INDUSTRIAL SAND AND GRAVEL

By Wallace P. Bolen

Industrial sand and gravel production, consumption, and exports increased in 1994 compared with 1993. However, imports of 22,000 metric tons represented only one-half of the level from the previous year. Several small mines ceased operation during 1994 and some consolidation continued among the larger producers. Industrial sand and gravel, often termed "silica," "silica sand," and "quartz sand," includes high SiO_2 content sands and gravels. These sands are used in glassmaking, for foundry, abrasive, and hydraulic fracturing applications, and many other uses. The specifications for each use varies but silica resources for most markets are abundant. Leading producing States were Illinois, New Jersey, Michigan, Texas, and California. In almost all cases, silica mining employs open pit mining methods with standard mining equipment. Sand and gravel mining, in the vast majority of cases, has little environmental impact except for temporarily disturbing the immediate environment while mining operations are active.

Production of industrial sand and gravel in 1994 increased to 27.3 million metric tons, about 4% more than 1993's production. Production increased in response to greater demand for many uses including foundry sand, flat and fiber glass sand, and for silica used in ceramics production and in the "whole grain filler/building products" category.

Exports of silica sand and gravel increased over 7% in quantity and 12% in value compared with that of 1993. Imports of industrial sand and gravel continued to decline, 50% in quantity and 27% in value compared with the previous year. Domestic apparent consumption of industrial sand and gravel in 1994 was 25.4 million tons, an increase of about 4% compared with that of 1993. (See table 1.)

Legislation and Government Programs

Health and safety regulations continued to be the predominate concern in the relationship between governments and the industrial sand and gravel industry. Trade rulings and foreign agreements also impacted this industry but to a much smaller degree.

The issues surrounding silica dust, silicosis, and cancer have been highlighted in this report in previous years. Beyond this continuing concern, another health concern involved the debate on whether ceramic fibers, including glass fibers, are carcinogens. Several reports in 1994 discussed the listing by the Department of Health and Human Services that these fibers are possible carcinogens and reviewed the ramifications for the Occupational Safety and Health Administration and other regulatory agencies. The findings on glass wool, or fiberglass, were disputed by the North American Insulation Manufacturers Association because of the methodology used in the study.[1]

Concerning the relationship between silica and lung cancer, California's Office of Environmental Health Hazard Assessment held a meeting to review health affects. Reports from the conference revealed that three prestigious researchers expressed consistent views that the relationship of silica and lung cancer is neither substantiated nor understood. Concerned Californians and others involved at the meeting have formed a coalition to educate the Government and the public and to present deficiencies in proposals to regulate crystalline silica.[2]

The American Mining Conference (AMC) also was involved in the issue through direct comments to the National Institute for Occupational Safety and Health and through legal challenges to recent air quality rulings. Additionally, AMC helped sponsor an International Conference on Crystalline Silica Health Effects in Baltimore in April 1994. With the National Industrial Sand Association, AMC has undertaken a major epidemiological study of lung cancer mortality in a mining population.[3] In a related development that will impact silica miners, the November 15, 1994, Federal Register published a proposed tougher standard on the training and use of respirators.

On the trade front, the International Trade Commission determined in June that no U.S. industry was either materially injured of threatened financially by imports of silicon carbide from China.[4] However, the number of North American silicon carbide producers has shrunk rapidly since the Chinese began to target exports of silicon carbide to North America.

Glass trade between Japan and the United States also has been a contentious issue. According to a Glass Industry magazine report, Japan's $4.5 billion flat glass market will become more accessible because of a recent agreement. Wholesalers in Japan will agree to obtain 30% to 40% of their flat glass from nontraditional sources.[5]

Production

Domestic production data for industrial sand and gravel were developed by the U.S. Bureau of Mines (USBM) from one voluntary survey of U.S. producers. Of the 163 industrial sand and gravel operations surveyed, 149 (91%) reported to the USBM. Their combined production represented about 96% of the U.S. total published in table 1. The production of nonrespondents was estimated mostly using employment data. Of the 163 operations, 152 (93%) were active and 11 idle.

The Midwest (East and West North Central regions) continued to lead the Nation in production with about 45% of the 27.3 million metric tons produced in the United States, followed by the South (South Atlantic, East and West South Central regions) with about 34% and the West (Pacific and Mountain regions) with 12%. *(See table 2 and figure 1.)*

The seven leading States in the production of industrial sand and gravel, in descending order of volume, were Illinois, Michigan, California, New Jersey, Wisconsin, Texas, and North Carolina. Their combined production represented 55% of the national total. Among these seven States, New Jersey experienced an 8% decrease in production while California had a 3% decrease compared with 1993. Michigan's production increased 12%, Wisconsin and Texas both had 10% increases, and North Carolina's production increased 9%. Illinois, the long-time leader among the States, had a healthy 5% increase in production. *(See tables 3.)*

The USBM canvassed 82 producers of industrial sand and gravel with 152 active operations. About 76% of the industrial sand and gravel was produced by 47 operations, each with an annual production of more than 200,000 tons. The 10 leading producers of industrial sand and gravel were, in descending order of tonnage, Unimin Corp., U.S. Silica Co., Fairmount Minerals Ltd., The Morie Co. Inc., Oglebay Norton Co., Badger Mining Corp., Construction Aggregates Corp., Nugent Sand Co. Inc., Simplot Industries Inc., and Sargent Sand Co. Their combined production,

from 62 operations, represented 72% of the U.S. total. (See tables 4 and 5.)

After a very quiet 1993, merger and acquisition activity heated up again in 1994 and is expected to continue in 1995. Oglebay Norton Industrial Sands, Inc., the industrial sand and gravel operations of Oglebay Norton Co., Cleveland, OH, purchased Vulcan Materials Co.'s, Voca, TX, sand plant and now controls two substantial hydraulic fracturing sand (frac sand) producers. Oglebay Norton also instituted historical changes in 1994 by removing the long held names of several of its subsidiaries in order to unify all its operations under the Oglebay Norton Industrial Sands name. This included the dropping of the following well known names: California Silica Products Co., San Juan Capistrano, CA; Central Silica Co., Howard and Glenford, OH plants; and Texas Mining Co., Brady, TX. Oglebay Norton should now maintain itself as one of the top five producers in the United States.

