



2012 Minerals Yearbook

SILICA

SILICA

By Thomas P. Dolley

Domestic survey data and tables were prepared by Annie Hwang, 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 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 50.7 million metric tons (Mt) in 2012 from 43.8 Mt in 2011 (table 1). Industrial sand production increased by 16%, and industrial gravel production declined slightly, compared with that of 2011. During the year, the value of production was \$2.67 billion—a 34% increase from that of 2011 and a record-high value for industrial sand and gravel production. As in the past several years, the most important driving force in the industrial sand and gravel industry remained the production and sale of hydraulic fracturing sand (frac sand). Estimated world production of industrial sand and gravel in 2012 was 139 Mt, a 5% increase compared with 2011 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, 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 2012, as reported to the USGS from a voluntary survey by U.S. producers, was largely attributable to increasing demand for frac sand, which resulted in production capacity increases and the opening of new frac sand operations in the United States. Increased demand was noted for uses such as ceramics, chemicals, container glass, flat glass, hydraulic fracturing, other ground silica, roofing granules and fillers, specialty glass, and whole grain silica. Production of silica sand for the remaining end uses in 2012 either remained static or declined compared with that of 2011. With the exception of filtration, demand for silica gravel decreased for all end uses.

The consumption of frac sand has increased greatly as hydrocarbon exploration in the United States has shifted to natural gas and petroleum trapped in shale deposits. It has been estimated that by 2018, hydraulic fracturing could be used to produce 23% of petroleum and 57% of natural gas in the United States (Industrial Minerals, 2012).

Legislation and Government Programs.—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. The understanding of the regulations, the implementation of the measurements and actions taken to mitigate exposure to crystalline silica, and the appreciation of the impact of such exposure on the future of many industries remained central to an ongoing and often heated debate (Industrial Minerals, 1998). The Occupational Safety and Health Administration (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).

On June 21, 2012, OSHA and the National Institute for Occupational Safety and Health (NIOSH) issued a hazard alert instructing employers in hydraulic fracturing operations to take appropriate steps to protect workers from silica exposure. The hazard alert followed a cooperative study by NIOSH and industry partners that identified overexposure to silica as a health hazard to workers conducting hydraulic fracturing operations (Occupational Safety and Health Administration, 2012).

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 120 producers with 177 operations known to produce industrial sand and gravel. Of the 177 surveyed operations, 173 (98%) were active, and 4 were idle. The USGS received responses from 77 operations, and their combined production represented 75% of the U.S. total. Production for the 100 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 56% of the 50.7 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 36%, the West (Pacific and Mountain divisions) with 5%, and the Northeast (New England and Middle Atlantic) with 3% (table 2).

The leading producing States were, in descending order, Wisconsin, Illinois, Texas, Minnesota, Oklahoma, Arkansas, Michigan, Missouri, North Carolina, and Ohio (table 3). Their combined production accounted for 78% of the national total. States for which data were withheld in table 3 were not included among the leading producers.

Of the total industrial sand and gravel produced, 89% was produced at 76 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 Holdings, Inc.; Fairmount Minerals, Ltd.; Proppant Specialists, LLC; Premier Silica LLC; Badger Mining Corp.; Preferred Sands; Pattison Sand Co., LLC; Cadre Material Products, LLC; and Hi-Crush Partners LP. Their combined production represented 69% of the U.S. total.

On August 16, 2012, Hi-Crush Partners LP, a frac sand producer, filed an initial public offering with the U.S. Securities and Exchange Commission (Hi-Crush Partners LP, 2012). During the year, U.S. Silica Co. opened nine frac sand transload facilities (Hughes, 2012). In 2012, Fairmount Minerals Ltd. began boosting frac sand production at its Illinois operation to 2.5 million metric tons per year (Mt/yr) and at its Wisconsin operation to 1 Mt/yr (Ollett, 2012).

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 50.7 Mt of industrial sand and gravel sold or used, 62% was consumed as frac sand and sand for well packing and cementing and 16% as glassmaking sand (table 6). Foundry uses accounted for 9% of industrial sand and gravel consumption. Other leading uses were whole grain fillers and building products (3%), chemicals (2%), and other whole grain silica (2%). Abrasives, ceramics, fillers, filtration, metallurgical flux, other ground silica, recreational sand, roofing granules, silica gravel, and traction sand accounted for about 6% of industrial sand and gravel end uses.

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 intentionally located near a silica resource. For example, 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 2012, 83% of foundry sand was produced in the Midwest.

The Ordovician St. Peter Sandstone in the Midwest is a primary source of silica sand for many end uses, including frac sand. Mined in five States, frac sand from the St. Peter Sandstone is within reasonable transport distance to numerous underground shale formations producing natural gas. In 2012, 68% of frac sand was produced in the Midwest. Additional geologic sources of frac sand include the Cambrian Jordan Sandstone in Minnesota and the Cambrian Hickory Sandstone in Texas (Industrial Minerals, 2007).

