



2010 Minerals Yearbook

SILICA

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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 in the United States increased to 29.9 million metric tons (Mt) in 2010 from 24.6 Mt in 2009 (table 1). After the steep decline from 2008 to 2009, industrial sand production increased by 22%, and industrial gravel production, by 3%, compared with that of 2009. During the year, the value of production exceeded \$1 billion—the first time in the history of the USGS voluntary survey of U.S. producers of industrial sand and gravel. Estimated world production in 2010 was 121 Mt, a 6% increase compared with 2009 production (table 10).

Industrial sand and gravel, often called “silica,” “silica sand,” and “quartz sand,” includes sands and gravels with high silicon dioxide (SiO₂) content. Some examples of end uses for these sands and gravels are in abrasives, filtration, foundry, glassmaking, hydraulic fracturing (frac), and silicon metal applications. The specifications for each use differ, 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 production increase for silica sand in 2010 was largely attributable to surging demand for hydraulic fracturing sand. The increased demand for hydraulic fracturing sand was the result of ongoing and increased exploration and production of natural gas from various underground shale formations throughout the United States. Additionally, most major silica sand producers had production capacity increases for hydraulic fracturing sand along with the addition of newer hydraulic fracturing sand operations to the USGS voluntary survey of U.S. producers. Increased demand was noted for uses such as sand for abrasives, chemicals, fiberglass, flat glass, hydraulic fracturing, well packing and cementing, and whole grain silica. Production of the remaining end uses for silica sand in 2010 either remained static or experienced declines compared with

those of the previous year. Demand for silica gravel increased slightly for all end uses.

Legislation and Government Programs.—Effective January 24, 2008, the 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 (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 have been the understanding of the regulations and the implementation of the measurements and actions taken to mitigate exposure to crystalline silica and appreciation of the impact of such exposure on the future of many industries (Industrial Minerals, 1998). OSHA created a permissible exposure limit that stipulated the maximum amount of crystalline silica to which workers may be safely exposed during an 8-hour work shift (29 CFR §§1926.55 and 1910.1000). OSHA also established guidelines and training for the proper handling of crystalline silica (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 68 producers with 116 operations known to produce industrial sand and gravel. Of the 116 surveyed operations, 113 (97%) were active, and 3 were idle. The USGS received responses from 68 operations, and their combined production represented 77% of the U.S. total. Production for the 48 nonrespondents was estimated, primarily on the basis of previously reported information, supplemented with worker-hour reports from the Mine Safety and Health Administration (MSHA) and information from State agencies.

The Midwest (East North Central and West North Central divisions) led the Nation with 49% of the 29.9 Mt of industrial sand and gravel produced in the United States, followed by the South (South Atlantic, East South Central, and West South Central divisions) with 39%, the West (Pacific and Mountain divisions) with 7%, and the Northeast (New England and Middle Atlantic) with 5% (table 2).

The leading producing States were, in descending order, Illinois, Texas, Wisconsin, Minnesota, Oklahoma, North Carolina, California, and Michigan (table 3). Their combined production represented 64% of the national total. States for

which data have been withheld in table 3 are not included among the leading producers.

Of the total industrial sand and gravel produced, 88% 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.; Fairmount Minerals Ltd.; Preferred Rocks of Genoa, LLC; Carmeuse Lime and Stone; Badger Mining Corp.; EOG Resources Inc.; Pattison Sand Co., LLC; Manley Bros. of Indiana, Inc.; and Little Six Corp. Their combined production represented 86% of the U.S. total.

In the past several years, as conventional natural gas sources in the United States have become less abundant, drilling companies have turned to deep natural gas and shale gas. Because of this, demand for hydraulic fracturing sand has increased dramatically, and the United States is the largest market for hydraulic fracturing sand. In response to this demand, Unimin Corp. was expanding capacity at its Arkansas operation for hydraulic fracturing sand and U.S. Silica Co. was increasing capacity for hydraulic fracturing sand at its Illinois operation. Additionally, Preferred Rocks of Genoa, LLC was upgrading its hydraulic fracturing sand capacity after entering the market in 2008 (Industrial Minerals, 2010).

Consumption.—Industrial sand and gravel production reported by producers to the USGS was material used by the producing companies or sold to their customers. Stockpiled material is not reported until consumed or sold. Of the 29.9 Mt of industrial sand and gravel sold or used, 41% was consumed as hydraulic fracturing sand and sand for well packing and cementing, and 26% as glassmaking sand (table 6). Foundry uses consumed 11% of industrial sand and gravel consumption. Other important uses were other whole grain silica (6%) and whole grain fillers and building products (6%).

