



# 2009 Minerals Yearbook

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FLUORSPAR [ADVANCE RELEASE]

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# FLUORSPAR

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In 2009, 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. Fluor spar consumption decreased significantly in 2009 as a result of the continuing effects of the major economic downturn that began in late 2007 and extended through at least the first half of 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 decreased significantly compared with that of 2008 (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 acid spar), 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 2009, small amounts of byproduct fluor spar were produced in Illinois. There is no U.S. Geological Survey (USGS) data survey for synthetic fluor spar. 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 2009, 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 64,800 metric tons (t) (100% basis  $\text{H}_2\text{SiF}_6$ ), and quantities sold or used totaled 64,700 t (equivalent to approximately 114,000 t of fluor spar grading 92%  $\text{CaF}_2$ ) valued at about \$10.6 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 continued development work on the Klondike II Mine project in Livingston County, KY. Construction of the tailings pond was completed, and work began on opening access to the vein ore body. The vein is about 7.6 meters (m) (25 feet) wide and extends for 1,220 m (4,000 feet) at a depth of about 61 m (200 feet), which was expected to allow relatively easy access by driving a decline into the ore body. It was expected that the ore body would be reached by late summer 2010 and that fluor spar production would begin by yearend or in early 2011. Output from the mine would be sent to Hastie's flotation mill near Salem in Crittenden County, KY. Hastie also has leased the mineral rights to an additional 486 hectares (1,200 acres) south of U.S. 60 in Livingston County between Burna and Salem (Crittenden Press, The, 2010; Boyce Moody, III, Moody Minerals Co., oral commun., March 5, 2010).

## Environment

As a result of accidental releases of HF at three U.S. refineries in Illinois, Pennsylvania, and Texas, the United Steelworkers union (USW) has called for the phaseout of HF used in petroleum alkylation units at refineries. The USW (the largest industrial union in North America) planned to discuss alternatives to HF with the refining industry, and, if necessary, would work through the regulatory agencies and Congress to get the issue resolved. One-third of refineries use HF as an alkylation catalyst, while the other two-thirds use sulfuric acid, which is less dangerous because of its much lower vapor pressure. The USW also stated that it planned to work with local and national environmental groups to end the use of HF in alkylation (PR Newswire, 2009). Petroleum alkylation accounted for 14% of HF consumption in the United States in 2008 (Will, 2009, p. 85).

## Consumption

Domestic consumption data were developed by the USGS from a quarterly consumption 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). Quarterly data were received from all six respondents, and these responses 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 decreased by 21% in 2009 compared with that of 2008 (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 fluor spar, which accounted for 95% of the total U.S. fluor spar consumption, was used primarily as a feedstock in the manufacture of HF. Two companies reported fluor spar consumption for the production of HF in 2009, E.I. du Pont de Nemours & Co. Inc. (DuPont) and Honeywell International Inc. Fluor spar consumption for HF production decreased substantially compared with that of 2008. Since most acid-grade fluor spar is converted to HF before consumption, it is necessary to discuss HF uses and markets in order to properly analyze fluor spar consumption.

The leading use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), fluor elastomers, 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 fluor spar 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 fluor spar 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 fluor spar 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 merchant fluor spar 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 fluor spar sales cannot be shown because consumption of acid-grade fluor spar for HF production has been combined with other uses in table

2 to prevent disclosure of company proprietary data. In 2009, merchant sales (excluding acid-grade for other uses) decreased by 40% compared with those of 2008. During the past 20 to 30 years, fluor spar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

As a result of the recession, operating rates of U.S. steel mills decreased dramatically beginning in late 2008. In December 2008, raw steel capacity utilization dropped to 41%—its lowest point during the recession. It averaged less than 44% through the first 6 months of 2009, and it slowly increased during the second half of the year but still only averaged 62% in the fourth quarter (Fenton, 2009; 2010). In the United States, consumption of fluor spar in metallurgical markets (mainly steel) decreased by 44% compared with that of 2008. Consumption in this sector was 66% metallurgical grade and 34% acid grade. This large decrease parallels the decrease in U.S. raw steel production of 37%, from 91.9 million metric tons (Mt) in 2008 to 58.2 Mt in 2009 (M.D. Fenton, U.S. Geological Survey, written commun., April 16, 2010).

