Silica/Quartz

Michel Dumont

The author is with the Minerals and Metals Sector, Natural Resources Canada.
Telephone: (613) 995-2917
E-mail: mdumont@nrcan.gc.ca

Quartz (i.e., SiO_2, also referred to as silicon dioxide or silica) is one of the most common minerals on the face of the earth with numerous uses. It is produced and consumed in most countries. Annual world production of silica is estimated at 120-150 Mt, of which more than one quarter is from the United States and the Netherlands. France, Austria, Spain, Germany, Paraguay and the United Kingdom are also major producers.

Sand is composed of tiny quartz pebbles, which are the primary ingredient for the manufacture of glass. This transparent rock crystal has electronic uses such as oscillators in radios, watches and pressure gauges. Quartz is also used as an abrasive for sandblasting, grinding glass, and cutting soft stones, and it is an important ingredient in the production of soaps and ceramics. Transparent rock crystal is used in the study of optics and quartz is essential for the computer industry as all important semi-conductors are made from quartz.

Quartz is not the only mineral composed of SiO_2. There are eight other known structures composed of SiO_2; they are polymorphs of silicon dioxide and belong to an informal group called the Quartz Group or Silica Group.

SUMMARY

In Canada, silica is recovered in: a) lump form for use as metallurgical flux and in the manufacture of silicon and ferrosilicon alloys; b) as sand, for glass and glass fibre manufacture, foundry moulding, silicate chemicals, silicon chips and optical fibres; and c) as finely ground silica flour for ceramics, asbestos cement and concrete products (Table 4).

Although Canada is self-sufficient for most of its requirements for silica, significant tonnages of high-quality sand for glass and foundry applications are imported, mainly by Ontario from the United States. As a result of widespread availability and low prices, trade is restricted to convenient cross-border shipments. However, silica with the desired specifications for specific applications may be shipped to large, distant markets.

Preliminary data reported by users (Table 3) in Canada show that silica use was 2.6 Mt in 2002, an increase of 16 747 t from the previous year, but still less than the 2000 level. Preliminary data (Table 1) reported by Canadian producers for 2003 indicate production was valued at $44.32 million, a $1.083 million decrease from 2002, even though production increased to 1.59 Mt from 1.54 Mt in 2002. Preliminary imports were valued at $107.1 million for 2003, a $1.8 million decrease from 2002, even though the import quantity increased to 875 197 t from 641 826 t in 2002. Preliminary exports for 2003 represented close to $12.0 million, an increase of $559 000 compared to exports in 2002, while the quantity increased to 354 685 t from 273 305 t in 2002.

Preliminary data for 2002 (Table 3),[1] show that the nonferrous smelting and refining industry represents 36.6% of the total use of silica in Canada and that it decreased 3.7% from 2001. The primary glass and glass containers, and glass fibre wool sectors represented 19.9% of total use. Foundries, which represented 9.9% of the total use of silica in Canada, observed a decrease of 11.0% compared to 2001. Silica use by the chemicals industry was 3.2% of total use, an observed increase of 8.4% compared to 2001 usage. The "other products" category, which includes a multitude of industry users, represents 30.4% of total silica use in Canada and observed an increase of 10.8% from 2001.

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1 Reported use of silica by Canadian manufacturing companies is done by surveys on a voluntary basis and might not reflect 100% consumption coverage. Also, data might not include silica purchased for exports resale.

With respect to the reported quantity of silica used by category (Table 4), sand represents 65.8% (1.7 Mt) of the total with a tonnage increase of 75 296 t from 2001. For lump silica, which represents 32.1% (836 590 t) of the total, a slight decrease of 0.2% from 2001 is observed. Preliminary data for flour, which represents 2.1% (54 511 t) of the total, indicate a drastic decrease of 50.9% from 2001. This flour usage decrease is attributed to one company's decision to replace its consumption of silica flour by silica sand, which in part explains the increase in sand consumption in 2002.

Mode of Occurrence

Silica occurs mainly as the mineral quartz. Quartz occurs in many forms, the common being vein and massive intrusive bodies, silica sand, sandstone and quartzite. Quartz also occurs as crystals and as masses or aggregates in igneous rocks such as granites or pegmatites. Amorphous, non-crystalline varieties of quartz are less common and include opal, flint, chalcedony, tripoli, and diatomaceous earth.

Although all occurrences of silica are of interest from a geological point of view, commercial interest and development are usually restricted to vein or intrusive deposits and to silica sand, sandstone and quartzite deposits. Vein and intrusive deposits are igneous in origin and vary widely in shape and size. Such deposits are widespread throughout Canada. The quartz usually varies from white to grey and is relatively free of impurities.

Silica sand has a high silica content (95% SiO_2 or more). The silica or quartz particles, having been derived from the mechanical disintegration and chemical decomposition of siliceous rocks, are selectively sorted and concentrated by the action of wind or water during transport to new locations where they accumulate to form high-grade deposits.