Minable deposits of industrial sand and gravel occur throughout the United States, and 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 2010, 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 the State or other location to which the material was shipped for consumption. The States that received the most industrial sand and gravel were Texas (15%), Illinois (5%), Pennsylvania (4%), California (4%), Oklahoma (3%), and Indiana (2%). Producers reported sending 174,000 t of silica to Mexico and 322,000 t to Canada (table 7). Because some producers did not provide this information, their data were estimated or assigned to the “Destination unknown” category. In 2010, 30% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking increased slightly compared with that of 2009. In 2010, sales to container glass manufacturers declined by about 9% compared with those in 2009. 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 increased by 18% compared with that of 2009.

In 2010, sales of sand for flat glass production increased by 21% compared with those in 2009. Consumption of sand for flat glass increased in all regions of the country in 2010.

Whole grain silica is regularly used in filler-type and building applications. In 2010, consumption of whole-grain fillers for building products was 1.8 Mt, up 6% compared with that in 2009.

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 2010, silica sales for chemical production were 808,000 t, an increase of about 21% compared with those in 2009. Reported sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses, increased by 3% in 2010 compared with those in 2009. 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, unchanged from that of 2009; 20% was transported by rail, down from that of 2009; and 28% by unspecified modes of transport.

Prices.—The average value, free on board plant, of U.S. industrial sand and gravel increased to \$34.58 per metric ton in 2010, compared with the average value of 2009 (table 6). The average unit values for industrial sand and industrial gravel were \$34.76 per ton and \$25.58 per ton, respectively. The average price for sand ranged from \$8.40 per ton for metallurgical flux for metal smelting to \$143.71 per ton for ground sand for foundry molding and core. For gravel, prices ranged from \$21.42 per ton for silicon and ferrosilicon to \$44.61 per ton for filtration. Producer prices reported to the USGS for silica commonly ranged from several dollars per ton to hundreds of dollars per ton. Prices for certain highly processed quartz products for specialized end uses, not covered in this chapter, can reach the \$50,000-per-ton level. Nationally, ground sand for foundry molding and core had the highest value (\$143.71 per ton), followed by silica for swimming pool filters (\$99.94 per ton), silica for sawing and sanding (\$81.00 per ton), ground sand used as fillers for paint, putty, and rubber (\$78.61 per ton), sand for municipal water filtration (\$69.77 per ton), ground sand for ceramics (\$69.44 per ton), and sand for other ground silica (\$63.63 per ton).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest (\$35.06 per ton), followed by the South (\$35.03 per ton), the Northeast (\$34.02 per ton), and the West (\$29.38 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 \$27.63 per ton in the West to \$15.79 per ton in the Midwest.

Foreign Trade.—Exports of industrial sand and gravel in 2010 increased by about 84% compared with the amount exported in 2009, and the associated value increased by 85% (table 8). The increase in exports can be attributed mainly to increased demand from markets in Asia, Europe, and Oceania. Canada was the leading recipient of U.S. exports. The distribution of exports was as follows: 44% to Canada, 32% to Japan, 12% to Mexico, and the remainder to Africa and the Middle East, Europe, Oceania, and South America. The average unit value of exports increased slightly to \$81.81 per ton in 2010 from \$81.31 per ton in 2009. In 2010, export unit values varied widely by region; exports of silica to Oceania averaged \$488 per ton, and exports to the rest of the world averaged \$81 per ton.

Imports for consumption of industrial sand and gravel increased to 131,000 t, which was an increase of 38% compared with those of 2009 (table 9). Canada supplied about 79% of the silica imports, which averaged \$40 per ton; this price included insurance and freight costs to the U.S. port of entry. The total value of imports was \$19.7 million, with an average unit value of \$150 per ton. Higher priced imports came from Australia, China, Germany, and Japan.

World Review.—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, Australia, France, Spain, Turkey, and the United Kingdom. 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 2011 was expected to be 29 to 31 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 by market. Total demand for all glass sand end uses was expected to remain relatively static through 2011. However, growth has been noted in some segments, such as sand for abrasives, chemicals, fiberglass, flat glass, hydraulic fracturing, well packing and cementing, and whole grain silica. Industrial sand and gravel sales may also be constrained by diminished demand owing to the ongoing economic sluggishness and by the rising energy costs for production and transportation of products.

