USGS
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2014 Minerals Yearbook

SILICA [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

October 2016

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 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 110 million metric tons (Mt) in 2014 from 62.1 Mt in 2013 (table 1). Industrial sand production increased by 77% and industrial gravel production nearly tripled compared with those of 2013. The value of production in 2014 was $8.25 billion—nearly 2.5 times that of 2013—and as in the past several years, reached a record-high value for industrial sand and gravel production. Estimated world production of industrial sand and gravel in 2014 was 195 Mt, a 33% increase compared with 2013 production (table 10).

As in recent years, the most important driving force in the industrial sand and gravel industry remained the production and sale of hydraulic fracturing sand (frac sand). It would be difficult to overemphasize the effect that frac sand has had on the industrial sand and gravel industry, as production tonnage of frac sand in the 10-year period ending in 2014 was about 24 times that in 2004 (fig. 1). In 2014, frac sand use was double that of 2013.

During the past several years, the consumption of frac sand increased greatly as hydrocarbon exploration in the United States shifted to natural gas and petroleum in shale deposits. Strong demand in the energy sector, along with newer frac sand production capacity expansions and new mines coming online by yearend 2013, led to record frac sand production levels. By yearend 2014, however, the fall in global oil and gas prices prompted a slowing in frac sand production that continued into 2015.

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands and gravels with high silicon dioxide (SiO_2) content. Some examples of end uses for these sands and gravels are in 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.

Legislation and Government Programs.—One of the most important issues affecting the industrial minerals industry 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 effect of such exposure on the future of many industries remain central to an ongoing and often heated debate. The Occupational Safety and Health Administration (OSHA) enforces permissible exposure limits that stipulate 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 provides guidelines and training tools for the proper handling of crystalline silica (Occupational Safety and Health Administration, 2002).

After many years of study, OSHA issued a Notice of Proposed Rulemaking (NPRM) for Occupational Exposure to Respirable Crystalline Silica in the Federal Register on September 12, 2013. The NPRM was a proposal and not a final rule. OSHA stated that the proposed rule was the result of extensive review of scientific evidence relating to the health risks of exposure to respirable crystalline silica, analysis of the diverse industries where worker exposure to crystalline silica takes place, robust outreach efforts to affected stakeholders, and careful consideration of current industry consensus standards for crystalline silica exposure. OSHA stated that current permissible exposure limits for crystalline silica were inadequate (Occupational Safety and Health Administration, 2013). The period for public comment on the NRPM ended in 2014. By yearend 2014 and extending into 2015, work on the new ruling had slowed and OSHA announced plans to issue a comprehensive final rule on crystalline silica by January 2017 (National Law Review, The, 2015).

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 230 producers with 352 operations known to produce industrial sand and gravel. Of the 352 surveyed operations, 335 (95%) were active and 17 were idle or closed. The USGS received responses from 116 operations, and their combined production represented 53% of the U.S. total tonnage. Production data for the nonrespondents were 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 production increase for silica sand in 2014 was largely attributable to increasing demand for frac sand, many new frac sand operations coming on stream by yearend 2013 and into 2014, and planned production capacity increases at the major companies being fully utilized.

The Midwest (East North Central and West North Central divisions) led the Nation with 64% of the 110 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 31%, the West (Pacific and Mountain divisions) with 3%, and the Northeast (New England and Middle Atlantic divisions) with 2% (table 2).

The leading producing States were, in descending order, Wisconsin, Texas, Illinois, Minnesota, Missouri, Oklahoma, Arkansas, Ohio, North Carolina, and Louisiana (table 3). Their combined production accounted for 85% of the national total.

Of the total industrial sand and gravel produced, 92% was produced at 127 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.; Superior Silica Sands, LLC; Fairmount Minerals, Ltd.; Eagle Materials, Inc.; Source Energy Services LP; Hi-Crush Partners LP; Badger Mining Corp.; NBR Sand, LLC; and Chieftain Sand and Proppant, LLC. Their combined production represented 58% of the U.S. total.

In 2014, increased demand for frac sand was intensified by several companies experimenting with using more frac sand at oil and gas wells. Employing hydraulic fracturing, a single well can use as much as 1,800 metric tons (t) of frac sand. Additional frac sand can raise the output of a single well by up to 30%. As a result of increased demand, many producers raised the price of silica sand by 10% to 20% (Sider, 2014). During the year, demand for frac sand exceeded supply and sand mining companies found it difficult to get approvals to build mining facilities (Zuckerman, 2014). Owing primarily to its low cost when compared to ceramic proppants along with widespread availability, frac sand remained the leading proppant. In 2014, frac sand accounted for approximately 80% to 85% of the proppant market by tonnage, with ceramic proppants and resin-coated products accounting for 10% to 15% of the market (Industrial Minerals, 2014).