In other developments, another Ohio-based company, Fairmount Minerals, Chardon, OH, on October 1, 1994, purchased Schrader Sand and Gravel Co.'s 60,000 to 80,000 tons per year operation in Beaver, OH. Fairmount now operates five plants in three States and has a secure position as the third largest producer in the United States. U.S. Silica finalized the closing of its Ledyard, CT, mine and mill, selling the site to Mashantucket Western, affiliated with the Pequot Tribe of Connecticut, a native American group. In North Carolina, KMG Minerals Inc., Kings Mountain, was purchased by Franklin Industries, Inc. KMG Minerals is a producer of silica and construction sands, mica, feldspar, and kaolin. Franklin Industries, Nashville, TN, is one of the nation's leading producers of chemical and filler grade calcium carbonate and will now become the largest muscovite mica producers in North America.

Recycling of silica sands was limited to some foundry sands, particularly those used for making cores and molds with no-bake resin-bonded sands, some abrasive and airblasting sands, and, increasingly, post consumer glass and scrap glass (cullet) that substitutes for batch mix (including industrial sand). Most glass recycling was restricted to container glass, with green and amber cullet consumed in greater amounts for glass production because it is more difficult to use cullet in flint batch mixes.

Glass recycling was put at 35% in the United States for 1993, the fifth straight year of growth. This included glass used in glasphalt and those that were refilled, and represents an increase from the 1992 rate of 33%. Some glass manufacturers reported a shortage of cullet while others experienced unacceptable cullet because of contamination and coloring mixing of the cullet.[6] The price for cullet varied based on region and grade (flint (clear), brown (amber), or green) and location. Cullet from consumers generally passes through a processor, who receives it from municipalities, counties, etc., and the processor then provides it to the glassmaker. Prices for flint glass to the glassmaker generally varied from $24 to $65 per ton in early 1994. Brown glass ranged from $15 to $55 per ton and green glass from $0 to $65 per ton.

As the level of cullet used in glass production increases, so does the level of quality required. Contamination of cullet by ceramics and nonmagnetic materials was an increasing concern. Because of the increased use of recycled glasses, restrictions on the iron and chromium levels in glass sands have become stricter and the proportion of refractory particles allowed has been reduced to almost zero. The Fe_2O_3 content of a typical glass silica sand is now as low as 0.015 to 0.02% for flint glass manufacture and 0.1 to 0.15% for colored glass. Additionally, recycling of amber and green glass was substantially greater than flint glass; and therefore, lower grade deposits are in less demand.

In the glass fiber arena, a 1993 report discussed the growing use of recycled container glass in fiberglass production. Adding another twist, Wil-Mfg., Inc., Guelph , Canada, opened a facility for glass fiber recovery. The recovered glass, from fiber glass waste materials, will be called Eco-Glass and used to strengthen composites of plastic and rubber, and as components of construction and building materials.[7]

Another example of sand recycling, albeit employing some license with the term recycling, was reported by a cement producer in Canada. At the Lafarge Corp.'s St. Constant, Quebec, plant, used foundry sand has been incorporated into the material mix for cement manufacture. Using innovation and common sense, the employees at the plant have successfully used a variety of "recycled" materials to meet their raw material needs.[8]

On the negative side, recycling of silica refractories is hardly ever done. Because recycling these refractories requires crushing and grinding, silica dust is generated. The dust must be controlled according to hazardous material regulations and this makes it prohibitively expensive to recycle.

International trends toward increased recycling of glass and foundries sands and innovative ideas on recycling other materials should influence greater recycling of silica products.

Consumption

Sand and gravel production reported by producers to the USBM was actually material used by the companies or sold to their customers. Stockpiled material was not reported until consumed or sold. Of the 27.3 million metric tons of industrial sand and gravel sold or used, 39% was consumed as glassmaking sand and 24% as foundry sand. Other important uses were frac sand (6%) and abrasive sand (5%).

The production of industrial sand and gravel in the United States has developed in response to market location and vice-versa as industry sometimes located near silica resources. Because silica deposits (or resources) are found throughout the United States, locating a consuming industry specifically to be near a silica source was not always a priority, although certainly a consideration. The auto industry, responding to iron, coal, clay, and silica resources, centered in the Midwest and thus foundry sands were greatly exploited in Michigan, Ohio, Indiana, Illinois, and other regional States. This resulted in over 75% of the foundry sand being produced in the Midwestern region in 1994.

The glass industry, somewhat conversely, had to locate plants where they could minimize the shipping distance of finished glass products. Hence, glass plants were more evenly distributed as 41% of glass sand was produced in the Southern region, 32% in the Midwest, 15% in the West, and 12% in the Northeast, in 1994. To varying degrees, all silica production was similarly influenced as markets and consuming industries either forced the silica mining location or were forced to locate near the silica source.

The amount of sand sold for container glass remained near 1993 levels, while the total shipments of glass containers dropped 1.3% during the year. These factors reinforce the idea that available cullet was not meeting the potential market; and therefore, more virgin material was being used to offset the lack of cullet. It is instructive to notice that container shipment numbers are a limited gauge when discerning silica sand's consumption and future. The share of silica sold for all types of glassmaking as a percentage of all silica sold dropped to its lowest level since 1985 when glass markets consumed only 35% of silica sold.

In an indication of improved demand for flat glass, PPG Industries announced plans to resume float glass production of the second line at its Mount Zion, IL, plant in 1995. The line has been idle since 1991 and will allow the plant to produce for the auto and other markets beyond the construction market it currently

served. Similarly, Guardian Industry announced plans to construct a float glass plant at DeWitt, IA. Its seventh float glass plant in the United States, the plant is expected to produce for applications including windows, doors, tabletops, mirrors, skylights, and commercial building curtain walls. AFG Industries, Inc., maneuvering to keep pace, announced that it would start manufacturing operations at its Cinnaminson, NJ, facility in April 1995. They also cited increased demand for flat glass experienced during 1994.

Besides flat glass, the fiberglass industry also showed signs of strengthening. Schuller International plans to invest $50 million in capacity additions to its Defiance and Waterville, OH plants. And, after sitting idle for 7 years, the Jackson, TN, plant of Owens-Corning Fiberglas Corp. was reopened.

The brightest market in 1994 was foundry, where sales were up 14% compared with 1993. Continued strong activity in the auto industry spurred greater foundry activity and silica consumption. Sales of light vehicles grew at an 8.5% rate in 1994, compared with 1993, and are expected to see continued growth in 1995.

