



# 2010 Minerals Yearbook

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## FLUORSPAR

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# FLUORSPAR

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In 2010, there was no primary fluor spar production in the United States, although a small amount of fluor spar was recovered as a byproduct of limestone quarrying in Illinois and was screened and sold as metallurgical grade. As the U.S. economy showed signs of recovery, fluor spar consumption rebounded in 2010, recovering about one-half of the large decrease reported in 2009. The bulk of U.S. consumption was supplied by imports and by small amounts of byproduct synthetic fluor spar produced from industrial waste streams. Byproduct fluorosilicic acid (FSA) production from some phosphoric acid producers supplemented fluor spar as a domestic source of fluorine but was not included in fluor spar production or consumption calculations.

According to the U.S. Census Bureau, U.S. trade in fluor spar, cryolite, and major fluorochemicals increased after the steep decline recorded in 2009 (tables 1, 4–6). Fluor spar is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, plastics, refrigerants, steel, and uranium fuel. Most fluor spar consumption and trade involve either acid grade (also called acidspar), which is greater than 97% calcium fluoride ( $\text{CaF}_2$ ), or subacid grade, which is 97% or less  $\text{CaF}_2$ . Subacid grade includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

## Production

In 2010, small amounts of byproduct fluor spar were produced in Illinois by a single company, but data were not collected on quantities produced. There is no U.S. Geological Survey (USGS) data survey for synthetic fluor spar produced in the United States. FSA is 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 93% 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 2010, there were three companies producing marketable byproduct FSA at phosphoric acid plants (part of a phosphate fertilizer operation). 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 71,600 metric tons (t) (100% basis  $\text{H}_2\text{SiF}_6$ ), and quantities sold or used totaled 72,600 t (equivalent to about 128,000 t of fluor spar grading 92%  $\text{CaF}_2$ ) valued at about \$10.4 million.

Some synthetic fluor spar 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 fluor spar 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 fluor spar. Hastie Mining also screened and sold small amounts of byproduct fluor spar from the company's limestone quarry operation.

Hastie Mining encountered additional delays in developing its Klondike II fluor spar mine in Kentucky. Development work continued but was slowed while the company waited for a road construction permit. The company installed a heavy-media separation plant, which because of the relatively simple mineralogy of the deposit was expected to be able to produce acid-grade fluor spar without the need for flotation processing. The company owns a flotation mill near Salem, KY, but it had been vandalized while it was idle, and renovation work would be required before it could be made operational. Originally, planned output from the Klondike II project was for combined acidspar and metspar production totaling 50,000 metric tons per year (t/yr). New plans called for production of large quantities of acidspar via the heavy-media plant with an ultimate goal of producing in excess of 200,000 t/yr. Production startup was expected in early 2012 (Don Hastie, Hastie Mining & Trucking Co., oral commun., March 16, 2011).

## Consumption

Domestic consumption data were developed by the USGS from a quarterly consumption survey of two large consumers that provide data on hydrofluoric acid (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 fluor spar—acid grade, containing more than 97%  $\text{CaF}_2$ ; ceramic grade, containing 85% to 95%  $\text{CaF}_2$ ; and metallurgical grade, normally containing 60% to 85%  $\text{CaF}_2$ . Fluor spar 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 quality fluor spar. For example, welding rod manufacturers may use acid-grade fluor spar rather than ceramic grade, and some steel mills use ceramic or acid grade rather than metallurgical grade.

Total reported U.S. fluor spar consumption increased by 12% in 2010 compared with that of 2009 (table 2). Because of the

closure of the single aluminum fluoride ( $\text{AlF}_3$ ) 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.

Acid-grade fluorspar, which accounted for 94% of the total U.S. fluorspar consumption, was used primarily as a feedstock in the manufacture of HF. Two companies reported fluorspar consumption for the production of HF in 2010—E.I. du Pont de Nemours & Co. Inc. (DuPont) and Honeywell International Inc. Fluorspar consumption for HF production increased substantially compared with that of 2009. Since most acid-grade fluorspar is converted to HF before consumption, it is necessary to discuss HF uses and markets in order to properly analyze 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 Inc., DuPont, Great Lakes Chemical Corp., Honeywell, Mexichem Fluor, Inc. (formerly Ineos Fluor Americas LLC), MDA Manufacturing Ltd., and Solvay Solexis Inc.