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. All States received industrial sand and gravel. The States that received the most industrial sand and gravel were, in descending order, Texas, Wisconsin, Illinois, Oklahoma, Pennsylvania, California, North Carolina, Arkansas, Tennessee, and North Dakota. Producers reported sending 405,000 t of silica to Mexico (table 7). Because some producers did not provide this information, their data were estimated or assigned to the “Destination unknown” category. In 2012, 50% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking increased by 10% compared with that of 2011. Sales of sand for container glass production increased by 14%, and sales to flat glass manufacturers increased by 3% compared with those in 2011. 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 36% compared with that of 2011, ground silica sand consumed for fiberglass production increased by 31%, and sales for specialty glass increased by 29%.

The increased demand for frac sand was the result of ongoing exploration and production of natural gas and petroleum from various underground shale formations throughout the United States. In 2012, sales of frac sand increased by 28% compared with those of 2011.

The demand for foundry sand is dependent mainly on automobile and light truck production. Although production and sales of automobiles and light trucks increased in 2012, sales of foundry sand decreased slightly compared with those of 2011.

Whole grain silica is regularly used in filler-type and building applications. In 2012, consumption of whole-grain fillers for building products was 1.68 Mt, a 10% decrease compared with that of 2011.

In 2012, silica sales for chemical production were 890,000 t, an increase of about 26% compared with those in 2011. Total sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses were about the same in 2012 as those in 2011. The main uses for silicon metal are in the manufacture of silanes and semiconductor-grade silicon and in the production of aluminum alloys.

Transportation.—The U.S. frac sand boom has created a logistics problem for hydraulic fracturing suppliers. Increased volumes of traffic have congested railways, making transportation of frac sand to sites of first use (oil and gas fields) difficult and expensive for frac sand producers. Of all industrial sand and gravel produced, 71% was transported by truck from the plant to the site of first sale or use, up 9% from that of 2011; 21% was transported by rail, down 28% from that of 2011; and 8% was transported by unspecified modes of transport.

Prices.—The average value, free on board plant, of U.S. industrial sand and gravel increased to \$52.80 per metric ton in 2012, a 16% increase compared with the average value of \$45.71 per metric ton in 2011 (table 6). Average values increased for some end uses and decreased for others, but

substantial increases for the leading end uses resulted in overall increased unit values. The average unit values for industrial sand and industrial gravel were \$52.99 per ton and \$25.74 per ton, respectively. The average price for sand ranged from \$23.21 per ton for other whole grain silica to \$71.07 per ton for sand for well packing and cementing. For gravel, prices ranged from \$19.88 per ton for silicon and ferrosilicon to \$24.17 per ton for filtration. In any given year, 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, sand for well packing and cementing had the highest value (\$71.07 per ton), followed by ground sand used as filler for paint, putty, and rubber (\$64.71 per ton), frac sand (\$62.67 per ton), sand for municipal water filtration (\$62.44 per ton), silica for ceramics (\$54.11 per ton), ground sand used for foundry molding and core (\$53.17 per ton), and sand for refractory uses (\$52.86 per ton).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest (\$57.67 per ton), followed by the South (\$46.78 per ton), the Northeast (\$46.34 per ton), and the West (\$45.59 per ton) (table 6). Prices can vary greatly for similar grades of silica at different locations in the United States, owing to tighter supplies and higher production costs in certain regions of the country. For example, the average value of container glass sand varied from \$29.92 per ton in the South to \$41.65 per ton in the West.

Foreign Trade.—Exports of industrial sand and gravel in 2012 increased slightly compared with the amount exported in 2011, and the associated value decreased by about 12% (table 8). Canada was the leading recipient of U.S. exports, receiving 53% of total industrial sand and gravel exports; Mexico received 19%, and Japan, 15%. The remainder went to many other countries. The average unit value of exports decreased to \$75.15 per ton in 2012 from \$85.69 per ton in 2011. In 2012, export unit values varied widely by region; exports of silica to Africa and the Middle East averaged \$649.33 per ton, and exports to the rest of the world averaged \$74.75 per ton.

Imports for consumption of industrial sand and gravel decreased by 3% to 306,000 t, compared with those of 2011 (table 9). Canada supplied about 74% of the silica imports, and imports from Canada averaged \$35.85 per ton; this included cost, insurance, and freight costs to the U.S. port of entry. The total value of imports was \$36.6 million, with an average unit value of \$119.54 per ton. Higher priced imports came from Australia, Chile, China, Germany, Japan, Mexico, and the Netherlands.