The blasting market consumed less silica in 1994, as sales continued to fall, dropping 5% from 1993. The blasting market suffers, not from increased recycling, although there was some blast sand recycled, but from increased concern about health hazards related to respirable silica. Consumers are increasingly using competing materials such as garnet, slags, and glass beads. *(See table 6.)*

Silica was generally used in plastics as a filler, extender, and reinforcer. More specifically, it was used to thicken liquid systems, as a thixotropic agent, flatting agent, and was used to avoid plateout in PVC (polyvinyl chloride). As segregated for this survey, ground silica used as a filler was 68,000 tons, whole grain filler amounted to 1.25 million tons in 1994.

Specialty silicas were usually produced by means of chemical and thermal processing of natural silica or as a byproduct of other mineral or chemical processing. Although the USBM did not specifically collect information for specialty silicas, its consumption does affect natural silica sales. Specialty silicas and silanes, included, but were not limited to, fumed silica, fused silica and quartz, precipitated silica, silica gels, silicones, and ultra-high purity silica. These silicas were used in abrasives, catalysts, coatings, electronics, encapsulants, food, health care, optics, paper, plastics, refractories, rubber, specialty coatings, water treatment, and many others. On table 6, industrial sand and gravel that would find its way into these specialty silicas is most likely reported in the categories "chemical" and "silicon metal." Silica sales for chemical production increased nearly 14% in 1994, compared with 1993. Sodium silicate, a prime silica chemical, has had increases in production for the last 3 years and reached a 10-year high in 1993. Production of sodium silicate rose 8% between 1983-1993 and 3% from 1992-1993.

Many silicon-based ceramics also are considered a specialty or nontraditional use for silica and offer potential growth for silica. Superior Graphite Co. had its first full year of operation at its Hopkinsville, Ky, plant. The plant has the capacity to produce 120 metric tons per year of beta silicon carbide and can expand to 180 tons per year which it is likely to do so in the near future.[9]

Northeast.—Cumberland County, NJ, continued to be the largest source for the glass and foundry sand markets in the region. Unimin, U.S. Silica, and Morie, all of which operated plants in the county, were among the largest producers of sand for these markets. U.S. Silica's plant in Huntingdon County, PA, also produced significant amounts of sand for the glass market. Morie and Ricci Brothers Sand Co. Inc., both in Cumberland County, NJ, produced a major percentage of the abrasive blast sand in the region.

Midwest.—Unimin's plants in LaSalle and Ogle Counties, IL; LeSueur and Scott Counties, MN; and Columbia County, WI, were among the leaders in producing sand for all four major markets: the blast, foundry, frac, and glass sand markets. Fairmount Minerals, with operations in Berrien and Van Buren Counties, MI; Geauga County, OH; and La Salle County, IL; was also a major producer of sand for the four major markets in the region. U.S. Silica's plant in La Salle County, IL, was a large producer for the glass, foundry, and frac markets and its St. Louis County, MO, operation was a large producer for the glass market. Construction Aggregates Corp., Ottawa County, MI; Nugent Sand Co. Inc., Muskegon County, MI; and Sargent Sand Co., Wexford County, MI; were all large producers for the foundry industry. Badger Mining, Jackson and Green Lake Counties, WI, was a major producer for the blast, foundry, and frac markets. Manley Brother's of Indiana, LaSalle County, IL, was a large producer for the foundry and glass markets. Kaw Valley Sand and Gravel Co., Wyandotte County, KS, was a major producer of blast sand.

South.—Unimin and U.S. Silica Co. were two of the largest producers of sand for the glass and foundry markets. Unimin's major plants were in Izard County, AR; Richmond County, NC; Pontotoc County, OK; and Frederick County, VA. U.S. Silica's Bullock County, AL; Johnston County, OK; Lexington County, SC; Limestone County, TX; and Morgan County, WV, operations were its major contributors for these markets. Morie's Tuscaloosa County, AL; Marion County, GA; and Carrol County, TN, plants were large producers of foundry and glass sand. Cobb Industrial Corp. Red River Parish, LA; Foster-Dixiana Corp., Lexington County, SC; Huey Stockstill Inc., Pearl River County, MS; Mid-State Sand and Gravel Co., Allen Parish, LA; Pioneer Concrete of Texas Inc., Liberty County, TX; and Specialty Sand Co., Newton County, TX, were large producers of blasting sand. JEBCO Abrasives Inc., Colorado County, TX, a company new to this year's report, was also a substantial blast sand producer. W. R. Bonsal and Co. and B. V. Hedrick Gravel and Sand Co., both in Anson County, NC, produced a large percentage of the industrial gravel used in the production of silicon and ferrosilicon. Oglebay Norton, with two operations in McCulloch County, TX, was the largest producer of frac sand, and an important contributor of blast sand for the region. WHIBCO in Kershaw County, SC, was an important producer of foundry sand. APAC Arkansas Inc., Crawford County, AR; Florida Rock Industries Inc., Putnam County, FL; and Short Mountain Silica Co., Hawkins County, TN, were important producers of glass sand.

West.—Corona Industrial Sand Co., Owens-Illinois, Simplot Industries, and Unimin were the four largest producers of glass sand in the region, with major operations in Riverside County, CA; Amador County, CA; Clark County, NV; and Contra Costa County, CA, respectively. Lane Mountain Silica, Stevens County, WA; Lone Star Industries Inc., Monterey County, CA; P.W. Gillibrand Co., Ventura County, CA; and Gordon Sand Co., Santa Barbara County, CA, were the major suppliers for the sand blasting industry in the region. Simplot Industries, Clark County, NV, also supplied a large portion of the foundry sand consumed. FMC Corp., Power County, ID; Rhone-Poulenc Basic Chemicals Co., Beaverhead County, ID; and Monsanto Industrial Chemicals Co., Caribou County, ID, each produced industrial gravel for use as a flux in elemental phosphorus production.

Transportation

Of the total industrial sand and gravel produced, 61% was transported by truck from the plant to the site of first sale or use, down from 63% in 1993; 36% was transported by rail, up from 34% in 1993; 2% by waterway; and 1% was not transported. Because most of the producers did not report shipping distances or

cost per ton per mile, no transportation cost data were available.

