consumption data for the two HF producers has been combined with "Other" uses in table 2 to avoid disclosing company proprietary data. As a result of a substantial increase in imports, apparent consumption (normally defined as production plus imports minus exports plus or minus changes in stocks) increased by about 37% to 672,000 t. However, some uncertainty exists about the accuracy of the large increase in U.S. fluorspar imports, as no direct reason for the large increase was evident and the reported exports of fluorspar to the United States from its major trading partners were much lower than reported U.S. imports.

Acid-grade fluorspar, which accounted for 93% of the total U.S. reported fluorspar consumption, was used primarily as a feedstock in the manufacture of HF. Two companies reported fluorspar consumption for the production of HF in 2011—E.I. du Pont de Nemours & Co. Inc. (DuPont) and Honeywell International Inc. Fluorspar consumption for HF production increased by about 4% compared with that of 2010. Since most acid-grade fluorspar is converted to HF before consumption, HF uses and markets are key to analyzing fluorspar consumption.

The leading use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), fluoroelastomers, and fluoropolymers. Production of these compounds accounted for about 75% of domestic HF consumption and 40% of world HF consumption. Major U.S. producers were Arkema, DuPont, Great Lakes Chemical Corp., Honeywell, Mexichem Fluor, Inc., MDA Manufacturing Ltd., and Solvay Solexis Inc.

The U.S. Environmental Protection Agency (EPA) approved two hydrofluoroolefin (HFO) compounds as replacements for chlorofluorocarbons—HFO–1234ze and HFO–1234yf. The compound HFO–1234ze, developed by Honeywell, has been approved for use as a foam blowing agent. HFO–1234ze has a very low global warming potential (GWP) (6, where carbon dioxide=1), is nonflammable, and can replace existing high-GWP blowing agents such as HFC–134a (GWP=1,320) and HFC–152a (GWP=122) (SprayFoam.com, Inc., 2011). HFO–1234yf (GWP=4), which was jointly developed by Honeywell and DuPont, may now be used in air conditioning for new cars and light trucks. It is the likely successor to HFC–134a, which is the standard refrigerant currently used in most modern vehicles (U.S. Environmental Protection Agency, 2011).

In a related matter, the EPA agreed to grant a petition filed by several environmental groups to withdraw the agency's approval of HFC–134a for use in air conditioning systems installed in new light duty vehicles (passenger cars, pick-up trucks, minivans, and sport utility vehicles). A formal "notice and comment" rulemaking to set the phaseout schedule was to follow (SustainableBusiness.com News, 2011).

Honeywell (Morristown, NJ) announced an expansion of its fluorochemical manufacturing plant in Baton Rouge, LA. The expansion project was expected to include construction of a new production line to manufacture HFO–1234ze. HFO–1234ze has been approved for use in aerosols and as a foam-blowing agent. The company's investment was considered critical to the viability of its Baton Rouge facility, as production of the site's primary product decreased substantially in 2011 and was expected to continue to do so as a result of current environmental regulations (Honeywell International Inc., 2011).

Internationally, acid-grade fluorspar was used in the production of AlF_3 and cryolite (Na_3AlF_6), which are the main fluorine compounds used in primary aluminum smelting. Alumina (Al_2O_3) is dissolved in a bath that consists primarily of molten cryolite and small amounts of AlF_3 and fluorspar to allow electrolytic recovery of aluminum. During the aluminum smelting process, excess sodium in the bath (a result of impurities in the alumina) is controlled by the addition of AlF_3, 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 called crushed tapped bath, secondary cryolite, bath cryolite, and other terms. In the aluminum smelting process, AlF_3 is also used to replace fluorine losses (either absorbed by the bath walls or captured as emissions). Most AlF_3 is produced directly from acid-grade fluorspar or from byproduct FSA. The United States ceased production of AlF_3 in 2008 when Alcoa World Alumina LLC (a business unit of Alcoa Inc.) closed its Point Comfort, TX, production facility. The AlF_3 requirements of U.S. aluminum industry are now met through imports (table 8).

The merchant fluorspar market in the United States included sales of metallurgical- and acid-grade material mainly to steel mills, where it was used primarily 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 2011, based on available data, merchant sales (excluding acid-grade for other uses) decreased by 8% compared with those of 2010. During the past 20 to 30 years, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

The U.S. steel industry continued its recovery from the effects of the 2008–09 recession, which resulted in a 36% decrease in steel production in 2009 compared with that of 2008. In 2010, steel demand picked up significantly, and production increased by 38% compared with that of 2009. In 2011, the recovery continued, albeit at a slower rate, and steel production increased by 7% (World Steel Association, undated). In the United States, reported consumption of fluorspar in metallurgical markets (mainly steel) increased by nearly 13% compared with that of 2010. Consumption in this sector was 72% metallurgical grade and 28% acid grade.