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 2009, byproduct FSA sold for water fluoridation was about 59,800 t valued at \$9.28 million, and about 4,900 t valued at \$1.3 million was sold or used for other uses.

## Stocks

Data for stocks were available from some fluor spar distributors and HF and  $\text{AlF}_3$  producers. Known consumer and distributor stocks at the end of 2009 totaled about 103,000 t. This represented a 10% decrease in known consumer and distributor stocks from the end of the previous year. The last sales from the National Defense Stockpile were made in 2006, and Government stocks of fluor spar were zero.

## Transportation

The United States depends on imports for the majority of its fluor spar supply. Metallurgical-grade fluor spar 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 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.

Ocean freight rates were extremely low at the beginning of 2009, but did increase somewhat during the year. Peak rates

in 2009, however, were still dramatically lower than the peak reached in the summer 2008. In January, the Baltic dry index (BDI) was well under 1,000, but edged up to about 3,000 by yearend (Stockcharts.com, 2010). The BDI tracks worldwide international shipping prices of handymax, panamax, and capesize dry bulk carriers.

## Prices

In 2009, as a result of the sharp downturn in world demand for fluorspar, Chinese fluorspar prices decreased dramatically from their peak import price of \$550 per metric ton in late 2008. According to published prices (Industrial Minerals, 2008; 2009), the 2009 yearend price range for Chinese acid-grade fluorspar (including cost, insurance, and freight at U.S. Gulf of Mexico ports, dry basis) had decreased by \$175 per metric ton compared with that of yearend 2008. Prices of Mexican and South African acid grade did not change as dramatically because of shifts in purchase patterns and variations in product quality. For example, in 2009, the United States purchased more acid-grade fluorspar from Mexico, which helped stabilize its price in about the same range as it had been in 2008. However, the average range for low-arsenic Mexican acid grade, free on board (f.o.b.) Tampico, decreased by \$80 per metric ton. The average price range of acid grade from South Africa, f.o.b. Durban, actually increased slightly, but this was primarily the result of the elimination of lower quality exports that sold at reduced prices. Adding some stability to prices was the closure of some fluorspar producers in Africa, which to some degree helped bring supply in balance with the reduced demand. Prices for metallurgical-grade fluorspar listed in table 3 were calculated from fourth-quarter statistics from the U.S. Census Bureau.

## Foreign Trade

The European Union, Mexico, and the United States requested World Trade Organization (WTO) dispute settlement consultations with China regarding China's export restraints on numerous important raw materials including fluorspar. China is a leading global producer of these raw materials, and the dispute concerned China's policy that provided substantial competitive advantages for the Chinese industries using these raw material inputs to produce numerous downstream products in the steel, aluminum, and chemical sectors. Specific to fluorspar, China imposes quantitative restrictions in the form of export quotas, export license fees, and export taxes and has abolished value-added tax export rebates. Article XI:1 of the General Agreement on Tariffs and Trade states that "No prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licences [sic] or other measures, shall be instituted or maintained . . . on the exportation or sale for export of any product destined for the territory of any other contracting party." In addition, China's WTO Accession Protocol contained broad commitments not to restrict the right to export goods. As part of its WTO accession, China committed to eliminate export duties for all products other than those listed in a specific annex. Further, China committed to limit any export duties on the listed products to specified levels. The export duties being challenged were on

products not listed in the annex or are imposed at rates that exceed the annex limits (Office of the United States Trade Representative, 2009).

The three petitioners held two rounds of dispute settlement consultations with China but failed to resolve the problem. Subsequently, each country requested that the WTO convene a dispute settlement panel to investigate and rule on the export restrictions. After China rejected the requests to establish the panel, the Dispute Management Body of the WTO established a single panel to examine the complaints (Chinadaily.com.cn, 2009; Gerson Lehrman Group, 2009; World Trade Organization, 2009).

In 2009, U.S. exports of fluorspar totaled 14,100 t, which was a decrease of 25% compared with those of 2008 (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 (56%), Taiwan (28%), and Mexico (16%).

In 2009, imports for consumption of fluorspar decreased by 17% compared with those of 2008 (table 5). The leading suppliers of fluorspar to the United States were Mexico (67%), China (14%), South Africa (13%), and Mongolia (6%).

