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2008 Minerals Yearbook

SILICA [ADVANCE RELEASE]

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SILICA

By Thomas P. Dolley

Domestic survey data and tables were prepared by Marc A. Angulo, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Four silica categories are covered in this report—industrial sand and gravel, quartz crystal (a form of crystalline silica), special silica stone products, and tripoli. Most of the stone covered in the special silica stone products section is novaculite. The section on tripoli includes tripoli and other fine-grained, porous silica materials, such as rottenstone, that have similar properties and end uses. Certain silica and silicate materials, such as diatomite and pumice, are covered in other chapters of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals. Trade data in this report are from the U.S. Census Bureau. All percentages were computed using unrounded data.

Industrial Sand and Gravel

Total industrial sand and gravel production increased marginally to 30.4 million metric tons (Mt) in 2008 (table 1). Compared with that of 2007, the increase in industrial sand production was negligible. Industrial gravel production increased by 9%, although industrial gravel was only 3.6% of the total.

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands and gravels with high silicon dioxide (SiO_2) content. Some examples of end uses for these sands and gravels are in glassmaking and for abrasives, filtration, foundry, hydraulic fracturing (frac), and silicon metal applications. The specifications for each use vary, but silica resources for most uses are abundant. In almost all cases, silica mining uses open pit or dredging methods with standard mining equipment. Except for temporarily disturbing the immediate area while operations are active, sand and gravel mining usually has limited environmental impact.

The marginal production increase for silica sand in 2008 followed slightly increased demand for uses such as abrasives, chemicals (ground and unground), hydraulic fracturing (frac sand), and roofing granules. Production of the remaining end uses for silica sand in 2008 either remained static or declined slightly, when compared to the previous year. Demand for silica gravel was predominantly for filtration.

Legislation and Government Programs.—Effective January 24, 2008, the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), announced a new National Emphasis Program to target worksites where employees are at risk for silicosis. Other elements included in the directive are an evaluation procedure for recording reductions of employee exposures to silica, as well as information on outreach programs, partnerships and alliances with employers to share resources, and training to reduce employee exposure (U.S. Department of Labor, Occupational Safety and Health Administration, 2008, p. 10).

One of the most important issues affecting the industrial minerals industry in recent years has been the potential effect of crystalline silica on human health. Central to the ongoing and often heated debate has been the understanding of the regulations and the implementation of the measurements and actions taken to mitigate exposure to crystalline silica and, most significantly, appreciation of its impact on the future of many industries (Industrial Minerals, 1998). OSHA created a permissible exposure limit that stipulates the maximum amount of crystalline silica to which workers may be safely exposed during an 8-hour work shift (29 CFR §§1926.55, 1910.1000). OSHA also established guidelines and training for the proper handling of crystalline silica (U.S. Department of Labor, Occupational Safety and Health Administration, 2002).

Production.—Domestic production data for industrial sand and gravel were developed by the USGS from a voluntary survey of U.S. producers. The USGS canvassed 70 producers with 144 operations known to produce industrial sand and gravel. Of the 144 surveyed operations, 119 (83%) were active, and 25 were idle. The USGS received responses from 115 operations, and their combined production represented 95% of the U.S. total. Production for the 29 nonrespondents was estimated, primarily on the basis of previously reported information supplemented with worker-hours reports from the U.S. Department of Labor's Mine Safety and Health Administration and information from State agencies.

The South (South Atlantic, East South Central, and West South Central divisions) led the Nation with 42% of the 30.4 Mt of industrial sand and gravel produced in the United States, followed by the Midwest (East North Central and West North Central divisions) with 44%, and the West (Pacific and Mountain divisions) with 9% (table 2).

The leading producing States were, in decreasing order, Illinois, Texas, Wisconsin, Oklahoma, North Carolina, California, Michigan, and New Jersey (table 3). Their combined production represented 60% of the national total. States for which data have been withheld in table 3 are not included among the leading producers. Of the 35 States that produced silica in 2008, 19 had decreased production, 14 had increased production, and 2 were unchanged, compared with those of 2007. Michigan, Oklahoma, and Wisconsin reported the largest increases, and Arkansas, California, and North Carolina reported the largest decreases.

Of the total industrial sand and gravel produced, 86% was produced by 49 operations, each with production of 200,000 metric tons per year (t/yr) or more (table 4). The 10 leading producers of industrial sand and gravel were, in descending order, Unimin Corp.; U.S. Silica Co.; Carmeuse Lime and Stone; Badger Mining Corp.; Fairmount Minerals, Ltd.; Wisconsin Industrial Sand Co. (a division of Fairmount

Minerals, Ltd.); Sand Products Corp.; Little Six, Inc.; Manley Bros. of Indiana, Inc.; and Kinder Sand Co. Inc. Their combined production represented 81% of the U.S. total.

In February 2008, Carmeuse Lime and Stone, a wholly owned subsidiary of Carmeuse Group, completed its acquisition of Oglebay Norton Industrial Sands, Inc. and all of the latter company's industrial sand and gravel operations.

Consumption.—Industrial sand and gravel production reported by producers to the USGS was material sold to their customers or used by the producing companies. Stockpiled material is not reported until consumed or sold. Of the 30.4 Mt of industrial sand and gravel sold or used, 31% was consumed as glassmaking sand, and 27% as frac sand and sand for well packing and cementing (table 6). Foundry sand consumed 14% of industrial sand and gravel consumption. Other important uses were whole grain fillers and building products (7%), and other whole grain silica (4%).