Internationally, acid-grade fluorspar was used in the production of  $\text{AlF}_3$  and cryolite ( $\text{Na}_3\text{AlF}_6$ ), which are the main fluorine compounds used in aluminum smelting. Alumina is dissolved in a bath that consists primarily of molten  $\text{Na}_3\text{AlF}_6$ ,  $\text{AlF}_3$ , and fluorspar to allow electrolytic recovery of aluminum. Fluorine losses are replaced entirely by the addition of  $\text{AlF}_3$ , the majority of which will react with excess sodium from the alumina to form  $\text{Na}_3\text{AlF}_6$ . Most  $\text{AlF}_3$  is produced directly from acid-grade fluorspar or from byproduct FSA. The United States ceased production of  $\text{AlF}_3$  in fall 2008 when Alcoa World Alumina LLC (a business unit of Alcoa Inc.) closed its Point Comfort, TX, production facility. The  $\text{AlF}_3$  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 2010, merchant sales (excluding acid-grade for other uses) increased by 40% compared with those of 2009. 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.

In 2009, U.S. steel production decreased by 36% (33.2 Mt) compared with that of 2008, and raw steel capacity utilization at U.S. steel mills averaged only 51% for the year. In 2010, demand picked up significantly; steel production increased by 38% (22.4 Mt) to 80.6 Mt, and raw steel capacity utilization averaged 70% (Fenton, 2011; World Steel Association, undated).

In the United States, consumption of fluorspar in metallurgical markets (mainly steel) increased by 40% compared with that of 2009. 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 hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2010, byproduct FSA sold for water fluoridation was 67,100 t valued at \$8.92 million, and about 5,600 t valued at \$1.47 million was sold or used for other uses.

## Stocks

Data for stocks were available from some fluorspar distributors and HF producers. Known consumer and distributor stocks at the end of 2010 totaled 121,000 t. This represented an 18% increase in known consumer and distributor stocks from yearend 2009. 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-t 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, which tracks worldwide international shipping prices of handymax, panamax, and capesize dry bulk carriers, ocean freight rates fluctuated during 2010 but remained low, especially compared with the highs reached in 2008. The Baltic dry index began the year above 3,100 but by yearend the index was below 1,700 indicating demand for shipping was still low (Bloomberg L.P., 2011). The low shipping rates benefited fluorspar buyers who could take advantage of low fluorspar prices and low ocean freight rates.

## Prices

Acidspar prices for the two major exporting countries, China and Mexico, stabilized in 2010 and at yearend were essentially unchanged from yearend 2009. The price range for low-arsenic acidspar from Mexico, however, did decrease slightly and the price of acidspar from South Africa increased compared with that of 2009. With the rebound in world steel production, the price range for Mexican metspar narrowed to \$170 to \$200

per metric ton, up from \$140 to \$195 per ton the previous year (table 3).

## Foreign Trade

In 2010, U.S. exports of fluorspar totaled 17,900 t—an increase of 27% compared with those of 2009 (table 4). With the disposal of all 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 (66%) and Taiwan (32%).

In 2010, imports for consumption of fluorspar increased by about 14% compared with those of 2009 (table 5). The leading suppliers of fluorspar to the United States were Mexico (71%), China (18%), South Africa (6%), and Mongolia (4%).

Compared with those of 2009, imports of HF increased by 18% to 135,000 t (table 6), imports of cryolite ( $\text{Na}_3\text{AlF}_6$ ) increased by 88% to 5,320 t (table 7), and imports of  $\text{AlF}_3$  more than doubled to nearly 38,000 t (table 8). The majority of HF imports were from Mexico (85%), with Canada (9%) and China (5%) supplying most of the balance. In 2010, almost all  $\text{AlF}_3$  imports were from three countries—Mexico (37%), Canada (32%), and China (30%).