The demand for foundry sand is dependent mainly on automobile and light truck production. Production and sales of automobiles and light trucks increased in 2010 and the trend continued into 2011. 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, production of silica foundry sand in 2011 was expected to be 3.5 Mt.

Frac sand sales increased in 2010 compared with those in 2009. On average, crude oil prices increased in 2010 with further increases in 2011. Based on this trend, coupled with natural gas exploration and production, primarily in the Eastern and Midwestern United States, demand for frac sand was expected to increase during 2011 to 16 Mt.

The United States is the leading producer and a major consumer of silica sand and is self-sufficient in this mined mineral commodity. Most silica sand is produced at deposits in the Midwest and near major markets in the Eastern United States. A significant amount of silica sand also is produced in the West and Southwest, mostly in California and Texas, respectively. Domestic production is expected to continue to meet 97% to 98% of demand well beyond 2011. Barring further declines in the overall U.S. economy, imports of silica sand from Canada and Mexico, and higher valued material from China are expected to slowly increase.

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 relationships 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 as raw materials for ceramics. Increased efforts to reduce waste and to increase recycling also would be likely to lower the demand for mined glass sand. Recycling of glass cullet has been increasing in most industrialized nations, and recycling has accounted for anywhere from 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 by approximately 2.5%. During the past 20 years, glass container weight has been reduced by 25% to 40% in many nations, including the United States, decreasing the amount of industrial sand required for each container (Industrial Minerals, 2004). Although other developments likely would cause the demand for silica sand to decrease, the total value of production likely would 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, and marketers of competing materials, which include garnet, olivine, and slags,

encouraged the use of their “safer” abrasive media. In hydraulic fracturing, other materials (such as bauxite-based proppants, ceramic proppants, and resin-coated sand) compete with silica sand, although they are more expensive and not used as extensively as silica sand. Bauxite-based and ceramic proppants exhibit improved performance in deeper, higher pressure formations than silica sand (Industrial Minerals, 2009).

Quartz Crystal

Electronic-grade quartz crystal, also known as cultured quartz crystal, is single-crystal silica with properties that make it uniquely suited for 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 smaller 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 lascalas, which is mined. Mining of lascalas in the United States ceased in 1997 owing to competition from less expensive imported lascalas, predominantly from mines in Brazil and Madagascar.

It has been estimated that in any given year, approximately 10 billion quartz crystals and oscillators are manufactured and installed worldwide in all types of electronic devices, from automobiles to cellular telephones.

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, 2010, 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 2010, and the Federal Government did 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 2010, no domestic companies reported the production of cultured quartz crystal. During the past several years, cultured quartz crystal was produced predominantly overseas, primarily in Asia.

Consumption.—In 2010, 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, 8 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 \$210 per kilogram in 2010. Prices for lumbered quartz ranged in price from \$20 per kilogram to more than \$900 per kilogram in 2010, depending on the application.

Foreign Trade.—The U.S. Census Bureau, which is the major Government source of U.S. trade data, does not provide specific import or export statistics on lascalas. The U.S. Census Bureau 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 was concentrated in China, Japan, and Russia; several companies produced crystal in each country. Other producing countries were 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 were 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 likely 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 consisted 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.—None of the three domestic firms known to produce special silica stone responded to a USGS production survey in 2010. To protect the proprietary data of all producers, production and value data for special silica stone in 2010 were 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 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 comprises a combination of craft, household, industrial, and leisure uses. The leading household use is for sharpening knives and other cutlery, lawn and garden tools, scissors, and shears. Major industrial uses include deburring metal and plastic castings, polishing metal surfaces, and sharpening and honing cutting surfaces. The major recreational use is in sharpening 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 2010, the average value of crude material suitable for cutting into finished products was estimated to be \$3,700 per ton.

Foreign Trade.—In 2010, silica stone product exports had a value of \$11.3 million, up by 48% from that in 2009. These exports were categorized as “hand sharpening or polishing stones” by the U.S. Census Bureau. This category accounted for most of or all the silica stone products exported in 2010.