Minable deposits of industrial sand and gravel occur throughout the United States, and successful mining companies are located near markets that have traditionally been in the Eastern United States. In some cases, consuming industries are specifically located near a silica resource. The automotive industry was originally located in the Midwest near clay, coal, iron, and silica resources. Therefore, foundry sands have been widely produced in Illinois, Indiana, Michigan, Ohio, and other Midwestern States. In 2008, at least 78% of foundry sand was produced in the Midwest.

Producers of industrial sand and gravel were asked to provide statistics on the destination of silica produced at their operations. The producers were asked to list only the quantity of shipments (no value data were collected in this section of the questionnaire) and to which State or other location the material was shipped for consumption. The States that received the most industrial sand and gravel were Texas (15.1%), Colorado (4.8%), Wisconsin (4.5%), Illinois (4.4%), Oklahoma (3.2%), and Indiana (3%). Producers reported sending at least 467,000 t of silica to Canada and 357,000 t to Mexico (table 7). Because some producers did not provide this information, their data were estimated or assigned to the "Destination unknown" category. In 2008, 18% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking as a percentage of all silica sold decreased compared with that of 2007. In 2008, sales to container glass manufacturers decreased slightly compared with those of 2007. On average, in the container glassmaking industry, silica accounts for 60% of raw materials used (Industrial Minerals, 2004). The amount of unground silica sand consumed for fiberglass production decreased by 17% compared with that of 2007.

In 2008, sales of sand for flat glass production decreased by 7% compared with those of 2007. In the Northeast, consumption for flat glass increased slightly, and in the South, consumption decreased by 9%.

Whole grain silica is used in filler-type and building applications. In 2008, consumption of whole-grain fillers for building products was 2.2 Mt, down 12% compared with that of 2007.

In table 6, industrial sand and gravel that would find its way into specialty silicas is most likely reported by the producers in the categories "Sand, abrasives, chemicals, ground and unground," "Gravel, silicon, ferrosilicon," and possibly "Glassmaking, specialty." In 2008, silica sales for chemical production were 826,000 t, which was an increase of about 2% compared with those of 2007. According to the USGS survey, reported sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses, increased by a negligible amount in 2008 compared with those of 2007. The main uses for silicon metal are in the manufacture of silanes and semiconductor-grade silicon and in the production of aluminum alloys.

Transportation.—Of all industrial sand and gravel produced, 52% was transported by truck from the plant to the site of first sale or use, up slightly from that of 2007; 34% was transported by rail, up from that of 2007; and 14% by unspecified modes of transport.

Prices.—Compared with the average value of 2007, the average value, free on board plant, of U.S. industrial sand and gravel increased 11% to $30.81 per metric ton in 2008 (table 6). The average unit values for industrial sand and industrial gravel were $31.02 per ton and $25.24 per ton, respectively. The average price for sand ranged from $9.30 per ton for other whole grain silica to $132.25 per ton for ground foundry sand. For gravel, prices ranged from $19.76 per ton for other uses to $65.08 per ton for filtration applications. Producer prices reported to the USGS for silica commonly ranged from several dollars per ton to hundreds of dollars per ton. Prices occasionally exceeded the $1,000-per-ton level. Nationally, ground sand for foundry molding and core had the highest value ($132.25 per ton), followed by ground sand for scouring cleansers ($121.62), ground sand for ceramics ($96.47 per ton), silica for swimming pool filters ($76.74 per ton), silica for water filtration ($61.37 per ton), ground sand used as fillers for paint, putty, and rubber ($59.42 per ton), ground sand for fiberglass ($51.61), and sand for hydraulic fracturing ($49.44 per ton).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest ($32.92 per ton), followed by the South ($29.94 per ton), the Northeast ($28.90 per ton), and the West ($26.93 per ton) (table 6). Prices can vary greatly for similar grades of silica at different locations in the United States, along with tighter supplies and higher production costs in certain regions of the country. For example, the average value of container glass sand varied from $25.20 per ton in the West to $16.40 per ton in the Midwest.

Foreign Trade.—Exports of industrial sand and gravel in 2008 increased by about 3% compared with the amount exported in 2007 and the associated value increased by 7% (table 8). The increase in exports can be attributed mainly to increased demand from markets in Africa and the Middle East, Asia, and Oceania. Japan was the leading recipient of U.S. exports. The distribution of exports was as follows: 39% to Japan, 33% to Canada, 13% to Mexico, and the remainder to Africa and the Middle East, Europe, Oceania, and South America. The average unit value of exports increased to $84 per ton in 2008 from $80 per ton in 2007. In 2008, export unit

values varied widely by region; exports of silica to Oceania averaged $445 per ton, and exports to the rest of the world averaged $83 per ton.

Imports for consumption of industrial sand and gravel declined to 355,000 t, which was a decrease of 31% compared with those of 2007 (table 9). Canada supplied 69% of the silica imports, which averaged $65 per ton; this price included insurance and freight costs to the U.S. port. The total value of imports was $23.5 million, with an average unit value of $66 per ton. Higher priced imports came from Australia, Chile, China, Germany, and Japan.

World Industry Structure.—Based on information provided mainly by foreign governments, world production of industrial sand and gravel was estimated to be 121 Mt (table 10). The United States was the leading producer followed, in descending order, by Italy, Germany, the United Kingdom, Australia, France, Spain, and Japan. Most countries had some production and consumption of industrial sand and gravel, which are essential to the glass and foundry industries. Because of the great variation in reporting standards, however, obtaining reliable information was difficult. In addition to the countries listed, many other countries were thought to have had some type of silica production and consumption.