## World Review

In 2010, world fluorspar production returned to 2008 levels of about 6 Mt, an increase of 8% compared with that of 2009.

**Bulgaria.**—The Chiprovtsi area in Montana Province has had a long history of mining, but the last mine in the area closed in the 1990s. N&N Group (Italy) began a geologic assessment in 2004 that resulted in expanded knowledge of the extent and quantity of fluorspar resources in the project area. This information encouraged the company to acquire the licenses for the old mines and production plant and to start rehabilitating the mines and constructing a new flotation mill. The new flotation mill and associated equipment was constructed to allow future capacity expansions. In 2009, the mine and flotation plant commenced final industrial tests, and by yearend, all mine- and mill-related obstacles had been resolved. Capacity of the flotation mill was about 2,500 metric tons per month (30,000 t/yr) at the beginning of 2010, with plans to double capacity to maximize mine and mill profitability. The acid-grade fluorspar product was reported to be of high quality; impurities such as arsenic, lead, and phosphates were either not present or found in trace amounts (N&N Group, 2010).

**Canada.**—Canada Fluorspar Inc. (Markham, Ontario) announced that it received the Federal environmental assessment screening report from the Canadian Government for the company's proposed fluorspar project in St. Lawrence, Newfoundland and Labrador. The report concluded that "the Project is not likely to cause significant adverse environmental effects with the application of the mitigation measures specified in the report." The Federal Government, therefore, has released the project from further environmental assessment. Approvals from the Federal Government closely followed environmental approval from the government of Newfoundland and Labrador. Both paved the way for Canada Fluorspar to pursue its objectives of commencing construction of its mine, mill, tailings

facilities, and wharf in the second half of 2011. Fluorspar production was expected to begin in 2013 (Canada Fluorspar Inc., 2010).

**China.**—China's 2010 fluorspar exports were 598,000 t, more than double those of 2009. Of the total, metspar accounted for 212,000 t and acidspar 386,000 t. Net fluorspar exports were 542,000 t, since China imported 54,000 t of metspar in 2010 (United Nations, 2011).

The Chinese Government issued a new policy concerning hydrogen fluoride called industrial admittance conditions for hydrogen fluoride, which was designed to protect fluorspar resources. The policy focuses on controlling HF capacity through tougher licensing requirements that encourage mergers or acquisitions. HF plants would be required to have a minimum capacity of 50,000 t/yr. The policy encourages existing fluoride companies to acquire fluorspar mine resources and would limit or bar companies without dedicated fluorspar resources from entering or further expanding into the fluoride industry. HF producers would be prohibited from purchasing fluorspar from unlicensed fluorspar companies. The policy is intended to improve integration of the fluoride industry by establishing larger vertically integrated companies producing higher value downstream products. This policy is an adjunct to the previously issued Government policies that limited the total volume of fluorspar produced in the first half of 2010. This reportedly has resulted in a dramatic increase in the domestic market price for fluorspar products (China Shen Zhou Mining & Resources, Inc., 2010).

**Kenya.**—Kenya Fluorspar Company Ltd. (Nairobi), which mothballed its mine in March 2009 because of low prices and a severe drop in sales, resumed mine production after fluorspar demand increased in the second quarter of 2010. The company's managing director stated earlier in the year that prices would have to exceed \$270 per metric ton before the company would consider restarting production (Watts, 2010). Kenya Fluorspar's 2010 production was 44,500 t, which was nearly three times its 2009 output but less than one-half that of 2008.

Maghreb Minerals plc (London, United Kingdom) agreed to acquire Firebird Global Master Fund's 20% shareholding in Kenya Fluorspar in return for 100.3 million Maghreb shares (Seccombe, 2010).

**Mexico.**—Mexico's second leading fluorspar producer, Fluorita de Mexico S.A. de C.V. (Coahuila) announced that it was in the process of developing new fluorspar mining concessions in the area of its main mine. The new operation would increase Fluorita de Mexico's annual acidspar capacity of 140,000 t by 30,000 to 40,000 t. The company was operating at about 90% of capacity during the early part of 2010. Plans called for the new mine to be in production by the end of 2011 (Industrial Minerals, 2010a). These plans had to be postponed owing to severe flooding and power outages in the northeastern region of the State of Coahuila resulting from hurricane Alex, which came ashore in late June as a category 2 hurricane (Industrial Minerals, 2011).