In 2010, the value of imported silica stone products was \$8.9 million, up by 8% from that in 2009. These imports were hand sharpening or polishing stones, which accounted for most of or all the imported silica stone products in 2010. 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 were not expected to change significantly during the next several

years. Most of the existing markets are well defined, and the probability of new uses being created 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 on 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 2010, three U.S. firms were known to produce and process tripoli. American Tripoli, Inc. closed their operation in Ottawa County, OK, in 2010, but operated a mine and produced finished material in Newton County, MO. Malvern Minerals Co. in Garland County, AR, produced crude and finished material from novaculite. Unimin Specialty Minerals Inc. in Alexander County, IL, produced crude and finished material. Of the three U.S. firms, none responded to the USGS survey. Production for nonrespondents was estimated based on reports from previous years and supplemented with worker-hour reports from MSHA.

Consumption.—It was estimated that sales of processed tripoli increased by 38% in quantity to 110,000 t with a value of \$20 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 40 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2010, 6% of tripoli output was used as an abrasive. Tripoli was mostly used as a filler and extender in enamel, caulking compounds, linings, paint, plastic, rubber, and other products. In 2010, the primary use of tripoli (91%) was as a filler and extender. The remaining 3% was in brake friction products and refractories.

Price.—The average unit value of all tripoli sold or used in the United States was estimated to be \$181 per ton in 2010. The average unit value of abrasive-grade tripoli sold or used in the United States during 2010 was estimated to be \$191 per ton, and the average unit value of filler-grade tripoli sold or used domestically was estimated to be \$186 per ton.

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

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TABLE 1
 SALIENT U.S. SILICA STATISTICS¹

(Thousand metric tons and thousand dollars unless otherwise specified)

	2006	2007	2008	2009	2010
Industrial sand and gravel.²					
Sold or used:					
Quantity:					
Sand	28,200	29,000	29,300	24,000	29,300
Gravel	725	1,010	1,110	565	582
Total	28,900	30,100	30,400	24,600	29,900
Value:					
Sand	745,000	810,000	909,000	762,000	1,020,000
Gravel	13,400	21,300	28,000	21,000	14,900
Total	759,000	832,000	937,000	783,000	1,030,000
Exports:					
Quantity	3,830	3,020	3,100	2,150	3,950
Value	183,000	242,000	260,000	175,000	323,000
Imports for consumption:					
Quantity	855	511	355	95	131
Value	21,000	24,000	23,500	8,080	19,700
Processed tripoli: ³					
Quantity metric tons	76,000	96,400	132,000	79,700	110,000
Value	17,500	17,400	17,100	16,400	20,000
Special silica stone:					
Crude production:					
Quantity metric tons	227	231	W	W	W
Value	992	1,020	W	W	W
Sold or used:					
Quantity metric tons	328	508	W	W	W
Value	1,460	823	W	W	W

¹Revised. W Withheld to avoid disclosing company proprietary data.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Excludes Puerto Rico.

⁴Includes amorphous silica and Pennsylvania rottenstone.

TABLE 2
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION¹

Geographic region	2009				2010			
	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	130	(2)	\$4,510	(2)	127	(2)	\$6,380	1
Middle Atlantic	1,670	7	48,200	6	1,440	5	47,000	5
Midwest:								
East North Central	8,470	34	266,000	34	9,910	33	346,000	33
West North Central	2,630	11	113,000	14	4,600	15	163,000	16
South:								
South Atlantic	3,480	14	89,900	11	3,480	12	93,400	9
East South Central	1,210	5	39,200	5	1,290	4	40,900	4
West South Central	4,780	19	164,000	21	6,880	23	274,000	26
West:								
Mountain	531	2	12,600	2	500	2	14,000	1
Pacific	1,670	7	45,600	6	1,680	6	49,900	5
Total	24,600	100	783,000	100	29,900	100	1,030,000	100

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

²Less than ½ unit.

TABLE 3
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN
THE UNITED STATES, BY STATE¹

(Thousand metric tons and thousand dollars)

State	2009		2010	
	Quantity	Value	Quantity	Value
Alabama	370	11,200	386	10,400
Arizona	W	W	W	W
Arkansas	W	W	W	W
California	1,300	35,800	1,320	39,400
Colorado	W	W	W	W
Florida	431	8,270	173	3,980
Georgia	775	19,300	670	17,800
Idaho	W	W	W	W
Illinois	3,440	104,000	4,370	148,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	682	25,900	629	25,600
Michigan	1,330	27,700	1,260	27,300
Minnesota	W	W	1,940	100,000
Mississippi	W	W	--	--
Missouri	763	28,900	608	20,000
Nebraska	W	W	W	W
Nevada	W	W	W	W
New Jersey	906	30,200	918	33,600
New York	W	W	W	W
North Carolina	1,300	28,000	1,400	30,900
North Dakota	W	W	W	W
Ohio	849	26,300	821	27,800
Oklahoma	1,410	40,300	1,900	57,200
Pennsylvania	618	15,600	524	13,400
Rhode Island	W	W	W	W
South Carolina	441	14,000	530	14,700
Tennessee	783	27,100	907	30,500
Texas	2,130	84,400	3,610	162,000
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	241	14,700	277	17,300
Wisconsin	2,730	105,000	3,390	142,000
Other	4,070	137,000	10,600	317,000
Total	24,600	783,000	29,900	1,030,000