Outlook.—U.S. consumption of industrial sand and gravel in 2009 was expected to be 29 to 30 Mt. All forecasts are based on previous performances within various end uses, contingency factors considered relevant to the future of the commodity, and forecasts made by analysts and producers in the various markets.

Sales of glass sand can be expected to vary from market to market. Growth has been noted in some segments, such as abrasives, chemicals (ground and unground), hydraulic fracturing, and roofing granules. Total demand for all glass sand end uses is expected to remain static or possibly exhibit slow growth or decline through 2009. Demand for industrial sand and gravel will also be constrained by the producers' rising energy costs for both production and transportation of product.

The demand for foundry sand is dependent mainly on automobile and light truck production. Production and sales of automobiles and light trucks declined by yearend 2008 and the trend continued into 2009. Another important factor for the future consumption of virgin foundry sand is the recycling of used foundry sand. The level of recycling is thought to be increasing. Other materials or minerals compete with silica as foundry sand, but these other "sands" usually suffer from a severe price disadvantage. Based on these factors, consumption of silica foundry sand in 2009 is expected to be 4 Mt, and consumption is expected to be 4.0 to 4.1 Mt.

Frac sand sales increased in 2008 compared with those of 2007. Part of this increase is a result of an improved USGS survey of frac sand producers. By yearend 2008 and into 2009, frac sand sales had declined. Based on this trend, demand for frac sand is expected to remain static or decline during 2009 to 6 Mt, in the range of 6 to 6.5 Mt.

The United States is the leading producer and a major consumer of silica sand and is self-sufficient in this mined commodity. Most of it is produced at premier deposits in the Midwest and near major markets in the Eastern United States. A significant amount of silica sand is also produced in the West and Southwest, mostly in California and Texas, respectively. Domestic production is expected to continue to meet 97% or 98% of demand well beyond 2009. Imports, mostly from Canada and Mexico and higher valued material from China, are expected to remain minor.

Because the unit price of silica sand is relatively low, except for a few end uses that require a high degree of processing, the location of a silica sand deposit in relation to market location is an important factor that may work for, or against, a sand producer. Consequently, a significant number of relatively small operations supply local markets with a limited number of products.

Several factors could affect supply and demand relations for silica sand. Further increases in the development of substitute materials for glass and cast metals could reduce demand for foundry and glass sand. These substitutes, which are mainly ceramics and polymers, would likely increase the demand for ground silica, which is used as a filler in plastics; glass fibers, which are used in reinforced plastics; and silica (chemical, ground, or whole-grain), which is used to manufacture ceramics. Increased efforts to reduce waste and to increase recycling also could lower the demand for mined glass sand. Recycling of glass cullet is increasing in most industrialized nations and recycling accounts for approximately 25% to 70% of the raw material needed for the glass container industry in many countries. It has been estimated that for every 10% of recycled glass cullet used in the melting process for glass container manufacture, energy use will fall approximately 2.5%. During the past 20 years, a 25% to 40% reduction in glass container weight has taken place in many nations, including the United States (Industrial Minerals, 2004). Although developments could cause the demand for silica sand to decrease, the total value of production will probably increase because of the increased unit value of the more specialized sands.

Health concerns about the use of silica as an abrasive and stricter legislative and regulatory measures concerning crystalline silica exposure could reduce the demand in many silica markets. The use of silica sand in the abrasive blast industry was being evaluated as a health hazard as marketers of competing materials, which include garnet, olivine, and slags, encouraged the use of their "safer" abrasive media. Additionally, abrasive-grade bauxite, the feedstock for brown fused alumina, is finding increasing use in abrasives and proppants; in the latter application, bauxite is used to hold fractures open in oil wells, as is silica sand (Industrial Minerals, 2002).

Quartz Crystal

Electronic-grade quartz crystal, also known as cultured quartz crystal, is single-crystal silica with properties that make it uniquely useful in accurate filters, frequency controls, and timers used in electronic circuits. These devices are used for a variety of electronic applications in aerospace hardware, commercial and military navigational instruments, communications equipment, computers, and consumer goods (for example, clocks, games, television receivers, and toys). Such uses generate practically all the demand for electronic-grade quartz crystal. A lesser amount of optical-grade

quartz crystal is used for lenses and windows in specialized devices, which include some lasers.

Natural quartz crystal was used in most electronic and optical applications until 1971, when it was surpassed by cultured quartz crystal. Cultured quartz is not a mined mineral commodity. Rather, it is synthetically produced from natural feedstock quartz, termed lascas, which is mined. Mining of lascas in the United States ceased in 1997, owing to competition from less expensive imported lascas predominantly from mines in Brazil and Madagascar.

Additionally, it has been estimated that approximately 10 billion quartz crystals and oscillators were manufactured and installed worldwide in all types of electronic devices, from automobiles to cellular telephones in 2006.

The use of natural quartz crystal for carvings and other gemstone applications has continued; more information can be found in the "Gemstones" chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs.—The strategic value of quartz crystal was demonstrated during World War II when it gained widespread use as an essential component of military communication systems. After the war, natural electronic-grade quartz crystal was officially designated as a strategic and critical material for stockpiling by the Federal Government. Cultured quartz crystal, which eventually supplanted natural crystal in nearly all applications, was not commercially available when acquisition of natural quartz crystal for a national stockpile began.

As of December 31, 2008, the National Defense Stockpile (NDS) contained 7,134 kilograms (kg) of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kg to more than 10 kg. The stockpiled crystals, however, are primarily in the larger weight classes. The larger pieces are suitable as seed crystals, which are very thin crystals cut to exact dimensions, to produce cultured quartz crystal. In addition, many of the stockpiled crystals could be of interest to the specimen and gemstone industry. Little, if any, of the stockpiled material is likely to be used in the same applications as cultured quartz crystal.