World Review.—Based on information provided mainly by foreign governments, world production of industrial sand and gravel was estimated to be 139 Mt (table 10). Of the countries listed, the United States was the leading producer followed, in descending order, by Italy, Germany, Turkey, France, Australia, Spain, United Kingdom, Mexico, 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 2013 was expected to be 51 to 52 Mt. 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.

Increased demand has been noted for most segments of silica sand for glassmaking. Based on these factors, production of silica sand for glassmaking in 2013 was expected to be 7.5 to 8 Mt.

The demand for foundry sand is dependent mainly on automobile and light truck production. Production and sales of automobiles and light trucks increased in 2012 and the trend continued into 2013. 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 2013 was expected to be 4.5 to 4.7 Mt.

Frac sand sales increased in 2012 compared with those in 2011. Production of crude oil and natural gas increased in the United States in 2012 with the trend continuing into 2013. On average, crude oil and natural gas prices fluctuated in 2012 with an overall trend toward slightly higher prices into 2013. Based on this trend, demand for and production of frac sand should be sustained in 2013. Myriad factors affect the demand for frac sand, such as fluctuating prices for natural gas as dictated by seasonal weather conditions. Hydrocarbon drilling and production efficiency improvements, coupled with slightly declining exploratory drilling activity and well completions, primarily onshore in the United States, could tend to decrease demand for frac sand. Based on available information, production of frac sand was expected to be 31 to 35 Mt. in 2013.

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 U.S. demand well beyond 2013. Barring future 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 will continue to be an important factor in determining the economic feasibility of developing a deposit. 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 a raw material for ceramics. Increased efforts to reduce waste and to increase recycling also would be likely to lower the demand for mined glass sand. Glass cullet is an industry term for furnace-ready scrap glass and is an important material used in the manufacturing of glass. 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 decrease by approximately 2% to 3%. In 2012, 41% of beer and soft drink glass bottles were recovered for recycling. An additional 34% of wine and liquor glass bottles and 15% of food and other glass jars were recycled. In total, about 34% of all glass containers were recycled (Glass Packaging Institute, 2013).

Health concerns about the use of silica sand 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, 2012, 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 2012, 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 2012, based on the USGS survey, 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 2012, the USGS collected domestic consumption data for quartz crystal through a survey of 19 U.S. operations that fabricate quartz crystal devices in 8 States. Of the 19 operations, 2 responded to the survey. Total U.S. consumption of quartz crystal in 2012, including nonrespondents, was estimated at 1,300 kilograms.

Prices.—The price of as-grown cultured quartz was estimated to be \$200 per kilogram in 2012. Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, was estimated to be \$400 per kilogram in 2012, however, prices ranged from \$20 per kilogram to more than \$900 per kilogram, 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 lascas. 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.—Continuing growth of the consumer electronics market (for example, automobiles, cellular telephones, electronic games, and personal computers) in the United States will likely continue to provide consumer outlets for domestically produced quartz crystal devices. The increasing global electronics market may require additional production capacity worldwide.

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.—In response to a USGS production survey, two of four domestic firms known to produce special silica stone, responded in 2012. 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 to Washita stone, a soft coarse 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 2012, the average value as reported by domestic producers of crude material suitable for cutting into finished products was estimated to be \$250 per ton.

Foreign Trade.—In 2012, silica stone product exports had a value of \$11.9 million, up by 8% from that in 2011. 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 2012.

In 2012, the value of imported silica stone products was \$11.2 million, down slightly from that in 2011. These imports were hand sharpening or polishing stones, which accounted for most of or all the imported silica stone products in 2012. 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 2012, three U.S. firms were known to produce and process tripoli. American Tripoli, Inc. 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, two responded to the USGS survey. Production for the nonrespondent 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 in 2012 increased by 63% in quantity to 120,000 t with a value of \$18.9 million (table 1). The increase in tripoli sales was due in large part to its use as a functional filler and extender in adhesives, plastics, rubber, and sealants.

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 42 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2012, 5% 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 2012, the primary use of tripoli (94%) was as a filler and extender. The remaining 1% was in brake friction products and refractories.

Prices.—The average unit value as reported by domestic producers of all tripoli sold or used in the United States was estimated to be \$158 per ton in 2012. The average unit value of abrasive-grade tripoli sold or used in the United States during 2012 was estimated to be \$247 per ton, and the average unit value of filler-grade tripoli sold or used domestically was estimated to be \$156 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.