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

¹Data 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 2010, BY SIZE OF OPERATION¹

Size range	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	21	18	207	(2)
25,000 to 49,999	17	15	586	2
50,000 to 99,999	14	12	938	3
100,000 to 199,999	15	13	1,850	6
200,000 to 299,999	9	8	1,930	6
300,000 to 399,999	8	7	2,490	8
400,000 to 499,999	5	4	1,980	7
500,000 to 599,999	8	7	3,930	13
600,000 to 699,999	4	3	2,340	8
700,000 and more	15	13	13,700	46
Total	116	100	29,900	100

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

²Less than ½ unit.

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2010, BY GEOGRAPHIC DIVISION

Geographic region	Mining operations on land			Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable		
Northeast:					
New England	1	--	--	--	1
Middle Atlantic	4	--	--	3	7
Midwest:					
East North Central	23	--	--	3	26
West North Central	9	--	--	3	12
South:					
South Atlantic	16	1	--	5	22
East South Central	7	--	--	2	9
West South Central	17	--	--	7	24
West:					
Mountain	4	--	--	--	4
Pacific	11	--	--	--	11
Total	92	1	--	23	116

-- Zero.

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2010, BY MAJOR END USE¹

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	\$24.07	1,060	\$16,700	\$15.79	1,770	\$37,500	\$21.25
Flat, plate and window	134	\$2,940	21.90	851	17,300	20.34	1,070	23,900	22.39
Specialty	103	3,470	33.65	155	5,370	34.62	152	5,990	39.43
Fiberglass, unground	W	W	22.42	132	2,190	16.58	362	8,670	23.95
Fiberglass, ground	--	--	--	30	1,980	66.07	387	18,800	48.55
Foundry:									
Molding and core, unground	72	2,300	31.99	2,460	47,500	19.31	554	11,800	21.32
Molding and core, ground	--	--	--	6	886	147.67	W	W	119.00
Refractory	(3)	29	--	20	719	35.95	23	1,130	48.91
Metallurgical, flux for metal smelting	--	--	--	--	--	--	(3)	W	--
Abrasives:									
Blasting	W	W	22.32	40	1,790	44.75	306	12,600	41.07
Scouring cleaners (ground)	--	--	--	(3)	59	--	(3)	1	--
Sawing and sanding	W	W	117.00	--	--	--	W	W	45.00
Chemicals, ground and unground	3	133	44.33	278	5,700	20.52	510	18,600	36.54
Fillers, ground, rubber, paints, putty, etc.	5	323	64.60	W	W	48.94	W	W	250.23
Whole-grain fillers/building products	252	11,400	45.29	357	14,100	39.63	798	27,500	34.50
Ceramic, ground, pottery, brick, tile, etc.	(3)	6	--	29	2,330	80.31	60	3,900	64.97
Filtration:									
Water, municipal, county, local	46	3,170	68.87	65	4,440	68.25	51	3,940	77.22
Swimming pool, other	11	988	89.82	11	1,160	105.73	41	4,250	103.54
Petroleum industry:									
Hydraulic fracturing	W	W	44.15	8,080	354,000	43.78	3,820	185,000	48.43
Well packing and cementing	5	570	114.00	87	4,070	46.77	76	3,730	49.01
Recreational:									
Golf course, greens and traps	43	1,620	37.72	171	4,140	24.18	246	3,580	14.57
Baseball, volleyball, play sand, beaches	21	3,140	149.67	31	721	23.26	68	1,550	22.85
Traction, engine	14	555	39.64	24	446	18.58	30	855	28.50
Roofing granules and fillers	32	1,210	37.91	82	2,050	24.96	208	4,390	21.09
Other, ground silica	W	W	49.00	199	9,770	60.67	47	9,420	49.64
Other, whole grain	809	20,700	25.65	256	9,650	37.92	604	8,690	14.64
Total or average	1,560	52,600	33.81	14,400	507,000	35.15	11,200	396,000	35.42
Gravel:									
Silicon, ferrosilicon	--	--	--	--	--	--	173	3,710	21.42
Filtration	W	W	69.67	W	W	39.38	48	1,980	41.33
Other uses, specified	W	W	41.75	W	W	14.10	255	6,560	25.73
Total or average	14	794	56.71	82	1,490	18.11	475	12,200	25.78
Grand total or average	1,570	53,400	34.02	14,500	509,000	35.06	11,700	408,000	35.03

