New Brunswick / Nouveau Brunswick

Natural Resources
Lands, Minerals and Petroleum Division

Silica

Mineral Commodity Profile No. 2

Silicon (Si) is the second most common element on Earth after oxygen. Si does not occur naturally in its pure state but instead is found chiefly in mineral form as either silica (SiO_2) or silicates. Silica and/or silicate minerals are a constituent of nearly every rock type in Earth's crust.

The most familiar silica mineral is quartz. In commodity terms, silica also refers to geological deposits enriched in quartz and/or other silica minerals. Silica resources include 1) poorly consolidated quartzose sand and gravel, 2) quartz sand/pebbles in consolidated rock (e.g. quartzose sandstone), 3) quartzite , and 4) quartz veins.

Uses

Silica is hard, chemically inert, has a high melting point, and functions as a semiconductor—characteristics that give it many industrial applications. Silica deposits generally must be processed to remove iron, clay and other impurities. The most valuable resources contain >98% SiO_2 and can be readily crushed into different sizes for the various end products.

Silica is used primarily by the metallurgical, cement/construction, glassmaking, water treatment, ceramics and chemical sectors. It is also the raw material needed to produce ferrosilicon and silicon metal.

Speciality Silicas

Speciality silicas include precipitated silica, fumed silica and silica gel. They represent a growing new market for ultrapure silica (polysilicon). Uses for precipitated silica include the production of footwear and "green" tires. Silica in tires helps to reduce wear, improve traction and decrease rolling resistance.

Solar-Grade Silicon

Polysilicon, refined from silicon metal, is the most important semiconductor material used in making solar cells. Polysilicon shortages are currently a limiting factor in solar energy growth. Research is ongoing to develop more cost-effective ways of manufacturing solar-grade silicon.

Iron and steel manufacturers consume most of the world's ferrosilicon, using it as a deoxidizer, alloying agent, and additive.

Silicon metal is vital to the aluminium and chemical industries. Light alloys for automotive manufacture represent the largest market for silicon metal, followed by silicone production (Kulikova 2007).

High-purity silica is processed into silicon for electronic (e.g. computers), photovoltaic and speciality silica applications. Global sales of speciality silica products alone total about $2000 million per year (Harris 2003).

The rubber industry consumes about half of the world's speciality silicas (Harris 2003). They are also used in making inkjet paper and other high-end paper products.

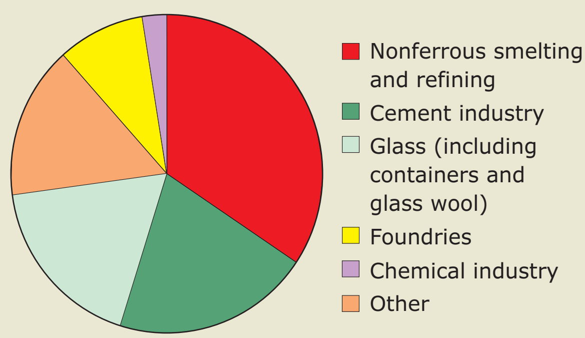
World Production and Reserves

Silica deposits occur, and are mined, in most countries. Global silica output is estimated at roughly 120 Mt to 150 Mt per year (Dumont 2006).

About 5.9 Mt of ferrosilicon were produced worldwide in 2006. The major contributors were China, Russia, United States, Brazil and South Africa (U.S. Geological Survey [USGS] 2006).

Global production of silicon metal reportedly approached 1.2 Mt in 2006, almost half of which came from China (USGS 2006). Other important producers are the United States, Brazil, Norway, France, Russia, South Africa and Australia.

Silica Consumption in Canada
(Total = 2.57 Mt)



2005 preliminary figures (from Dumont 2006)

Raw silica is mined and/or quarried in most Canadian provinces. Quebec and Ontario are the only provinces currently producing ferrosilicon and silicon metal. In 2005 Canada consumed 2.57 Mt of silica, 1.8 Mt of which came from domestic sources; the American market absorbed about 95% of Canadian silica exports (Dumont 2006).