In 2009, responding to higher prices and reduced supply, U.S. consumers of acid-grade fluorspar continued to reduce purchases from China and replace them with increased purchases from Mexico and South Africa. This continued a trend that began in 2007. Mexico accounted for 62% of acidspars imports (50% in 2008, 41% in 2007); China, 16% (37% in 2008, 48% in 2007); and South Africa, 15% (11% in 2008, 7% in 2007).

Compared with those of 2008, imports of HF decreased by 14% to 114,000 t (table 6), imports of cryolite ( $\text{Na}_3\text{AlF}_6$ ) decreased by 63% to 2,830 t (table 7), and imports of  $\text{AlF}_3$  decreased by 61% to 18,700 t. The majority of HF imports were from Mexico (86%), with Canada and China supplying most of the balance. In 2009, the bulk of  $\text{AlF}_3$  imports were from China (55%) and Canada (37%), with a small but significant amount from a newly opened  $\text{AlF}_3$  plant in Mexico (More information can be found under World Review).

## World Review

World fluorspar production decreased by about 9% compared with that of 2008. Much of the decrease was in the major exporting countries—China, Kenya, Namibia, and South Africa.

**Canada.**—Rivera Capital Corp. (North Vancouver, British Columbia) and Burin Fluorspar Ltd. (Alberta) announced that shareholders of both companies voted unanimously in favor of combining the two companies. The companies amalgamated, effective April 15, 2009, and began operating under the name Canada Fluorspar Inc. (Trading Markets.com, 2009).

Canada Fluorspar continued with plans to reopen the St. Lawrence Fluorspar Mine in Newfoundland. A significant development was the company's announcement of the completion of its NI 43-101 compliant technical report on the St. Lawrence property. According to the report, drilling was completed on two separate, identifiable vein resources, each of which had the potential to become a separate mine. The Blue Beach vein contained approximately 4.4 million Mt of

indicated mineral resources at an average grade of 39.0% CaF<sub>2</sub>. In addition, Blue Beach north vein contained approximately 355,000 t of inferred mineral resources at an average grade of 30.0% CaF<sub>2</sub>. The Tarefare vein (and the associated Blowout vein) contained approximately 4.7 Mt of indicated mineral resources at an average grade of 44.8% CaF<sub>2</sub>. The Blowout vein contained an additional 600,000 t of inferred mineral resources at an average grade of 31.8% CaF<sub>2</sub>. Using a cutoff grade of 20% CaF<sub>2</sub> and minimum horizontal thickness of 2 m, the mineral resources of the St. Lawrence property totaled about 9.1 Mt of indicated mineral resources at an average grade of 42.0% CaF<sub>2</sub> and 950,000 t of inferred mineral resources at an average grade of 31.0% CaF<sub>2</sub> (CNW Group, 2009).

**China.**—At the same time as the WTO was investigating complaints against China's fluor spar export restrictions, China announced plans to restrict future production of fluor spar. Citing concerns over decreasing reserves and environmental pollution, Chinese authorities have been rejecting new exploration and production licenses for fluor spar. Additional actions included increasing the resource tax for fluor spar production to 15% and, as with many other industries, the Government was continuing its efforts to close down small and inefficient producers. Finally, the Chinese Government had reportedly abolished the export quota for fluor spar for 2010, since little or no bidding for quota volumes had taken place (Globe Metals & Mining, 2010; Russell, 2010).

**Kenya.**—Kenya Fluor spar Company Ltd. (KFC) ceased production from its fluor spar mine in the Kerio Valley. Demand for the company's acid-grade fluor spar had dropped by more than 70% compared with that of 2008, when the company exported 106,000 t of fluor spar to its customers in Asia and Europe. KFC had accumulated stocks of more than 15,000 t at its flotation plant at the time of the shutdown in March. The closure had a severe impact on the local economy since KFC employed 500 workers directly and was the most important economic enterprise in the district (Bii, 2009).

**Mexico.**—Despite the global economic downturn, Mexico's fluor spar production increased slightly compared with that of 2008. Exports of acid-grade fluor spar were 361,000 t or nearly the same level as in 2008. Metallurgical-grade fluor spar exports, however, decreased by about 37% to 244,000 t reflecting the large decrease in world steel output.