In the United States, FSA is used primarily for water fluoridation, but it may also be used as a metal surface treatment and cleaner and for pH adjustment in industrial textile processing or laundries. It can also be used in the processing of animal hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2011, byproduct FSA sold for water fluoridation was 65,900 t valued at $12.1 million, and 4,230 t valued at $1.33 million was sold or used for other applications.

Stocks

Data for stocks were available from some fluorspar distributors and HF producers. Known consumer and distributor stocks at the end of 2011 totaled 162,000 t. This represented nearly a 24% increase in known consumer and distributor stocks from yearend 2010. The last sales from the National Defense Stockpile were made in 2006, and Government stocks of fluorspar were zero.

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 acid grade and ceramic grade is marketed in bags for small users and shipped by truck.

According to the Baltic Dry Index (BDI), which tracks worldwide international shipping prices of handymax, panamax, and capesize dry bulk carriers, ocean freight rates fluctuated during 2011 but were even lower than those of 2010. The BDI began the year at about 1,600 (compared with about 3,100 the previous January), fluctuated between a low of 1,045 and a high of 2,173 before ending the year at slightly above 1,600. The traditional explanation for a low BDI was low demand for shipping (especially in Europe). In addition, demand was adversely impacted by weather-related commodity export bottlenecks in some countries, and deliveries of new ships added capacity faster than old ships were taken out of commission (Pacific Basin Shipping Ltd., 2011, p. 4; Bloomberg L.P., 2012). The low shipping rates benefited fluorspar buyers who could take advantage of low fluorspar prices and low ocean freight rates.

Prices

Yearend 2011 acidspar and metspar prices increased for all major exporting countries when compared with those at yearend 2010. According to Industrial Minerals magazine, fluorspar prices began rising in the first quarter of 2011 and continued to rise in the second quarter. Prices for Chinese fluorspar, acidspar and metspar, exhibited the largest increases owing to increases in production costs, appreciation of the Chinese yuan to the U.S. dollar, and rising demand. Chinese acidspar prices stabilized in the third quarter, but free-on-board (f.o.b.) China prices decreased in the fourth quarter. Mexican high-arsenic acidspar prices stabilized in the second quarter and remained unchanged through the rest of the year. The price of Mexican low-arsenic acidspar, however, increased throughout 2011 and the fourth quarter f.o.b. price was higher than comparable Chinese acidspar f.o.b. China. South African acidspar prices saw some late year movement upward, but remained lower than Chinese or Mexican prices (table 3). Rising fluorspar prices have caused price increases for fluorspar-derived products such as aluminum fluoride and fluoropolymers. For example, Daikin Industries, Ltd. (Osaka, Japan) raised the prices for all fluorochemical products by 20% to 30%, effective March 1, 2011. The company cited rising raw material costs for fluorspar and hydrofluoric acid as the reasons (Daikin Industries, Ltd., 2011).

Foreign Trade

In 2011, U.S. exports of fluorspar totaled 24,100 t, an increase of 34% compared with those of 2010 (table 4). With the absence of fluorspar stocks in the National Defense Stockpile and only a small amount of mined fluorspar, exports are likely reexports of imported material. The leading recipients of U.S. exports were Canada (53%) and Taiwan (41%).

In 2011, imports for consumption of fluorspar increased by 35% compared with those of 2010 (table 5). The leading suppliers of fluorspar to the United States were Mexico (78%), China (16%), and South Africa (5%).

The following imports are compared with those of 2010: imports of HF decreased slightly to 132,000 t (table 6); the majority of HF imports were from Mexico (83%), with Canada (12%) and China (4%) supplying most of the balance. Imports of cryolite increased by 80% to 9,560 t (table 7). A large portion of the increase came from Canada, Iceland, and Mozambique and was thought to be crushed tapped bath rather than synthetic cryolite. Imports of AlF_3 increased by 9% to 41,000 t (table 8), with almost all coming from three countries—Mexico (44%), Canada (34%), and China (21%).