Worldwide demand for silicon is expected to rise dramatically through 2012, driven largely by increased consumption of speciality silicas and other silica-based chemical products such as solar-grade silicon for photovoltaic cells (CRU 2008).

Silicon plays a crucial role in making computer microchips—hence the name "Silicon Valley." Microchips or integrated circuits are etched onto the surface of a thin "wafer" of ultrapure (>99.99%) silicon.

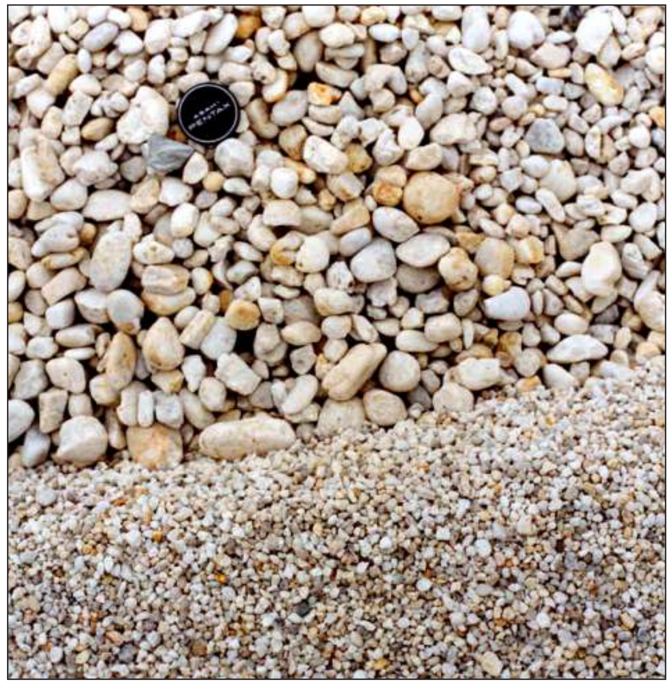
Silica Exploration and Mining in New Brunswick

New Brunswick's quartzose sandstones were quarried for decades as dimension stone, millstone and grindstone material. Quartz veins in the province were (and still are) prospected regularly for gold. However, siliceous rocks in New Brunswick received little attention for their silica potential until the mid-1960s.

In the early 1960s, the planned opening of a base-metal smelter at Belledune in northeastern New Brunswick prompted developers to examine a silica deposit at nearby Bass River (Fig. 1) in anticipation of selling smelter flux.

The Bass River quarry was opened in 1974 and two years later was acquired by Chaleur Silica Inc. The company supplied >90% SiO_2 flux to the Belledune smelter from 1976 until 1986. As well, it regularly shipped other silica products to local consumers.

Silica extraction at Bass River ended in 1992, five years after Chaleur Silica lost its smelter contract. L.E. Shaw Limited of Nova Scotia acquired the property in 1992 but has yet to reactivate the operation (Webb 2006).



Silica products from the Atlantic Silica Inc. plant at Cassidy Lake range from quartz pebbles to fine-grained sand.

In southern New Brunswick, the Burchill Road quartzite deposit southwest of Saint John (Fig. 1) was investigated in the late 1960s as raw material for smelter flux, concrete whitener and sandblast sand.

A New Brunswick Department of Natural Resources (NBDNR) survey of provincial silica resources (Hamilton and Sutherland 1968) encouraged work on the deposit, including sample analyses and beneficiation tests. Legal complications over land tenure emerged in 1971, however, and development ended around 1974.

In the mid-1970s, silica deposits on Nantucket and White Head islands in southwestern New Brunswick (Fig. 1) were considered as a potential source of ferrosilicon feedstock. The deposits underwent some mapping, sampling and drilling, but efforts ceased in 1975. Around the same time, a similar, short-lived exploration program took place on a quartz vein east of Saint John.

The Cassidy Lake deposit near Sussex (Fig. 1) is New Brunswick's most productive and longstanding silica operation. The silica was first noted in the late 1970s when a potash exploration drillhole intersected 150 m of white quartzose material. When the silica unit was drill-tested and analyzed, results indicated a reserve of 16.7 Mt of high-grade (98–99%) SiO_2 in the form of poorly consolidated Cretaceous sand and gravel (Lockhart 1984).