As part of its expansion into downstream, higher-value products, Mexico's leading fluor spar producer, Mexichem S.A.B. de C.V., opened an AlF<sub>3</sub> plant in Matamoros, Tamaulipas. The 60,000-metric-ton-per-year plant will operate as part of the Mexichem Fluor division of Mexichem and was expected to primarily supply export markets (Mexichem S.A.B. de C.V., 2009). Indicative of this increase in exports, Mexico's exports of AlF<sub>3</sub> to the United States increased to 1,460 t in 2009 from 1 t in 2008 to (table 8).

In August, Mexico joined the United States and the European Union when it also filed a complaint with the WTO over China's export restrictions. The complaint requested formal WTO consultations; China had 30 days to respond to Mexico's request for trade consultations; otherwise, Mexico could request an arbitration panel (Kiernan, 2009).

**Mongolia.**—Lotus Resources plc (London, United Kingdom) signed four joint-venture agreements with partners in Mongolia for the exploration and development of fluor spar deposits. The agreements included the formation of Lotus Dai Uul LLC and Lotus Ambuulan LLC. Lotus Dai Uul began sales of metallurgical-grade fluor spar through MGB Mining LLC (Mongolia) to customers in Russia, and the mining license in Dornogobi Province was successfully transferred to Lotus Ambuulan in July. After approval of an environmental assessment and mining plan, open pit mining was expected to begin almost immediately (Lotus Resources plc, 2009).

**Namibia.**—Okorusu Fluor spar (Pty.) Ltd. (Namibia) suspended fluor spar production for several months from August until late fall in order to draw down excessive stocks that accumulated owing to a decrease in sales of approximately 50% compared with those of 2008. Okorusu produced acid-grade fluor spar for its parent company Solvay S.A. (Belgium), which used it to produce HF at its plants in Germany and Italy. Solvay's 2009 fluor spar requirements from Okorusu were projected to be only about 56,000 t of fluor spar compared with a recent year figure of 109,000 t (Kaira, 2009; O'Driscoll, 2009).

**South Africa.**—South African fluor spar producer Sallies Ltd. (Pretoria), which mothballed its Buffalo Mine in the fourth quarter of 2008, was forced to suspend mining at its primary fluor spar mine—Witkop Fluor spar Mine (Pty.) Ltd.—owing to the dramatic decrease in demand for acid-grade fluor spar. The mine was mothballed in June when the company was unable to secure future orders from its customers. According to the company, the mine had already produced sufficient fluor spar to meet its contractual obligations through yearend 2009 (Miningreview.com, 2009).

A decision was handed down in the supply contract dispute between Sallies and Honeywell International (Morristown, NJ) that dates to 2006. The International Chamber of Commerce International Court of Arbitration in Switzerland ruled that fluor spar producer Sallies had to pay R11.5 million (\$1.24 million) plus interest to Honeywell. The amount awarded was significantly lower than either the R65 million originally claimed by Honeywell or the R42 million claimed by Sallies in its countersuit (Schumacher, 2009). Subsequent to the decision, Sallies requested that the Federal Supreme Court of Switzerland review the Court of Arbitration's finding against it. As part of its request, Sallies asked the Swiss Supreme Court to instruct the Court of Arbitration to reject Honeywell's claim and to approve Sallies counterclaim (Creamer, 2009).

Sephaku Holdings Ltd. (South Africa) completed a definitive feasibility study on its proposed Nokeng Fluor spar Mine in South Africa's Gauteng Province. The study called for the development of two separate deposits—the Outwash Fan (formerly described as Naauwpoort/Kromdraai) and the Plattekop deposits—both of which are in the vicinity of Vergenoeg Mining Co. (Pty.) Ltd.'s fluor spar mine. The proposed mine complex would include an open pit mine, a 130,000-metric-ton-per-year flotation mill, tailings disposal facility, and associated infrastructure and services. Ore production was scheduled to begin in the spring of 2012 (Swanepoel, 2009). The two deposits have a combined measured resource of 12 Mt, which would be used to feed a

blend of ore to the flotation mill at 32% CaF<sub>2</sub> average feed grade (Mineweb, 2008).