No natural quartz crystal was sold from the NDS in 2008, and the Federal Government does not intend to dispose of or sell any of the remaining material. Previously, only individual crystals in the NDS inventory that weighed 10 kg or more and could be used as seed material were sold. Brazil traditionally has been the source of such large natural crystals, but changes in mining operations have reduced output.

Quartz crystal is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" portion of the "Industrial Sand and Gravel" section of this chapter.

Production.—The USGS collects production data for quartz crystal through a survey of the domestic industry. In 2008, no domestic companies reported the production of cultured quartz crystal. During the past several years, cultured quartz crystal was being produced predominantly overseas, primarily in Asia.

Consumption.—In 2008, the USGS collected domestic consumption data for quartz crystal through a survey of 23 U.S. operations that fabricate quartz crystal devices in 9 States. Of the 23 operations, 9 responded to the survey. Consumption for nonrespondents was estimated based on reports from previous years.

Prices.— Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, was estimated to be $199 per kilogram in 2008.

Foreign Trade.—The U.S. Department of Commerce (DOC), which is the major Government source of U.S. trade data, does not provide specific import or export statistics on lascas. The DOC collects export and import statistics on electronic and optical-grade quartz crystal; however, the quartz crystal export and import quantities and values reported in previous years included zirconia, which was inadvertently reported as quartz crystal, not including mounted piezoelectric crystals.

World Review.—Cultured quartz crystal production is concentrated in China, Japan, and Russia; several companies produce crystal in each country. Other producing countries are Belgium, Brazil, Bulgaria, France, Germany, South Africa, and the United Kingdom. Details concerning quartz operations in China, the Eastern European countries, and most nations of the Commonwealth of Independent States are unavailable. Operations in Russia, however, have significant capacity to produce synthetic quartz.

Outlook.—Growth of the consumer electronics market (for example, automobiles, cellular telephones, electronic games, and personal computers), particularly in the United States, will continue to provide consumer outlets for domestic production of quartz crystal devices. The increasing global electronics market may require additional production capacity worldwide. Quartz technology could face competition in the near future with the advent of more cost effective microelectromechanical systems (MEMS). MEMS technology was first developed in 1965 and consists of silicon on insulated wafers. MEMS technology is physically compatible with existing quartz oscillator products and has better long-term stability performance characteristics for use in automotive, consumer, and computational products, and wireless applications (Partridge, 2006).

Special Silica Stone Products

Silica stone (another type of crystalline silica) products are materials for abrasive tools, such as deburring media, grinding pebbles, grindstones, hones, oilstones, stone files, tube-mill liners, and whetstones. These products are manufactured from novaculite, quartzite, and other microcrystalline quartz rock. This chapter, however, excludes products that are fabricated from such materials by artificial bonding of the abrasive grains (information on other manufactured and natural abrasives may be found in other USGS Minerals Yearbook, volume I, Metals and Minerals chapters).

Special silica stone is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—One of three domestic firms known to produce special silica stone, responded to a USGS production survey in 2008. To protect the proprietary data of all producers, production and value data for special silica stone in 2008 was

withheld (table 1). In recent years, Arkansas accounted for most of the value and quantity of production that was reported. Plants in Arkansas manufactured files, deburring-tumbling media, oilstones, and whetstones.

The industry has produced and marketed four main grades of Arkansas whetstone in recent years. The grades range from the high-quality black hard Arkansas stone down to Washita stone. In general, the black hard Arkansas stone has a porosity of 0.07% and a waxy luster, and Washita stone has a porosity of 16% and resembles unglazed porcelain.

Consumption.—The domestic consumption of special silica stone products is by a combination of craft, household, industrial, and leisure uses. The leading household use is for sharpening of knives and other cutlery, lawn and garden tools, scissors, and shears. Major industrial uses include deburring of metal and plastic castings, polishing of metal surfaces, and sharpening and honing of cutting surfaces. The major recreational use is in sharpening of arrowheads, fishhooks, spear points, and sports knives. The leading craft application is sharpening tools for engraving, jewelry making, and woodcarving. Silica stone files also are used in the manufacture, modification, and repair of firearms.

Prices.—In 2008, the average value of crude material suitable for cutting into finished products was $5,483 per ton. The average value of stone products made from crude material was $8.00 per kilogram.

Foreign Trade.—In 2008, silica stone product exports had a value of $8.7 million, up slightly from that of 2007. These exports were categorized as "hand sharpening or polishing stones" by the DOC. This category accounted for most, if not all, of the silica stone products exported in 2008.

In 2008, the value of imported silica stone products was $9.3 million, a slight increase compared with that of 2007. These imports were hand sharpening or polishing stones, which accounted for most or all the imported silica stone products in 2008. A portion of the finished products that were imported may have been made from crude novaculite produced in the United States and exported for processing.

Outlook.—Consumption patterns for special silica stone are not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses is low.

Tripoli

Tripoli, broadly defined, includes extremely fine grained crystalline silica in various stages of aggregation. Grain sizes usually range from 1 to 10 micrometers (µm), but particles as small as 0.1 to 0.2 µm are common. Commercial tripoli contains 98% to 99% silica and minor amounts of alumina (as clay) and iron oxide. Tripoli may be white or some shade of brown, red, or yellow depending upon the percentage of iron oxide.