References Cited

- Glass Packaging Institute, 2013, Glass recycling facts: Alexandria, VA, Glass Packaging Institute. (Accessed March 18, 2014, at <http://www.gpi.org/recycling/glass-recycling-facts>.)
- Hi-Crush Partners LP, 2012, Hi-Crush Partners LP company overview: Houston, TX, Hi-Crush Partners LP, September. (Accessed November 13, 2013, at <http://hicrushpartners.com/>.)
- Hughes, Emma, 2012, Frac freight—US Silica opens new storage facility in Ohio: *Industrial Minerals*, October 4. (Accessed October 4, 2012, via <http://www.indmin.com>.)
- Industrial Minerals*, 1998, Crystalline silica: *Industrial Minerals*, no. 367, April, p. 109–117.
- Industrial Minerals*, 2004, The glass pack—Minerals in container glass: *Industrial Minerals*, no. 439, April, p. 75–81.
- Industrial Minerals*, 2007, The facts of frac: *Industrial Minerals*, no. 472, January, p. 58–61.
- Industrial Minerals*, 2009, Gas fuels proppant prospects: *Industrial Minerals*, no. 506, November, p. 37–43.
- Industrial Minerals*, 2012, Frac sand in the pipeline: *Industrial Minerals*, no. 533, February, p. 32–40.
- Occupational Safety and Health Administration, 2002, Crystalline silica exposure health hazard information: Occupational Safety and Health Administration factsheet, 2 p. (Accessed August 14, 2009, at http://www.osha.gov/OshDoc/data_General_Facts/crystalline-factsheet.pdf.)

Occupational Safety and Health Administration, 2012, OSHA and NIOSH issue hazard alert on ensuring workers in hydraulic fracturing operations have appropriate protections from silica exposure: Occupational Safety and Health Administration news release. (Accessed June 27, 2012, at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=22596.)

Ollett, John, 2012, Fairmount boosts frac sand production at two mines: *Industrial Minerals*, September 13. (Accessed September 26, 2012, via <http://www.indmin.com>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Abrasives, Manufactured. Ch. in *Minerals Yearbook*, annual.
- Abrasives, Manufactured. Mineral Industry Surveys, quarterly.
- Garnet, Industrial. Ch. in *Minerals Yearbook*, annual.
- Historical Statistics for Mineral and Material Commodities in the United States, Data Series 140.
- Pumice and Pumicite. Ch. in *Minerals Yearbook*, annual.
- Quartz Crystal. Ch. in *Mineral Commodity Summaries*, annual.
- Silica Sand. Ch. in *United States Mineral Resources*, Professional Paper 820, 1973.

Other

- Aggregates Manager, monthly.
- Ceramics Industry, monthly.
- Electronic Component News, monthly.
- Electronic News, weekly.
- Electronics, biweekly.
- Engineering and Mining Journal, monthly.
- Glass International, monthly.
- Industrial Minerals*, monthly.
- Pit & Quarry, monthly.
- Rock Products, monthly.
- Sand and Gravel. Ch. in *Mineral Facts and Problems*, U.S. Bureau of Mines Bulletin 675, 1985.
- Stockpile Primer, A. U.S. Department of Defense, Directorate of Strategic Materials Management, August 1995.

TABLE 1
SALIENT U.S. SILICA STATISTICS¹

(Thousand metric tons and thousand dollars unless otherwise specified)

	2008	2009	2010	2011	2012
Industrial sand and gravel:²					
Sold or used:					
Quantity:					
Sand	29,300	26,900	31,700	43,400	50,300
Gravel	1,110	565	582	348	345
Total	30,400	27,500	32,300	43,800 ^r	50,700
Value:					
Sand	909,000	921,000	1,130,000	1,990,000 ^r	2,670,000
Gravel	28,000	21,000	14,900	14,400	8,880
Total	937,000	942,000	1,150,000	2,000,000	2,670,000
Exports:					
Quantity	3,100	2,150	3,950	4,330	4,360
Value	260,000	175,000	323,000	371,000	327,000
Imports for consumption:					
Quantity	355	95	132	316	306
Value	23,500	8,080	19,300	87,900	36,600
Processed tripoli: ³					
Quantity metric tons	132,000	79,700	110,000	73,700	120,000
Value	17,100	16,400	20,000	16,500	18,900
Special silica stone:					
Crude production:					
Quantity metric tons	W	W	W	W	156 ^e
Value	W	W	W	W	39 ^e
Sold or used:					
Quantity metric tons	W	W	W	W	500 ^e
Value	W	W	W	W	823 ^e

^eEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data.

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

²Excludes Puerto Rico.

³Includes amorphous silica and Pennsylvania rottenstone.

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

Geographic region ²	2011				2012			
	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	123	(3)	\$6,110	(3)	133	(3)	\$6,600	(3)
Middle Atlantic	1,540	4	62,100	3	1,360	3	62,500	2
Midwest:								
East North Central	14,700	34	714,000	36	20,900	41	1,210,000	47
West North Central	7,480	17	405,000	20	7,470	15	422,000	16
South:								
South Atlantic	3,460	8	101,000	5	3,660	7	113,000	4
East South Central	1,400	3	27,000	1	1,440	3	39,800	2
West South Central	12,200	28	592,000	30	13,200	26	701,000	24
West:								
Mountain	1,180	3	39,300	2	1,200	2	66,900	3
Pacific	1,700 [†]	4	55,700 [†]	3	1,350	3	49,400	2
Total	43,800 [†]	100	2,000,000	100	50,700	100	2,670,000	100

[†]Revised.