Sandstone is a sedimentary rock composed of quartz grains cemented by a bonding mineral. Sandstones, in which the bonding material is clay, calcite or iron oxide, are usually quite friable and easily reduced to grain size. Others may be more firmly cemented by a siliceous cement and thus are more difficult to reduce to grain size. Most sandstones are white, grey or brown and usually contain varying amounts of mineral impurities, e.g., feldspar, hornblende, magnetite, pyrite, iron oxide stain and mica.

Quartzite is a hard, compact, metamorphosed sandstone composed of grains of quartz firmly bonded with a siliceous cement. The original quartz grains, having coalesced with the siliceous cement to form a continuous homogeneous mass, are not apparent to the naked eye.

Trade

Although Canada has sufficient silica deposits to meet all of its needs, it still imports the commodity to serve particular markets in regions where market conditions warrant this action. Imports for 2003 (Table 1) from the United States totaled 853 058 t (97.5%) of all imports (875 197 t) from all countries. Imports of silica sands and quartz sands from the United States have increased significantly since 2001 (2001 to 2002 = 103.9%, 2002 to 2003 = 38.6%). The increases are attributable mainly to demand from the foundry industry, but also due to increased demand from the oil and gas (e.g., the price of oil barrels has justified increased exploration), and fibreglass market segments (e.g., lower interest rates favouring construction [e.g. residential] projects).

Imports from the United States come from loosely consolidated and easily processed sandstone or lake sand deposits located near the Great Lakes. Major U.S. operations are located in the states of Illinois, Wisconsin, Michigan and Indiana.

In 2003, world imports of silica sand were mainly attributed to the Canadian iron and steel foundry industries and the Canadian glass manufacturing industry segments (Table 2), with combined imports of 739 265 t. The tonnage of imports by the foundry industry increased by 187.5% from 2001 to 2002, and preliminary figures for 2003 show an increase of 44.7% from 2002. Demand for foundry sand is dependent mainly on automobile and light truck production and, in the recent years of lower interest rates and special dealership deals offering favourable purchasing conditions, consumers have benefitted from replacing their used vehicles. On an overall basis, the use of silica in foundries decreased by 11.0% in 2002, which suggests that, even with a decrease in demand, there was still a preference for U.S. silica due to Canadian markets being closer to the silica deposits in the United States.

Preliminary data for 2003 indicate that Canada's exports (Table 1) of silica totaled 354 685 t, an increase of 29.8% from 2002. The value of these exports totaled $12.0 million, an increase of 4.9% over the 2002 value of $11.4 million. The major increase in the quantity exported is principally due to the quartz, silica sands, and quartz sands categories. Of all the exports from Canada to various countries, 335 332 t (94.5%) of these were made to the United States.

Production and Market Considerations

The economics of the production and sale of the many types of silica are governed by many factors, but world demand for silica is controlled mostly by the fortunes of the glass and foundry industries. Throughout North America, the silica sand industry is highly competitive and the industry is dominated by a few large producers. A silica sand source location close to its users is important due to transportation cost considerations and thus is shipped only to local or regional markets. Beneficiation is the key to producing high-quality glass or foundry sand from most deposits.

The diverse uses of silica and quartz complicate its market demand analysis. In the glass sector, construction and automobile markets drive flat glass sales, new construction being the basis for fibreglass sales. These markets are driven by the Gross Domestic Product. Silica sand demand in container glass is influenced by reductions in the number of consumption points through industry rationalization; decreased production as a result of strong competition from PET bottles (i.e., made of virgin resin of polyethylene terephthalete), alumina, and paper containers; and increasing and mandated recycling rates in the glass container industry. Use in foundry applications depends on metal production (depending upon automobile sales, etc.) combined with recycling efficiencies and competitive sands. Hydraulic fracturing sand demand is influenced by the price of oil, regional oil production factors such as flow rate and pressure, and changes in drilling technologies. Overall, demand for foundry sand has been reduced by the advent of continuous casting in the steel industry.

SUPPLY

Silica deposits of commercial interest occur in all 10 provinces. The important Canadian production sites are discussed below. The provinces of Quebec, Ontario and Alberta are the main producers of silica, followed by Saskatchewan, British Columbia and Nova Scotia. Generally, silica mining uses open-pit or dredging mining methods.

Newfoundland and Labrador

Shabogamo Mining and Exploration Co. Ltd. began mining its Roy's Knob quartzite deposit near Labrador City in October 1999. The company's washing and screening plant is located in Wabush, Labrador. The quartzite product is sent by rail to Sept-Îles, Quebec. Shabogamo supplies quartzite to Silicum Bécancour Inc. of Quebec, which uses the material to manufacture silicon metal. Shipments in 2003 are forecast to be valued at approximately $1.8 million. The operation has a seasonal work force of 15-20.