Tripoli also is affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—In 2008, five U.S. firms were known to produce and process tripoli. American Tripoli, Inc. produced crude material in Ottawa County, OK, and finished material in Newton County, MO. Keystone Filler and Manufacturing Co. in Northumberland County, PA, processed rottenstone, which is decomposed fine-grained siliceous shale purchased from local suppliers. Malvern Minerals Co. in Garland County, AR, produced crude and finished material from novaculite. Harbison-Walker Refractories Co. in Hot Springs County, AR, produced crude and finished tripoli that is consumed in the production of refractory bricks and shapes. Unimin Specialty Minerals Inc. in Alexander County, IL, produced crude and finished material. With the exception of one, all firms responded to the USGS survey.

Consumption.—The 2008 USGS annual survey of producers indicated that sales of processed tripoli increased by 37% in quantity to 132,000 t with a value of $17.1 million (table 1).

Tripoli has unique applications as an abrasive because of its hardness and its grain structure, which lacks distinct edges and corners. It is a mild abrasive, which makes it suitable for use in toothpaste and tooth-polishing compounds, industrial soaps, and metal- and jewelry-polishing compounds. The automobile industry uses it in buffing and polishing compounds for lacquer finishing.

The end-use pattern for tripoli has changed significantly in the past 38 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2008, 5% of tripoli output was used as an abrasive. Tripoli also was used in brake friction products, as a filler and extender in enamel, caulking compounds, linings, paint, plastic, refractories, rubber, and other products.

In 2008, the primary use of tripoli (93%) was as a filler and extender in paints. The remaining 2% was in brake friction products and refractories.

Price.—The average reported unit value of all tripoli sold or used in the United States was $129 per ton in 2008. The average reported unit value of abrasive tripoli sold or used in the United States during 2008 was $208 per ton, and the average reported unit value of filler tripoli sold or used domestically was $126 per ton.

Outlook.—Consumption patterns for tripoli are not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses is low.

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TABLE 1
SALIENT U.S. SILICA STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2004	2005	2006	2007	2008
Industrial sand and gravel:[2]						
Sold or used:						
Quantity:						
Sand		28,700	29,700	28,200	29,000	29,300
Gravel		1,070	955	725	1,010	1,110
Total		29,700	30,600	28,900	30,100	30,400
Value:						
Sand		668,000	733,000	745,000	810,000 r	909,000
Gravel		16,600	19,500	13,400 r	21,300 r	28,000
Total		685,000	752,000	759,000 r	832,000 r	937,000
Exports:						
Quantity		1,790	2,910	3,830	3,020	3,100
Value		174,000	154,000	183,000	242,000	260,000
Imports for consumption:						
Quantity		490	711	855	511	355
Value		12,400	18,200	21,000	24,000	23,500
Processed tripoli:[3]						
Quantity	metric tons	94,000	91,100	76,000	96,400	132,000
Value		19,400	18,700	17,500	17,400	17,100
Special silica stone:						
Crude production:						
Quantity	metric tons	227	193	227	231	W
Value		132	191	992	1,020	W
Sold or used:						
Quantity	metric tons	655	576	328	508	W
Value		3,660	2,290	1,460	823	W

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Excludes Puerto Rico.
[3]Includes amorphous silica and Pennsylvania rottenstone.

TABLE 2
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1]

	2007				2008			
Geographic region	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
Northeast:								
New England	164	1	$6,000	1	147	(2)	$5,160	1
Middle Atlantic	1,800 r	6	49,500 r	6 r	1,710	6	48,600	5
Midwest:								
East North Central	9,310	31 r	242,000 r	29 r	9,890	33	291,000	31
West North Central	2,560	9 r	102,000	12 r	2,600	9	120,000	13
South:								
South Atlantic	4,640	15	103,000 r	12 r	4,240	14	102,000	11
East South Central	1,630	5	43,000	5	1,660	5	48,200	5
West South Central	6,490	22 r	204,000	25 r	7,230	24	243,000	26
West:								
Mountain	1,170	4	27,800	3	1,030	3	26,800	3
Pacific	2,290	8 r	53,900	6	1,920	6	52,700	6
Total	30,100 r	100	832,000 r	100	30,400	100	937,000	100

rRevised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than ½ unit.

TABLE 3
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2007		2008	
State	Quantity	Value	Quantity	Value
Alabama	459	9,810	619	14,600
Arizona	W	W	W	W
Arkansas	W	W	W	W
California	1,850	43,400	1,500	42,300
Colorado	W	W	W	W
Florida	441	8,110	573	7,480
Georgia	1,040	18,100	841	20,700
Idaho	W	W	W	W
Illinois	4,090	86,800	3,980	108,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	635	21,200	748	23,100
Maryland	W	W	W	W
Michigan	1,360	30,000	1,500	26,800
Minnesota	W	W	W	W
Mississippi	W	W	W	W
Missouri	642	19,400	648	21,400
Nevada	W	W	W	W
New Jersey	1,090 r	33,200 r	1,010	31,800
New Mexico	W	W	W	W
New York	W	W	W	W
North Carolina	1,670	31,300 r	1,500	29,400
North Dakota	W	W	W	W
Ohio	1,080	33,000	1,010	34,300
Oklahoma	1,710	44,600	2,040	63,700
Pennsylvania	685	15,800	677	16,300
Rhode Island	W	W	W	W
South Carolina	837	22,000	679	21,100
Tennessee	1,070	32,400	983	32,800
Texas	3,280	123,000	3,580	139,000
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	345	17,600	338	17,200
Wisconsin	2,650	90,100	3,290	120,000
Other	5,120	152,000	4,910	168,000
Total	30,100 r	832,000 r	30,400	937,000

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2008, BY SIZE OF OPERATION[1]

