CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

THE CANADIAN SILICA INDUSTRY

by

R.K.COLLINGS

INDUSTRIAL MINERALS DIVISION

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INTRODUCTION

Interest in the search for and development of Canadian silica deposits has shown a marked increase in the last few years. This report is designed to acquaint present and prospective producers with the silica situation in Canada today. It briefly covers the various forms, specifications and uses of silica; silica deposits; mining and processing methods; as well as the various economic factors that govern the success of a particular silica operation.

Canada annually imports large quantities of silica sand for use in the manufacture of glass and silicon carbide, and for other industries requiring high-quality silica. Recent investigation has shown that there are a number of favourably situated silica deposits which might be used for the production of good-quality silica sand. This report is presented with the hope that it will stimulate and encourage the utilization of Canadian silica deposits for domestic consumption.

FORMS OF SILICA

Silica is the common name for silicon dioxide. This compound is represented by the formula SiO_2 and is composed of 46.7 per cent silicon and 53.3 per cent oxygen.

Silica occurs in the free state chiefly as quartz, but hydrous silica (amorphous silica carrying a variable amount of combined water) occurs as opal, flint, diatomaceous earth, tripoli, etc. The mineral quartz occurs in many forms, the more common of which are vein quartz, silica sand and gravel, sandstone, and quartzite. It also occurs as crystals and as masses or aggregates in igneous rocks such as granites and pegmatites.

The various forms of high-quality silica used for industrial purposes include:

1. crystalline quartz,
2. silica sand,
3. sandstone,
4. quartzite,
5. others, including chalcedony, flint, chert, tripoli and diatomaceous earth.

Crystalline Quartz

Crystalline quartz is of igneous origin. It occurs in a relatively pure state as crystals, veins, or large intrusive masses. Crystalline quartz is usually white and opaque; however, impurities may cause it to be brown, grey, blue, etc. Some varieties of crystalline quartz are transparent.

Silica Sand

Silica sand is the term applied to a sand that has a high silica content. Silica sand deposits are derived from the detritus formed by the mechanical disintegration and chemical decomposition of silicious rocks. These deposits are formed as the residual particles of rock are transported to new locations. The quartz particles, being very hard and resistant to abrasion, tend to accumulate and, as a result of selective sortation by water or wind, form deposits of high-purity silica sand. Sand grains may be rounded to angular in shape, depending upon the amount of erosional action to which whey have been subjected. Manufactured sand, formed by the mechanical reduction of quartz, quartzite, or sandstone to grain size, will generally have sharp, angular grains if formed from quartz or quartzite, and rounded to sub-angular grains if formed from sandstone.

Sandstone

Sandstone is a sedimentary rock composed of grains of quartz held together by a cementing material. The cementing material may be silica, dolomite, calcite, clay, iron oxide or other mineral. Many sandstones are quite friable and may easily be reduced to grain size. This is usually the case when the cementing material is clay, calcite, or other fairly soft mineral. However, sandstones bonded with a silicious bond are usually very hard. Sandstones generally contain varying amounts of impurities such as feldspar, hornblende, magnetite, mica, etc. Most sandstones are white, grey or brown, but other colours are frequently encountered.

Quartzite

Quartzite is a metamorphosed sedimentary rock usually derived from sandstone. It is a hard, compact rock, composed of grains of quartz united by a silicious cement. The original grains are not always apparent in many quartzites as they are united with the cementing material to form a continuous, homogeneous substance. Quartzite in which the grain shape is in evidence may be distinguished from a sandstone by noting the fracture; it passes through the grains in a quartzite and around them in a sandstone.

Other Forms

Chalcedony is a waxy, translucent, crypto-crystalline (very finely crystallized) variety of quartz. It is formed by deposition from aqueous solutions and is frequently found lining or filling cavities in rocks.

Flint is also a crypto-crystalline variety of quartz. It is somewhat like chalcedony in appearance but is dull, often dark in colour. Flint occurs as nodules in chalk and breaks with a conchoidal fracture.