Prince Edward Island

There are no silica quarries currently in operation.

Nova Scotia

Shaw Resources Ltd., a member of The Shaw Group Limited, produces a high-purity (98.5-99.5%) silica from sand deposits located at Nine Mile River, Hants County, near Shubenacadie. In addition, fine sand from its silica operation is beneficiated to flint glass-grade material. Fine sand products are sold in the Maritimes, Quebec and northeastern United States for use in sandblasting, filter sand, traction sand, cement and concrete manufacturing, refractory and decorative sand, and as a flux for base-metal smelters. Production is estimated at 59 682 t.

British Columbia's Black Bull Resources Inc. has obtained regulatory approvals from the Nova Scotia Department of Natural Resources to commence mining at its White Rock quartz project in Yarmouth County. The site is located 42 km northwest of the deep port of Shelburne. Reserves of 16.3 Mt of high-quality quartz have been estimated.

New Brunswick

Shaw Resources' Chaleur Silica Ltd. – a division of The Shaw Group Limited currently operates the Bass River silica quarry providing silica as flux material to the nearby Belledune lead smelter, and silica for use in cement manufacture. It also manufactures abrasive products using raw material from Nova Scotia, Ontario and the United States.

Since 1986, Atlantic Silica Inc. mines and processes a high-grade (+98%) silica deposit 22 km southwest of Sussex near Cassidy Lake. The quartz pebbles have been used to produce silicon metal and decorative stone. The quartz sand has been marketed for use in sandblasting, silicon carbide, nursery grit, cement powder, glass, golf course sand, smelter flux and filtration sand. Most of it is used in eastern Canada, although some is shipped to the United States.

Quebec

Unimin Canada Ltd., a subsidiary of Unimin Corp. of the United States, is the largest producer of silica in the province. Silica is mined from a quartzite deposit at Saint-Donat-de-Montcalm and from a sandstone deposit at Saint-Canut. Silica from Saint-Donat is shipped and refined at the Saint-Canut plant near Montréal. The majority of the silica produced by Unimin originates from Saint-Canut where the ore is ground, screened and beneficiated by magnetic separation. Most of Unimin's output is used in the production of glass containers, flat glass and fibreglass, and also in the silicon carbide industries.

Bécancour Chemical Industries operates the silica plant in Bécancour. It also owns the quartzite deposit north of La Mabaie that is being developed by Sitec Inc. Sitec Inc. is a joint venture between Baskatong Quartz Inc. and SOQUEM INC., a wholly owned subsidiary of SGF

Minéral Inc. Sitec mines and processes high-purity quartz in Malbaie, Quebec, for a range of end uses, including silicon metal and silicon carbide. The company also operates a custom crushing, drying, and screening plant in Shawinigan, Quebec.

La Compagnie Bon Sable Ltée mines silica sand at Saint-Joseph-du-Lac and Ormstown. The material is used mainly for sandblasting and as a concrete sand; it is also suitable for the production of fibreglass.

Silco Sands Inc. mines and grinds its silica at its plant in Sainte-Clotide-de-Châteauguay. The products are sold to a chemical company, a cement plant and a ferromanganese plant.

Opta Minerals' Temisca Silice Inc. Division mines and processes silica near Saint-Bruno-de-Guigues for the golf course, filtration, frac, abrasives and construction markets. The processing facility includes a 200 000-t/y hydrosizer as well as screening, drying and packaging equipment. Temisca had been sold to Stake Technology Ltd. (StakeTech) of Norval, Ontario, which recently changed its name to SunOpta Inc.

Béton provincial ltée operates a silica sandstone quarry in Gaspé's Larivière County and Société Minière Gerdin Inc. operates a silica sand quarry on a seasonal basis in Saint-Rémi-d'Amherst.

Ontario

Unimin Canada Ltd. is the largest producer of silica in Ontario with a capacity of about 500 000 t/y. Lump quartzite from Badgeley Island (150 000-t/y capacity) in northern Georgian Bay is shipped by boat to Canadian destinations for the manufacture of ferrosilicon. The finer material, produced by grinding, is shipped to Unimin's plant at Midland (400 000-t/y capacity), south of Georgian Bay, where it is further processed to a glass-grade silica sand and silica flour for ceramic and other uses.

Crystal Quartz Canada, located west of Sudbury near Dryden, is the only lascas-grade silica producer in North America. It supplies lascas to North American cultured quartz producers.

Significant amounts of silica are extracted by others across Ontario for use as flux for base-metal smelting operations in Timmins and Sudbury, for silicon metal production, for specialty brick production, and for decorative uses. Other Ontario producers are: Arriscraft International Inc. with its Elgin Quarry in Bastard Township; Rapier Resources Inc. with its Deagle Township Quarry, west of Sudbury; Great White Minerals Ltd. with its Fripp Quarry, near Timmins; Northern Mining and Exploration Inc. with its Shaw Township Quarry, in Timmins; and Roseval Silica with its Penhorwood Township Quarry, also near Timmins.