Size range	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	21	18	258	1
25,000 to 49,999	12	10	421	1
50,000 to 99,999	19	16	1,160	4
100,000 to 199,999	18	15	2,360	8
200,000 to 299,999	9	8	2,080	7
300,000 to 399,999	11	9	3,370	11
400,000 to 499,999	4	3	1,690	6
500,000 to 599,999	3	3	1,470	5
600,000 to 699,999	6	5	3,420	11
700,000 and more	16	13	14,200	47
Total	119	100	30,400	100

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

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2008, BY GEOGRAPHIC DIVISION

	Mining operations on land				
Geographic region	Stationary	Portable	Stationary and portable	Dredging operations	Total active operations
Northeast:					
New England	1	--	--	--	1
Middle Atlantic	4	--	--	4	8
Midwest:					
East North Central	22	--	4	3	29
West North Central	7	--	--	2	9
South:					
South Atlantic	16	1	--	5	22
East South Central	9	--	--	2	11
West South Central	17	--	--	5	22
West:					
Mountain	6	--	--	--	6
Pacific	11	--	--	--	11
Total	93	1	4	21	119

-- Zero.

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2008, BY MAJOR END USE[1]

Major use	Northeast			Midwest			South		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:									
Glassmaking:									
Containers	W	W	$22.89	1,240	$20,300	$16.40	1,950	$35,800	$18.39
Flat, plate and window	131	$2,710	20.70	843	12,400	14.67	1,370	28,500	20.83
Specialty	W	W	30.65	200	5,200	26.00	195	5,820	29.83
Fiberglass, unground	W	W	21.41	206	3,170	15.40	457	8,440	18.47
Fiberglass, ground	--	--	--	40	2,620	65.53	421	21,400	50.76
Foundry:									
Molding and core, unground	99	2,640	26.70	3,280	58,400	17.81	646	13,800	21.37
Molding and core, ground	--	--	--	7	946	135.14	1	112	112.00
Refractory	(3)	9	22.50	21	704	33.52	51	1,500	29.41
Metallurgical:									
Silicon carbide	--	--	--	--	--	--	--	--	--
Flux for metal smelting	--	--	--	--	--	--	W	W	20.50
Abrasives:									
Blasting	62	2,150	34.61	42	2,770	66.00	395	17,100	43.39
Scouring cleansers, ground	(3)	1	8.33	(3)	53	119.37	(3)	1	7.14
Sawing and sanding	W	W	36.00	--	--	--	--	--	--
Chemicals, ground and unground	7	274	39.14	293	5,030	17.16	505	15,500	30.78
Fillers, ground, rubber, paints, putty, etc.	9	485	53.89	272	11,100	40.94	54	8,330	154.24
Whole-grain fillers/building products	311	12,700	40.68	464	15,300	33.00	1,060	30,500	28.70
Ceramic, ground, pottery, brick, tile, etc.	(3)	30	75.00	37	3,090	83.62	90	9,470	105.22
Filtration:									
Water, municipal, county, local	40	2,390	59.63	51	2,890	56.59	66	4,200	63.67
Swimming pool, other	14	1,080	77.00	15	1,430	95.20	61	4,400	72.15
Petroleum industry:									
Hydraulic fracturing	W	W	38.28	4,610	238,000	51.50	2,720	124,000	45.53
Well packing and cementing	11	1,220	110.64	61	4,050	66.34	695	27,900	40.11
Recreational:									
Golf course, greens and traps	84	2,840	33.85	225	5,180	23.02	364	5,040	13.86
Baseball, volleyball, play sand, beaches	30	1,490	49.60	24	973	40.54	59	1,170	19.85
Traction, engine	13	445	34.23	52	1,170	22.46	49	1,350	27.53
Roofing granules and fillers	W	W	34.30	142	4,060	28.56	457	6,950	15.20
Other, ground silica	W	W	50.00	107	3,600	33.62	3	137	45.67
Other, whole grain	1,040	22,500	21.76	132	3,000	22.73	836	6,620	7.92
Total or average	1,850	52,900	28.67	12,400	405,000	32.75	12,500	378,000	30.22
Gravel:									
Silicon, ferrosilicon	--	--	--	--	--	--	497	10,500	21.09
Filtration	W	W	67.60	W	W	74.05	W	W	54.69
Other uses, specified	W	W	35.00	W	W	27.55	W	W	24.36
Total or average	15	851	56.73	129	6,340	49.18	617	14,900	24.09
Grand total or average	1,860	53,800	28.90	12,500	411,000	32.92	13,100	393,000	29.94

See footnotes at end of table.

TABLE 6—Continued
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2008, BY MAJOR END USE[1]