Chert is a compact, massive, silicious rock. It is similar to flint but is usually lighter in colour and duller in appearance.

Tripoli is finely divided, porous silica. Tripoli is formed by the weathering of silicious limestone.

Diatomaceous earth is a silicious material composed of the shells of minute aquatic organisms known as diatoms. It is white to grey-white in colour. Diatomaceous earth is quite porous and contains varying proportions of combined water.

SPECIFICATIONS AND USES OF SILICA

Lump Silica

Silica Flux

Quartz, quartzite, and in some cases, sandstone and sand are used as fluxes in smelting base-metal ores low in silica. The composition and amount of silica used is dependent upon the composition of the ore being fluxed; however, the silica content should be as high as possible. Small amounts of impurities such as iron and alumina are not objectionable. Silica used for flux is generally all - 1, + 5/16 inches in size.

Silicon Alloys

Lump quartz, quartzite and well-cemented sandstone are used in the manufacture of silicon, ferrosilicon, and other alloys of silicon. The silica content should be 98 per cent while the iron and alumina contents should each be less than 1 per cent, and the total iron and alumina less than 1 1/2 per cent. Lime and magnesia should each be less than 0.20 per cent. Phosphorous and arsenic are objectionable as they cause deterioration and disintegration of the manufactured product. The silica used is generally - 6, + 1 inch in size. Ferrosilicon is produced in large, pot-type electric furnaces from silica, iron, wood chips and coke. Silicon and ferrosilicon alloys are used in the manufacture of steel, iron and certain non-ferrous metals.

Silica Brick

Quartz and quartzite, crushed to pass an 8-mesh screen, are used in the manufacture of silica brick for use in the construction of high-temperature refractory furnace linings. The silica grains are bonded with 1 to 2 per cent lime, moulded into the desired shape, dried and fired in a kiln. The silica content of the quartz used should be 97 per cent. The iron and alumina contents should each be less than 1 per cent and other impurities such as lime and magnesia should be low.

Other Uses

Lump quartz and quartzite, shaped to proper size are used as linings in ball and tube mills, and as a lining and packing for acid towers. Naturally occurring flint pebbles are used as a grinding media for the reduction of various non-metallic ores.

Silica Sand

Glass Manufacture

Naturally occurring sand and sand produced by crushing quartz, quartzite, or sandstone are used in the manufacture of glass and fused silica-ware. The silica content should be over 99 per cent and the iron content should be uniform and less than 0.04 per cent; other impurities such as alumina, lime and magnesia should be low. Uniformity of grain size is very important; glass sand should be between 20 and 100 mesh in size with a minimum of coarse or fines. Ordinary soda-lime glass, such as bottle, common tableware, and plate and window glass, contains from 65 to 75 per cent silica. Glass is made by fusing a batch composed of silica sand, soda ash, dolomite, nepheline syenite, and small percentages of other minerals in special furnaces.

Silicon Carbide

Silicon carbide is produced in an electric resistance furnace from a mixture of silica sand, coke, sawdust and salt. It is used as an abrasive and as a refractory material. Sand used for silicon carbide manufacture should have a silica content of 99 per cent. The iron and alumina contents should each be under 0.10 per cent. Lime, magnesia and phosphorus are objectionable. A coarse-grained sand is preferred for silicon carbide manufacture; however, finer sands are sometimes used. All sand should be +100 mesh and the bulk of the sand should be +35 mesh in size.

Hydraulic Fracturing

Silica sand is used in the hydraulic fracturing of oil-bearing formations. This consists of pumping a viscous fluid containing suspended sand into the oil-bearing strata under pressure sufficient to cause fracturing and parting of the formation. When the pressure is released the sand remains as a propping

agent to hold the fracture open and thus provides a permeable passage for the flow of oil. The amount of sand used varies greatly but is generally from 5,000 to 15,000 pounds per treatment. Sand used in the hydraulic fracturing of oil-bearing formations must be clean and dry and have a high compressive strength. It should have a high silica content and must be free of all acid-consuming constituents. The grain size of the sand must be closely controlled; all sand should be between 20 and 35 mesh. The grains should be well rounded to facilitate placement and to provide maximum permeability.