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 110 Mt of industrial sand and gravel sold or used, 75% was consumed as frac sand and sand for well packing and cementing, 8% as other whole-grain silica, and 8% as glassmaking sand (table 6). Other leading uses were foundry sand (2%), whole-grain fillers for building products (2%), other ground silica (2%), and chemicals (1%). Abrasives, ceramics, fillers, filtration, metallurgical flux, recreational sand, roofing granules, silica gravel, and traction sand, combined, accounted for about 2% of industrial sand and gravel end uses. Increased consumption was noted for uses such as frac sand; ground sand for fiberglass; municipal water filtration; other ground silica; other whole-grain silica; recreational sand; refractory foundry sand; sand for flat, fiber, and specialty glass; whole-grain silica fillers for building products; and other uses. Production of silica sand for the remaining end uses in 2014 declined or remained unchanged compared with that of 2013. Silica gravel consumption increased substantially for all end uses, included silicon and ferrosilicon metal production, filtration, and other uses.

Minable deposits of industrial sand and gravel occur throughout the United States, and mining operations 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 2014, 81% of foundry sand was produced in the Midwest (table 6).

The Ordovician St. Peter Sandstone in the Midwest is a primary source of silica sand ("Northern White" or "Ottawa" 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 2014, 76% of frac sand was produced in the Midwest. The principal sources of "Northern White" or "Ottawa" sand in the upper Midwest are the Middle and Upper Ordovician St. Peter Sandstone and the Lower Ordovician and Upper Cambrian Jordan Formation, along with the Upper Cambrian Wonewoc and Mount Simon Formations gaining in importance. Additional frac sand sources to the south include the Upper Cambrian Hickory Sandstone Member of the Riley Formation in Texas, which is referred to informally as "Brown" or "Brady" sand, and the Middle Ordovician Oil Creek Formation in Oklahoma (Benson and Wilson, 2015).

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, Oklahoma, North Dakota, Illinois, North Carolina, Pennsylvania, Ohio, Louisiana, and California. Producers reported exporting 650,000 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 2014, 55% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking decreased by 3% compared with that of 2013. Sales of sand for container glass production decreased by 14% in 2014 and sales to flat glass manufacturers increased slightly compared with those in 2013. On average, in the container glassmaking industry, silica accounts for 60% of raw materials used (Industrial Minerals, 2004). Owing principally to a number of smaller producers being added to the USGS canvass for 2014, the amount of unground silica sand consumed for fiberglass production increased by 89%, ground silica sand consumed for fiberglass production increased by 4%, and sales for specialty glass increased by 34%, compared with that of 2013.

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 2014, sales of foundry sand reportedly decreased by about 40% compared with those of 2013. Although a slight decrease in sales of foundry

sand was anticipated in 2014, it is unlikely that the decrease was as large as reported. Reasons for the shortfall in foundry sand production could be due to inadvertent misallocation of some foundry sand to another end use or possibly inadvertent estimation and reporting errors. However, some nonautomotive markets for metal casting were down or slowed in 2014, such as agricultural equipment, construction equipment, casting for pumps and valves, and mining equipment (Folk Group, The, 2015). Additionally, some nonautomotive segments of U.S. metal casting production were operating at 50% to 60% of capacity with others operating at 85% to 90% of capacity by mid-2015 (Spada, 2015).

Whole-grain silica is used regularly in filler-type and building applications. In 2014, consumption of whole-grain fillers for building products was 1.85 Mt, an 8% increase compared with that of 2013.

In 2014, silica sand sales for chemical production were 991,000 t, a decrease of about 14% compared with those in 2013. Total sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses nearly tripled in 2014 compared with those in 2013. The main uses for silicon metal are in the manufacture of silanes and semiconductor-grade silicon and in the production of aluminum alloys.

Transportation.—According to the USGS voluntary survey of U.S. producers, of all industrial sand and gravel produced, 44% was transported by truck from the plant to the site of first sale or use, 29% was transported by rail, 1% was transported by waterway, and 26% was transported by unspecified modes of transport. In any given year, most industrial sand and gravel, including frac sand, was transported by rail and truck to sites of first use, but because some producers did not provide transportation information, some transportation data were assigned to the "unspecified modes of transport" category.

Prices.—The average value, free on board plant, of U.S. industrial sand and gravel increased to $74.78 per metric ton in 2014, a 34% increase compared with the average value of $55.76 per metric ton in 2013 (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 $75.23 per ton and $10.61 per ton, respectively. The average unit value for sand ranged from $26.10 per ton for silica for roofing granules and fillers to $87.13 per ton for frac sand. For gravel, unit values ranged from $5.31 per ton for silicon and ferrosilicon feedstock to $36.94 per ton for filtration uses. Nationally, frac sand had the highest value ($87.13 per ton), followed by unground sand used for fiberglass ($75.45 per ton), ground sand for foundry molding and core ($68.45 per ton), sand for swimming pool filtration ($63.43 per ton), ground and unground sand for chemicals ($56.26 per ton), sand for abrasives ($55.62 per ton), and ground sand used as filler for paint, putty, and rubber ($55.19 per ton).