Major use	West			U.S. total		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:						
Glassmaking:						
Containers	913	$23,000	$25.20	W	W	$19.75
Flat, plate and window	532	13,800	25.98	2,880	$57,400	19.96
Specialty	W	W	15.77	539	15,100	27.96
Fiberglass, unground	W	W	25.31	805	14,800	18.44
Fiberglass, ground	W	W	47.15	W	W	51.61
Foundry:						
Molding and core, unground	124	2,880	23.19	4,150	77,700	18.73
Molding and core, ground	--	--	--	8	1,060	132.25
Refractory	--	--	--	73	2,210	30.32
Metallurgical:						
Silicon carbide	--	--	--	--	--	--
Flux for metal smelting	W	W	7.89	W	W	10.18
Abrasives:						
Blasting	80	1,620	20.20	579	23,700	40.89
Scouring cleansers, ground	--	--	--	(3)	54	121.62
Sawing and sanding	--	--	--	W	W	36.00
Chemicals, ground and unground	21	596	28.38	826	21,400	25.96
Fillers, ground, rubber, paints, putty, etc.	W	W	45.00	W	W	59.42
Whole grain fillers/building products	404	16,200	40.02	2,240	74,700	33.29
Ceramic, ground, pottery, brick, tile, etc.	W	W	47.40	W	W	96.47
Filtration:						
Water, municipal, county, local	20	1,330	66.35	176	10,800	61.37
Swimming pool, other	--	--	--	90	6,910	76.74
Petroleum industry:						
Hydraulic fracturing	W	W	88.29	7,390	365,000	49.44
Well packing and cementing	14	475	33.93	781	33,600	43.04
Recreational:						
Golf course, greens and traps	216	5,250	24.29	889	18,300	20.60
Baseball, volleyball, play sand, beaches	W	W	27.75	W	W	31.98
Traction, engine	4	159	39.75	118	3,120	26.46
Roofing granules and fillers	W	W	22.60	640	12,400	19.35
Other, ground silica	54	2,420	44.81	W	W	35.25
Other, whole grain	220	5,810	26.42	7,140	171,000	23.95
Total or average	2,600	73,500	28.26	29,300	909,000	31.02
Gravel:						
Silicon, ferrosilicon	--	--	--	497	10,500	21.09
Filtration	--	--	--	119	7,740	65.08
Other uses, specified	348	5,910	16.98	493	9,740	19.76
Total or average	348	5,910	16.98	1,110	28,000	25.24
Grand total or average	2,950	79,400	26.93	30,400	937,000	30.81

W Withheld to avoid disclosing company proprietary data; for sand, included in "Other, ground silica" or "Other, whole grain." -- Zero.
[1]Data are rounded to no more than three significant digits except for unit values; may not add to totals shown.
[2]Calculated using unrounded data.
[3]Less than ½ unit.

TABLE 7
INDUSTRIAL SAND AND GRAVEL SOLD OR USED, BY DESTINATION[1]

(Thousand metric tons)

Destination	2007	2008	Destination	2007	2008
States:			States—Continued:		
Alabama	511	403	New Jersey	685	W
Alaska	W	W	New Mexico	126	130
Arizona	30	W	New York	W	W
Arkansas	304	536	North Carolina	W	W
California	1,930	W	North Dakota	106	185
Colorado	1,260	1,470	Ohio	1,110	696
Connecticut	92	72	Oklahoma	W	987
Delaware	26	23	Oregon	W	W
District of Columbia	W	W	Pennsylvania	W	W
Florida	500	W	Rhode Island	W	25
Georgia	1,040	829	South Carolina	426	W
Hawaii	W	W	South Dakota	11	W
Idaho	W	W	Tennessee	735	599
Illinois	1,430	1,350	Texas	3,770	4,600
Indiana	999	917	Utah	46	18
Iowa	W	W	Vermont	W	W
Kansas	W	289	Virginia	313	214
Kentucky	284	W	Washington	W	W
Louisiana	776	472	West Virginia	186	W
Maine	W	W	Wisconsin	1,150	1,390
Maryland	W	W	Wyoming	W	312
Massachusetts	W	106	Countries:		
Michigan	518	427	Canada	563	467
Minnesota	W	W	Mexico	351	357
Mississippi	82	79	Other	54	12
Missouri	W	W	Other:		
Montana	20	9	Puerto Rico	W	W
Nebraska	25	W	U.S. possessions and territories	W	W
Nevada	W	W	Destination unknown	5,200 r	5,420
New Hampshire	W	W	Total	30,100 r	30,400

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8
U.S. EXPORTS OF INDUSTRIAL SAND AND GRAVEL, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2007		2008	
	Quantity	Value[2]	Quantity	Value[2]
Africa and the Middle East:				
Egypt	2	1,480	(3)	147
Israel	(3)	190	2	511
Other	3	1,720	9	948
Total	5	3,390	11	1,610
Asia:				
China	32	32,800	106	55,700
Hong Kong	5	295	1	375
Japan	946	61,400	1,200	50,100
Korea, Republic of	11	3,550	22	4,490
Singapore	4	2,170	1	776
Taiwan	2	2,080	3	1,660
Other	15	1,460	(3)	1,010
Total	1,020	104,000	1,340	114,000
Europe:				
Belgium	11	5,030	23	10,600
Germany	33	19,800	39	16,800
Italy	1	859	2	751
Netherlands	104	17,600	145	7,000
Russia	(3)	149	(3)	39
United Kingdom	3	4,240	4	4,800
Other	311	12,700	46	12,100
Total	463	60,400	259	52,000
North America:				
Bahamas, The	42	1,130	(3)	77
Canada	1,080	43,300	1,010	54,700
Mexico	348	13,600	417	19,000
Trinidad and Tobago	1	280	1	211
Other	9	1,520	5	1,530
Total	1,480	59,800	1,440	75,500
Oceania:				
Australia	2	1,040	2	1,050
New Zealand	(3)	265	(3)	85
Other	(3)	58	1	204
Total	2	1,360	3	1,340
South America:				
Argentina	39	8,140	26	7,810
Brazil	3	2,340	4	850
Colombia	2	546	1	391
Peru	9	1,230	21	4,620
Venezuela	2	854	2	1,070
Other	1	423	1	444
Total	56	13,500	55	15,200
Grand total	3,020	242,000	3,100	260,000