See footnotes at end of table.

TABLE 6—Continued
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2010, BY MAJOR END USE¹

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	713	\$19,700	\$27.63	3,950	\$83,900	\$21.24
Flat, plate and window	476	13,700	28.83	2,530	57,800	22.88
Specialty	W	W	51.33	416	15,100	36.38
Fiberglass, unground	49	1,270	25.98	602	13,500	22.35
Fiberglass, ground	W	W	52.86	424	21,100	49.86
Foundry:						
Molding and core, unground	34	809	23.79	3,120	62,400	20.00
Molding and core, ground	--	--	--	W	W	143.71
Refractory	(3)	(3)	--	44	1,870	42.57
Metallurgical, flux for metal smelting	W	W	8.30	W	W	8.40
Abrasives:						
Blasting	80	1,360	16.94	469	16,700	35.59
Scouring cleaners (ground)	--	--	--	(3)	60	--
Sawing and sanding	--	--	--	W	W	81.00
Chemicals, ground and unground	18	556	30.89	808	25,000	30.98
Fillers, ground, rubber, paints, putty, etc.	W	W	38.33	239	18,800	78.61
Whole grain fillers/building products	411	15,600	37.84	1,820	68,600	37.76
Ceramic, ground, pottery, brick, tile, etc.	W	W	43.00	91	6,320	69.44
Filtration:						
Water, municipal, county, local	16	807	50.44	177	12,400	69.77
Swimming pool, other	--	--	--	64	6,400	99.94
Petroleum industry:						
Hydraulic fracturing	W	W	35.41	12,100	546,000	45.24
Well packing and cementing	15	1,790	119.00	183	10,100	55.46
Recreational:						
Golf course, greens and traps	87	2,220	25.46	548	11,600	21.09
Baseball, volleyball, play sand, beaches	2	43	21.50	123	5,460	44.40
Traction, engine	5	242	48.40	72	2,100	29.14
Roofing granules and fillers	W	W	32.33	358	8,810	24.61
Other, ground silica	25	1,060	37.54	38	2,420	63.63
Other, whole grain	234	4,470	12.33	1,900	43,600	11.97
Total or average	2,160	63,600	29.38	29,300	1,020,000	34.76
Gravel:						
Silicon, ferrosilicon	--	--	--	173	3,710	21.42
Filtration	--	--	--	70	3,120	44.61
Other uses, specified	12	338	--	338	8,030	23.77
Total or average	12	338	28.17	582	14,900	25.58
Grand total or average	2,180	63,900	29.38	29,900	1,030,000	34.58

W Withheld to avoid disclosing company proprietary data; for sand, included in "Other, whole grain"; for gravel, included in "Total or average."
-- Zero.

¹Data are rounded to no more than three significant digits except for unit values; may not add to totals shown.

²Calculated using unrounded data.

³Less than ½ unit.

TABLE 7
INDUSTRIAL SAND AND GRAVEL SOLD OR USED, BY DESTINATION¹

(Thousand metric tons)

Destination	2009	2010	Destination	2009	2010
States:			States—Continued:		
Alabama	361	341	New Jersey	W	W
Alaska	W	W	New Mexico	90	68
Arizona	W	W	New York	W	W
Arkansas	748	410	North Carolina	W	W
California	W	1,260	North Dakota	167	230
Colorado	1,050	W	Ohio	588	425
Connecticut	67	W	Oklahoma	516	754
Delaware	30	W	Oregon	65	W
District of Columbia	W	W	Pennsylvania	W	1,270
Florida	657	W	Rhode Island	22	W
Georgia	788	614	South Carolina	W	W
Hawaii	W	W	South Dakota	W	W
Idaho	W	W	Tennessee	471	639
Illinois	1,280	1,500	Texas	3,020	4,350
Indiana	792	712	Utah	W	W
Iowa	W	W	Vermont	W	W
Kansas	194	W	Virginia	172	206
Kentucky	W	189	Washington	W	W
Louisiana	480	W	West Virginia	74	W
Maine	W	W	Wisconsin	1,130	W
Maryland	W	W	Wyoming	371	W
Massachusetts	W	W	Countries:		
Michigan	341	359	Canada	298	322
Minnesota	W	W	Mexico	293	174
Mississippi	52	W	Other	7	W
Missouri	W	W	Other:		
Montana	9	W	Puerto Rico	W	W
Nebraska	W	W	U.S. possessions and territories	W	--
Nevada	W	W	Destination unknown	3,940	8,890
New Hampshire	W	W	Total	24,600	29,900