World Review

Fluorspar production estimates for China have been revised for 2008–10 based on recent data released by the Chinese Government. There is still uncertainty, however, concerning the data's accuracy and some industry analysts consider these numbers to be too high. , In 2011, incorporating these revised data, world production was 7.52 Mt, an increase of nearly 5% compared with that of 2010.

Bulgaria.—Solvay S.A. (Brussels, Belgium) announced that it had acquired a fluorspar mine near Chiprovtzi from the Italy-based N&N Group. The agreement included the transfer of all fluorspar concession and exploration rights to Solvay. Production capacity was about 30,000 metric tons per year (t/yr) of mostly acid-grade fluorspar, with plans to increase capacity to 50,000 t/yr by yearend 2011 (Solvay S.A., 2011). Despite this announcement, according to industry sources, production was less than 5,000 t in 2011.

Canada.—Canada Fluorspar Inc. (CFI) (Markham, Ontario) and Arkema signed an agreement worth about $85 million to fund reopening of the St. Lawrence fluorspar mine. The agreement called for the initial purchase of about $16 million of CFI shares. The deal combined the mine, mill, and associated assets into a limited partnership in which CFI and Arkema will each hold 50% stakes. As part of the partnership, CFI and Arkema will enter into an offtake agreement whereby the partners will each receive a prorated share of the output at a price equal to the cost of production plus an agreed-upon fee. In addition, for a period of 10 years, Arkema will have the right to purchase approximately 20% of CFI's share of the output on a pricing basis that includes costs plus a fixed margin. Arkema agreed to fund the partnership with about $70 million (Canada Fluorspar Inc., 2011). The mine last operated in the early 1990s and is near the town of St. Lawrence on the Burin Peninsula of Newfoundland Island in the Province of Newfoundland and Labrador.

China.—A World Trade Organization (WTO) dispute settlement panel ruled that aspects of China's export policies on several important industrial raw materials (including fluorspar) were inconsistent with China's WTO obligations. The panel recommended that China bring its policies into conformity with its WTO obligations, although China had until September 3, 2011, to appeal the findings. The WTO panel's findings were the result of complaints filed in 2009 by the European Union, Mexico, and the United States about China's policy of applying export duties, export licenses, export quotas, and minimum export prices on fluorspar and several other mineral commodities. The panel found that China's export duties and export quotas were inconsistent with WTO rules, and that certain aspects of China's export licensing system restricted exports and were therefore inconsistent with WTO rules. China argued that its export policies were justified on grounds of natural resource conservation, but the panel found that China was unable to prove that it imposed such export restrictions while restricting domestic production or consumption of the raw materials in order to conserve the raw materials (O'Driscoll, 2011). On September 2, China appealed the WTO ruling that its export restrictions were inconsistent with WTO rules. The WTO panel had 3 months to rule on China's appeal (United Press International, Inc., 2011). A final ruling on China's appeal had not been made by yearend 2011.

China's 2011 fluorspar exports were 722,000 t, an increase of 21% compared with those of 2010. Of the total, metspar accounted for 289,000 t with the Republic of Korea, India, and Japan, in descending order, being leading reported trading partners. Acidspar exports totaled 433,000 t, with the United States, Japan, India, the Netherlands, and Canada, in descending order, being the leading trading partners. Net Chinese fluorspar exports were 626,000 t, since China imported nearly 96,000 t of metspar in 2011, of which 96% came from Mongolia (United Nations, 2012).

India.—Indian firms Gujarat Mineral Development Corp. (GMDC) (Ahmedabad, Gujarat), Gujarat Fluorochemicals Ltd. (Noida, Uttar Pradesh), and Navin Fluorine International Ltd. (Mumbai, Maharashtra) entered into a joint venture to construct a fluorspar flotation mill in India with a capacity to produce 40,000 t/yr of fluorspar concentrate. GMDC would supply the fluorspar and hold a 50% stake, while the other two companies would each hold 25% shares. Gujarat Fluorochemicals and Navin produce fluorocarbon refrigerants and fluoropolymers (Economic Times, The, 2012).

Mexico.—Mexichem S.A.B. de C.V. (Tlalnepantla) announced that it had received permission from the Mexican antitrust commission to acquire Mexico's second leading fluorspar producer Fluorita de Mexico S.A. de C.V. (Mexico City). Fluorita de Mexico, which reportedly has more than 13 Mt of reserves, mined high-purity low-arsenic fluorspar in the State of Coahuila. This acquisition gives Mexichem access to low-arsenic fluorspar that would supplement the company's production of high-arsenic fluorspar from its mine in San Luis Potosi. Mexichem intended to invest in the modernization of Fluorita de Mexico's facilities and to increase its annual production capacity (Mexichem S.A.B. de C.V., 2011).