Prices

Compared with that of 1993, the average value, f.o.b. plant, of U.S. industrial sand and gravel increased 3% to $17.86 per metric ton. Average unit values for industrial sand and industrial gravel were $18.14 and $11.88 per ton, respectively. Nationally, ground industrial sand used as fillers for rubber, paint, and putty, etc., had the highest value per ton ($151.97), followed by silica for swimming pool filters ($67.00), silica for well packing and cementing ($51.37), ground silica sand used in ceramics ($48.91), molding and core facings ($46.31), ground silica for scouring cleansers ($44.86), ground sand used for fiberglass ($35.01), frac sand ($31.54), and silica for whole grain fillers/building products ($29.24).

Industrial sand and gravel price changes were greatly mixed as some markets were level, others had small increases or decreases, and still others experienced large increases or decreases. This situation was possible because although the silica was essentially the same, most markets were very independent from each other and price competition was influenced by availability, regulations and health concerns, and competition from other materials. Those end uses that sustained greater prices in 1994, compared with 1993, included: blasting, chemicals, container and specialty glass, fiberglass, fillers, filtration, foundry, recreational, roofing granules and fillers, and traction. Silica for ceramics, flat glass, metallurgical, and well packing and cementing experienced a decrease in unit value.

The average value per ton of industrial sand and gravel was highest in the West ($19.89), followed by the South ($19.08), the Northeast ($18.57), and the Midwest ($16.22). Prices can vary greatly for similar grades of silica at different locations in the United States. For example, glass sand average value per ton varied markedly, from $20.02 in the West to $11.15 in the Midwest. Tighter supplies and higher production costs in the West and much greater competition in the Midwest caused the difference in the cost of sand and gravel in these two regions.

Foreign Trade

Exports of industrial sand, compared with those of 1993, increased 7% to 1,880,000 tons, while the value increased 12%. Export distribution is as follows: 79% went to Canada, 8% went to Mexico, and the remainder to numerous other countries throughout the world.

Compared with those of 1993, imports for consumption of industrial sand dropped 50% to 22,000 tons valued at $1.8 million. Silica imports vary greatly from year to year but are always rather insignificant. Australia supplied 50% of the silica imports for 1993, averaging near $58.55 per ton (including insurance and freight cost to the U.S. port). The Australian imports were the relatively low priced silica while higher priced silica came from Germany, Italy, Japan, Sweden, the United Kingdom, and Venezuela. *(See tables 7 and 8.)*

World Review

World production of industrial sand and gravel, based on information usually provided by foreign Governments, was estimated to be 111 million metric tons, up nearly 5% from 1993. The United States was the leading producer followed by, in descending order, the Netherlands, Germany, Austria, and France. Most countries in the world had some production and consumption of industrial sand and gravel because it is essential to the glass and foundry industries. However, because of the great variation in descriptions and usage for silica sand and gravel, it was difficult to get reliable information. Beyond those countries listed, several other countries were believed to have had some type of silica production and consumption. *(See table 9.)*

The Financial Times of London reported a serious shortage of lead glass used in televisions and computers. The manufacturers of these lead glass cathode tubes are running at full capacity but will still come up 10 million tubes below the demand of 160 million in 1994. There are no U.S. manufacturers of these tubes. All production is done in France, Germany, Japan, and the Netherlands.[10]

Current Research and Technology

Research and development involving specialty silicas flourished in 1994 as reflected in the regular reporting on the topic. Silicones used in the electronics industry were praised for their quick curing times as they compete for the adhesives and sealants needs of the industry. With silicones currently holding only a 7% share of the $70 million market, projections are that silicones' share will rise.[11]

Another sign of growth in the specialty segment was Degussa Corp.'s announcement of a 30 to 50 million pound capacity increase for precipitated silica per year until 1997 in North America. The new capacity will allow for new high-performance product applications. Degussa has fumed silica plants in Waterford, NY, and Mobile, AL, and a precipitated silica plant in Chester, PA.[12]

Additionally, Cabot Corp., PPG Industries, and W. R. Grace, have all announced capacity increases for silica products. These capacities increases will mainly be outside of the United States but indicate growth potential for the specialty markets overall.[13] PPG announced it is planning to expand its precipitated amorphous silicas plant at Lake Charles, LA. The plant will produce several types of reinforcing silicas and a dentifrice silica.[14]

PQ Corp, Valley Forge, PA, the largest producer of sodium silicate, a traditional silicate, is also a major producer of zeolites, colloidal silicas and silica gels. PQ has seen great growth in all its segments and has rapidly opened new manufacturing facilities. They also opened a new plant in April 1994, at Raleigh, NC, to make hollow glass spheres. Its silica gel is used as catalyst and catalyst support for polyethylene production, and for brewing applications. They are also targeting zeolites and silicas for beer fining.[15]

In another promising announcement, Rhone-Poulenc is building a 20,000-ton-per-year precipitated silica plant at Chicago Heights, IL. The facility will produce material for the rubber, dentifrice, and specialty chemical markets. The plant will also produce special abrasive grades of silicas. Rhone-Poulenc is also developing the "green" tires concept through micropearl silicas for use in these fuel-saving tires.[16]

Also, OSi Specialties Inc. has more than doubled trisiloxane copolymers capacity at its Sisterville, WV, plant. The company said that the use of trisiloxane compositions is growing at a rapid rate. Uses for these products include household and institutional specialties, printing inks, adhesives and sealants, agriculture, and chemical processing markets.[17]

Finally, Wacker-Chemie is studying a project to produce silicone raw materials in the United States, possibly in Louisiana or Michigan. Annual U.S. silicone sales are more than $100 million and growing at 5% per year.[18]

In other silica related research and development, Dow Corning reports completing pilot-plant studies of a silicon production process that it says is environmentally cleaner, more energy efficient, and safer than current technologies. This plant study, in Selkirk, Manitoba, Canada, was mentioned in this publication in 1992. Dow Corning is currently looking for a silicon producing company partner(s) to commercialize the technology.[19]

Researchers at Lawerence Livermore National Laboratory are using buckyballs to manufacture silicon carbide microchips, electromechanical devices, and sensors. The technology is expected to be used for microelectromechanical devices, flameout

detectors in aircraft engines and tiny engine parts built onto microchips.[20]

Scientists at General Electric report the first commercially feasible process for making high-temperature integrated circuits from silicon carbide (SiC). These devices will be able to withstand temperatures as high as 500° C.[21]

Glass Fiber Enterprises Ltd., partnered with a group from the former Soviet Union, announced a new product in the Siltex™ line of high-silica yarns and fabrics. The product has improved strength and abrasion resistance for aerospace applications.[22]