Mexichem Fluor S.A. de C.V. [a subsidiary of Mexichem S.A. de C.V. (Tlalnepantla)] acquired the fluorochemicals business of the INEOS Group (Lyndhurst, United Kingdom). The deal comprised the international business and assets related to

INEOS' fluorochemical operations in North America, Europe, and Asia. Prior to the Ineos Fluor acquisition, all of Mexichem's primary fluorospar-related businesses were in Mexico. These included fluorospar mines in the State of San Luis Potosi and an HF plant and  $\text{AlF}_3$  plant in Matamoros. The acquisition established Mexichem as a major, vertically integrated fluorochemicals company (Mexichem S.A.B. de C.V., 2010).

**Mongolia.**—Lotus Resources plc (London, United Kingdom), having failed to raise financing to develop its fluorospar projects in Mongolia, sold its Mongolian mining subsidiary (Lotus Minerals Mongolia Ltd.) to Mongolian Minerals Pte. Ltd. Lotus Minerals, through joint-venture partnerships, controlled four fluorospar projects in Mongolia—two exploration licenses (Gat and Dai-Uul) and two mining licenses (Chuluut and Tsagaan Chuluut). All projects were small in scale and were in the country's central eastern region (Eurasia Capital Ltd., 2010).

**Mozambique.**—Globe Metals and Mining Ltd. (Perth, Australia) performed preliminary drilling on its Mount Muambe fluorospar and rare-earths project. Mount Muambe is a carbonatite crater roughly 6 kilometers (km) in diameter located in the Tete Province of Mozambique. Globe's exploration permit covers the entire crater. To date, results have shown the crater to be mineralized with fluorospar and heavy rare earths, but only a small fraction of the crater has been explored. A total of 16 drill holes were completed for a total of 1,118 meters (m) targeted mostly on the high-grade fluorospar and heavy rare-earths zone in the southwestern part of the carbonatite complex. Results of the preliminary drilling program were due in February 2011 (Globe Metals and Mining Ltd., 2010).

**Namibia.**—Okorusu Fluorspar (Pty.) Ltd.'s production of acid-grade fluorospar at Okorusu rose to more than 95,000 t in 2010 compared with 73,580 t in 2009. The company, which has always produced acid-grade fluorospar, reported its first sales of metallurgical-grade fluorospar (metspar, 85%  $\text{CaF}_2$ ) to Turkey. As planned, exploration during 2010 focused on the E ore body, which is within the mine's mining license area. Mapping, trenching and sample collecting, and gridding and line cutting were conducted on a 1.5-square-kilometer area. A total of 5,400 m of diamond drilling was completed, with additional drilling planned for 2011. In 2011, the company planned to commission a dense media separation plant (also referred to as heavy-media plant) that would allow the company to upgrade low-grade ores. Okorusu's plans also called for the construction of a new drying plant to improve the metspar business and to begin underground mining of the A ore body (Chamber of Mines of Namibia, 2011).

**Norway.**—Tertiary Minerals plc (Macclesfield, United Kingdom) acquired fluorospar exploration rights at the former Lassedalen Mine in Norway. The underground mine operated on a small scale during World War II, supplying fluorospar for use in aluminum production. Norsk Hydro A/S dewatered the mine in the late 1970s and carried out a surface and subsurface drilling program. The results of the program were not compliant with any current reserve or resource code. Potentially economic fluorospar mineralization occurs in steeply dipping veins that can be followed more or less continuously on the surface for at least 1 km. The largest veins have a width of 10 to 13 m and extend 200 to 250 m along strike. The company indicated that

development of such a high-grade vein deposit would allow production of both metallurgical and acid-grade fluorospar. Future plans included an exploration and metallurgical testing program. Tertiary Minerals' exploration rights extend through the end of 2016 (Tertiary Minerals plc, 2010b).