Manitoba

There are no known silica quarries currently in operation.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited (HBMS) produces silica in the Amisk Lake area of northern Saskatchewan and is the largest user of the province's silica sand at its Flin Flon, Manitoba, smelter. HBMS uses sand as a fluxing agent which, in the molten state, reacts with various impurities in the copper and zinc ore to produce a slag. The slag produced with the impurities drawn off leaves a refined metal.

Red Deer Silica Inc. produces a small amount of silica, northeast of the village of Hudson Bay, for use in golf course bunkers, stucco sand and sandblasting sand.

In mid-2002, the mineral deposit of Hanson Lake Silica Sand Project was appropriated by Trican Well Services and Saskatchewan Opportunities Corporation (SOCO). The mineral dispositions have been optioned to Winn Bay Sand Ltd., a company affiliated with the Ochapwace First Nation. Lonesome Prairie Sand and Gravel Ltd. is the contractor carrying out all quarrying operations. All processing takes place on site. The processing facility was in the final construction stages and was anticipated to be operational by mid-May. Stockpiling of 400 000 t of silica sand is expected to take place during February-April 2004. The silica sand is used as frac sand, predominantly in the gas fields in Saskatchewan. The silica sand is transported to Burstall, Saskatchewan, just west of the Great Sand Hills, where it is offloaded. Customers pick up their orders from this site.

Alberta

Sil Industrial Minerals Inc. of Edmonton produces silica sand from local sand dunes in the Bruderheim area. It also operates a silica processing facility near Edmonton. The silica is sold mainly for the manufacture of fibreglass and as sandblasting material. Other uses are in foundry, filtration, fracturing and railway traction applications. The company also produces silica flour by processing the silica sand through a ball mill. The flour is used in thermal insulating cement in the oil and gas industries.

Cementec Industries Inc. of Calgary produces, among other unique and proprietary products, silica flour, silica fume and sandblasting sand for use in the oil and gas and construction industries.

British Columbia

The Mountain Minerals Division of Highwood Resources Ltd., in Calgary, Alberta (now a wholly owned unit of Dynatec Corp.), mines a high-purity (99.5%) silica sand for diverse industrial applications (e.g., glass grade) at the Moberly mine in the Golden area. The friable sandstone is ground, screened, washed, dried and separated into several sizes at a plant near Golden. These different sizes are sold mainly as glass sand, but also as sandblasting sand, foundry sand, filter media sand and golf course sand.

Lafarge Canada Inc. mines silica-alumina material from the Buse Lake deposit as feedstock for its Kamloops cement plant.

PRICES

Prices for actual transactions vary according to geographic region and will take into account the quantity purchased, application, quality assurance, exact grade purchased, credit terms, and other parameters. Due to the unavailability of Canadian prices, the following price examples from other sources are provided to facilitate an understanding. The May 2004 edition of *IM Magazine* reported that silica sand prices (Ex-works, U.K. foundry sand, dry, bulk) were in the range of £15.50-£16.50/t (C$38.54-$41.02/t). The price range for the other categories (glass sand, flint, container, ex-works) was £15-£17/t (or C$37.29-$42.26/t). Ex-works USA (foundry sand, dry, bulk) prices were in the range of US$14.00-$25.00/t (or C$19.22-$34.31).

U.S. prices (source: U.S. Geological Survey[2] [USGS] 2002 review), as an example, for the North American market, when compared with the average value of 2001 (i.e., the average value, free on board [f.o.b.] plant) for U.S. industrial sand and gravel, increased slightly to US$20.96/t in 2002. The average unit values for industrial sand and industrial gravel were US$21.36/t and US$13.66/t, respectively. The average price for sand ranged from US$11.67/t for metallurgical flux to US$82.87/t for ground fillers. For gravel, prices ranged from US$10.05/t for non-metallurgical flux to US$31.31/t for filtration. U.S. producer prices reported to the USGS for silica commonly ranged from several dollars per tonne to hundreds of dollars per tonne and occasionally exceeded the US$1000/t level. In the United States, ground sand used as fillers for rubber, paint and putty had the highest value per tonne at US$82.87, followed by ground sand for foundry molding and core, US$82.43; silica for swimming pool filters, US$77.07; sand for well packing and cementing, US$64.63; silica for municipal water filtration, US$41.83; ground sand for fibreglass, US$40.87; abrasives for sawing and sanding, US$36.86; and sand for hydraulic fracturing, US$40.08.