Metorex Ltd. (Johannesburg) announced that it was selling its 55% share in Vergenoeg Mining to Spanish fluor spar producer Minerales y Productos Derivados S.A. (Minersa). Minersa already owned a 30% stake in Vergenoeg, with the remaining 15% owned by Medu Capital, a consortium of Black Economic Empowerment-controlled entities (Metorex Ltd., 2009).

Eurasian Natural Resources Corp. Plc (United Kingdom) agreed to purchase Central African Mining and Exploration Co. (London, United Kingdom), which owned, among other properties, a 51% interest on the South African Doornhoek fluor spar project, which comprises the Doornhoek property and five other farms in the immediate vicinity. Eurasian Natural Resources is the holding company of a leading diversified natural resources group principally based in Kazakhstan (Freat, 2009). Results from a previously completed scoping study on the Doornhoek fluor spar project reported an indicated and inferred resource of about 30 Mt at 20% CaF<sub>2</sub>. This potential was identified by historical drilling and was not compliant with any modern reporting code. The ore grade of the underground ore body is low, but is roughly 40% higher than that of the adjoining idle Witkop Fluorspar Mine (Londonstockexchange.com, 2009).

**Sweden.**—Tertiary Minerals plc (Macclesfield, United Kingdom) continued to evaluate its Storuman fluor spar deposit. Metallurgical testwork on fluor spar samples from the deposit successfully produced a fluor spar concentrate to a specification that would be salable to consumers of acid-grade fluor spar with respect to both chemical and grain-size specifications. This was considered important because previous testwork carried out in the 1970s produced fluor spar with acceptable chemical specifications, but only on samples that were ground to a grain size that was too fine for use in most HF plants (Tertiary Minerals plc, 2009a). Preliminary information from the company's scoping study estimated a potential fluor spar resource of 28 to 31 Mt grading 11.2% to 12.3% CaF<sub>2</sub>. The estimates were based on the incomplete records of 39 drill holes from the 1970s and data from 10 confirmation drill holes completed in 2008 by Tertiary Minerals, mostly within the same area (Tertiary Minerals plc, 2009b).

## Outlook

In the short term, the demand for fluor spar in the United States (and other countries whose economies were severely affected by the global economic downturn) depends on how quickly the world economy recovers. Consumption in China and India was expected to continue to increase although at a slightly slower pace than before the economic downturn.

Long-term demand for fluor spar may depend to a large degree on the competition for the future refrigeration market between fluorochemical and not-in-kind systems (ammonia, carbon dioxide, hydrocarbons, and so forth). Fluorocarbons developed to replace ozone-depleting CFCs have high global warming potential (GWP) and are being targeted for phaseout as part of an international response to climate change. Faced with the pending phaseout of HFC-134a in automotive air-conditioning systems in the European Union, fluorochemical producers

Du Pont and Honeywell developed a likely new drop-in replacement with low GWP—hydrofluoroolefin HFO-1234yf. Another compound, HFO-1234ze, is being tested as a replacement in aerosols, foam blowing, and refrigeration. These two compounds each have low GWP and rapidly break down in the atmosphere.

Development of new fluor spar mine projects or work on reopening long-idle mines has been slowed by the global economic downturn, which resulted in both decreased demand for fluor spar and reduced availability of project funding. With China continuing to reduce its fluor spar exports, long-term supplies of fluor spar are expected to come from countries such as Mexico, Mongolia, and South Africa, all of which have large fluor spar resources that provide the potential for development of multiple new mining operations or the expansion of existing operations. Additional material will likely be supplied by other countries with smaller resources, but with single mine projects underway such as in Canada, Sweden, the United States, and Vietnam.

Major markets for fluor spar 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 capacity in China and the reduced capacities in traditional production areas in Europe, Japan, and North America. China is already the world's leading fluor spar consumer and its share of global consumption will likely continue to increase in the future. China still possesses large fluor spar resources, but it is conceivable that China may find it necessary or expedient to become a net importer of fluor spar in the not too distant future.