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

²Sales region equivalent to U.S. Census Bureau Geographic Division as follows: New England (CT, MA, ME, NH, RI, VT); Middle Atlantic (NJ, NY, PA); East North Central (IL, IN, MI, OH, WI); West North Central (IA, KS, MN, MO, NE, ND, SD); South Atlantic (DC, DE, FL, GA, MD, NC, SC, VA, WV); East South Central (AL, KY, MS, TN); West South Central (AR, LA, OK, TX); Mountain (AZ, CO, ID, MT, NM, NV, UT, WY); Pacific (AK, CA, HI, OR, WA).

³Less 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	2011		2012	
	Quantity	Value	Quantity	Value
Alabama	352	10,500	401	13,200
Arizona	W	W	W	W
Arkansas	W	W	2,800	211,000
California	1,320 ^r	43,500 ^r	1,010	37,600
Colorado	W	W	W	W
Florida	180	4,370	195	5,800
Georgia	655	19,600	585	16,500
Idaho	W	W	--	--
Illinois	6,160	311,000	7,440	504,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kansas	W	W	--	--
Louisiana	550	23,700	512	21,800
Michigan	1,830	67,500	1,450	59,100
Minnesota	W	W	3,670	210,000
Missouri	1,970	101,000	1,390	76,000
Nebraska	W	W	W	W
Nevada	W	W	W	W
New Jersey	974	34,400	773	32,100
New York	W	W	W	W
North Carolina	1,330	35,300	1,230	30,700
North Dakota	W	W	W	W
Ohio	1,100	54,000	1,160	34,500
Oklahoma	1,780	69,600	2,850	112,000
Pennsylvania	W	W	W	W
Rhode Island	W	W	W	W
South Carolina	451	16,700	483	20,300
Tennessee	1,050	16,500	1,040	26,600
Texas	7,000	337,000	7,010	357,000
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	W	W	W	W
Wisconsin	5,510	280,000	10,700	611
Other	19,700	951,000 ^r	17,800	1,680,000
Total	43,800 ^r	2,000,000	50,700	2,670,000

^rRevised. 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 2012, BY SIZE OF OPERATION¹

Size range	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	37	23	407	(2)
25,000 to 49,999	14	8	494	3
50,000 to 99,999	20	11	1,270	2
100,000 to 199,999	26	15	3,290	6
200,000 to 299,999	17	9	3,780	7
300,000 to 399,999	9	5	2,810	5
400,000 to 499,999	4	2	1,710	3
500,000 to 599,999	12	8	5,390	12
600,000 to 699,999	8	5	4,700	11
700,000 and more	26	14	26,800	51
Total	173	100	50,700	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 2012, BY GEOGRAPHIC DIVISION

Geographic region	Mining operations on land		Dredging operations	Total active operations
	Stationary	Stationary and portable		
Northeast:				
New England	1	--	--	1
Middle Atlantic	4	--	3	7
Midwest:				
East North Central	62	--	2	66
West North Central	14	1	2	17
South:				
South Atlantic	17	--	3	20
East South Central	5	--	3	9
West South Central	36	--	3	39
West:				
Mountain	4	--	--	4
Pacific	10	--	--	10
Total	153	1	16	173

-- Zero.