The Cassidy Lake operation started production in 1986 under what became Sussex Silica Inc., and a processing plant was erected on site. Atlantic Silica Inc. acquired the Sussex Silica assets in 1993 and currently manages the quarry and facilities. Nova Scotia-based interests took ownership of Atlantic Silica in early 2003.

Silica resources at Cassidy Lake comprise about 20 Mt of material averaging >99% SiO_2, 0.06% Fe_2O_3, <0.01% CaO and 0.2% Al_2O_3 (Atlantic Silica Inc. 2003). The processing plant sells its silica products across eastern Canada and the northeastern United States.

End uses of the sand- and pebble-sized materials include silicon metal, silicon carbide, glass, recreational sand, decorative stone, filtration sand, foundry sand, refractory sand, smelter flux, cement additive, landscaping material and construction sand.

Sizing Silica

Silica is processed according to three size categories, each with specific industrial applications. Lump silica (3 mm–15 cm) is obtained from vein quartz, quartzite, and quartz pebbles. Silica sand (3 mm–75 μm) is derived from sandstone or unconsolidated sand deposits. Dry grinding of silica sand yields silica flour (<75 μm).

Silica Use in Canada

2005 preliminary figures (from Dumont 2006)

Lump silica	28.9%
Sand	68.6%
Silica flour	2.5%

Cassidy Lake silica operation.

Geology of New Brunswick Silica Deposits

Silica deposits generally consist of quartz particles derived from the weathering of igneous and metamorphic rocks. After being redeposited elsewhere, the granular sand and/or pebbles can either 1) remain as poorly consolidated quartzose sand and gravel, or 2) become compacted into sandstone or quartzite. Less commonly, silica deposits occur as hydrothermal quartz veins.

Silica in New Brunswick occurs in a variety of geological environments (Fig. 1), some of which favour the formation of high-grade deposits. Available data suggest that several areas of silica-enriched rocks in the province merit thorough exploration and testing to determine their industrial silica potential.

New Brunswick's silica deposits are divided into four categories, based on their geological setting.

1. **Cretaceous quartzose sand and gravel**: poorly consolidated sedimentary material, weathered from older siliceous rocks and deposited in ancient lakes and rivers.

2. **Late Carboniferous quartzose sandstone and quartz-pebble conglomerate**: quartz grains and/or pebbles bonded loosely or firmly by a matrix of clay, calcite, iron oxide and/or siliceous material.

3. **Neoproterozoic–Silurian quartzite**: formed when siliceous sandstone is subjected to heat and/or pressure so that the matrix becomes strongly cemented, producing a hard, compact rock.

4. **Quartz veins:** monominerallic quartz veins typically associated with fault zones, fold axes, and/or in felsic intrusive rocks of varied types and ages.

These four categories of silica deposits are expanded upon below, using selected examples. Although most deposits have not been developed, they provide generic geological models for future exploration. See Webb (2006) and NBDNR (2008a, 2008b) for additional details on these and other provincial silica deposits.

1. Cretaceous Deposits

New Brunswick's largest known silica resource is situated near Cassidy Lake south of Sussex (Fig. 1) and supports a major quarry and processing plant. The deposit occurs in poorly consolidated quartzose material of the Cretaceous Vinegar Hill Formation (Fundy Group).

The formation lies immediately south of the Clover Hill Fault, on the down-faulted southern block. The fault separates Carboniferous clastic rocks of the Horton and Mabou groups. The silica-rich material comprises quartzose sand and quartz-pebble to quartz-cobble gravel within a sandy to argillaceous matrix.

The Cassidy Lake deposit is interpreted as a thick remnant of Cretaceous sand and gravel preserved in a narrow, fault-bounded basin. The silica-bearing material is truncated to the east but continues westward along the fault trend, possibly becoming finer grained to the southwest.

Cretaceous sand and gravel deposits resembling those at Cassidy Lake have yet to be located elsewhere in New Brunswick. However, remnant deposits may exist in structurally similar settings—that is, on the down-ice side of down-faulted blocks in horst-and-graben terrain. Other potential deposit sites could include the area immediately south of the Harvey–Hopewell Fault in southeastern New Brunswick.