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

		2005	2006	2007	2008	2009
United States:						
Exports: <sup>3</sup>						
Quantity	metric tons	36,100	13,000	13,600	18,800	14,100
Value <sup>4</sup>	thousands	\$7,840	\$2,430	\$2,650	\$3,340	\$2,230
Imports: <sup>3</sup>						
Quantity	metric tons	629,000	553,000	620,000	572,000	475,000
Value <sup>5</sup>	thousands	\$122,000	\$112,000	\$111,000	\$133,000	\$105,000
Average value: <sup>5</sup>						
Acid grade	dollars per metric ton	202	217	(6)	(6)	(6)
Metallurgical grade	do.	93	101	111	107	109
Consumption:						
Reported	metric tons	582,000	523,000	539,000	506,000	400,000
Apparent <sup>7</sup>	do.	616,000	607,000 <sup>r</sup>	613,000	529,000	473,000
Stocks, December 31:						
Consumer and distributor	do.	131,000 <sup>8</sup>	89,900 <sup>8</sup>	90,100	115,000	103,000
Government stockpile	do.	35,200	8,110	1,450	--	--
World, production	do.	5,360,000 <sup>r</sup>	5,660,000 <sup>r</sup>	5,720,000 <sup>r</sup>	5,990,000 <sup>r</sup>	5,460,000 <sup>e</sup>

<sup>e</sup>Estimated <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; 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.

<sup>6</sup>Value data for acid-grade fluor spar imports appear to be underreported; accurate average value calculations cannot be made.

<sup>7</sup>Imports minus exports plus adjustments for changes in stocks held by Government and three leading consumers.

<sup>8</sup>Includes fluor spar 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	
	2008	2009	2008	2009	2008	2009
Hydrofluoric acid and aluminum fluoride	429,000	W	--	--	429,000	W
Metallurgical	14,900	9,390	33,800	17,900	48,700	27,200
Other <sup>2</sup>	28,700	371,000	--	2,030	28,700	373,000
Total	472,000	380,000	33,800	19,900	506,000	400,000
Stocks, consumer, December 31	94,300	87,200	20,500	15,600	115,000	103,000

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 (2009).

TABLE 3  
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source and grade	2008	2009
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	530–550	350–380
Mexican, free on board (f.o.b.) Tampico, filtercake	250–325	260–290
Mexican, f.o.b. Tampico, arsenic <5 parts per million	400–420	300–360
South African, f.o.b. Durban, filtercake	250	250–300
Metspar, Mexican, c.i.f. port of U.S. entry, metspar <sup>1</sup>	108	97

<sup>1</sup>Metspar prices are the average value per metric ton of imported Mexican metspar for the fourth quarter calculated from the U.S. Census Bureau statistics.

Sources: Industrial Minerals, no. 495, December 2008, p. 88; no. 507, December 2009, p. 68.

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

Country	2008		2009	
	Quantity (metric tons)	Value <sup>2</sup>	Quantity (metric tons)	Value <sup>2</sup>
Australia	15	\$7,200	6	\$3,840
Brazil	22	3,120	--	--
Canada	4,870	1,270,000	7,900	1,260,000
China	4,280	621,000	--	--
Dominican Republic	524	95,000	--	--
India	24	7,000	--	--
Indonesia	5	2,860	--	--
Israel	15	4,500	--	--
Korea, Republic of	72	18,000	--	--
Malaysia	15	9,630	6	3,660
Mexico	29	3,200	2,320	394,000
Netherlands	30	4,400	--	--
Philippines	161	18,000	--	--
Taiwan	8,780	1,280,000	3,890	564,000
Total	18,800	3,340,000	14,100	2,230,000