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2012, BY MAJOR END USE¹

Major use	Northeast			Midwest			South			West			U.S. total			
	Quantity (thousand metric tons)	Value (thou-sands)	Unit value ² (dollars per ton)	Quantity (thousand metric tons)	Value (thou-sands)	Unit value ² (dollars per ton)	Quantity (thousand metric tons)	Value (thou-sands)	Unit value ² (dollars per ton)	Quantity (thousand metric tons)	Value (thou-sands)	Unit value ² (dollars per ton)	Quantity (thousand metric tons)	Value (thou-sands)	Unit value ² (dollars per ton)	
																Quantity (thousand metric tons)
Sand:																
Glassmaking:																
Containers	W	W	\$40.23	916	\$33,900	\$37.04	2,420	\$72,300	\$29.92	479	\$20,000	\$41.65	4,240	\$144,000	\$33.83	
Flat, plate and window	W	W	51.28	655	12,700	19.32	1,480	33,300	22.45	428	15,600	36.51	2,710	68,800	25.41	
Specialty	W	W	51.14	218	7,640	35.05	174	6,220	35.73	W	W	61.17	506	19,700	39.03	
Fiberglass, unground	W	W	10.44	W	W	34.21	206	7,290	35.37	3	115	38.33	236	8,150	34.52	
Fiberglass, ground	--	--	--	(3)	(3)	--	506	25,800	50.97	W	W	57.43	513	26,200	51.06	
Foundry:																
Molding and core, unground	39	\$1,660	42.62	3,840	160,000	41.75	580	21,900	37.70	38	1,900	49.89	4,490	186,000	41.30	
Molding and core, ground	--	--	--	W	W	72.00	W	W	49.40	--	--	--	W	W	53.17	
Refractory	W	W	--	W	W	72.47	79	3,250	41.09	--	--	--	126	6,660	52.86	
Metallurgical, flux for metal smelting	--	--	--	--	--	--	W	W	48.83	W	W	10.43	W	W	36.86	
Abrasives:																
Blasting	W	W	55.64	26	1,620	62.19	341	12,600	36.92	80	1,500	18.76	492	18,300	37.24	
Chemicals, ground and unground	W	W	46.00	312	18,500	59.45	559	23,500	41.99	17	686	40.35	890	42,800	48.14	
Filters, ground, rubber, paints, putty, etc.	W	W	62.50	W	W	24.68	W	W	121.92	W	W	51.80	165	10,700	64.71	
Whole-grain fillers/building products	244	10,900	44.75	305	14,500	47.68	699	23,900	34.20	435	19,800	45.47	1,680	69,100	41.06	
Ceramic, ground, pottery, brick, tile, etc.	W	W	71.07	4	246	61.50	70	3,010	42.96	W	W	--	117	6,330	54.11	
Filtration:																
Water, municipal, county, local	41	2,610	63.56	93	5,620	60.42	55	3,750	68.24	10	510	51.00	200	12,500	62.44	
Swimming pool, other	9	508	56.44	23	991	43.09	64	2,060	32.13	W	W	161.00	98	3,720	37.93	
Petroleum industry:																
Hydraulic fracturing	W	W	72.59	21,200	1,360,000	64.09	8,950	533,000	59.61	834	48,300	57.90	31,100	1,950,000	62.67	
Well packing and cementing	--	--	--	51	3,180	64.50	359	25,100	70.01	17	2,040	119.94	427	30,300	71.07	
Recreational:																
Golf course, greens and traps	42	1,840	43.79	128	2,230	17.38	323	8,220	25.44	23	964	41.91	517	13,200	25.62	
Baseball, volleyball, play sand, beaches	19	765	40.26	35	1,540	43.89	97	3,680	37.89	16	646	40.38	168	6,620	39.41	
Traction, engine	9	361	40.11	17	404	23.76	32	967	30.22	9	483	53.67	68	2,210	32.56	
Roofing granules and fillers	W	W	39.44	73	1,700	23.33	417	12,800	30.68	24	789	32.88	573	17,600	30.74	
Other, ground silica	W	W	50.75	20	898	29.06	18	682	33.23	W	W	24.00	44	1,830	32.59	
Other, whole grain	1,060	49,200	11.99	402	11,000	19.31	610	25,300	30.73	134	2,960	15.52	975	24,600	23.21	
Total or average	1,460	67,800	46.52	28,300	1,630,000	57.76	18,000	849,000	47.07	2,550	116,000	45.64	50,300	2,670,000	52.99	
Gravel:																
Silicon, ferrosilicon	--	--	--	--	--	--	122	2,410	19.77	5	93	21.20	126	2,510	19.88	
Filtration	W	W	88.56	W	W	34.87	66	1,540	23.30	--	--	--	101	2,440	24.17	
Other uses, specified	W	W	--	W	W	--	50	1,980	--	1	13	--	118	3,940	--	
Total or average	33	1,260	38.30	69	1,580	22.90	238	5,930	24.92	6	106	21.20	345	8,880	25.74	
Grand total or average	1,490	69,100	46.34	28,300	1,630,000	57.67	18,300	855,000	46.78	2,550	116,000	45.59	50,700	2,670,000	52.80	

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 1/2 unit.