MAJOR USES AND SPECIFICATIONS

Silica in the form of quartz, sand, sandstone and quartzite is used in many applications. Uses may be subdivided on the basis of particle size requirements, e.g., lump silica, 2 or 3 mm to 15 cm or more in size; silica sand, 2 or 3 mm in size down to 75 microns; and silica flour, which is essentially minus 75 microns in size. Applications for the silica with general specifications are discussed under the three general size categories stated (CANMET, *Summary Report No. 4: Silica*).

Lump Silica[3]

Flux: Quartz, quartzite, and occasionally sandstone and sand are used as fluxes in smelting base-metal ores with low silica contents. The silica content of the flux should be as high as possible, but a small percentage of impurities such as iron oxide and alumina can be tolerated. Size is generally minus 2.5 to 0.5 cm.

Silicon Alloys: Quartz, quartzite and well-cemented sandstone are used in the manufacture of silicon, ferrosilicon and other alloys of silicon. The silica content of ferrosilicon should be 98% and the total iron oxide and alumina less than 1.5%. Lime and magnesia should not exceed 0.20% each; phosphorous and arsenic should also be very low. Silicon metal manufacture requires a high-purity quartz grading 99.5% SiO_2 or better with less than 0.04% iron oxide and alumina. Size specifications vary between 5 and 10 cm.

Silica Brick: Quartz and quartzite crushed to 2.5 mm are used in the manufacture of silica brick for high-temperature refractory furnace linings. The silica content should be a minimum of 95%, and iron oxide and alumina should each be less than 0.1%. Other impurities such as lime and magnesia should be low.

Other Uses: Lump quartz and quartzite are used as linings in ball and tube mills, and as lining and packing for acid towers. Naturally occurring flint pebbles may be used as a grinding medium for nonmetallic ores.

Silica Sand[3]

Glass and Glass Fibre: Naturally occurring quartz sands, and sands produced by crushing quartz, quartzite or sandstone are used in the manufacture of glass, glass fibre and fused silica ware. The silica content should be greater than 99% and the iron oxide content should be uniform and

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[2] Different countries have different terminology and specifications for silica. In the United States, industrial sand and gravel is often called "silica," "silica sand" and "quartz sand," which include sand and gravel with high silicon dioxide content.

[3] High-purity quartz, quartz crystal and silica sand are used as starting materials in the production of artificial quartz crystal, fused quartz and optical fibres. The silica content should be as high as possible and the metallic elements should be as low as possible, usually in the ppm range.

less than 0.025%. Other impurities such as alumina, lime and magnesia should be less than 0.15% each. Chromium, cobalt and titanium are undesirable and should be less than 2 or 3 ppm. Uniformity of grain size is important and sand generally should be between 600 and 100 microns in size with a minimum of coarse and fine material.

Silicon Carbide: Sand for silicon carbide manufacture should have a silica content of 99% and iron oxide and alumina should each be less than 0.1%; lime, magnesia and phosphorus are particularly objectionable. Although coarse-grained sand is preferred, finer sands are used where coarser grades are not available. All sand should be plus 150 microns, with the bulk of the sand being minus 2.0 plus 0.5 mm in size.

Hydraulic Fracturing: Silica sand is used as a "propping agent" in the hydraulic fracturing of oil-bearing formations to improve the recovery of oil. The sand should be clean, dry and have a high compressive strength. The silica content should be high and carbonates and other acid-consuming minerals should be low. The sand grains should be between 850 and 500 microns in size and be well rounded to facilitate placement and provide maximum permeability.

Foundry Moulding: Naturally occurring sand and sand produced by the reduction of sandstone to grain size are used extensively in the foundry industry for moulding purposes. The purity and size of sand used depend on the type of casting and on the particular foundry practice. Iron and steel foundry sands vary in grain size between 850 and 75 microns in closely sized fractions. American Foundryman's Society (AFS) numbers vary between 55 and 65, with the bulk of the sand being preferably on three adjacent sieves; a rounded grain shape is preferred. The silica content should be high, 99% SiO_2, with low aluminum, iron, sodium and potassium oxides.

Silicate Chemicals: Sand for the manufacture of sodium silicate and other chemicals should be of high purity. Sodium silicate requires a silica content of 99%, the alumina less than 1%, the combined lime and magnesia less than 0.5%, and iron oxide less than 0.1%. All sand should be between 840 and 150 microns in size.

Other Uses: Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit for sandblasting purposes and for the manufacture of abrasives papers. Various grades of closely sized, round-grained sand are used in water filtration plants as a filtering medium. Silica sand is used as an additive in portland cement manufacture when the source cement is low in silica.