Mongolia.—Mongolia's fluorspar mining industry continued to expand in 2011. As of midyear 2011, the Government had issued 139 mining licenses and more than 700 exploration licenses, and more than 120 entities were involved in some stage of the fluorspar mining industry. Eight companies operated or were constructing flotation mills (in descending order of capacity)—Mongolrostsvetmet LLC, Kevin Invest LLC, Yantai Uul LLC, Mongolia International Minerals Corp., Northwind LLC, Chuluut International LLC, Boston International LLC (under construction), and Resource Min Kom LLC (under construction). The total capacity of these plants was 265,000 t/yr, although only Mongolrostsvetmet operated year round. Mongolia exported a range of fluorspar products that included fluorspar lump at 35% to 70% CaF_2, lump at 75% CaF_2, lump at 80% to 92% CaF_2, acid grade at 95% CaF_2, and acid grade at 97% CaF_2. According to midyear 2011 data on exports, Mongolia shipped 96% of its fluorspar exports to Russia (70%) and China (26%). Most of Russia's imports were consumed for aluminum and steel production (Dorjbal, 2011).

Norway.—In 2011, Tertiary Minerals plc (Macclesfield, United Kingdom) reported that significant progress had been made at the company's Lassedalen fluorspar mine project in southern Norway. Tertiary Minerals relogged drill core from 23 of the 28 surface diamond holes drilled in the 1970s. This core was resampled for assay and metallurgical test work in order to economically accelerate the definition of a JORC (Joint Ore Reserves Committee—an Australasian code for reporting exploration results) compliant inferred mineral resource, which could form the basis for a scoping study (Tertiary Minerals plc, 2011, p. 8).

South Africa.—Sallies Ltd. (Pretoria) restarted fluorspar production at its Witkop Mine in March 2011, and by the end of June, had produced 32,000 wet metric tons of acid-grade fluorspar and had exported 11,100 wet metric tons at average prices in excess of $387 per dry metric ton. Witkop's production reportedly was sold through the end of December 2011. Future production was expected to be about 135,000 t/yr (Sallies Ltd., 2011).

In September, Firebird Global Fund II (New York, NY) announced the sale of its majority holding in Sallies to Fluormin plc

(London, United Kingdom). This was the culmination of the deal announced in late 2010 between Firebird and Maghreb Minerals plc, which subsequently changed its name to Fluormin. Sallies became part of Fluormin, which also owned a minority share in Kenya Fluorspar Co. (Nairobi, Kenya) and a 49% share of FluorOne Trading Ltd. FluorOne was set up in 2011 and was expected to be involved in all aspects of trading fluorspar (whether produced by the Fluormin group of companies or from other firms) and planned to market all fluorspar production from the Witkop Mine (Fluormin plc, 2011, p. 4–5).

Sweden.—Tertiary Minerals performed a resource definition drilling program and reported a maiden JORC compliant mineral resource on its Storuman fluorspar project in the Västerbottens district. The results were an indicated and inferred mineral resource of 28 Mt grading 10.2% CaF_2, with 90% of the mineral resource reportedly in the "indicated" category. The company began preliminary feasibility studies, environmental baseline sampling programs, mine and environmental permitting studies, and ran additional metallurgical tests on the ore. Additional drilling to the west and northwest of the mineral resource established that a potentially much larger fluorspar resource with higher grade mineralization existed, although still low grade by international standards. The new resource would require underground mining, which highlighted the need to include an evaluation of underground mining options in the preliminary feasibility studies (Tertiary Minerals plc, 2011, p. 6–9).

United Kingdom.—Fluorspar producer Glebe Mines Ltd. (Derbyshire), which ceased operations in December 2010, was acquired by a small group of investors in September. Plans were to restart mine and mill production, but at yearend, Glebe Mines was still idle (Lambert, 2011).

Vietnam.—Efforts to develop the Nui Phao polymetallic mining project have been going on for years, but with its acquisition in 2010 by the Masan Group Corp. (Ho Chi Minh City) the project took on new life. Nui Phao was placed under the control of the Masan Group's mineral resource division, Masan Resources Corp. In 2011, Masan signed agreements for more than $200 million in additional project financing, commenced design work, acquired necessary equipment, began construction of earthworks and concrete works, and hired a mining contractor that started prestripping the orebody. By yearend 2011, land acquisition, compensation, and resettlement plans for displaced local inhabitants had been nearly completed. Production was scheduled to begin in 2013, at which time the mine would produce substantial amounts of bismuth, fluorspar, and tungsten, with lesser amounts of copper and gold. When in full production, the mine was expected to produce an average of 207,000 t/yr of acid-grade fluorspar (Masan Group Corp., 2012, p. 4–11, 37).