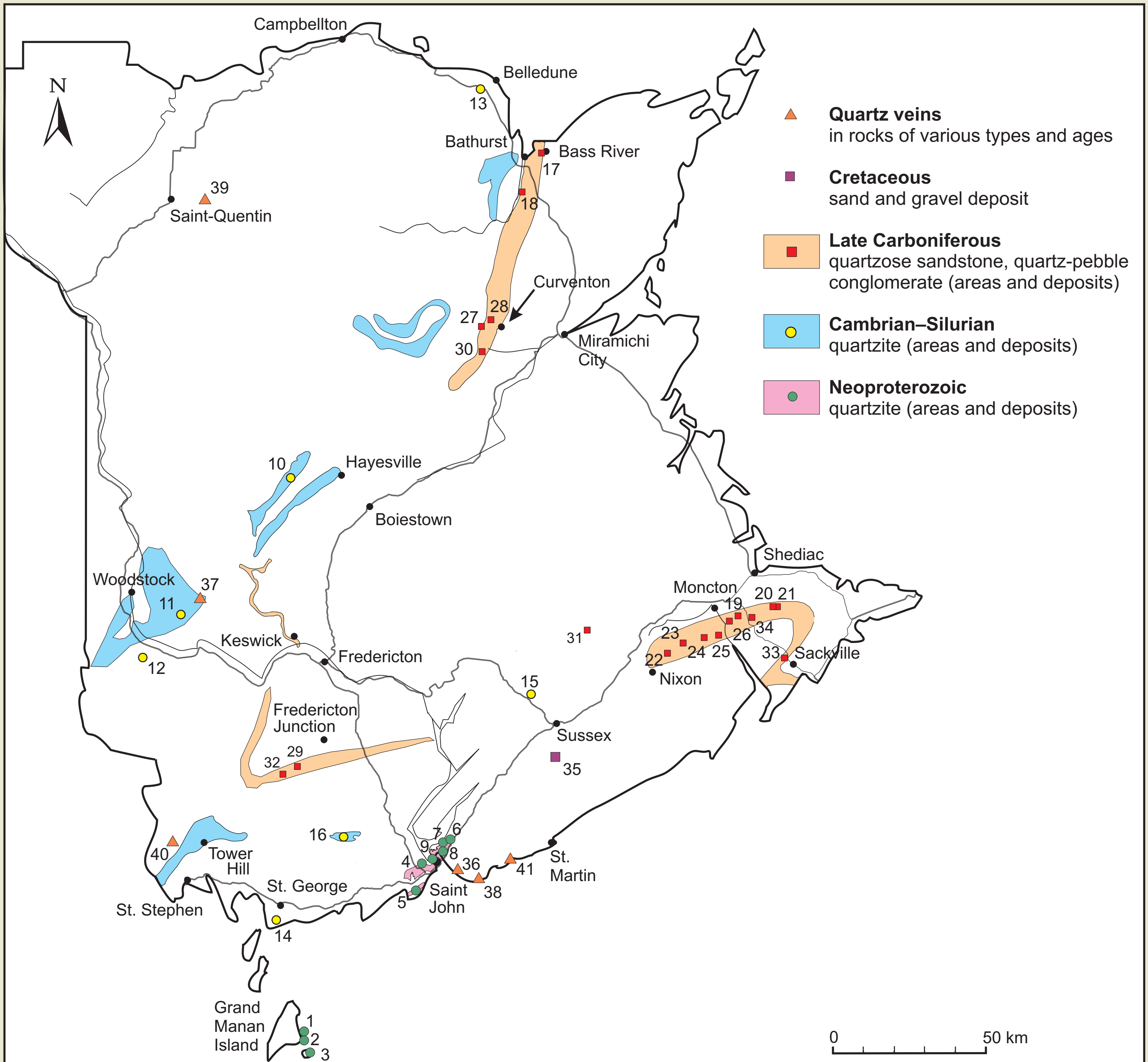

Cretaceous sand and gravel deposit at Cassidy Lake.