A typical specification of silica for optical fibre is as follows:

Chemical Analysis	Size Analysis	Composition
SiO_2, 99.98 % min.	+200 μm	40.0%
Metal elements or oxides,	-200 +100 μm	50.0%
1.5-5 ppm range	-100 +75 μm	9.0%
	-75 μm	1.0%

Silica Flour

Silica flour, formed by grinding quartz, quartzite, sandstone and sand to 75 microns and finer, is used in the ceramic industry for enamel frits and pottery flint. It is also used in the manufacture of asbestos cement and autoclave-cured concrete products, as an inert filler/extender mineral in rubber and paints, and as an abrasive ingredient in soaps and scouring powders.

MINING, PROCESSING AND BENEFICIATION

Mining

Commercial silica is obtained from vein quartz, sand, sandstone and quartzite deposits. Mining is usually by an open-pit benching using standard quarrying methods. Following primary breakage, the rock is trucked to the mill site for further size reduction, processing and beneficiation.

Processing

Silica may be used in the lump form, as sand, as a finely ground powder, and as silica flour. Primary crushing of lump silica is readily accomplished by jaw and cone crushers, and secondary crushing is done by hammer or impact-type mills. Further reduction to sand size may be accomplished by roll crusher or rod mill, and to flour size or finer by ball, vibratory or jet-milling, or by attrition grinding in a "stirred" ball mill using small ceramic pebbles as grinding media.

Following primary and secondary crushing, lump quartz, sandstone and quartzite for use as flux in the manufacture of silicon and ferrosilicon, etc., must be screened to meet size specifications. Screening may result in minor upgrading through removal of impure fines, but such material is essentially used as quarried with no beneficiation apart from sizing.

Beneficiation

Uses requiring silica in the form of sand or flour, e.g., glass, silicon carbide, foundry and asbestos cement, usually require precise sizing and a high-purity product. Thus, further processing and beneficiation are normally required to both size and upgrade the raw silica feed material.

Further reduction of the silica to a specific size, e.g., minus 850 plus 150 microns, must be carefully carried out to avoid introducing extraneous impurities such as mill iron and other contaminants, and care must be exercised to avoid over-crushing. Whole unfractured grains are preferred in foundry moulding, and fines are detrimental in both foundry and glass sand applications. Over-crushing is more difficult to control when the starting material is quartz or quartzite, which do not possess a well-defined granular structure, than when crushing a more weakly cemented friable sandstone. The choice of grinding unit is also important; for example, impact mills produce more fractured grains and fines than jaw, cone or roll crushers.

Following reduction to the size required, various beneficiation steps may be employed to remove impurities, typically clay, feldspar, carbonates and ferromagnesian minerals. Beneficiation can include one or more of the following:

1. Screening to remove the coarse and fine fractions, which usually contain a significant percentage of the total impurity.

2. Magnetic separation to remove iron-bearing minerals.

3. Jigging or tabling to remove heavy minerals.

4. Attrition scrubbing and washing to remove clay and slimes.

5. Flotation to remove minerals that do not respond to magnetic or gravity methods, e.g., feldspar and pyrite.

6. Acid leaching to further reduce iron and carbonate minerals.

HEALTH/SAFETY/RECYCLING/ ENVIRONMENT

Health and Safety Concerns

Crystalline silica is silicon dioxide (SiO_2). Most mined minerals contain some SiO_2. "Crystalline" refers to the orientation of SiO_2 molecules in a fixed pattern. The three most common crystalline forms of silica encountered in industry are quartz, tridymite and cristobalite.

Silicosis is a disabling, non-reversible and sometimes fatal lung disease caused by overexposure to respirable crystalline silica. Silicosis can be prevented when crystalline silica is used safely and appropriate precautions are taken. Silicosis is preventable if employers, workers and health professionals work together to reduce exposures (source: U.S. Department of Labor, Occupational Safety & Health Administration). In the United States, any mineral product with a crystalline silica content of >0.1% may be regulated under the U.S. Occupational Safety & Health Administration Hazard Communication Standards (see www.osha.gov/SLTC/silicacrystalline/).

In Canada, the Workplace Hazardous Materials Information System (WHMIS) (see www.hc-sc.gc.ca/hecs-sesc/whmis/) is Canada's hazard communication standard. WHMIS is implemented through coordinated federal, provincial and territorial legislation.

Recycling

The use of recycled glass (cullet) is increasing, which in turn is reducing the need for virgin raw material in the glass batch. The second largest use for recycled container glass is as a feedstock for insulation fibreglass manufacture (up to 40% of the feed). Silica sand used in abrasive blasting is usually single pass as it is cheap and breaks down rapidly during use. The reclamation and re-use of foundry sands are on the increase due to escalating purchasing and disposal costs.

Environmental Concerns

Except for temporarily disturbing the immediate area while mining operations are active, sand and gravel mining usually has a manageable environmental impact.

OUTLOOK

In 2002, the Canadian economy experienced modest growth. The demand for foundry sand (source: USGS) is dependent mainly upon automotive and light truck production levels that parallel GDP growth. Sales of glass are expected to vary from market to market (e.g., flat glass and specialty glass). The demand for quartz crystal devices is likely to continue to increase; thus, quartz crystal production will probably remain strong well into the future.