Owens-Corning has introduced Miraflex fiber, the first new form of glass fiber in nearly 60 years, according to the company. Miraflex is composed of two different forms of glass fused together in a single filament. According to the company, it is the first glass fiber that successfully holds up under typical textile processes. Unlike traditional, straight glass fibers, the product's fibers are randomly twisted, flexible, soft to the touch, and virtually itch-free.[23]

Research and development also continued in ceramics concerning SiC and silicon nitride (Si_3N_4). Advanced Refractory Technologies Inc. will participate in a metal composites demonstration program with Hughes Aircraft. The program will address the feasibility of SiC whisker-reinforced aluminum composites for the U.S. Army.[24]

Other developments concerned improvements in SiC fiber making processes. Japan's Nippon Carbon Co. produced SiC fibers derived from polycarbonsilane precursors. The University of Michigan has developed a simple three-step process that can also produce pure highly crystalline SiC fiber. Also discussed was the high cost of SiC fibers, upwards of $5,000 per pound.[25]

Dupont researchers have produced a microcomposite composed of Kevlar and silicon carbide whiskers. The company says that the material has properties that are beneficial in structural applications and could overcome drawbacks associated with Kevlar.[26]

A National Aeronautics and Space Administration brief discussed a new precursor for Si_3N_4. The process for the production of Si_3N_4 involves the thermal decomposition of silicon dimide.[27]

Scientists at the University of Wisconsin report making a silicon compound that has only a pair of bonds rather than the usual four. The divalent silyene could dramatically expand the number and types of commercially feasible silicon compounds.[28]

Outlook

The forecast range of total U.S. demand in the year 2000 was expected to be 25 to 30 million metric tons for industrial sand and gravel. Probable demand was expected to be about 29 million tons. All forecasts were based on previous performances for this commodity within various end uses and contingency factors considered relevant to the future of the commodity.

Since 1987, annual demand for glass sand had fluctuated between 10.0 and 11.1 million tons. The amount of sand consumed for container glass has generally decreased since 1987 mainly because some glass containers were being replaced by aluminum cans and plastic containers and also because the amount of glass being recycled was increasing. Additionally, many manufacturers of container glass were using thinner walls in glass containers, and this has lowered the amount of sand used. However, glass fibers and novel uses for glass may offer new avenues for silica sales for glass.

The amount of flat glass shipped had excellent growth in 1994 finishing close to 10% ahead of 1993. Continued expansion of the light auto and construction industry, near 8.5% each in 1994, helped spur on greater flat glass production. However, 1995 growth was predicted to be slightly negative for flat glass shipments even as flat producers announced several flat glass capacity increases. An interesting development in Japan could eventually have negative affects on flat glass consumption. The Japanese Ministry of Transportation announced that it will lift the ban on thermoplastic resins for passenger car windows. The lifting of the rule is in response to improved coating technology that has been developed to protect resin surfaces from being scratched. Design concerns will not allow this change to plastic quickly but this possibility could eventually result in lower silica consumption for automobile glass.[29]

KMI Corp., Newport, RI, forecasted very positive growth for fiber optic cable for many locations throughout the world. They placed growth at 10% for 1993, compared with 1992, for a total of $3.7 billion. Growth is expected to be particularly strong in most of Asia, Africa, Eastern Europe, and Latin America. Telephone companies use of fiberoptic cable in local loops will have the greatest impact on growth. Worldwide, 29% of the world wide market was held by local loops and this is expected to increase to 47% by 1998.[30]

In other specialty glass news, GE Quartz broke ground on August 4, 1994, for an expansion of its Newark, OH, quartz plant. The quartz glass is essentially a fused quartz that utilizes high quality quartz and is included in the industrial sand and gravel category. The source of the quartz was not revealed.[31] Additionally, an article in Glass Industry magazine related the affect that increased specialty glass variety and production has had in the current capacity tightness in the flat glass market. The glass manufacturers had shifted unused capacity to specialty glass and when flat glass demand improved, the capacity was no longer available.[32] As referenced in the Consumption section of this report, some companies are now planning to install new or reopen mothballed flat capacity.

The domestic fiberglass market began to recover in 1992 after posting decreases from 1988-1991. Imports are increasing but are still less than 10% of domestic consumption while exports increased about 41%, to $392 million, from 1988-1992. The United States-Canada Free-Trade Agreement has helped to double exports of fiberglass during the same period. Additionally, reinforced glass composites also were expected to see strong growth throughout the decade.

Overall, although demand for specialty and fiber glass is expected to increase, the largest tonnage consumers, the container and flat segments, will probably experience small or no total growth. Therefore, demand for glass sand was expected to grow slowly in quantity through the year 2000. Probable demand for glass sand for the year 2000 was forecast to be 11.5 million tons, with a range of 9 to 12.5 million tons.

The use of foundry sand was seen to be dependent mainly on automobile production. Another important factor for the future consumption of virgin foundry sand was the recycling of used foundry sand. The level of recycling, though not clear, was thought to be increasing. Other materials or minerals compete with silica as foundry sand but these other "sands" usually suffer a severe price disadvantage.

As reported in the Japanese press, several automakers were planning expansions of their automaking in the United States. Toyota Motor Corp. plans to raise production in the United States by about 13%, and committed to manufacturing all trucks for sale in the United States in California through its GM joint-venture facility. Mitsubishi Motors Corp. plans to boost production at its U.S. manufacturing base, Diamond Star Motors Corp., to 180,000 units in 1994, a 31% increase over 1993. Isuzu Motor Co. and Fuji Heavy Industries are expanding production to 100,000 vehicles built in the United States, a 30% increase. Nissan Motor Co., Honda Motor Co., and Mazda

Motor Co. plan 10%, 25%, and 10% increases in U.S. production, respectively.

Based on these factors: foundry activity (mainly auto related), competing materials, and recycling, the probable forecast for silica foundry sand consumption in the year 2000 was expected to be 7.5 million tons, and the demand range was expected to be 6 to 8 million tons.

Frac sand was consumed near 1993 levels throughout 1994. The Baker-Hughes' cumulative rig count comparing year to year data shows that 1994 stayed ahead of 1993's rig count until September and ended the year slightly behind 1993's week by week comparison. The number of permits issued rose throughout much of 1994 with sharp advances in Texas and Oklahoma. As has been the case when comparing oil and gas drilling, U.S. production of oil will likely suffer as imports continue to control a higher percentage of supply but natural gas production will likely maintain steady increases.