2. Late Carboniferous Deposits

Noteworthy silica resources occur locally in Late Carboniferous sedimentary rocks of the Maritimes Basin in New Brunswick, particularly along the margins of regional sedimentary basins. They consist of quartzose sandstone and quartz-pebble conglomerate, and typically contain >90% SiO_2.

Sandstone in these deposits is generally clean, white to pale grey, well sorted, well rounded, and crossbedded. The rocks are interpreted as terrestrial (fluvial channels) sequences composed of sand that underwent prolonged washing and winnowing by wave action during the Carboniferous, giving rise to a mature quartz sand with only minor clay in the matrix.

Late Carboniferous silica occurrences with varied potential as industrial material are found in the 1) Boss Point Formation of the Cumberland Group, 2) Clifton Formation of the Pictou Group, and 3) Minto Formation, also of the Pictou Group. Representative examples of each formation type are described here.



Neoproterozoic
1 Nantucket Island
2 Ross Island
3 White Head Island
4 Delaney Lake
5 Burchill Road
6 Drury Cove
7 Hunters Cove
8 Frying Pan Lake
9 Green Head Peninsula

Cambrian–Silurian
10 Burnt Hill
11 Central Waterville
12 Dorrington Hill
13 Turgeon
14 Letang
15 Snider Mountain
16 Mosquito Lake

Late Carboniferous
17 Bass River
18 Nepisiguit River
19 Saint-Anselme
20 Memramcook River (w)
21 Memramcook River (e)
22 Nixon
23 Turtle Creek
24 Baltimore Station
25 Lower Coverdale
26 Fox Creek
27 Big Sevogle River
28 Curventon
29 Black Brook (s)
30 Sunny Corner (n)
31 Salem
32 Shin Creek
33 Cherry Burton
34 Meadow Brook

Cretaceous
35 Cassidy Lake

Quartz Veins
36 Black River
37 Nortondale
38 Cape Spencer
39 Manzer Giberson–Black Brook (n)
40 Blakeney Mine
41 West Beach

Figure 1. Types and locations of selected New Brunswick silica deposits (see also NBDNR 2008a, 2008b). Numbered symbols represent silica deposits. Coloured areas show geological districts containing silica-enriched rocks.

Boss Point Formation

Quartzose sandstone of the Boss Point Formation occurs in a 65 km long, arcuate band that reaches from Nixon eastward to the Sackville area (Fig. 1). Exposures of the rock in this area are sparse but are consistent enough along strike to suggest continuity.

The silica-enriched strata represent the uppermost part of the Boss Point Formation, known as the Cole Point Member. They consist of grey, medium- to coarse-grained, quartzose sandstone; pebbly sandstone and quartz-pebble conglomerate; and minor intercalations of siltstone and shale up to tens of metres thick.

Boss Point sandstone is generally clean and well sorted and contains <10% argillaceous material as matrix, characteristics that are typical of slowly deposited, well washed sedimentary particles. Although highly siliceous, this unit has been only cursorily investigated as a silica source.


Sandstone of the Boss Point Formation.

Analyses of siliceous rocks of the Boss Point Formation in this area of southeastern New Brunswick gave values of 96.17% to 98.57% SiO_2, 0.21% to 1.66% Fe_2O_3, and 0.63% to 2.85% Al_2O_3 (Webb 1976).

The high iron content would limit the use of pit-run material for high-purity end uses such as glassmaking. However, beneficiation tests on two bulk samples yielded a qualitative improvement, including a 1% increase in SiO_2 and a 0.33% reduction in Fe_2O_3 (Webb 2006). Additional improvements through flotation or other methods would be needed to further reduce iron content and to satisfy colour requirements of flint glass.

Clifton Formation

Siliceous deposits of the Clifton Formation occur at several locations in northeastern New Brunswick, including the Big Sevogle River–Curventon area west of Miramichi City and Bass River just east of Bathurst (Fig. 1).


Sandstone of the Clifton Formation.

Grey to white quartz sandstone and quartz-pebble to quartz-cobble conglomerate of the Clifton Formation (Member A) are exposed in sections 3 m to 5 m thick along the banks of the **Big Sevogle River**. Similar strata have been confirmed in the subsurface north and south of outcrops by the river.