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

¹Data 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 REGION AND COUNTRY¹

(Thousand metric tons and thousand dollars)

Destination	2009		2010	
	Quantity	Value ²	Quantity	Value ²
Africa and the Middle East:				
Egypt	--	--	(3)	91
Israel	(3)	301	(3)	204
Other	6	938	--	1,380
Total	7	1,240	2	1,680
Asia:				
China	23	36,000	133	82,400
Hong Kong	(3)	267	2	584
Japan	396	15,500	1,270	51,300
Korea, Republic of	9	2,950	18	3,790
Singapore	1	966	4	1,420
Taiwan	4	1,210	1	1,010
Other	4	984	3	1,450
Total	437	57,800	1,430	142,000
Europe:				
Belgium	3	1,640	2	1,390
Germany	34	19,800	105	39,000
Italy	1	700	1	167
Netherlands	52	4,260	115	7,630
Russia	(3)	20	(3)	140
United Kingdom	5	2,430	2	2,340
Other	5	10,700	6	12,300
Total	100	39,500	229	62,900
North America:				
Bahamas, The	(3)	82	1	198
Canada	1,150	43,200	1,750	68,800
Mexico	420	22,600	480	36,300
Trinidad and Tobago	1	410	(3)	93
Other	5	1,260	12	1,970
Total	1,580	67,500	2,250	107,000
Oceania:				
Australia	2	993	3	1,390
New Zealand	(3)	69	(3)	74
Total	2	1,060	3	1,460
South America:				
Argentina	17	3,390	21	3,710
Brazil	3	1,480	1	1,350
Colombia	4	1,650	2	501
Peru	2	445	15	1,980
Venezuela	(3)	264	(3)	133
Other	2	418	1	412
Total	28	7,640	40	8,080
Grand total	2,150	175,000	3,950	323,000

-- Zero.

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

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

³Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL
SAND, BY COUNTRY¹

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value ²	Quantity	Value ²
Australia	(3)	567	(3)	1,160
Canada	88	4,170	103	4,080
Chile	(3)	62	--	--
China	(3)	160	(3)	281
Germany	(3)	143	(3)	671
Japan	(3)	47	(3)	105
Mexico	5	2,540	26	11,500
Netherlands	(3)	30	--	--
Other	1	372	2	1,860
Total	95	8,080	131	19,700

-- Zero.

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

²Cost, 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.