In another important development that could affect domestic frac sand sales, Canadian company Ultrasonic Industrial Sciences Ltd., announced the acquisition of a silica sand mining permit near Peace River, Alberta that could put a significant dent in frac sand imports from the United States. The deposit's total measured and inferred sand reserves approach 48 million tons.[33]

Based on these factors, demand was expected to grow for this end use during the decade, partially due to strong exports and a growing demand for natural gas. Probable demand for hydraulic fracturing sand for the year 2000 was expected to be 1.75 million tons, with a range of 1.6 to 2.0 million tons.

Based on the reports covered in the Current Research and Technology section, it is obvious that specialty silicas will continue to see sustained growth through at least 2000. Assuming that the silica route will be through the chemical and silicon metal categories, it is expected that the chemical and silicon metal categories should see better than average growth, probably in the 2% to 4% annual growth range. This positive forecast would be tempered if the specialty silicas producers are using a silica source other than industrial sand and gravel. The process for each type of silica is highly variable and certainly not well advertised; and therefore, it is difficult to determine the natural source and the processing route for the silica or silicate.

The United States was the largest producer and consumer of silica sand among the market economy countries and was self-sufficient in this commodity. Most of it was produced in the eastern part of the United States, where the premier deposits and major markets are. A significant amount of silica sand also was produced in the West and Southwest, mostly in California and Texas. Domestic production was expected to continue to meet more than 99% of demand well beyond 2000. Imports, mostly from Australia, Canada, and Europe were expected to remain minor.

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

Several factors could affect supply-demand relationships for silica sand. Further increases in the development of substitute materials for glass and cast metals could reduce demand for glass sand and foundry sand. These substitutes, mainly polymers and ceramics, would likely increase demand for ground silica, which is used as a filler in plastics, for glass fibers, which are used in reinforced plastics and for silica either chemically, whole grain or ground, which are used to manufacture ceramics. Also, increased efforts to reduce waste and increase recycling could hinder glass sand demand. However, with advances in high tech materials, silica sand may see increased consumption for fiber optics and other silicon and glass compounds. Although developments could cause demand for silica sand to decrease, the total value of production could increase because of the increased unit value of the more specialized sands.

An increase in the price of oil on the international market would stimulate domestic drilling and extraction from new and old oil deposits. This would increase demand for domestic hydraulic fracturing sand.

Concern over the use of silica as an abrasive due to health concerns and the imposition of stricter legislative and regulatory measures concerning silica exposure could decrease demands in many silica markets. Silica sand for use in the abrasive blast industry was being attacked as a health hazard as marketers of competing materials including garnet, slags, and olivine, pushed the use of their "safer" abrasive medium.

Development of more efficient mining and processing methods are expected to continue. This will enhance development of lower grade silica sand deposits closer to markets but not presently mined. Such developments are expected to increase silica sand reserves.

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TABLE 1
SALIENT U.S. INDUSTRIAL SAND AND GRAVEL STATISTICS 1/ 2/

		1990	1991	1992	1993	1994
Sold or used:						
Sand:						
Quantity	thousand metric tons	24,500	22,300	23,700	24,500	25,500
Value	thousands	$421,000	$378,000	$415,000	$436,000	$466,000
Gravel:						
Quantity	thousand metric tons	1,320	961	1,520	1,700	1,790
Value	thousands	$15,300	$12,900	$19,800	$18,500	$22,400
Total industrial:						
Quantity	thousand metric tons	25,800	23,200	25,200	26,200	27,300
Value	thousands	$436,000	$390,000	$434,000	$454,000	$488,000
Exports:						
Quantity	thousand metric tons	1,050	1,490	1,340	1,750	1,880
Value	thousands	$83,800	$107,000	$90,400	$91,000	$102,000
Imports for consumption:						
Quantity	thousand metric tons	66	83	164	44	22
Value	thousands	$3,150	$932	$2,450	$2,440	$1,790

1/ Puerto Rico excluded from all industrial sand and gravel statistics.
2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE2
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC REGION 1/

Geographic region	1993				1994			
	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	102	(2/)	$4,420	1	93	(2/)	$2,370	(2/)
Middle Atlantic	2,430	9	39,700	9	2,330	9	42,600	10
Midwest:								
East North Central	9,760	37	147,000	32	10,300	38	159,000	32
West North Central	1,770	7	37,600	8	1,910	7	39,900	8
South:								
South Atlantic	3,910	15	71,700	16	4,010	15	77,400	16
East South Central	1,280	5	19,400	4	1,350	5	20,400	4
West South Central	3,750	14	68,700	15	3,940	14	79,500	16
West:								
Mountain	1,230	5	19,500	4	1,440	5	23,100	5
Pacific	2,010	8	46,200	10	1,970	7	44,500	9
Total	26,200	100	454,000	100	27,300	100	488,000	100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

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

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value	Quantity	Value
Alabama	559	6,800	610	7,160
Arizona	W	W	W	W
Arkansas	642	7,600	W	W
California	1,800	41,700	1,740	39,400
Colorado	W	W	W	W
Connecticut	W	W	W	W
Florida	504	5,910	540	6,120
Georgia	491	7,940	440	7,040
Idaho	W	W	481	7,410
Illinois	4,220	61,700	4,420	65,700
Indiana	W	W	120	1,010
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	465	9,360	454	9,320
Maryland	W	W	W	W
Massachusetts	2	42	W	W
Michigan	2,570	25,100	2,870	31,300
Minnesota	W	W	W	W
Mississippi	W	W	W	W
Missouri	520	9,390	559	9,970
Montana	W	W	W	W
Nebraska	W	W	W	W
Nevada	480	W	572	W
New Jersey	1,830	28,600	1,690	30,600
New York	W	W	W	W
North Carolina	1,340	18,600	1,460	24,200
North Dakota	W	W	W	W
Ohio	1,360	27,500	1,260	27,700
Oklahoma	1,210	23,200	1,230	24,000
Pennsylvania	W	W	W	W
Rhode Island	W	W	W	W
South Carolina	749	19,000	699	18,100
Tennessee	644	11,700	659	11,600
Texas	1,430	28,600	1,570	37,900
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	W	W	W	W
Wisconsin	1,480	31,400	1,630	32,400
Other	3,930	90,300	4,320	96,500
Total	26,200	454,000	27,300	488,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 1994, BY SIZE OF OPERATION 1/