Outlook

The outlook for fluorspar has some long-term concerns that include environmental pressures opposing the use of some fluorochemical products, safety concerns for the use of HF, availability of future fluorspar supplies, and a shift in fluorspar-consuming industries to Asia. More immediate problems result from the effects of a slowdown in the global economy. This slowdown has had a direct adverse effect in metallurgical markets such as aluminum and steel, which may continue.

Long-term demand for fluorspar may depend to a large degree on the development and acceptance of fluorine-based replacements for existing fluorocarbon compounds, which are likely to be phased out owing to high GWP. Strong replacement candidates are hydrofluoroolefins HFO–1234yf and HFO–1234ze for use in automotive air-conditioning systems and foam blowing, respectively. These two compounds each have low GWP and rapidly break down in the atmosphere. For the fluorspar industry, they also have the advantage of containing greater amounts of fluorine (thus requiring more fluorspar to manufacture) compared with some of the compounds they would replace.

Demand for fluorspar in China has slowed as its economy has slowed. This has resulted in an increase in fluorspar exports in the short term; in the long term, exports from China still are expected to decline as more is consumed domestically, and China reduces fluorspar mining to conserve fluorspar resources. After depending on China for the past 20 years as the primary source of fluorspar, fluorochemical companies have become concerned about the future availability of fluorspar on the open market. This has resulted in a number of acquisitions of fluorspar mines by fluorochemical companies to guarantee secure supplies, and in one case the acquisition of a fluorochemical company by a fluorspar producer.

Major markets for fluorspar in developed countries have been stagnant or have decreased as first HF and more recently fluorocarbon production has moved to China, and aluminum smelting capacity has moved to countries or regions with access to abundant, low-cost energy. This shift is evident in the increasing HF and fluorocarbon production capacity in China and the reduced capacities in traditional production areas in Europe, Japan, and North America. China is already the world's leading fluorspar consumer, and its share of global consumption will likely continue to increase in the future.

References Cited

Bloomberg L.P., 2012, Baltic Dry Index—Interactive chart for Baltic Dry Index (BDIY): Bloomberg L.P., May 21. (Accessed May 22, 2012, at http://www.bloomberg.com/quote/BDIY:IND/chart.)

Canada Fluorspar Inc., 2011, Canada Fluorspar announces strategic agreement with Arkema resulting in a CDN$83.5 million investment to fund the St. Lawrence fluorspar project: Markham, Ontario, Canada, Canada Fluorspar Inc. news release, June 15, 4 p. (Accessed May 23, 2012, at http://www.canadafluorspar.com/pdf/CFI_Arkema_press_release_June_15_Final.pdf.)

Daikin Industries, Ltd., 2011, Daikin Industries, Ltd. will raise the prices for all fluorochemical products: Osaka, Japan, Daikin Industries, Ltd. news release, February 3, 2 p. (Accessed October 14, 2011, at http://www.daikin.com/press/2011/110203/press_20110203.pdf.)

Dorjbal, 2011, Mongolia—Growing source of fluorspar: Fluorspar 2011, Johannesburg, South Africa, November 15–17, 2011, presentation, 20 p.

Economic Times, The, 2012, GMDC gets Gujarat government's nod for 3 joint ventures: Times Internet Ltd., January 4. (Accessed January 5, 2012, at http://articles.economictimes.indiatimes.com/2012-01-04/news/30588745 _1_gujarat-mineral-development-corporation-gmdc-jv-partner.)