Foundry Use

Naturally occuring sand and sand produced by the reduction of sandstone to grain size are used extensively in the foundry industry for moulding purposes. Silica sands for foundry use vary greatly in screen size and chemical composition. The purity and size of the sand used depends upon the type of casting to be produced and the foundry practice followed. Grain size is usually between 20 and 200 mesh in closely sized ranges. A sand with a rounded grain is preferred for the foundry industry.

Sodium Silicate and other Chemicals

Sand used in the manufacture of sodium silicate and other chemicals should be very pure. For sodium silicate the silica content should be 99 per cent. The alumina content should be less than 1 per cent, the combined lime and magnesia less than 0.5 per cent, and the iron less than 0.1 per cent. All sand should be between 20 and 100 mesh.

Other Uses

Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as an abrasive grit for sand-blasting purposes and for the manufacture of sandpapers.

Various grades of closely sized sand are used in water-filtration plants as a filtering medium.

Silica sand is used by the cement industry as an ingredient in the manufacture of portland cement.

Silica Flour

Silica flour, formed by grinding quartz, quartzite, sandstone, and sand to a very fine powder is used in the ceramic industry for enamel frits and pottery flint. It is also used as an inert filler in rubber and asbestos-cement products, as an extender for paint, and as an abrasive ingredient in soaps and scouring powders.

Quartz Crystals

Quartz crystals, possessing the necessary piezo-electric properties, are used in radio-frequency control apparatus, radar, and other electronic devices. Crystals used for this purpose must be water clear, perfectly transparent, and free from all visible impurities or flaws. The individual crystals should weight 100 grams or more and should measure at least 2 inches in length by an inch or more in diameter.

THE CANADIAN SILICA PICTURE

The greater part of the silica being produced in Canada is in the form of lump quartz and low-grade silica for use as flux by the metallurgical industries. Smaller quantities of higher quality lump silica and silica sand are produced for use in the manufacture of silicon and ferrosilicon alloys, silicon carbide, cement, asbestos-cement products, silica brick, bottle glass, and for use as foundry and sand-blast sand. Part of the Canadian output of lump silica is exported to the United States where it is used in the manufacture of silicon and ferrosilicon alloys.

The silica requirements of the glass, chemical, and other industries using high-purity silica are supplied, for the most part, by imports from the United States, Belgium, and other countries. However, a limited amount of good-quality silica sand is being manufactured from a Canadian deposit of quartzite by a Montreal firm, and a number of other firms are actively investigating the possibility of producing high-quality silica sand from Canadian deposits of sandstone.

Canadian Production and Trade of Silica, 1955[1]

	Short Tons	Dollar Value
Production		
Quartz and silica sand[2]	1,869,913	2,039,575
	Thousands of brick	
Silica brick	4,763	602,625
	Short Tons	
Imports, silica sand		
From: United States	711,432	2,113,042
Belgium	23,828	32,453
United Kingdom	198	593
Other countries	--	--
Total	735,458	2,146,088
Exports, quartzite		
To: United States	87,622	265,374

(1) Dominion Bureau of Statistics, Ottawa. (2) Includes crude and crushed quartz, crushed sandstone and quartzite, and natural silica sands.