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

(Thousand metric tons)

Destination	2011	2012	Destination	2011	2012
States:			States—Continued:		
Alabama	W	270	New Jersey	W	400
Alaska	W	W	New Mexico	W	W
Arizona	W	W	New York	W	W
Arkansas	623	765	North Carolina	W	811
California	1,330 ^r	1,060	North Dakota	330	504
Colorado	W	W	Ohio	259	316
Connecticut	W	W	Oklahoma	W	1,620
Delaware	W	W	Oregon	W	W
District of Columbia	W	W	Pennsylvania	1,140	1,090
Florida	254	275	Rhode Island	W	W
Georgia	W	W	South Carolina	W	175
Hawaii	W	W	South Dakota	3	9
Idaho	W	W	Tennessee	W	577
Illinois	W	1,620	Texas	5,920	7,150
Indiana	W	W	Utah	W	W
Iowa	W	W	Vermont	W	W
Kansas	W	155	Virginia	W	W
Kentucky	W	W	Washington	W	W
Louisiana	406	270	West Virginia	W	W
Maine	W	W	Wisconsin	W	2,520
Maryland	W	W	Wyoming	W	W
Massachusetts	W	W	Countries:		
Michigan	W	399	Canada	W	W
Minnesota	W	345	Mexico	337	405
Mississippi	W	W	Other	W	W
Missouri	W	165	Other:		
Montana	15	12	Puerto Rico	--	W
Nebraska	W	W	U.S. possessions and territories	W	W
Nevada	W	W	Destination unknown	23,100	25,200
New Hampshire	W	W	Total	43,800 ^r	50,700

^rRevised. 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	2011		2012	
	Quantity	Value ²	Quantity	Value ²
Africa and the Middle East:				
Egypt	(3)	117	--	--
Israel	(3)	378	(3)	267
Other	--	995	3	1,680
Total	1	1,490	3	1,950
Asia:				
China	239	98,100	30	58,800
Hong Kong	1	329	(3)	215
Japan	1,340	48,700	632	29,600
Korea, Republic of	9	5,380	6	4,360
Singapore	2	966	1	526
Taiwan	7	1,830	2	1,810
Other	2	1,670	4	3,030
Total	1,600	157,000	675	98,400
Europe:				
Belgium	2	1,320	175	6,060
Germany	134	41,000	150	28,600
Italy	(3)	145	(3)	85
Netherlands	15	8,090	11	6,130
Russia	(3)	13	(3)	7
United Kingdom	2	2,880	2	1,550
Other	93	8,270	135	8,670
Total	246	61,700	473	51,100
North America:				
Bahamas, The	(3)	97	1	178
Canada	1,700	87,800	2,330	116,000
Mexico	702	47,700	807	45,100
Trinidad and Tobago	1	133	1	277
Other	20	1,870	8	1,670
Total	2,420	138,000	3,140	163,000
Oceania:				
Australia	23	1,250	1	324
New Zealand	1	71	--	126
Total	24	1,320	1	450
South America:				
Argentina	18	4,780	25	5,150
Brazil	3	1,010	13	1,510
Colombia	6	3,500	6	994
Peru	15	2,110	15	3,680
Venezuela	1	412	1	418
Other	1	457	1	586
Total	44	12,300	61	12,300
Grand total	4,340	371,000	4,360	327,000

-- 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	2011		2012	
	Quantity	Value ²	Quantity	Value ²
Australia	2	943	1	741
Canada	106	5,860	226	8,100
Chile	1	162	1	294
China	1	684	3	557
Germany	(3)	529	(3)	586
Japan	(3)	19	(3)	7
Mexico	198	76,300	64	23,400
Netherlands	(3)	62	(3)	58
Other	8	3,380	11	2,840
Total	316	87,900	306	36,600