Over the long term, glass demand has been growing at around 3.5%/y, which is a rate lighter than GDP (source: Pilkington). Demand for value-added products is growing at a faster rate than demand for basic glass. These value-added products are becoming increasingly important in the automotive market, delivering greater functionality to a vehicle's glazing.

The Freedonia Group forecasts that U.S. demand for advanced flat glass will increase at 6.5%/y and reach US$6.7 billion in 2008. Increased demand will be driven largely by the introduction and commercialization of new products, specifically smart glass products, self-cleaning window glass, and heads-up display wide screens for motor vehicles. More mature product lines, such as low-emissivity solar control glass and automotive safety glass, will continue to dominate overall demand, but will record slower growth.

The silicon (source: Roskill) that is used in the aluminum, chemical and electronics industries is expected to show growth in demand of about 6%/y over the next five years, with silicone chemicals being the fastest-growing sector in volume terms. Ferrosilicon demand depends upon demand for cast iron. Market growth for ferrosilicon is expected to be less than 1.5%/y up to 2007, but demand for steel will exceed 2%.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 64. (2) Information in this review was current as of May 30, 2004. (3) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mms/cmy/com_e.html.

NOTE TO READERS

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2804.61	Silicon containing by weight not less than 99.99% of silicon	Free	Free	Free	Free
2804.69	Silicon, n.e.s.	5%	3%	3%	Free
2811.22	Silicon dioxide	Free	Free	Free	Free
2849.20	Silicon carbide	Free	Free	Free	Free
7202.21.10	Ferro-silicon containing by weight more than 55% but less than 60% of silicon	Free	Free	Free	Free
7202.21.20	Ferrosilicon containing by weight 60% or more of silicon but less than 90%	Free	Free	Free	Free
7202.21.30	Ferro-silicon containing by weight 90% or more of silicon	Free	Free	Free	Free
7202.29	Ferro-silicon, n.e.s.	Free	Free	Free	Free
7202.30	Ferro-silico-manganese	Free	Free	Free	Free
7202.50	Ferro-silico-chromium	Free	Free	Free	Free

Sources: Canadian *Customs Tariff*, effective January 2004, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States*, 2004.
n.e.s. Not elsewhere specified.

TABLE 1. SILICA, CANADIAN PRODUCTION AND TRADE, 2001-03

Item No.		2001		2002		2003	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (Shipments)							
	By province						
	Newfoundland and Labrador	x	x	x	x	x	x
	Nova Scotia	x	x	x	x	x	x
	New Brunswick	x	x	x	x	x	x
	Quebec	565 096	15 436	534 817	16 519	490 000	15 085
	Ontario	512 605	11 560	479 016	10 999	492 049	11 608
	Manitoba	x	x	x	x	x	x
	Alberta	241 548	8 646	221 871	8 444	327 031	9 249
	British Columbia	x	x	x	x	x	x
	Total	1 612 628	44 725	1 539 878	45 398	1 586 206	44 315
IMPORTS (1)							
2505.10	Silica sands and quartz sands						
	United States	289 789	46 759	590 859	44 865	818 967	44 430
	Australia	446	376	608	509	1 095	964
	Germany	726	516	1 102	714	2 194	736
	Sweden	647	329	348	215	523	285
	Netherlands	392	174	223	127	307	154
	Belgium	262	71	2 472	123	6 561	153
	Others	2 428	1 347	995	309	1 010	348
	Total	294 690	49 572	596 607	46 862	830 657	47 070
2506.10	Quartz (other than natural sands)						
	United States	16 512	755	8 535	437	6 727	364
	Brazil	4 514	251	2 306	134	2 094	99
	Spain	–	–	4	–	1 285	50
	Others	2 531	146	2 493	134	629	40
	Total	23 557	1 152	13 338	705	10 735	553
2506.21	Quartzite, crude or roughly trimmed						
	United States	1 302	253	1 781	354	1 633	281
	Brazil	20	4	44	7	82	19
	Others	11	. . .	32	5	245	12
	Total	1 333	257	1 857	366	1 960	312
2506.29	Quartzite n.e.s.						
	United States	1 323	84	1 086	91	2 363	174
	Japan	1 648	112	1 266	106	759	44
	Brazil	922	55	741	48	948	43
	United Kingdom	55	4	26	2	422	28
	Others	438	16	338	25	719	46
	Total	4 386	271	3 457	272	5 211	335
2811.22	Silicon dioxide						
	United States	21 409	40 824	22 202	47 640	23 368	44 607
	Germany	1 621	7 514	1 080	6 466	1 357	7 608
	China	678	2 065	1 115	2 580	1 141	2 634
	United Kingdom	88	331	50	197	197	1 525
	Japan	318	1 103	182	985	271	1 183
	Switzerland	59	481	107	736	87	774
	Norway	235	111	728	283	82	116
	Others	2 796	4 455	1 103	1 792	131	363
	Total	27 204	56 884	26 567	60 679	26 634	58 810
	Total imports	351 170	108 136	641 826	108 884	875 197	107 080