**South Africa.**—Maghreb Minerals announced plans to take a controlling interest in South African fluorospar company Sallies Ltd. (Pretoria) in an all-shares deal. Maghreb was expected to purchase the 66.9% stake in Sallies held by Firebird Global Master Funds, giving it a total holding of 78.3%, in return for 335.6 million Maghreb shares. The ownership share would trigger a mandatory offer to minority shareholders. Maghreb raised \$10 million in financing in a rights issue and planned to use the funds to restart fluorospar production from Sallies' Witkop Mine. After performing new geologic modeling and revising mining plans, Maghreb intended to produce 125,000 t/yr of acidspars from Witkop for the export market and a small amount of metspar for domestic markets. It was estimated that it would take 3 months to bring Witkop into production once the decision was made to restart operations (Seccombe, 2010). Sallies' Witkop fluorospar was idle most of 2010, but it did sell some stockpiled material into the domestic market for the year ended June 30, 2010, and restarted production in the fall to fill a small order for delivery in October (Prinsloo, 2010).

**Sweden.**—Tertiary Minerals announced the completion of an independent scoping study on its Storuman fluorospar project in Sweden. A fluorospar mine producing 100,000 t/yr of acid-grade fluorospar, with a mine life of 18 years, was judged feasible. The deposit is low grade, and the study was based on a mine model with a deposit of 18 Mt grading 12.3%  $\text{CaF}_2$  that was minable by open pit methods. The current study was based on drilling results from a prior exploration project (1970s) and the 10 holes drilled by Tertiary Minerals in 2008. The company planned additional drilling to define further the ore body and to establish a JORC (Joint Ore Reserves Committee—an Australasian code for reporting exploration results) classified mineral resource (Tertiary Minerals plc, 2010a).

**Thailand.**—Thailand was a major fluorospar producer and exporter through the 1980s, but production began to decrease during the 1990s owing to Chinese competition. From the late 1990s to 2007, Thailand's fluorospar production was less than 5,000 t/yr. In 2008, production increased to 29,529 t and, in 2009, it increased to 120,340 t. Almost all of this increased production came from the provinces of Lamphun and Mae Hong Son in Thailand's Northern Region. In 2009, reported production from Lamphun Province was 81,670 t and from Mae Hong Son Province 37,750 t. A small amount of additional production came from Kanchanaburi Province in the country's Central Region (Thailand Department of Primary Industries and Mines, undated a). As a result of this increased production, employment in Thailand's fluorospar mining industry has increased to 186 in 2009 from 69 in 2006 (Thailand Department of Primary Industries and Mines, undated b).

Thailand has experienced problems with illegal fluorospar mining, and, in early 2010, the Thailand Department of Special Investigation and border patrol police raided three large-scale illegal mines and confiscated 102,800 t of fluorospar in the Pai district of Mae Hong Son Province (Laohong and Saththa, 2010).

**United Kingdom.**—After failing to find a buyer or investors, the United Kingdom's sole fluorospar producer, Glebe Mines Ltd. (Derbyshire), reportedly was shutting down at yearend 2010. Glebe Mines was not included in the sale (finalized in March 2010) of its parent, INEOS Fluor, to Mexico's Mexichem Fluor (Industrial Minerals, 2010b). Glebe Mine's primary customer was INEOS Fluor's HF plant at Runcorn in Cheshire, which was part of the sale to Mexichem. Glebe Mines' supply contracts with the Runcorn plant apparently expired at the end of 2010. Glebe Mines remained a part of the INEOS Group, but after the sale of the fluorochemicals business, it was considered a poor fit with the INEOS Group's remaining businesses.

## Outlook

The outlook for fluorospar is complicated by world economic concerns over the health of economies in Europe and the United States debt, environmental pressures opposing the use of some fluorochemical products, safety concerns for the use of HF, availability of future fluorospar supplies, and a shift in fluorospar-consuming industries to Asia.

After the worldwide recession, fluorospar markets showed signs of recovery in 2010, especially for metspar, which was driven by the rebound in world steel production (up 17% compared with that of 2009). Demand for acidspar outside of China was slower to recover but began to rise in 2010 and was expected to display continued growth in 2011.