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	2008	2009	2010	2011	2012 ^e
Algeria	276 ^r	134 ^r	95 ^r	95 ^{r,e}	100
Argentina	473	364	531	517 ^r	450
Australia ^e	5,500	5,000 ^r	5,100 ^r	5,300 ^r	5,300
Austria	2,175	1,200	939	898 ^r	900
Belgium	NA ^r	NA ^r	NA ^r	NA ^r	NA
Belize ^{e,4}	479 ^r	601 ^r	601 ^r	601 ^r	601
Bosnia and Herzegovina	702	525	495	1,075 ^r	500
Brazil, silex ^c	2	2	2	2	2
Bulgaria ^e	734 ⁵	657 ⁵	660	660	660
Canada, quartz	1,979	1,296	1,171	1,620 ^r	1,593 ^{p,5}
Chile	1,401	1,405	1,326	1,237	1,267 ⁵
Croatia	150 ^e	278 ^r	241 ^r	227 ^r	230
Cuba	29	16 ^r	11 ^r	16 ^r	15
Czech Republic, foundry sand	1,853	1,364	1,361	1,371 ^r	1,340
Denmark	NA ^r	NA ^r	NA ^r	NA ^r	NA
Ecuador	25	74	--	--	--
Egypt ⁶	384 ^r	410 ^r	401 ^r	400 ^{r,e}	400
Eritrea ^c	2 ^r	2 ^r	2 ^r	2 ^r	2
Estonia, industrial sand	--	--	36	NA	NA
Ethiopia ⁷	7	31	70	71 ^{r,e}	71
Finland	3,160	2,241	NA ^r	2,400 ^{r,e}	2,400
France	5,200 ^{r,e}	7,442 ^r	8,498 ^r	6,286 ^r	6,290
French Guyana ^c	1,500	1,500	437 ^{r,5}	500 ^r	500
Gambia	1,065	1,062	1,121	1,200 ^e	1,200
Germany	8,186	6,453	7,234	7,770	7,498 ⁵
Greece ^c	65 ⁵	38 ⁵	40 ^r	40 ^r	36
Guatemala	65	36	62	60 ^{r,e}	49
Guyana ⁸	684	479	652	652	652
Hungary, foundry and glass sand	220 ^r	85 ^r	271 ^r	170 ^r	200
Iceland ^c	4	4	4	4	4
India ^c	1,700	1,700	1,800	1,800	1,900
Indonesia ^e	38	32 ⁵	36	37	38
Iran ⁹	NA ^r	NA ^r	NA ^r	NA ^r	NA
Iraq	19	18	20 ^r	20 ^e	20
Ireland	NA ^r	NA ^r	NA ^r	NA ^r	NA
Israel	195	163	198	233 ^r	240
Italy	14,000 ^e	19,759	17,656 ^r	16,369 ^r	16,400
Jamaica	15	7	13	13 ^e	10
Japan	3,664	2,856	3,078	3,003 ^r	3,200
Jordan	23	298	173 ^r	88 ^r	100
Kenya ^c	16	15	17 ^r	18 ^r	18
Korea, Republic of	1,757	455	535	394 ^r	400
Latvia ^c	12 ^r	12 ^r	12 ^r	12 ^r	12
Lithuania	38	41 ^r	67	53 ^r	53
Malaysia	1,467	630	932	1,340 ^r	1,200
Mexico	2,779	2,484	2,608	2,570	3,593 ⁵
Moldova	2,707 ^r	1,830 ^r	2,146 ^r	2,547 ^r	2,966 ⁵
Netherlands	NA ^r	NA ^r	NA ^r	NA ^r	NA
New Zealand	49	43	113	109 ^r	100
Nigeria ^c	26 ⁵	32 ⁵	30	30	30
Norway, quartz and quartzite	1,025 ^r	1,022 ^r	1,055 ^r	1,000 ^{r,e}	1,000
Paraguay	NA ^r	NA ^r	NA ^r	NA ^r	NA
Peru, quartz and quartzite (crushed) ^c	124 ^{r,5}	124 ^r	124 ^r	124 ^r	124
Philippines	270	284	296	352 ^r	350
Poland	2,398	2,127	2,458	2,570 ^r	2,570
Portugal, quartz and quartzite	9 ^r	35 ^r	76 ^r	29 ^r	29

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	2008	2009	2010	2011	2012 ^c
Romania	NA ^r	NA ^r	NA ^r	NA ^r	NA
Saudi Arabia	799	709	820	830 ^{r, e}	900
Slovakia ^c	619 ⁵	502 ⁵	500	500	500
Slovenia	354	327	511 ^r	500 ^{r, e}	500
South Africa	3,342	2,306	2,905	2,863 ^r	2,600
Spain, industrial sand ^c	5,000	5,000	5,000	5,000	5,000
Sri Lanka	61	60	68	65 ^e	63
Sweden, quartz and quartzite ^c	151	56	85	NA ^r	NA
Taiwan	250	328	306	173	16 ⁵
Thailand ^c	496 ⁵	500 ⁵	500	500	500
Turkey	2,423	4,499	4,022 ^r	7,021 ^r	7,000
United Kingdom ^c	4,777 ⁵	3,755 ⁵	3,760	3,760	3,760
United States, sold or used by producers	30,441	27,511	32,264	43,762 ^r	50,651 ⁵
Venezuela ^c	500	500	500	500	500
Total	118,000 ^r	113,000 ^r	118,000 ^r	132,000 ^r	139,000

^cEstimated. ^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.

²Includes data available through April 28, 2014.

³In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, Belgium, Denmark, Iran, Ireland, Netherlands, Paraguay, and Romania produce industrial sand, but current available information is inadequate to formulate reliable estimates of output levels. Based on estimates of glass end use consumption, China is the world's largest producer of industrial sand; however, available information is inadequate to formulate reliable estimates of output levels.

⁴Belize reports silica production, in cubic meters, as follows: 2008—399,000 (revised estimate); 2009—500,000 (revised estimate); 2010—500,000 (revised estimate); 2011—500,000 (revised estimate); and 2012—500,000 (estimate).

⁵Reported figure.

⁶Fiscal year beginning July 1 of that stated. Silica sand only; no gravel.

⁷Ethiopian calendar year ending July 7 of that stated.

⁸Source: Guyana Geology and Mines Commission and the Bank of Guyana.

⁹Fiscal year beginning March 21 of that stated.