-- 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	2008		2009	
	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:				
Cleveland, OH	3,720	\$1,540	--	--
Great Falls, MT	6	15	319	\$38
Houston, TX	117,000	39,100	45,100	15,000
Los Angeles, CA	--	--	103	13
New Orleans, LA	63,200	26,400	21,600	9,210
Seattle, WA	--	--	234	31
Total	184,000	67,100	67,300	24,300
Germany, Savannah, GA	133	17	--	--
Mexico:				
Baltimore, MD	--	--	536	241
Laredo, TX	74,100	18,600	42,100	12,900
New Orleans, LA	175,000	23,400	217,000	33,100
Total	249,000	42,000	260,000	46,200
Mongolia:				
Houston, TX	--	--	28,600	8,590
New Orleans, LA	5,500	2,100	--	--
Total	5,500	2,100	28,600	8,590
Russia, Philadelphia, PA	1	7	--	--
South Africa:				
Great Falls, MT	258	106	--	--
Houston, TX	51,100	12,000	38,800	11,800
New Orleans, LA	5,360	1,960	22,000	7,300
Total	56,700	14,100	60,800	19,100
United Kingdom:				
Houston, TX	55	51	130	17
Los Angeles, CA	588	69	446	52
Total	643	120	576	70
Grand total	496,000	125,000	417,000	98,300
<b>Containing not more than 97% CaF<sub>2</sub>:</b>				
Mexico:				
Cleveland, OH	--	--	1	5
Laredo, TX	5,100	522	4,430	448
New Orleans, LA	70,100	7,510	52,900	5,810
Total	75,200	8,040	57,300	6,260
Namibia:				
Charleston, SC	283	26	--	--
Houston, TX	519	45	203	24
Total	802	71	203	24
Grand total	76,000	8,110	57,500	6,290
Grand total, all grades	572,000	133,000	475,000	105,000

-- 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; 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	2008		2009	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Canada	23,900	\$48,400	11,000	\$39,500
China	1,690	2,430	4,110	4,270
France	(3)	2	--	--
Germany	562	1,420	404	1,250
Hong Kong	--	--	33	39
India	71	142	120	164
Japan	1,240	2,520	559	1,180
Liechtenstein	1	90	--	--
Lithuania	--	--	(3)	9
Mexico	105,000	117,000	97,600	114,000
Singapore	79	209	64	211
South Africa	--	--	13	22
Spain	--	--	(3)	3
Switzerland	--	--	(3)	2
Taiwan	34	133	49	134
United Kingdom	(3)	5	(3)	3
Total	133,000	172,000	114,000	161,000

-- 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	2008		2009	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Canada	398	\$118	5	\$14
China	1,590	1,460	498	357
Denmark	450	416	151	288
Germany	2,280	2,440	878	1,330
Hungary	345	382	250	346
India	1	9	--	--
Japan	2,450	3,200	860	1,070
Mexico	--	--	81	30
Turkey	20	4	--	--
United Kingdom	120	160	103	195
Other	-- <sup>r</sup>	-- <sup>r</sup>	--	--
Total	7,650	8,180	2,830	3,630

<sup>r</sup>Revised. -- 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	2008		2009	
	Quantity (metric tons)	Value <sup>2</sup> (thousands)	Quantity (metric tons)	Value <sup>2</sup> (thousands)
Canada	15,400	\$21,100	6,950	\$11,000
China	28,900	44,500	10,200	14,500
Italy	102	149	--	--
Japan	65	201	( <sup>3</sup> )	4
Mexico	1	9	1,460	1,280
Other <sup>4</sup>	3,100	3,400	45	95
Total	47,600	69,400	18,700	26,800

-- 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.

<sup>4</sup>Includes Brazil (2008), Germany, India (2009), the Netherlands (2009), Sweden, Switzerland (2008), and the United Kingdom (2008).