Size range	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	27	18	289	1
25,000 to 49,999	18	12	617	2
50,000 to 99,999	31	20	1,960	7
100,000 to 199,999	29	19	3,660	13
200,000 to 299,999	9	6	2,060	8
300,000 to 399,999	13	9	4,190	15
400,000 to 499,999	8	5	3,220	12
500,000 to 599,999	3	2	1,480	6
600,000 to 699,999	7	4	4,080	15
700,000 and over	7	4	5,770	21
Total	152	100	27,300	100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 1994, BY GEOGRAPHIC REGION

Geographic region	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Northeast:						
New England	2	--	--	--	1	3
Middle Atlantic	9	--	3	1	4	17
Midwest:						
East North Central	37	1	--	1	2	41
West North Central	5	--	--	--	6	11
South:						
South Atlantic	16	--	1	3	5	25
East South Central	9	--	1	--	2	12
West South Central	8	--	1	1	12	22
West:						
Mountain	8	1	1	--	--	10
Pacific	8	--	--	2	1	11
Total	102	2	7	8	33	152

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 1994, BY MAJOR END USE 1/

(Thousand metric tons and thousand dollars)

Major use	Northeast			Midwest			South			West			U.S. total		
	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton
Sand:															
Glassmaking:															
Containers	975	16,000	$16.39	1,840	18,500	$10.04	1,890	27,400	$14.49	1,260	26,200	$20.86	5,960	88,000	$14.77
Flat (plate and window)	W	W	15.14	832	7,910	9.50	1,480	21,400	14.48	W	W	16.34	2,610	34,200	13.10
Specialty	W	W	19.82	321	5,150	16.04	398	7,060	17.74	W	W	30.00	959	17,200	17.95
Fiberglass (unground)	W	W	14.30	365	4,990	13.67	323	8,040	24.88	W	W	20.57	779	14,500	18.60
Fiberglass (ground)	--	--	--	W	W	40.16	261	10,300	39.39	W	W	16.34	363	12,700	35.01
Foundry:															
Molding and core	342	6,790	19.86	5,190	66,300	12.77	1,130	14,200	12.62	71	1,550	21.83	6,730	88,800	13.20
Molding and core facing (ground)	--	--	--	W	W	46.31	--	--	--	--	--	--	W	W	46.31
Refractory	W	W	15.69	W	W	6.82	8	375	46.88	1	12	12.00	61	857	14.05
Metallurgical:															
Silicon carbide	--	--	--	W	W	14.31	--	--	--	--	--	--	W	W	14.31
Flux for metal smelting	--	--	--	W	W	9.97	W	W	5.17	W	W	8.60	53	478	9.02
Abrasives:															
Blasting	143	3,950	27.65	258	6,470	25.07	944	20,600	21.81	166	5,090	30.69	1,510	36,100	23.89
Scouring cleansers (ground)	--	--	--	W	W	46.50	W	W	36.00	--	--	--	W	W	44.86
Sawing and sanding	W	W	19.00	--	--	--	(2/)	2	55.67	--	--	--	W	W	20.00
Chemicals (ground and unground)	W	W	18.06	W	W	12.29	227	5,640	24.84	55	1,130	20.53	603	11,200	18.60
Fillers (ground):															
Rubber, paints, putty, etc.	W	W	79.86	W	W	94.69	36	7,300	202.75	--	--	--	68	10,300	151.97
Whole grain fillers/building products	105	2,810	26.80	528	14,100	26.64	445	14,900	33.44	175	4,880	27.91	1,250	36,600	29.24
Ceramic (ground):															
Pottery, brick, tile, etc.	W	W	37.14	148	7,400	50.03	W	W	49.26	--	--	--	259	12,700	48.91
Filtration:															
Water (municipal, county, local, etc.)	74	1,660	22.42	69	2,130	30.83	135	2,250	16.64	74	2,580	34.85	352	8,610	24.47
Swimming pool, other	W	W	58.50	11	773	70.27	6	411	68.50	W	W	77.08	23	1,540	67.00
Petroleum industry:															
Hydraulic fracturing	--	--	--	1,320	42,300	32.10	310	9,120	29.42	27	782	28.96	1,650	52,200	31.54
Well packing and cementing	--	--	--	12	1,640	136.58	14	215	15.36	15	252	16.80	41	2,110	51.37
Recreational:															
Golf course (greens and traps)	74	1,140	15.34	168	3,460	20.60	179	1,510	8.45	166	3,310	19.93	587	9,420	16.04
Baseball, volleyball, play sand, beaches	108	1,120	10.34	9	84	9.33	52	517	9.94	2	41	20.50	172	1,760	10.23
Traction (engine)	W	W	13.95	113	1,130	9.97	119	1,420	11.93	W	W	22.40	292	3,540	12.12
Roofing granules and fillers	30	627	20.90	W	W	3.24	130	1,260	9.68	W	W	14.86	217	2,150	9.92
Other (ground silica)	21	785	37.38	W	W	23.57	W	W	31.30	70	1,140	16.29	46	1,700	27.96
Other (whole grain)	429	7,940	13.18	568	7,850	20.26	302	6,310	21.21	474	9,110	19.44	942	18,800	20.04
Total or average	2,340	43,300	18.54	11,900	196,000	16.50	8,490	165,000	19.44	2,870	61,500	21.47	25,500	466,000	18.23
Gravel:															
Silicon, ferrosilicon	--	--	--	W	W	12.74	W	W	14.06	--	--	--	568	7,920	13.94
Filtration	38	1,440	38.00	W	W	10.66	38	1,150	30.29	W	W	91.49	157	3,450	21.96
Nonmetallurgical flux	--	--	--	--	--	--	--	--	--	497	5,720	11.50	497	5,720	11.50
Other uses, specified	47	221	4.70	224	795	3.55	254	3,920	15.43	39	378	9.69	564	5,310	9.41
Total or average	85	1,670	19.59	357	2,320	5.42	807	12,300	17.35	536	6,090	11.37	1,790	22,400	11.88
Grand total or average	2,420	45,000	18.57	12,300	199,000	16.22	9,290	185,000	19.08	3,400	67,600	19.89	27,300	488,000	17.86

W Withheld to avoid disclosing company proprietary data; included in "Total".
1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