³Less 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	2006	2007	2008	2009	2010 ^e
Algeria	NA	254	243	118	84 ⁴
Argentina	446	457	473	364 ^r	400
Australia ^e	5,200	5,300	5,300	5,200	5,300
Austria	2,008	1,915 ^r	2,175 ^r	1,170 ^r	939 ⁴
Belgium ^e	1,800	1,800	1,800	1,800	1,800
Belize ^e	11	12	12	12	1
Bosnia and Herzegovina	711	671	702	501 ^r	600
Brazil, silex ^e	2	2	2	2	2
Bulgaria	250	551	734	657 ^r	660
Canada, quartz	2,146	1,987	1,979	1,296	1,171 ^{p,4}
Chile	1,081	1,234	1,401	1,405	1,400
Croatia	140	148	150 ^e	278 ^r	241 ⁴
Cuba ^e	9	21	29	16 ^r	16
Czech Republic, foundry sand	773	850	702	1,364	1,400
Denmark, sales ^e	60	60	60	60	60
Ecuador ^e	36 ⁴	36	36	36	--
Egypt ⁵	650 ^e	1,725	1,612	1,342 ^r	1,757 ⁴
Eritrea	1 ^r	NA ^r	NA ^r	NA ^r	NA
Estonia, industrial sand	--	--	--	--	36 ⁴
Ethiopia ⁶	6 ^e	6	7	15 ^r	30
Finland	3,003	2,958	3,160	2,241	2,250
France ^e	5,000	5,000	5,000	5,000	5,000
French Guyana ^e	1,500	1,500	1,500	1,500	1,500
Gambia	1,390 ^e	712	1,065	850 ^r	897 ⁴
Germany	7,703	8,382	8,186	6,453	7,000
Greece	100 ^e	100 ^e	65	38	38
Guatemala	58	68	65	36	62 ⁴
Guyana ⁷	285	715	684	479	652
Hungary, foundry and glass sand	371 ^r	337 ^r	320 ^r	196 ^r	180 ⁴
Iceland ^e	4	4	4	4	4
India ^e	1,600	1,600	1,700	1,700	1,800
Indonesia ^e	135	135	138	138	140
Iran ^{e,8}	1,900 ⁴	2,000	2,000	1,500	1,500
Iraq	--	(9)	19	18	(9) ⁴
Ireland ^e	5	5	5	5	5
Israel	204	220	195 ^r	163 ^r	198 ⁴
Italy ^e	14,000 ^r	14,000 ^r	14,000 ^r	19,759 ^{r,4}	19,800
Jamaica	10	14	15	7	13 ⁴
Japan	4,593	4,314	3,664	2,856 ^r	3,078 ⁴
Jordan	392	628	23 ^r	298 ^r	300
Kenya ^e	34	34	34	30 ^r	32
Korea, Republic of	1,437	2,227	1,757	455	535 ⁴
Latvia	2,133 ^r	4,285 ^r	2,223 ^r	1,339 ^r	1,359 ⁴
Lithuania	43	45	38	42 ^r	67 ⁴
Malaysia	512	719	1,467	630 ^r	932 ⁴
Mexico	2,662	2,950 ^r	2,779	2,484 ^r	2,480
Netherlands ^e	5	5	5	5	5
New Caledonia ^e	-- ^r	-- ^r	-- ^r	-- ^r	--
New Zealand	59	86	49	43 ^r	45
Nigeria	--	--	--	32	30
Norway ^e	1,500	1,500	1,500	1,500	1,500
Paraguay ^e	25	25	25	25	25
Peru ^e	900	900	900	900	900
Philippines	179	221 ^r	270 ^r	284 ^r	300
Poland	1,525 ^r	2,268 ^r	2,398 ^r	2,731 ^r	2,730

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	2006	2007	2008	2009	2010 ^e
Portugal ^e	5	5	5	5	5
Romania ^e	522 ⁴	520	520	520	520
Saudi Arabia	781 ^{r,e}	820 ^{r,e}	799	709 ^r	820 ⁴
Serbia ^e	260	260	260	260	260
Slovakia	524 ^r	591 ^r	619 ^r	502 ^r	500
Slovenia	350 ^{r,e}	350 ^{r,e}	354 ^r	327 ^r	330
South Africa	3,216 ^r	3,352	3,648 ^r	2,306	2,910 ⁴
Spain ^e	5,100	5,000	5,000	5,000	5,000
Sri Lanka	46	70	61	60	68 ⁴
Sweden ^e	700	700	700	700	700
Thailand	862	844	496	500 ^r	500
Turkey	2,608 ^r	4,998 ^r	2,423 ^r	4,499 ^r	4,000
United Kingdom	5,174 ^r	4,909 ^r	4,777 ^r	3,755 ^r	3,760
United States, sold or used by producers	28,900	30,100	30,400	24,600	29,900 ⁴
Venezuela ^e	500	500	500	500	500
Zimbabwe ¹⁰	1 ^e	--	--	--	--
Total	118,000 ^r	128,000 ^r	123,000 ^r	114,000 ^r	121,000

^eEstimated. ^pPreliminary. ^rRevised. NA Not available. -- Zero.

¹World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through July 1, 2011.

³In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, China, and countries of the Commonwealth of Independent States produce industrial sand, but current available information is inadequate to formulate reliable estimates of output levels.

⁴Reported figure.

⁵Fiscal years beginning July 1 of that stated.

⁶Ethiopian calendar year ending July 7 of that stated.

⁷Source: Guyana Geology and Mines Commission and the Bank of Guyana.

⁸Fiscal years beginning March 21 of that stated.

⁹Less than ½ unit.

¹⁰Includes rough and ground quartz as well as silica sand.