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

[2]Free alongside ship value of material at U.S. port of export. Based on transaction price, includes all charges incurred in placing material alongside ship.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL SAND, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2007		2008	
Country	Quantity	Value[2]	Quantity	Value[2]
Australia	3	1,330	2	1,030
Canada	203	12,200	244	15,900
Chile	4	994	1	374
China	4	1,590	(3)	173
Germany	1	659	(3)	384
Japan	(3)	198	(3)	29
Mexico	292	3,680	103	3,590
Netherlands	(3)	163	(3)	134
Norway	(3)	31	(3)	48
Other	4	3,100	5	1,830
Total	511	24,000	355	23,500

[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Cost, insurance, and freight value of material at U.S. port of entry. Based on purchase price; includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10
INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2004	2005	2006	2007[e]	2008[e]
Argentina	473	461	446	456 [r, 4]	450
Australia	4,142	5,169	5,200 [e]	5,300	5,300
Austria	764 [r]	1,610 [r]	2,008 [r]	1,890 [r, 4]	2,000
Belgium[e]	1,800	1,800	1,800	1,800	1,800
Belize	28 [r]	18 [r]	11 [r, e]	12	12
Bosnia and Herzegovina[e]	50	50	50	50	50
Brazil, silex[e]	2 [r]	2 [r]	2 [r]	2 [r]	2
Bulgaria	1,026	1,229	1,495	1,500	1,500
Canada, quartz	1,690	1,466	2,146 [r]	1,987 [r, 4]	1,979 [p, 4]
Chile	1,085	1,151	1,081	1,234 [4]	1,401 [4]
Croatia[e]	300	300	304 [4]	300	300
Cuba[e]	33	14	9	14 [r]	14
Czech Republic[e]	900	900	1,000	1,000	1,000
Denmark, sales[e]	60	60	60	60	60
Ecuador	32	38	36	36	36
Egypt[e, 5]	640	650	650	650	650
Eritrea[e]	(6)	(6)	(6)	(6)	(6)
Ethiopia[e, 7]	5 [4]	5	5	5 [r]	5
Finland[e]	100	100	100	100	100
France	5,300	5,100	5,000 [e]	5,000	5,000
Gambia[e]	1,389 [4]	1,390	1,390	1,390	1,400
Germany	8,162	7,681	7,703	8,382 [r, 4]	8,186 [4]
Greece[e]	100	100	100	100	100
Guatemala	1	0	58	68 [r, 4]	65
Hungary	5,900	7,300	3,800 [e]	3,800	3,800
Iceland[e]	4	4	4	4	4
India[e]	1,500	1,600	1,600	1,600	1,700
Indonesia[e, 8]	132	132	135	135	138
Iran[9]	1,880	1,900	1,900	2,000	2,000
Ireland[e]	5	5	5	5	5
Israel	196	196	204	220 [r]	220
Italy	12,800	14,400	13,800	13,800	13,800
Jamaica	11	14	10	14 [r, 4]	15
Japan	4,705	4,549	4,593	4,314 [r, 4]	4,500
Jordan	73 [r]	229 [r]	392 [r]	628 [r, 4]	650
Kenya[e]	34 [r]	34 [r]	34 [r]	34 [r]	34
Korea, Republic of	554	461	1,437	2,191 [4]	2,000
Latvia	7	18	13	13	12
Lithuania	58	47	42	45	45
Malaysia	631	532	512	719 [r, 4]	700
Mexico	2,056	2,121	2,662	2,700	2,779 [4]
Netherlands[e]	5	5	5	5	5
New Caledonia[e]	40	40	40	40	40
New Zealand	60	65	59	86 [r, 4]	70
Norway[e]	1,500	1,600	1,500	1,500	1,500
Paraguay[e]	25	25	25	25	25
Peru[e]	871 [4]	900	900	900	900
Philippines	237	224	179 [r]	221 [r]	200
Poland	2,850	3,270	3,850	4,000	4,000
Portugal[e]	5	5	5	5	5
Romania	555	475	522	520	520
Serbia[e]	260 [10]	260 [10]	260	260	260
Slovakia[e]	2,200	2,000	2,000	2,000	2,000
Slovenia[e]	200	200	200	200	200
South Africa	2,249	2,671	3,231 [r]	3,352 [r, 4]	3,648 [p, 4]

See footnotes at end of table.

TABLE 10—Continued
INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2004	2005	2006	2007[e]	2008[e]
Spain[e]	5,063 [4]	5,100	5,100	5,000	5,000
Sweden[e]	700	700	700	700	700
Thailand	588	718	862	860	860
Turkey[e]	1,188 [4]	1,200	1,100	1,200	1,200
United Kingdom	5,011	5,200	5,600	5,600	5,600
United States, sold or used by producers	29,700	30,600	28,900	30,100 [r, 4]	30,400 [4]
Venezuela	943	207	500 [e]	500	500
Zimbabwe[11]	(6)	1	1 [e]	--	--
Total	113,000 [r]	118,000 [r]	117,000 [r]	121,000 [r]	121,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.
[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Table includes data available through June 17, 2009.
[3]In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, China, countries of the Commonwealth of Independent States, Iraq, and Saudi Arabia produce industrial sand, but current available information is inadequate to formulate reliable estimates of output levels.
[4]Reported figure.
[5]Fiscal years beginning July 7 of that stated.
[6]Less than ½ unit.
[7]Ethiopian calender year ending July 7 of that stated.
[8]The quantities for quartz sand and silica stone, in cubic meters, were estimated as follows: 2004–05—150,000; 2006—153,000; 2007—155,000; and 2008—160,000.
[9]Fiscal years beginning March 21 of that stated.
[10]Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.
[11]Includes rough and ground quartz as well as silica sand.