TABLE 7
U.S. EXPORTS OF INDUSTRIAL SAND AND GRAVEL, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	F.a.s. value 2/	Quantity	F.a.s. value 2/
North America:				
Bermuda	(3/)	24	10	62
Canada	1,400	17800	1,480	20,100
Mexico	43	1720	159	2,900
Panama	12	229	11	166
Other	3	834	11	523
Total	1,450	20,700	1,670	23,800
South America:				
Argentina	4	649	29	1,280
Brazil	78	530	12	900
Peru	2	144	3	290
Venezuela	(3/)	132	4	649
Other	2	14	1	589
Total	86	1,990	48	3,710
Europe:				
Germany	34	3760	22	12,600
Italy	3	701	4	1,020
Netherlands	14	5040	6	3,840
United Kingdom	3	1070	24	2,270
Other	20	6630	15	4,630
Total	74	17,200	71	24,300
Asia:				
Hong Kong	1	243	11	7,050
Japan	84	39100	43	29,700
Korea, Republic of	10	3040	7	2,980
Singapore	8	3880	5	2,400
Taiwan	22	3100	19	4,780
Other	1	904	4	1,960
Total	126	50,100	88	48,900
Middle East and Africa:				
Total	9	572	5	628
Oceania:				
Australia	2	462	2	547
Other	(3/)	56	(3/)	115
Total	2	518	2	662
Grand total	1,750	91000	1,880	102,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL SAND, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	C.i.f. value 2/	Quantity	C.i.f. value 2/
Australia	42	1,760	11	644
Belgium	(3/)	5	--	--
Canada	(3/)	28	1	103
France	(3/)	19	--	--
Germany	1	76	(3/)	145
Guyana	--	--	8	150
Italy	(3/)	18	(3/)	36
Japan	(3/)	147	(3/)	234
Mexico	--	--	(3/)	2
Solomon Islands	(3/)	7	--	--
Sweden	1	329	2	415
United Kingdom	(3/)	2	(3/)	7
Venezuela	(3/)	45	(3/)	57
Total	44	2,440	22	1,790

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
INDUSTRIAL (SILICA) SAND AND GRAVEL: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	335 r/	374	340 r/	396 r/	380
Australia e/	2,000	2,000	2,000	2,000	2,500
Austria	818	2,090	5,880	4,300 r/	6,460 4/
Belgium	2,560	2,550	2,480 e/	2,480 e/	2,480
Bosnia and Herzegovina e/	XX	XX	50	50	50
Brazil e/	2,700	2,700	2,700	2,700	2,700
Canada	2,080	1,500	1,750	1,600 e/	1,600
Chile e/	300	300	300	300	300
Croatia e/	XX	XX	150	100	100
Cuba e/	500	500	450	400	350
Denmark (sales)	333 r/	325 r/ e/	315 r/ e/	315 r/	315
Ecuador e/	52	33	51	46	45
Egypt 5/	507	500	500 e/	500 e/	500
Estonia e/ 6/	XX	XX	30	25	25
Finland	276	201	169	167 r/	162 4/
France e/	3,500	3,500	6,300	5,400 r/	6,000
Germany:					
Western states	9,400	XX	XX	XX	XX
Eastern states	1,850 e/	XX	XX	XX	XX
Total	11,200 e/	11,000 e/	10,700	9,770 r/	10,000
Greece	94	--	--	--	--
Guatemala	30	17	34	27 e/	56 4/
Hungary	1,250	781	844	780 e/	750
Iceland e/	5	5	5	5	5
India	1,140	1,920	1,320 r/	1,290 r/	1,300
Indonesia	165	429	400 e/	240 r/	240
Iran 7/	870 e/	832	756	932 r/	950
Ireland e/	7	7	7	7	8
Israel	85	60	60	60 e/	60
Italy e/	4,300	4,200	4,000	4,000	4,000
Jamaica	17	16	16	21 r/	18 4/
Japan	4,440	4,340	3,840 r/	3,880	3,940 4/
Kenya e/	12	12	12	12	12
Korea, Republic of e/	2	1	2	2	2
Latvia e/ 6/	XX	XX	110 r/	90 r/	90
Liberia e/	5	--	--	--	--
Lithuania e/ 6/	XX	XX	80	60	60
Malaysia	687	668	579	355 r/	231 4/
Mexico	1,170	1,200	1,130	1,310 r/	1,360 4/
Namibia e/	--	--	-- r/	-- r/	--
Netherlands e/	25,100 4/	25,000	20,000	20,000	20,000
New Caledonia e/	31	31	31	31	39
New Zealand	545	594	500 r/	720 r/	750
Norway e/	800 r/	800 r/	900 r/	900 r/	900
Pakistan	131	151	135	168 r/	170
Panama	15	18	23	23 e/	23
Paraguay e/	2,000	2,000	2,000	2,000	2,000
Peru	100 e/	150	152	152 e/	150
Philippines	256 r/	532	500	828 r/	800
Portugal e/	5	5	5	5	5
Serbia and Montenegro	XX	XX	613 r/	185 r/	200
Slovenia e/	XX	XX	300	200	200

See footnotes at end of table.

TABLE 9--Continued
INDUSTRIAL (SILICA) SAND AND GRAVEL: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
South Africa, Republic of	1,990	2,070	1,750	1,740 r/	1,920 4/
Spain e/	2,200	2,200	2,200	2,200	2,000
Sweden e/	1,230 r/	1,470 r/	1,430 r/	1,500 r/ e/	1,500
Tanzania	6	4	4	4 e/	4
Thailand	422	657 r/	594 r/	459 r/	471
Turkey e/ 8/	469 4/	358 e/	510	300 r/	315
United Kingdom	4,300 e/	3,900	3,620	4,000 e/	3,600
United States (sold or used by producers)	25,800	23,200	25,200	26,200	27,900 4/
Venezuela	443	343	703	753 r/	780
Yugoslavia 9/	2,450	2,100	XX	XX	XX
Zimbabwe 10/	63	70	77	80 e/	130
Total	110,000 r/	108,000 r/	109,000 r/	106,000 r/	111,000

e/ Estimated. r/ Revised. XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through July 20, 1995.
3/ In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas and China, among others, produce industrial sand, but current available information is not adequate to formulate estimates of production levels.
4/ Reported figure.
5/ Fiscal years beginning July 1 of that stated.
6/ Formerly part of the U.S.S.R., which was dissolved in Dec. 1991. Information was inadequate to formulate reliable estimates of production prior to 1992.
7/ Fiscal years beginning Mar. 21 of that stated.
8/ Washed product.
9/ Dissolved in Apr. 1992.
10/ Includes rough and ground quartz as well as silica sand.