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 high-purity quartz products for specialized end uses, not covered in this chapter, can reach the $5,000 per ton level. These specialized end uses include fused quartz crucibles (for the manufacture of silicon metal ingots that are later processed into silicon wafers for the photovoltaic cell and semiconductor markets), solar power cells, high-temperature lamp tubing, and telecommunications uses (Industrial Minerals, 2013).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest ($83.14 per ton), followed by the South ($61.80 per ton), the Northeast ($46.86 per ton), and the West ($46.60 per ton) (table 6). Prices can vary greatly for similar grades of silica at various 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 $33.42 per ton in the South to $51.97 per ton in the West.

Foreign Trade.—Exports of industrial sand and gravel in 2014 increased by 50% compared with the amount exported in 2013 and the associated value increased by about 31% (table 8). Canada was the leading recipient of U.S. exports, receiving 73% of total industrial sand and gravel exports; Mexico received 15%, and Japan, 6%. The remainder went to many other countries. The average unit value of exports decreased to $103.70 per ton in 2014 from $119.12 per ton in 2013. In 2014, export unit values varied widely by region; exports of silica to Europe averaged $550.30 per ton, and exports to the rest of the world averaged $94.48 per ton.

Imports for consumption of industrial sand and gravel increased by 53% to 244,000 t, compared with those of 2013 (table 9). Canada supplied about 88% of the silica imports, and imports from Canada averaged $16.89 per ton; this included cost, insurance, and freight costs to the U.S. port of entry. The total value of imports was $20.4 million, with an average unit value of $83.55 per ton. Higher priced imports came from Australia, Chile, China, Germany, Japan, and Mexico.

World Review.—Based on information provided mainly by foreign governments, world production of industrial sand and gravel was estimated to be 195 Mt (table 10). Of the countries listed, the United States was the leading producer followed, in descending order, by Italy, France, Turkey, Germany, Australia, United Kingdom, Mexico, Moldova, India, and Spain. 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 sometimes difficult. In addition to the countries listed, many other countries were thought to have had some type of silica production and consumption.

Outlook.—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 is also produced in Arkansas, Missouri, Oklahoma, and Texas. Domestic production is expected to continue to satisfy 97% to 98% of U.S. consumption well beyond 2014. Barring future declines in the overall United States economy, imports of silica sand from Canada and Mexico and higher valued material from China are expected to slowly increase. The fall in global oil and gas prices that started in late 2014 and continued into 2015 resulted in decreased oilfield activity and concomitant

declining consumption of frac sand and sand for well packing and cementing. U.S. consumption of industrial sand and gravel in 2015 is expected to be 90 to 95 Mt.

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 decreases by approximately 2% to 3%. In 2012, 41% of beer and soft drink glass bottles were recovered for recycling in the United States. 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). Based on these factors, production of silica sand for glassmaking in 2015 is expected to be 8.0 to 8.5 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 2014 and the trend continued into 2015. 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 2015 is expected to be 4.0 to 4.5 Mt (Statista, 2016).

The United States remained the world's leading producer of petroleum and natural gas in 2014. Frac sand sales increased dramatically in 2014 compared with those in 2013, resulting in the largest annual reported production of frac sand in the United States. On average, global crude oil and natural gas prices declined by yearend 2014 and the downward trend continued in 2015. Based on this trend, demand for and production of frac sand are expected to decline in 2015. 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, coupled with improved hydraulic fracturing techniques that require more frac sand volume use per well, could tend to ameliorate declining demand for frac sand in 2015. Frac sand has a lower unit cost when compared with other proppants. Based on available information, production of frac sand is expected to be 60 to 67 Mt in 2015.

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

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. Historically, it is synthetically produced from natural feedstock quartz, termed "lascas," which is mined. However, cultured quartz crystal that has been rejected owing to crystallographic imperfections is used by certain companies as feedstock for growing cultured quartz crystal. Mining of lascas in the United States ceased in 1997 owing to competition from less expensive imported lascas, predominantly from mines in Brazil and Madagascar.

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, 2014, the National Defense Stockpile (NDS) contained 7,148 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 individual crystals in the NDS inventory that weigh 10 kg or more and 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. Brazil traditionally has

been the source of such large natural crystals, but changes in mining operations have reduced output.

No natural quartz crystal was sold from the NDS in 2014, and the Federal Government did not intend to dispose of or sell any of the remaining material.

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 2014, no domestic companies reported the production of cultured quartz crystal. However, cultured quartz crystal production was thought to take place in the United States, but production statistics were not available. Anecdotal evidence indicated that two companies produced cultured quartz crystal in the United States. At least one of these companies used cultured quartz crystal that had been rejected owing to crystallographic imperfections as feedstock for growing cultured quartz crystal. Larger quantities of cultured quartz crystal were produced overseas, primarily in Asia and Europe.

Consumption.—In 2014, the USGS collected domestic consumption data for quartz crystal through a survey of 10 U.S. operations that fabricate quartz crystal devices in 7 States. Of the 10 operations, 5 responded to the survey. Total U.S. consumption of quartz crystal in 2014, including nonrespondents, was estimated to be 1,600 kg.

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 of 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.

Prices.—The price of as-grown cultured quartz was estimated to be $280 per kilogram in 2014. Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, was estimated to range from $20 per kilogram to more than $1,000 per kilogram in 2014, 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 were thought to include large quantities of fused mullite and fused zirconia, which was inadvertently reported as quartz crystal, not including mounted piezoelectric crystals. Although no definitive data exist listing import sources for cultured quartz crystal, imported material was thought to be mostly from China, Japan, Romania, and the United Kingdom.