Long-term demand for fluorospar may depend to a large degree on the development and acceptance of fluorine-based replacements for existing fluorocarbon compounds that are likely to be phased out owing to high global warming potentials (GWP). A couple of 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.

Development of new fluorospar mine projects or work on reopening long-idle mines is beginning to pick up after the global economic downturn. With fluorospar exports from China expected to continue to decrease in the long term and major fluorospar-exporting countries looking to follow China's business model of producing higher value downstream fluorochemical products, fluorochemical companies have begun to worry about the future availability of fluorospar on the open market. As a result, fluorochemical companies are starting to acquire fluorospar mines in order to guaranty secure supplies. Solvay S.A. (Brussels, Belgium) was the first company in recent years to secure a source of fluorospar when it acquired Okorusu Fluorospar in Namibia. Several non-Chinese fluorochemical companies have expressed interest in exploring the possibility of acquiring dedicated sources of fluorospar for their needs. This type of vertical integration is being encouraged by the Chinese Government as part of its domestic hydrogen fluoride policy. Vertical integration is not new in the fluorospar business. In the 1970s and earlier, aluminum, fluorochemical, and steel companies owned fluorospar mines outright or were major shareholders in mines in Mexico, South Africa, the United States, and other countries.

Major markets for fluorospar 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 less expensive energy. This shift is evident in the growing 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 fluorospar consumer and its share of global consumption will likely continue to increase in the future.

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

		2006	2007	2008	2009	2010
United States:						
Exports: <sup>3</sup>						
Quantity	metric tons	13,000	13,600	18,800	14,100	17,900
Value <sup>4</sup>	thousands	\$2,430	\$2,650	\$3,340	\$2,230	\$2,740
Imports: <sup>3</sup>						
Quantity	metric tons	553,000	620,000	572,000	475,000	539,000
Value <sup>5</sup>	thousands	\$112,000	\$111,000	\$133,000	\$105,000	\$103,000
Consumption:						
Reported	metric tons	523,000	539,000	506,000	400,000	448,000
Apparent <sup>6</sup>	do.	608,000 <sup>r</sup>	613,000	529,000	473,000	502,000
Stocks, December 31:						
Consumer and distributor	do.	89,900 <sup>7</sup>	90,100	115,000	103,000	121,000
Government stockpile	do.	8,110	1,450	--	--	--
World, production	do.	5,660,000	5,730,000 <sup>r</sup>	6,000,000 <sup>r</sup>	5,550,000 <sup>r</sup>	6,010,000

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

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Does not include fluorosilicic acid production or imports of hydrofluoric acid and cryolite.

<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>Average unit value for the year, includes cost, insurance, and freight values at U.S. ports. Value data for fluorspar imports appear to be underreported.

<sup>6</sup>Imports minus exports plus adjustments for changes in stocks held by Government and three leading consumers.

<sup>7</sup>Includes fluorspar purchased from the National Defense Stockpile (NDS) but still located at NDS depots.

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	
	2009	2010	2009	2010	2009	2010
Hydrofluoric acid and aluminum fluoride	W	W	--	--	W	W
Metallurgical	9,390	10,900	17,900	27,400	27,200	38,300
Other <sup>2</sup>	371,000	410,000	2,030	--	373,000	410,000
Total	380,000	421,000	19,900	27,400	400,000	448,000
Stocks, consumer, December 31	87,200	109,000	15,600	12,400	103,000	121,000

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

<sup>1</sup>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, steel castings, welding rod coatings, and hydrofluoric acid.

TABLE 3  
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source and grade	2009	2010
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	350–380	360–380
Mexican, free on board (f.o.b.) Tampico, filtercake	260–290	260–290
Mexican, f.o.b. Tampico, arsenic <5 parts per million	300–360	280–320
South African, f.o.b. Durban, filtercake	250–300	290–310
Metspar, Mexican, f.o.b. Tampico	140–195	170–200

Sources: Industrial Minerals, no. 507, December 2009, p. 68; no. 519, December 2010, p. 70.