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>	2005	2006	2007	2008	2009 <sup>e</sup>
Argentina	7,502	8,278	9,735	15,098 <sup>r</sup>	15,000
Brazil, marketable:					
Acid grade	42,043	41,373	44,869	45,342 <sup>r</sup>	44,559
Metallurgical grade	24,469	22,231	20,582 <sup>r</sup>	19,014 <sup>r</sup>	19,500 <sup>p</sup>
Total	66,512	63,604	65,451 <sup>r</sup>	64,356 <sup>r</sup>	64,059
China: <sup>e</sup>					
Acid grade	1,650,000	1,800,000	1,850,000	1,900,000	1,600,000
Metallurgical grade <sup>5</sup>	1,150,000	1,300,000	1,350,000	1,350,000	1,300,000
Total	2,800,000	3,100,000	3,200,000	3,250,000	2,900,000
Egypt	549	550 <sup>e</sup>	1,080 <sup>r</sup>	470 <sup>r</sup>	500
France: <sup>e,6</sup>					
Acid and ceramic grades	80,000	35,000	--	--	--
Metallurgical grade	10,000	5,000	--	--	--
Total	90,000	40,000	--	--	--
Germany, acid grade	35,364	53,009	54,359	48,519 <sup>r</sup>	45,000
India: <sup>e,7</sup>					
Acid grade	4,400	500	1,000	1,500	1,600
Metallurgical grade	6,500	5,800	5,000	5,500	5,600
Total	10,900	6,300	6,000	7,000	7,200
Iran <sup>8</sup>	64,601	65,000	68,192 <sup>r</sup>	65,000 <sup>e</sup>	65,000
Italy <sup>6</sup>	15,000	8,000	--	--	--
Kazakhstan <sup>e</sup>	4,750 <sup>9</sup>	30,000	64,000 <sup>9</sup>	66,300	67,000
Kenya, acid grade	97,261	83,428	82,000	98,248	15,667
Korea, North, metallurgical grade <sup>e</sup>	-- <sup>r</sup>	-- <sup>r</sup>	-- <sup>r</sup>	-- <sup>r</sup>	--
Kyrgyzstan <sup>e</sup>	4,000	4,000	4,000	4,000	4,000
Mexico: <sup>e,10</sup>					
Acid grade	324,568 <sup>9</sup>	466,000 <sup>9</sup>	513,000	630,000	630,000
Metallurgical grade	550,882 <sup>9</sup>	470,000 <sup>9</sup>	420,000	428,000	410,000
Total	875,450 <sup>9</sup>	936,000 <sup>9</sup>	933,000	1,060,000	1,040,000
Mongolia: <sup>11</sup>					
Acid grade <sup>12</sup>	93,700 <sup>r</sup>	108,300 <sup>r</sup>	109,900	115,700	115,300
Other grades	233,400	239,400 <sup>r</sup>	245,000 <sup>r</sup>	219,100 <sup>r</sup>	344,200
Total	327,100 <sup>r</sup>	347,700 <sup>r</sup>	354,900 <sup>r</sup>	334,800 <sup>r</sup>	459,500
Morocco, acid grade	114,740	94,254	78,900	60,700	75,000
Namibia, acid grade <sup>13</sup>	105,700	121,700	109,300 <sup>r</sup>	108,800 <sup>r</sup>	73,580
Pakistan, metallurgical grade <sup>e</sup>	1,040	2,839 <sup>9</sup>	1,500	1,400	1,300
Romania, metallurgical grade <sup>e</sup>	15,000	15,000	15,000	15,000	15,000
Russia <sup>e</sup>	245,500 <sup>9</sup>	210,000	180,000	269,000	240,000
South Africa: <sup>e,14</sup>					
Acid grade	250,000	240,000	268,000	281,000 <sup>r</sup>	196,000
Metallurgical grade	16,000	16,000	17,000	18,000 <sup>r</sup>	8,000
Total	266,000	256,000	285,000	299,000 <sup>r</sup>	204,000
Spain:					
Acid grade	133,495	135,864	132,753	133,000	125,000
Metallurgical grade	10,500	17,241	16,279	16,300	15,000
Total	143,995	153,105	149,032	149,300	140,000
Tajikistan <sup>e</sup>	8,500	8,500	8,500	8,500	8,500
Thailand, metallurgical grade	295	3,240	1,820	29,529 <sup>r</sup>	3,000
United Kingdom <sup>15</sup>	56,417 <sup>r</sup>	49,676 <sup>r</sup>	44,936 <sup>r</sup>	36,801 <sup>r</sup>	18,536
Grand total	5,360,000 <sup>r</sup>	5,660,000 <sup>r</sup>	5,720,000 <sup>r</sup>	5,990,000 <sup>r</sup>	5,460,000

See footnotes at end of table.

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

<sup>0</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Table includes data available through May 25, 2010.

<sup>3</sup>In addition to the countries listed, Bulgaria is thought to have produced fluorspar in the past, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.

<sup>4</sup>An effort has been made to subdivide production of all countries by grade (acid, ceramic, and metallurgical). Where this information is not available in official reports of the subject country, the data have been entered without qualifying notes.

<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. Data for 2005 is reported by Iranian Mines and Mining Development and Renovation 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>Based on data from the South African Minerals Bureau; data show estimated proportions of acid-, ceramic-, and metallurgical-grade fluorspar within the reported totals.

<sup>15</sup>Data are reported by British Geological Survey.