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, Romania, South Africa, and the United Kingdom. Details concerning quartz operations in China, Eastern Europe, and most nations of the Commonwealth of Independent States were unavailable. Operations in Russia, however, have significant capacity to produce synthetic quartz.

Outlook.—Demand for cultured quartz crystal for frequency-control oscillators and frequency filters in a variety of electronic devices should remain stable. However, during the past several years, silicon has gradually replaced cultured quartz in two very important markets—cellular telephones and automotive stability control applications. Future capacity increases to grow cultured quartz crystal may be negatively affected by this development. Growth of the consumer electronics market (for example, personal computers, electronic games, and tablet computers) is likely to sustain global production of cultured quartz crystal.

Special Silica Stone Products

It was estimated that, in 2014, crude production of special silica stone remained unchanged compared with that of 2013 (table 1). The value of crude production in 2014 was $36,000—unchanged from that in 2013. 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 chapters of the USGS Minerals Yearbook, volume I, Metals and Minerals).

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, none of the six domestic firms thought to produce special silica stone responded in 2014. 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 consists of 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 2014, the average value of crude material suitable for cutting into finished products was estimated to be $247 per metric ton.

Foreign Trade.—In 2014, silica stone product exports had a value of $12.8 million, up by 17% from that in 2013. 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 2014.

In 2014, the value of imported silica stone products was $12.3 million, up by 3% from that in 2013. These imports were hand sharpening or polishing stones, which accounted for most or all of the imported silica stone products in 2014. A portion of the finished products that were imported may have been made from crude novaculite produced in the United States and exported for processing.

Outlook.—Consumption patterns for special silica stone are not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses 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 2014, 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 2014 decreased by 15% in quantity to 93,100 t with a value of $19.5 million (table 1). The decrease in tripoli sales was due to lessened demand for its use as an abrasive and as a functional filler and extender in adhesives, plastics, rubber, and sealants. Tripoli was mostly used as a filler and extender in caulking compounds, concrete admixture, enamel, linings, paint, plastic, rubber, and other products. Most of the filler-grade tripoli was used in the relatively low-cost concrete admixture end use. In 2014, the primary use of tripoli (94%) was as a filler and extender. Less than 1% of the tripoli was used in brake friction products and refractories. The end-use pattern for tripoli has changed significantly in the past 44 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2014, about 6% of tripoli output was used as an abrasive.

Price.—The average unit value as reported by domestic producers of all tripoli sold or used in the United States was estimated to be $210 per metric ton in 2014. The average unit value of abrasive-grade tripoli sold or used in the United States during 2014 was estimated to be $279 per metric ton, and the average unit value of filler-grade tripoli sold or used domestically was estimated to be $208 per metric ton.

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

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

(Thousand metric tons and thousand dollars unless otherwise specified)

		2010	2011	2012	2013	2014
Industrial sand and gravel:[2]						
Sold or used:						
Quantity:						
Sand		31,700	43,400	50,300	61,900	110,000
Gravel		582	348	345	276	772
Total		32,300	43,800	50,600	62,100	110,000
Value:						
Sand		1,130,000	1,990,000	2,670,000	3,460,000	8,240,000
Gravel		14,900	14,400	8,880	9,350	8,190
Total		1,150,000	2,000,000	2,670,000	3,470,000	8,250,000
Exports:						
Quantity		3,950	4,330	4,360	2,960	4,450
Value		323,000	371,000	327,000	352,000	461,000
Imports for consumption:						
Quantity		132	316	306	160	244
Value		19,300	87,900	36,600	11,700	20,400
Processed tripoli:[3]						
Quantity	metric tons	110,000	73,700	120,000	110,000	93,100
Value		20,000	16,500	18,900	17,600	19,500
Special silica stone:						
Crude production:						
Quantity	metric tons	W	W	156	146 e	146 e
Value		W	W	39	36 e	36 e
Sold or used:						
Quantity	metric tons	W	W	500	465 e	465 e
Value		W	W	823	765 e	765 e

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

TABLE 2

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

Geographic region[2]	2013				2014			
	Quantity (thousand metric tons)	Percent of total	Value (thousands)	Percent of total	Quantity (thousand metric tons)	Percent of total	Value (thousands)	Percent of total
Northeast:								
New England	141	(3)	$7,310	(3)	163	(3)	$9,000	(3)
Middle Atlantic	1,550	2	62,800	2	1,750	2	80,500	1
Midwest:								
East North Central	32,200	52	1,830,000	53	56,300	51	4,770,000	58
West North Central	8,600	14	576,000	16	14,700	13	1,140,000	14
South:								
South Atlantic	3,840	6	144,000	4	5,490	5	154,000	2
East South Central	1,560	3	57,500	2	3,170	3	115,000	1
West South Central	12,000	19	693,000	20	25,200	23	1,820,000	22
West:								
Mountain	1,040	2	44,500	1	1,690	2	99,800	1
Pacific	1,220	2	55,300	2	1,890	1	66,800	1
Total	62,100	100	3,470,000	100	110,000	100	8,250,000	100

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

[2]Sales 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, ND, NE, 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).