TABLE 1 (cont'd)

Item No.		2001		2002		2003	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS							
2505.10	Silica sands and quartz sands						
	United States	350 095	5 620	239 113	7 528	311 845	6 850
	Australia	–	–	200	41	1 883	737
	Norway	19 006	666	18 562	707	9 631	381
	Korea, South	–	–	–	–	1 626	107
	Others	26 487	261	6 277	93	2 412	330
	Total	395 588	6 547	264 152	8 369	327 397	8 405
2506.10	Quartz (other than natural sands)						
	United States	4 974	1 881	4 889	1 201	21 493	875
	Bulgaria	2 142	136	153	55	720	111
	New Zealand	–	–	–	–	740	48
	Others	241	28	270	34	106	7
	Total	7 357	2 045	5 312	1 290	23 059	1 041
2506.21	Quartzite, crude or roughly trimmed						
	United States	845	323	1 131	390	1 606	578
	Norway	11 294	565	–	–	–	–
	Total	12 139	888	1 131	390	1 606	578
2506.29	Quartzite n.e.s.						
	Cuba	93	9	135	13	343	34
	United States	–	–	75	27	97	20
	Total	93	9	210	40	440	54
2811.22	Silicon dioxide						
	United States	159	714	274	1 081	289	1 514
	Taiwan	–	–	–	–	145	89
	Swaziland	–	–	–	–	441	83
	Switzerland	–	–	25	2	500	79
	Others	289	485	2 201	235	808	123
	Total	448	1 199	2 500	1 318	2 183	1 888
	Total exports	415 625	10 688	273 305	11 407	354 685	11 966

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; x Confidential.
(1) Includes sand for use in foundries and glass manufacturing, ground and flour sand, and volatized and silica flue dust.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, IMPORTS OF SILICA SAND FROM OTHER COUNTRIES, BY PROVINCE AND BY USE, 2001-03

	2001		2002		2003 (p)	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
FOUNDRY						
Nova Scotia	–	–	–	–	91	1
New Brunswick	461	20	989	21	2 509	37
Quebec	20 671	875	34 421	992	39 709	808
Ontario	95 332	8 654	353 168	9 937	596 193	9 141
Manitoba	22 200	882	45 931	1 196	53 026	809
Saskatchewan	116	30	3 638	93	2 035	49
Alberta	26 316	1 303	30 517	792	8 869	143
British Columbia	4 381	320	18 530	481	2 306	37
Total	169 477	12 085	487 194	13 513	704 738	11 026
GLASS MANUFACTURING						
Nova Scotia	114	72	164	98	233	92
New Brunswick	12	2	–	–	–	–
Quebec	213	73	106	58	1 616	573
Ontario	38 460	1 950	23 416	2 050	32 593	1 223
Manitoba	24	1	132	7	37	23
Alberta	857	47	125	9	13	6
British Columbia	77	45	155	50	35	19
Total	39 757	2 191	24 098	2 272	34 527	1 935

Source: Statistics Canada.
– Nil; (p) Preliminary.
Note: Numbers may not add to totals due to rounding.

TABLE 3. REPORTED USE (1) OF SILICA IN CANADA, BY INDUSTRY, 2000-2002

	2000	2001	2002 (p)
		(tonnes)	
Nonferrous smelting and refining	889 034	989 863	953 064
Primary glass and glass containers, and glass fibre wool	555 319	515 207	517 495
Foundries	312 400	290 806	258 768
Chemicals	98 649	75 800	82 185
Other products (2)	1 015 066	(r) 713 993	790 902
Total	2 870 468	(r) 2 585 669	2 602 414

Source: Natural Resources Canada.
(p) Preliminary; (r) Revised.
(1) Available data, as reported by users. (2) Includes abrasives, asbestos products, asphalt roofing products, cement (construction), ceramic products, structural clay products, cleansers, fertilizers, paint and varnish, pulp and paper products, refractory brick, rubber products, ferroalloys, primary steel and other miscellaneous products.

TABLE 4. SILICA, REPORTED QUANTITY USED (1) IN CANADA, 2000-2002

	2000	2001	2002 (p)
		(tonnes)	
Sand	1 733 853	(r) 1 636 017	1 711 313
Lump	1 028 753	838 544	836 590
Flour	107 862	(r) 111 108	54 511
Total	2 870 468	(r) 2 585 669	2 602 414

Source: Natural Resources Canada.
(p) Preliminary; (r) Revised.
(1) Available data, as reported by users.