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

Country	2009		2010	
	Quantity (metric tons)	Value <sup>2</sup>	Quantity (metric tons)	Value <sup>2</sup>
Australia	6	\$3,840	135	\$19,800
Canada	7,900	1,260,000	11,800	1,820,000
France	--	--	16	4,550
Israel	--	--	29	9,590
Malaysia	6	3,660	28	17,500
Mexico	2,320	394,000	107	27,100
Spain	--	--	32	3,540
Taiwan	3,890	564,000	5,720	829,000
Total	14,100	2,230,000	17,900	2,740,000

-- Zero.

<sup>1</sup>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	2009		2010	
	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:				
Great Falls, MT	319	\$38	--	--
Houston, TX	45,100	15,000	89,800	\$26,300
Los Angeles, CA	103	13	420	49
New Orleans, LA	21,600	9,210	8,500	2,170
Seattle, WA	234	31	--	--
Total	67,300	24,300	98,700	28,500
Germany, Savannah, GA	--	--	252	32
Mexico:				
Baltimore, MD	536	241	1,550	690
Laredo, TX	42,100	12,900	47,200	12,700
New Orleans, LA	217,000	33,100	239,000	36,600
Total	260,000	46,200	287,000	49,900
Mongolia:				
Houston, TX	28,600	8,590	17,900	5,120
New Orleans, LA	--	--	4,200	1,180
Total	28,600	8,590	22,100	6,300
South Africa:				
Houston, TX	38,800	11,800	33,300	8,300
New Orleans, LA	22,000	7,300	--	--
Total	60,800	19,100	33,300	8,300
United Kingdom:				
Houston, TX	130	17	226	40
Los Angeles, CA	446	52	334	40
Total	576	70	560	79
Grand total	417,000	98,300	442,000	93,100
<b>Containing not more than 97% CaF<sub>2</sub>:</b>				
China, Cleveland, OH	--	--	1	3
Mexico:				
Cleveland, OH	1	5	--	--
Laredo, TX	4,430	448	6,240	880
New Orleans, LA	52,900	5,810	90,200	8,810
Total	57,300	6,260	96,500	9,690
Namibia, Houston, TX	203	24	--	--
Grand total	57,500	6,290	96,500	9,690
Grand total, all grades	475,000	105,000	539,000	103,000

-- Zero.

<sup>1</sup>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; data may be adjusted by the U.S. Geological Survey.

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

Country	2009		2010	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Belgium	--	--	(3)	\$4
Canada	11,000	\$39,500	12,000	41,900
China	4,110	4,270	6,520	7,820
Germany	404	1,250	356	1,060
Hong Kong	33	39	55	63
India	120	164	60	78
Japan	559	1,180	892	2,110
Lithuania	(3)	9	--	--
Mexico	97,600	114,000	115,000	145,000
Singapore	64	211	81	264
South Africa	13	22	5	20
Spain	(3)	3	47	80
Switzerland	(3)	2	(3)	3
Taiwan	49	134	209	516
United Kingdom	(3)	3	--	--
Total	114,000	161,000	135,000	199,000

-- Zero.

<sup>1</sup>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<sup>1</sup>

Country	2009		2010	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Australia	--	--	2	\$13
Canada	5	\$14	2	5
China	498	357	1,200	886
Denmark	151	288	--	--
Germany	878	1,330	1,580	2,080
Hungary	250	346	225	261
Italy	--	--	19	25
Japan	860	1,070	1,810	2,350
Mexico	81	30	--	--
United Kingdom	103	195	484	895
Total	2,830	3,630	5,320	6,510

-- Zero.

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

Country	2009		2010	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Canada	6,950	\$11,000	12,300	\$17,800
China	10,200	14,500	11,400	14,800
Mexico	1,460	1,280	14,100	16,500
Other <sup>3</sup>	45	99 <sup>r</sup>	74	156
Total	18,700	26,800	38,000	49,200

<sup>r</sup>Revised.

<sup>1</sup>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 Brazil, Germany, Japan, Sweden, Switzerland, and the United Kingdom.