Analyses of samples from outcrops and test holes at the confluence of the Big Sevogle and Northwest Miramichi rivers yielded values of 94.83% to 98.01% SiO_2 and 0.06% to 0.54% Fe_2O_3 (Ball et al. 1981; Webb 2006). The material could be used in metallurgical silica, silica brick and amber glass. However, it would require substantial upgrading for most glassmaking purposes.

At **Bass River**, a light grey, medium- to coarse-grained, massive to flaggy sandstone is typically associated with pebbly sandstone and quartz-pebble conglomerate. The


Conglomerate of the Clifton Formation.

sandstone consists almost entirely of clear to milky, poorly cemented quartz grains. One report suggested a speculative reserve estimate of 0.3 Mt averaging 98% SiO_2 (Hamilton and Sutherland 1968).

Kingston (1976) gave the following values for a composite sample representing a 3.3 m [11 foot] section: 98.51% SiO_2, 1.55% Al_2O_3, 0.28% Fe_2O_3, 0.08% CaO, 0.02% Na_2O, 0.07% K_2O, 0.10% TiO_2, and 0.01% MnO.

From 1974 until 1992, the Bass River deposit supplied flux-grade silica sand (minimum 90% SiO_2) to the nearby Belledune smelter, and several other silica products to regional markets.

Minto Formation

Rocks of the Minto Formation lie west and northwest of Fredericton, starting near Keswick; they also form an arcuate band in the area of Fredericton Junction (Fig. 1).

In the latter district, several occurrences of very clean, white to buff, coarse-grained to granular sandstone are situated along Shin Creek (Fig. 1). They contain about 90% to 95% quartzose material and 5% to 10% feldspar that is partially altered to kaolin.

3. Neoproterozoic Quartzite Deposits

Neoproterozoic quartzites in New Brunswick represent metamorphosed fine- to coarse-grained quartzose sandstones. The sandstones were deposited in a shallow-marine environment, and the quartzite generally is associated with siliceous dolomite and limestone.

Silica deposits of this type appear most commonly in the southwestern part of the province, where they form stratified zones of massive quartzite that are spatially distributed and preserved in fault blocks. Quartzite in the region typically was intruded by younger felsic plutonic rocks such as granite. In such cases, the quartzite underwent silica enrichment and recrystallization, the latter of which caused a textural coarsening.

High-grade (98% SiO_2) quartzite occurs on Nantucket Island and White Head Island, which lie just off Grand Manan Island in southwestern New Brunswick (Fig. 1). The deposits are associated with the Late Neoproterozoic Thoroughfare Formation (Grand Manan Group) and are estimated to contain several million tonnes of silica.

Coastal waters surrounding Nantucket and White Head islands support major fisheries and ecotourism activities and represent significant marine habitat. Development of the silica would conflict with the region's economic, social and environmental fabric. However, geological and geochemical data available for these deposits may help to locate and evaluate similar silica resources elsewhere in the region.

Quartzite deposit on White Head Island.

Generic examples of Neoproterozoic quartzite deposits can be observed along Burchill Road southwest of Saint John, and on Nantucket and White Head islands in the Bay of Fundy (Fig. 1).

Burchill Road Deposit

The Burchill Road quartzite deposit is situated 17 km southwest of Saint John (Fig. 1). It is associated with interbedded argillite, quartzite and carbonate sedimentary rocks of the Early Neoproterozoic Ashburn Formation (Green Head Group).

The quartzite is a pinkish grey, fine- to medium-grained, generally massive rock. It consists mainly of quartz with minor feldspar, chlorite, sericite and opaque minerals. At one location, the siliceous unit is exposed over a width of 600 m and is traceable along strike for about 1 km.

The Burchill Road deposit underwent sporadic investigation and testing between 1966 and 1974. Unconfirmed reserve estimates ranged from a few million tonnes to several tens of million tonnes (Hamilton 1968; Smith 1971). Analyses of the quartzite unit indicated SiO_2 values of 79.27% to 95.00%. Thirteen samples were tested for iron and aluminum; they showed values of 0.63% to 2.47% Fe_2O_3 and 1.67% to 4.27% Al_2O_3. (See Webb 2006 for full analytical references.) These percentages exceed the limits for most glass, ceramic, and refractory applications.