[3]Less than ½ unit.

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

(Thousand metric tons and thousand dollars)

	2013		2014	
State	Quantity	Value	Quantity	Value
Alabama	334	14,900	1,180	42,400
Arizona	W	W	W	W
Arkansas	2,130	133,000	3,180	248,000
California	863	42,500	1,520	52,500
Colorado	W	W	W	W
Florida	200	10,300	219	12,100
Georgia	596	15,800	520	18,000
Illinois	9,850	501,000	13,500	1,290,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kentucky	W	W	W	W
Louisiana	709	36,200	2,140	147,000
Michigan	1,230	49,000	1,590	112,000
Minnesota	4,140	271,000	7,220	574,000
Mississippi	--	--	373	5,520
Missouri	1,990	127,000	4,290	289,000
Nebraska	W	W	W	W
Nevada	W	W	W	W
New Jersey	882	28,200	961	37,200
New York	W	W	W	W
North Carolina	1,290	30,700	2,730	42,300
North Dakota	W	W	W	W
Ohio	1,230	61,100	2,850	211,000
Oklahoma	2,120	89,100	3,340	122,000
Oregon	--	--	W	W
Pennsylvania	W	W	W	W
Rhode Island	W	W	W	W
South Carolina	521	23,600	589	26,800
South Dakota	W	W	W	W
Tennessee	1,090	35,600	1,490	60,500
Texas	7,080	434,000	16,500	1,300,000
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	429	21,900	536	29,500
Wisconsin	19,800	1,210,000	38,300	3,150,000
Other	5,690	329,000	7,270	478,000
Total	62,100	3,470,000	110,000	8,250,000

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

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

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2014, BY SIZE OF OPERATION[1]

Size range	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	102	31	913	(2)
25,000 to 49,999	33	10	1,140	2
50,000 to 99,999	38	11	2,520	2
100,000 to 199,999	35	10	4,460	4
200,000 to 299,999	21	6	4,780	4
300,000 to 399,999	13	4	3,930	4
400,000 to 499,999	17	5	6,950	6
500,000 to 599,999	8	2	3,970	4
600,000 to 699,999	10	3	5,810	6
700,000 and more	58	18	75,900	68
Total	335	100	110,000	100

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

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2014, 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	7	--	3	10
Midwest:				
East North Central	89	5	3	97
West North Central	30	7	9	46
South:				
South Atlantic	40	3	3	46
East South Central	16	--	5	21
West South Central	74	4	9	87
West:				
Mountain	5	1	--	6
Pacific	19	2	--	21
Total	281	22	32	335

-- Zero.

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2014, BY MAJOR END USE[1]

Major use	Northeast			Midwest			South		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:									
Glassmaking:									
Containers	W	W	$44.39	1,230	$45,600	$37.12	W	W	$33.42
Flat, plate and window	181	$9,960	55.02	W	W	26.70	1,390	$37,400	26.99
Specialty	139	7,660	55.11	W	W	55.59	225	6,690	29.75
Fiberglass, unground	--	--	--	99	3,970	40.09	457	38,000	83.11
Fiberglass, ground	--	--	--	(3)	3	--	420	22,400	53.39
Foundry:									
Molding and core, unground	21	1,180	55.95	2,110	89,000	42.13	359	25,100	69.87
Molding and core, ground	--	--	--	9	470	52.22	11	899	81.73
Refractory	(3)	10	--	40	1,630	40.85	80	3,370	42.18
Metallurgical, flux for metal smelting	--	--	--	W	W	39.00	W	W	46.55
Abrasives, blasting	W	W	91.00	37	2,130	57.43	370	20,300	54.77
Chemicals, ground and unground	3	192	64.00	526	29,100	55.29	461	26,500	57.44
Fillers, ground, rubber, paints, putty, etc.	3	156	52.00	212	11,700	55.31	W	W	55.25
Whole-grain fillers/building products	227	10,900	48.08	365	17,700	48.49	995	24,000	24.17
Ceramic, ground, pottery, brick, tile, etc.	(3)	1	--	7	411	58.71	92	5,000	54.29
Filtration:									
Water, municipal, county, local	15	1,060	70.60	80	4,100	51.19	439	24,100	54.89
Swimming pool, other	4	282	70.50	16	1,030	64.63	W	W	51.75
Petroleum industry:									
Hydraulic fracturing	--	--	--	61,900	5,500,000	88.79	19,200	1,580,000	82.41
Well packing and cementing	384	11,800	30.82	176	10,200	58.02	71	2,330	32.76
Recreational:									
Golf course, greens and traps	19	1,060	55.79	88	3,010	34.20	406	16,300	40.14
Baseball, volleyball, play sand, beaches	W	W	52.69	88	4,210	47.81	178	8,550	48.02
Traction, engine	1	32	32.00	24	1,000	41.83	53	2,220	41.87
Roofing granules and fillers	10	574	57.40	23	506	22.00	247	8,250	33.38
Other, ground silica	--	--	--	244	13,400	55.04	1,300	27,800	20.19
Other, whole grain	900	44,100	49.04	3,680	167,000	45.35	6,450	205,000	31.74
Total or average	1,910	89,000	46.69	70,900	5,900,000	83.18	33,200	2,090,000	62.83
Gravel:									
Silicon, ferrosilicon	--	--	--	--	--	--	235	1,250	5.31
Filtration	3	451	150.33	W	W	24.23	7	197	28.14
Other uses, specified	--	--	--	W	W	22.48	157	2,230	14.18
Total or average	3	451	150.33	53	1,230	23.23	650	5,830	8.97
Grand total or average	1,910	89,500	46.86	71,000	5,900,000	83.14	33,800	2,090,000	61.80