Source: U.S. Census Bureau.

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

(Metric tons)

Country and grade <sup>3,4</sup>	2006	2007	2008	2009	2010
Argentina	8,278	9,735	15,098	13,424 <sup>r</sup>	14,000 <sup>e</sup>
Brazil, marketable:					
Acid grade	41,373	44,869	45,032 <sup>r</sup>	28,803 <sup>r</sup>	44,600 <sup>e</sup>
Metallurgical grade	22,231	20,657 <sup>r</sup>	18,209 <sup>r</sup>	15,161 <sup>r</sup>	19,500 <sup>e</sup>
Total	63,604	65,526 <sup>r</sup>	63,241 <sup>r</sup>	43,964 <sup>r</sup>	64,100 <sup>e</sup>
China: <sup>e</sup>					
Acid grade	1,800,000	1,850,000	1,900,000	1,600,000	1,900,000
Metallurgical grade <sup>5</sup>	1,300,000	1,350,000	1,350,000	1,300,000	1,400,000
Total	3,100,000	3,200,000	3,250,000	2,900,000	3,300,000
Egypt	550 <sup>e</sup>	11,588 <sup>r</sup>	9,115 <sup>r</sup>	4,343 <sup>r</sup>	5,000
France: <sup>e,6</sup>					
Acid and ceramic grades	35,000	--	--	--	--
Metallurgical grade	5,000	--	--	--	--
Total	40,000	--	--	--	--
Germany, acid grade	53,009	54,359	48,519	49,962 <sup>r</sup>	50,000 <sup>e</sup>
India: <sup>e,7</sup>					
Acid grade	500	1,000	1,500	1,600	1,800
Metallurgical grade	5,800	5,000	5,500	5,600	5,800
Total	6,300	6,000	7,000	7,200	7,600
Iran <sup>8</sup>	65,000	68,192	65,000 <sup>e</sup>	65,000 <sup>e</sup>	65,000 <sup>e</sup>
Italy <sup>6</sup>	8,000	--	--	--	--
Kazakhstan <sup>c</sup>	30,000	64,000 <sup>9</sup>	66,300	67,000	67,000
Kenya, acid grade	83,428	82,000	98,248	15,667	44,500
Kyrgyzstan <sup>c</sup>	4,000	4,000	4,000	4,000	4,000
Mexico: <sup>10</sup>					
Acid grade	466,000	513,000 <sup>e</sup>	591,955 <sup>r</sup>	640,676 <sup>r</sup>	640,000 <sup>e</sup>
Metallurgical grade	470,000	420,000 <sup>e</sup>	465,694 <sup>r</sup>	405,264 <sup>r</sup>	430,000 <sup>e</sup>
Total	936,000	933,000 <sup>e</sup>	1,057,649 <sup>r</sup>	1,050,000 <sup>r</sup>	1,070,000 <sup>e</sup>

See footnotes at end of table.

TABLE 9—Continued  
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY<sup>1,2</sup>

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<sup>5</sup>Includes submetallurgical-grade fluorspar used primarily in cement that may account for 33% to 50% of the quantity.

<sup>6</sup>Mine closed in 2006.

<sup>7</sup>Year beginning April 1 of that stated.

<sup>8</sup>Year beginning March 21 of that stated.

Organization.

<sup>9</sup>Reported figure.

<sup>10</sup>Data are reported by Servicio Geológico Mexicano, quantities by grade may be estimated.

<sup>11</sup>Data are reported by Mineral Resource Authority of Mongolia.

<sup>12</sup>Flotation concentrate, including less than 97% CaF<sub>2</sub> material.

<sup>13</sup>Data were in wet tons, but have been converted to dry tons to agree with other data in table.

<sup>14</sup>Data for 2006–09 based on data from the South African Minerals Bureau; data show estimated proportions of acid-grade and metallurgical-grade fluorspar within the reported totals.

<sup>15</sup>USGS inferred estimate based on 2006 to 2009 series.

<sup>16</sup>Data for 2006–09 are reported by British Geological Survey.