Samples subjected to beneficiation yielded values that were 3% to 7% higher for SiO_2, 0.4% to 1.0% lower for Fe_2O_3, and 1.0% to 2.0% lower for Al_2O_3 (Hamilton 1968). In addition, a composite sample of randomly collected quartzite chips showed a 66% reduction in Fe_2O_3 content after treatment with hydrochloric acid. With appropriate processing, the quartzite could be marketed as a low-grade silica product.

The Burchill Road deposit lies on expropriated ground in an area reserved from staking. Nonetheless, qualitative properties of the resource may typify those of similar Early Neoproterozoic quartzites elsewhere in New Brunswick. Some of these deposits may well warrant further investigation.

Quartzite deposits of **Cambrian–Silurian** age also occur in New Brunswick (Fig. 1). They are found in several geological formations, typically interbedded with rocks such as siltstone, conglomerate and slate. The quartzite occurrences have been geologically mapped, but their silica potential has not yet been evaluated. See Webb (2006) for more information.

4. Quartz Vein Deposits

Quartz veins are ubiquitous in rocks across New Brunswick, especially in deformed pre-Carboniferous formations. Most veins are only a few centimetres thick. However, quartz veins of sizeable dimensions have been mapped at West Beach in southern New Brunswick and near Saint-Quentin in northwestern New Brunswick. Both vein occurrences have been investigated as potential silica sources, but the most substantial exploratory work was conducted at West Beach.

West Beach

The West Beach quartz vein is exposed on the Bay of Fundy coast about 25 km east of Saint John (Fig. 1). It was emplaced along a thrust fault within sheared sedimentary and felsic volcanic rocks of the Middle Neoproterozoic Broad River Group. The vein can be traced for 425 m along shore. It is milky white, highly fractured, and shows varied degrees of iron oxide staining between crystals and along the fracture plane near the contact with country rock.

The West Beach silica deposit underwent several investigations, analyses and a diamond drill program during the 1970s. Drilling results indicated that the vein had a true thickness of 4.6 m and contained some high-quality material. However, its reserves were limited and too inconsistent in quality to merit consideration as a reliable source of glass-grade silica (Boyle 1977).


Quartzite at the Burchill Road deposit

Summary

New Brunswick's silica deposits can be divided into four geological types: 1) unconsolidated Cretaceous sand and gravel, 2) Late Carboniferous quartzose sandstone and quartz-pebble conglomerate, 3) Neoproterozoic–Silurian quartzite, and 4) quartz veins.

The province's only known Cretaceous sand and gravel occurrence lies near Cassidy Lake. The high-grade (>99% SiO_2) deposit supports a major operation that has sold silica products to clients across eastern North America since 1986. Neoproterozoic quartzite in southwestern New Brunswick also feature some high-silica (95–99%) rock with few or no impurities. Individual deposits can be extensive, some exceeding 0.5 Mt.

Noteworthy silica-enriched units occur locally in Late Carboniferous strata along the margins of regional sedimentary basins. These units can contain fairly high-grade (>90% SiO_2) material but include undesirable levels of impurities. New


Quartz vein at West Beach.

Brunswick's known quartz vein deposits hold only marginal interest as a silica resource.

Given the foregoing, it appears that Neoproterozoic quartzite and, especially, Cretaceous sand and gravel deposits offer the most promise as potential sources of industrial silica in New Brunswick.

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For More Information

For more information on silica and other New Brunswick mineral commodities, please see the NBDNR Mineral Occurrence Database (NBDNR 2008a) and its Industrial Mineral Database (NBDNR 2008b), or contact:

mpdgs_ermpegweb@gnb.ca

Serge Allard
Geologist
Serge.Allard@gnb.ca
Telephone: 506.462.5082

Geological Surveys Branch
Lands, Minerals and Petroleum Division
New Brunswick Department of Natural Resources
PO Box 6000, Fredericton, NB E3B 5H1

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