See footnotes at end of table.

TABLE 6—Continued
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2014, BY MAJOR END USE[1]

Major use	West			U.S. total		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:						
Glassmaking:						
Containers	308	$16,000	$51.97	4,100	$153,000	$37.27
Flat, plate and window	W	W	51.76	2,650	87,400	33.04
Specialty	W	W	59.60	569	25,800	45.38
Fiberglass, unground	--	--	--	556	42,000	75.45
Fiberglass, ground	W	W	60.75	428	22,900	53.53
Foundry:						
Molding and core, unground	W	W	55.65	2,530	117,000	46.37
Molding and core, ground	--	--	--	20	1,370	68.45
Refractory	--	--	--	120	5,020	41.83
Metallurgical, flux for metal smelting	W	W	10.80	31	1,220	39.32
Abrasives, blasting	W	W	67.00	416	23,100	55.62
Chemicals, ground and unground	--	--	--	991	55,800	56.26
Fillers, ground, rubber, paints, putty, etc.	W	W	52.71	266	14,700	55.19
Whole-grain fillers/building products	267	12,700	47.43	1,850	65,300	35.25
Ceramic, ground, pottery, brick, tile, etc.	(3)	W	--	100	5,420	54.17
Filtration:						
Water, municipal, county, local	W	W	34.23	784	37,800	48.27
Swimming pool, other	W	W	91.40	58	3,680	63.43
Petroleum industry:						
Hydraulic fracturing	W	W	66.53	81,700	7,120,000	87.13
Well packing and cementing	18	2,400	133.33	649	26,800	41.25
Recreational:						
Golf course, greens and traps	49	2,100	42.80	563	22,500	39.90
Baseball, volleyball, play sand, beaches	W	W	36.36	300	14,200	47.46
Traction, engine	W	W	51.50	74	2,340	31.66
Roofing granules and fillers	W	W	51.50	449	11,700	26.10
Other, ground silica	W	W	29.01	1,840	48,500	26.41
Other, whole grain	2,870	133,000	46.31	8,560	338,000	39.46
Total or average	3,510	166,000	47.29	110,000	8,240,000	75.23
Gravel:						
Silicon, ferrosilicon	--	--	--	235	1,250	5.31
Filtration	--	--	--	32	1,180	36.94
Other uses, specified	66	680	10.30	253	3,610	14.25
Total or average	66	680	10.30	772	8,190	10.61
Grand total or average	3,570	167,000	46.60	110,000	8,250,000	74.78

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

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

(Thousand metric tons)

Destination	2013	2014	Destination	2013	2014
State:			State—Continued:		
Alabama	207	228	New Jersey	418	367
Alaska	W	W	New Mexico	W	W
Arizona	8	21	New York	W	W
Arkansas	653	218	North Carolina	823	1,750
California	796	1,120	North Dakota	437	2,020
Colorado	W	W	Ohio	1,730	1,550
Connecticut	W	W	Oklahoma	1,280	2,860
Delaware	W	W	Oregon	W	W
District of Columbia	W	W	Pennsylvania	2,630	1,620
Florida	338	98	Rhode Island	W	W
Georgia	W	W	South Carolina	186	195
Hawaii	W	W	South Dakota	33	71
Idaho	W	W	Tennessee	563	913
Illinois	847	1,890	Texas	9,590	14,800
Indiana	W	W	Utah	W	W
Iowa	W	W	Vermont	W	W
Kansas	144	217	Virginia	W	W
Kentucky	W	W	Washington	W	W
Louisiana	259	1,210	West Virginia	W	W
Maine	W	W	Wisconsin	3,440	5,680
Maryland	W	W	Wyoming	W	W
Massachusetts	W	W	Countries:		
Michigan	266	180	Canada	W	W
Minnesota	212	315	Mexico	175	650
Mississippi	W	W	Other	W	W
Missouri	152	600	Other:		
Montana	13	102	Puerto Rico	W	W
Nebraska	W	W	U.S. possessions and territories	W	W
Nevada	W	W	Destination unknown	29,200	61,100
New Hampshire	W	W	Total	62,100	110,000

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

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

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

(Thousand metric tons and thousand dollars)