Fluormin plc, 2011, Notice of general meeting: London, United Kingdom, Fluormin plc, September 12, 21 p. (Accessed December 1, 2011, at http://www.fluormin.com/pdf/Notices of General Meeting.pdf.)
Honeywell International Inc., 2011, Honeywell to invest $33 million in Louisiana facility: Honeywell International Inc. news release, July 6. (Accessed November 25, 2011, at http://www51.honeywell.com/sm/genetron/news-events/news-release-details/BatonRougeInvestment.html.)
Lambert, John, 2011, Fluorspar quarrying to resume on Longstone Edge: Derbyshire, United Kingdom, Save Longstone Edge Group Newsletter, December, 2 p. (Accessed July 31, 2012, at http://www.longstone-edge.org.uk/news/Newsletter_16December11.pdf.)
Masan Group Corp., 2012, Masan Resources—Nui Phao project: Ho Chi Minh City, Vietnam, Masan Group Corp. corporate presentation, April, 48 p. (Accessed July 31, 2012, at http://www.masangroup.com/static/uploads/downloads/mr_nui_phao_presentation_apr12_en.pdf.)
Mexichem S.A.B. de C.V., 2011, Mexichem Fluor announces the acquisition of "Fluorita de Mexico": Tlalnepantla, Mexico, Mexichem S.A.B. de C.V. news release, December 27. (Accessed March 27, 2012, at http://www.mexichem.com/English/detalle_noticia.php?id=124.)
O'Driscoll, Mike, 2011, WTO finds against Chinese export mineral policies: Industrial Minerals, no. 527, August, p. 10.
Pacific Basin Shipping Ltd., 2011, 2011 interim results: Hong Kong, China, Pacific Basin Shipping Ltd., August 3, 31 p. (Accessed May 22, 2012, at http://www.pacificbasin.com/UserFiles/upload/FinancialReporting/e2343_interim_report_2011.pdf.)
Sallies Ltd., 2011, Condensed audited consolidated results for the year ended 30 June 2011: Pretoria, South Africa, Sallies Ltd., 3 p. (Accessed November 30, 2011, at http://www.sallies.co.za/images/pdfs/Results_Announcements/Results_announcement_June_2011.pdf.)
Solvay S.A., 2011, Solvay secures the development of its fluorinated products by acquiring a Bulgarian fluorspar mine: Brussels, Belgium, Solvay S.A. news release, February 22. (Accessed July 19, 2011, at http://www.solvay.com/EN/NewsPress/20110222_Bulgarianfluorsparmine.aspx.)
SprayFoam.com, Inc., 2011, Honeywell announces EPA acceptance for new blowing agent: SprayFoam.com, Inc., February 2. (Accessed June 17, 2011, at http://sprayfoam.com/npps/story.cfm?nppage=659.)
SustainableBusiness.com News, 2011, EPA to ban powerful GHGs from auto air conditioners: SustainableBusiness.com News, March 25. (Accessed June 21, 2011, at http://www.sustainablebusiness.com/index.cfm/go/news.display/id/22121.)
Tertiary Minerals plc, 2011, Building a strategic position in the fluorspar sector—Annual report for the year ended 30 September 2011: Macclesfield, United Kingdom, Tertiary Minerals plc annual report, December 14, 44 p. (Accessed July 23, 2012, at http://www.tertiaryminerals.com/uploads/Tertiary Minerals Annual Report 2011.pdf.)
United Press International, Inc., 2011, China appeals WTO ruling: UPI.com, September 2. (Accessed November 28, 2011, at http://www.upi.com/Business_News/2011/09/02/China-appeals-WTO-ruling/UPI-10141314939704/.)
United Nations, 2012, Basic query results: United Nations commodity trade statistics database. (Accessed July 17, 2012, via http://comtrade.un.org/db/.)
U.S. Environmental Protection Agency, 2011, Protection of stratospheric ozone—New substitute in the motor vehicle air conditioning sector under the Significant New Alternatives Policy (SNAP) Program: Federal Register, v. 76, no. 60, March 29. (Accessed March 29, 2011, at http://www.gpo.gov/fdsys/pkg/FR-2011-03-29/html/2011-6268.htm.)
World Steel Association, [undated], Statistics archive: Brussels, Belgium, World Steel Association. (Accessed July 18, 2012, at http://www.worldsteel.org/statistics/statistics-archive.html.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Fluorspar. Ch. in Mineral Commodity Summaries, annual.
Fluorine. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Fluorspar. Mineral Industry Surveys, quarterly.
Geology and Resources of Fluorine in the United States. Professional Paper 933, 1976.
Historical Statistics for Mineral and Material Commodities in the United States, Data Series 140.

Other

Economics of Fluorspar, The. Roskill Information Services Ltd., 2009.
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.
Fluorocarbons. Chemical Economics Handbook Marketing Research Report, IHS Chemical, 2011.
Fluorspar and Inorganic Fluorine Compounds. Chemical Economics Handbook Marketing Research Report, IHS Chemical, 2009.
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.