Destination	2013		2014	
	Quantity	Value[2]	Quantity	Value[2]
Africa and the Middle East:				
Egypt	(3)	5	--	--
Israel	2	407	(3)	274
Other	4	1,520	4	1,120
Total	6	1,930	4	1,390
Asia:				
China	17	35,700	23	39,700
Hong Kong	1	381	(3)	118
Japan	142	27,700	277	45,200
Korea, Republic of	4	4,830	3	3,400
Singapore	1	710	1	722
Taiwan	2	2,100	2	1,470
Other	3	2,790	2	2,240
Total	170	74,200	308	92,800
Europe:				
Belgium	47	7,790	5	2,380
Germany	32	26,300	18	26,500
Italy	(3)	280	(3)	125
Netherlands	14	7,530	15	7,820
Russia	(3)	37	1	1,310
United Kingdom	2	1,550	2	975
Other	40	7,290	49	10,400
Total	135	50,700	90	49,500
North America:				
Bahamas, The	3	577	1	351
Canada	2,060	174,000	3,240	226,000
Mexico	504	34,800	664	52,200
Trinidad and Tobago	2	903	1	653
Other	7	1,740	6	2,220
Total	2,580	212,000	3,910	281,000
Oceania:				
Australia	1	462	1	409
New Zealand	3	514	1	159
Total	4	976	2	568
South America:				
Argentina	56	8,370	120	32,300
Brazil	2	1,820	1	695
Colombia	2	395	2	849
Peru	4	951	4	845
Venezuela	(3)	151	(3)	41
Other	1	606	3	943
Total	65	12,300	130	35,700
Grand total	2,960	352,000	4,450	461,000

-- Zero.

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

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

[3]Less than ½ unit.

Source: U.S. Census Bureau.

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

(Thousand metric tons and thousand dollars)

Country	2013		2014	
	Quantity	Value[2]	Quantity	Value[2]
Australia	2	2,170	8	8,250
Canada	142	2,340	215	3,630
Chile	(3)	21	(3)	51
China	(3)	324	1	370
Germany	(3)	299	(3)	106
Japan	(3)	60	(3)	8
Mexico	8	2,520	9	2,380
Netherlands	(3)	3	--	--
Other	8	3,990	11	5,590
Total	160	11,700	244	20,400

-- Zero.

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

[2]Cost, insurance, and freight value of material at U.S. port of entry. Based on purchase price; includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

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

(Thousand metric tons)

Country[3]	2010	2011	2012	2013[e]	2014[e]
Algeria[e]	95 [4]	95	95	100	100
Argentina	531	517	615	500	500
Australia[e]	3,100	3,500	3,500	5,500 [r]	5,500
Austria	939	898	820	808	810
Bosnia and Herzegovina	228	119	121	114 [4]	114
Bulgaria[e]	660	660	660	660	660
Canada, quartz	1,171	1,431	1,593	1,690	1,690
Chile	1,326	1,237	1,267	1,358 [4]	1,360
Croatia	241	227	106	102 [4]	102
Cuba	11	20	25	26	26
Czech Republic, foundry and glass sand	1,361	1,371	1,340 [e]	1,274 [4]	1,270
Ecuador	6	27	30 [e]	30	30
Egypt[e, 5]	401 [4]	400	400	400	400
Estonia, industrial sand	36	14	21	20	20
Ethiopia[e, 6]	70 [4]	7	7	33	33
Finland[e]	267	312	257	2,400 [r]	2,400
France	8,498	6,286	8,880	8,752	8,750
Gambia[e]	1,121 [4]	--	--	--	--
Germany	7,234	7,770	7,498	7,500	7,500
Greece	40 [e]	2	NA	NA	NA
Guatemala	62	60 [e]	49	53 [4]	53
Hungary, foundry and glass sand	271	287	124	145	145
India	3,172	4,496	3,985	3,432 [4]	3,430
Indonesia[e]	36	37	38	35	35
Iraq	(7)	(7)	(7)	2	2
Israel	198	233	180 [e]	200	200
Italy	17,656	16,369	13,946	13,870 [4]	13,900
Jamaica	13	14	14	16 [4]	16
Japan	3,078	3,003	2,877	3,000	3,000
Jordan	150	88	88 [e]	90	90
Kenya[e]	16	17	18	19	19
Korea, Republic of, quartzite	4	4	4	4 [4]	4
Lithuania	67	53	54	57 [4]	57
Malaysia	932	1,340	932	1,244 [4]	1,240
Mexico	2,608	2,542	3,593	3,590	3,600
Moldova	2,146	2,547	3,042	3,502 [4]	3,500
New Zealand	113	109	73	102 [4]	102
Nigeria[e]	30	30	30	30	30
Norway, quartz and quartzite	1,055	1,162	1,083	1,000	1,000
Peru, quartz and quartzite (crushed)[e]	124	124	87 [4]	88	88
Philippines	296	352	260 [e]	430	430
Poland	1,995	2,290	2,149	2,112 [4]	2,300
Portugal, quartz and quartzite	76	84	80 [e]	37	37
Saudi Arabia	820	1,303	1,368	1,300	1,400
Slovakia[e]	620	600	600	600	600
Slovenia	254	231	219	224 [4]	225
South Africa, industrial or glass sand	2,905	2,863	2,150	2,107 [4]	2,110
Spain, industrial sand	5,057	5,073	3,416	3,400	3,400
Sri Lanka[e]	34 [4]	36	37	38	38
Sweden, quartz and quartzite[e]	85 [4]	163	101	102 [4]	102
Taiwan	306	173	58	62 [4]	132 [4]
Thailand[e]	500	500	500	500	500
Turkey	4,022	7,021	7,085	7,969 [4]	7,970
United Kingdom	4,070	3,969	3,888	4,000	4,000
United States, sold or used by producers	32,300	43,800	50,600	62,100	110,000 [4]
Venezuela	459	500 [e]	118	8 [4]	8
Total	113,000	126,000	130,000	147,000 [r]	195,000

See footnotes at end of table.

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

[e]Estimated. [r]Revised. NA Not available. -- Zero.
[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes data available through June 29, 2016.
[3]In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, Belgium, Brazil (silex), Denmark, Iran, Ireland, Latvia, 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 thought to be the world's leading producer of industrial sand; however, available information is inadequate to formulate reliable estimates of output levels.
[4]Reported figure.
[5]Fiscal year beginning July 1 of that stated. Silica sand only; no gravel.
[6]Ethiopian calendar year ending July 7 of that stated.
[7]Less than ½ unit.

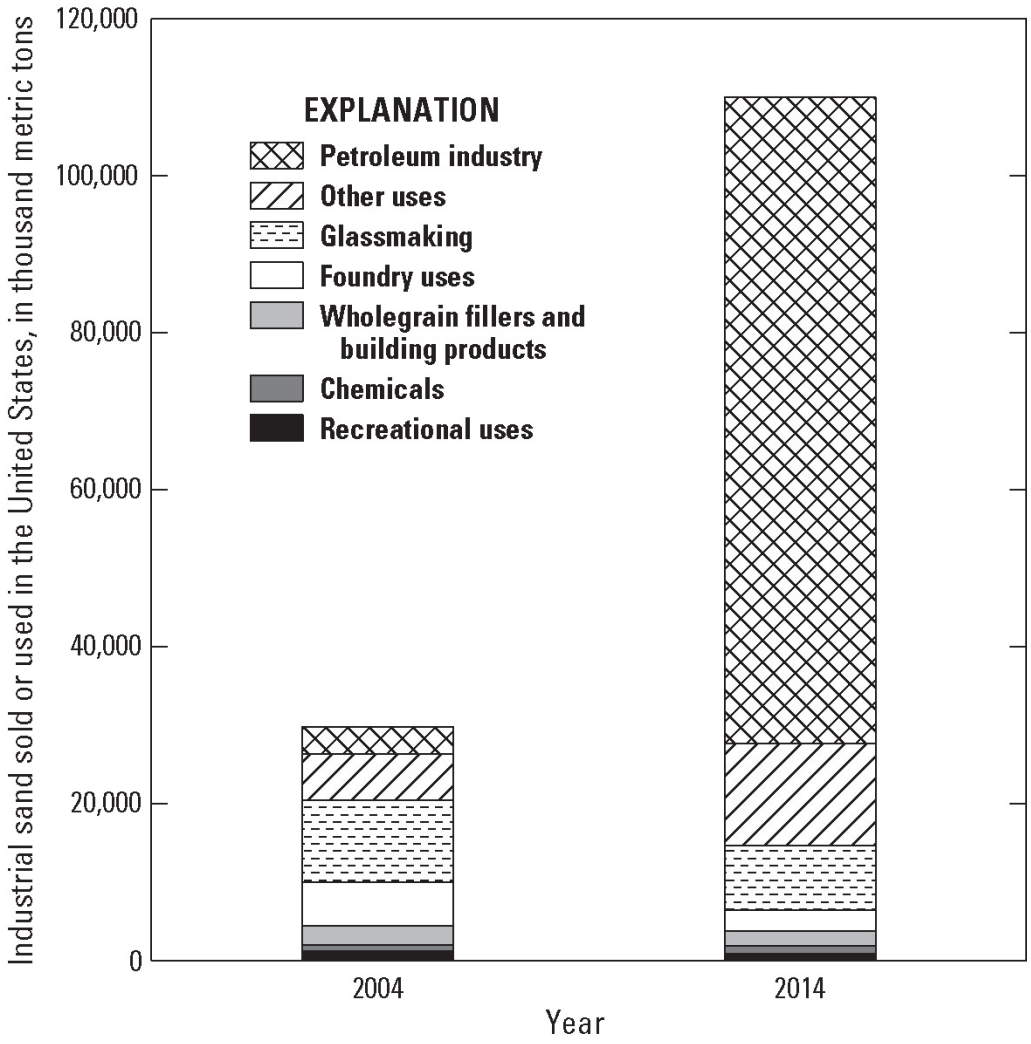

Figure 1. Industrial sand end uses changed significantly from 2004 to 2014. The increased use by the petroleum industry, especially for hydraulic fracturing, has resulted in sales and use of industrial sand expanding by nearly a factor of four during the time period.