Canadian Production and Trade of Silica, 1945 - 1955[1]

Year	Production	Exports	Imports				
	All Types Short Tons	Quartzite Short Tons	Ground Flint[2] Short Tons	Ganister[3] Short Tons	Silica Sand Short Tons	Silex or Crystallized Quartz Short Tons	Fire Brick Dollar Value
1945	1,513,628	121,435	712	426	410,427	7,251	741,394
1946	1,413,378	200,316	823	518	390,014	10,690	579,075
1947	1,836,428	223,240	335	400	533,456	15,004	988,029
1948	2,017,262	228,100	739	230	584,019	17,473	1,211,511
1949	1,722,476	144,302	602	176	511,116	22,966	914,481
1950	1,730,695	195,430	939	128	573,362	24,757	1,012,041
1951	1,904,885	281,379	1,231	144	692,937	30,398	2,054,816
1952	1,783,081	193,955	481	261	642,880	26,174	2,098,036
1953	1,785,574	200,169	1,106	286	703,221	30,534	1,863,068
1954	1,716,151	162,374	1,219	540	655,863	28,412	849,110
1955	1,869,913	87,622			735,458		

(1) Dominion Bureau of Statistics, Ottawa.
(2) Finely ground silica for use by the ceramic industry.
(3) A highly silicious rock used for refractory furnace linings.

There has been little change in the annual production and export of silica by Canada during the last 10 years; however, imports of high-quality silica have shown a steady upward trend, a direct result of increased production of glass, silicon carbide and other products made with high-purity silica. Imports of high-quality silica sand will probably continue at a very high level for some time; however, the development of a number of Canadian silica deposits now under investigation will eventually have a decided effect on the amount of silica imported.

CANADIAN SILICA DEPOSITS

Deposits of sand, sandstone, quartz and quartzite occur in all ten provinces of Canada. However, many of these deposits are too impure or too far from existing markets to warrant present development. The principal silica deposits are described below under the three headings, namely, operating deposits, deposits under investigation, and miscellaneous silica deposits. A table listing the principal silica deposits by provinces is also included. This table contains a brief description of each occurrence together with typical sample analyses.

Operating Deposits

Ontario

Killarney, Georgian Bay

Lorrain quartzite is quarried from a deposit near Killarney, on the northern shore of Georgian Bay, by Electro Metallurgical Company, a division of Union Carbide Canada Limited. Lump silica from this deposit is shipped by boat to Welland, Ontario, Niagara Falls, New York, and Ashtabula, Ohio, where it is used in the manufacture of ferrosilicon. The quartzite at Killarney is fine-grained and very hard.

Sheguiandah, Manitoulin Island

The Lorrain quartzite deposits at Sheguiandah are similar to those at Killarney. Quartzite from this area is quarried by Canadian Silica Corporation Limited for use in the manufacture of silicon and ferrosilicon alloys and for silica flour. Lump quartzite from the quarry at Sheguiandah is shipped to Beauharnois, Quebec, and to markets in the United States for use in silicon carbide manufacture. A small percentage of the production from Sheguiandah is shipped to Whitby, Ontario, where it is ground to silica flour at Canadian Silica's plant.

Bellevue

Algoma Steel Corporation quarries quartzite from a deposit at Bellevue, 20 miles north of Sault Ste. Marie, Ontario. Silica from this deposit is crushed, sized, and used in the manufacture of silica brick for furnace linings.

Quebec

St. Donat de Montcalm

This silica deposit, 90 miles north of Montreal, consists of a massive deposit of friable, coarse-grained quartzite. The chief impurity is a kaolinite that occurs as small pits and pockets scattered throughout the deposit. This property is operated by Dominion Silica Corporation Limited of Lachine, Quebec. Quartzite from St. Donat is trucked to Ste. Agathe, Quebec, where it is stockpiled and shipped, as needed, to Dominion Silica's modern mill at Lachine. At Lachine the quartzite is reduced to sand, sized, and sold for a variety of industrial purposes, including the manufacture of glass and silicon carbide. Silica flour for use in asbestos-cement products is also produced at Lachine.

Melocheville

Electro Metallurgical Company quarries quartzite at a deposit at Melocheville, near Beauharnois, Quebec. This deposit is a very hard, fairly pure Potsdam sandstone. Rock from this quarry is broken, sized, and trucked

to Beauharnois where it is used in making ferrosilicon at a company plant. Fine sand resulting from the breakdown of the sand grains during milling operations is used in cement manufacture and by foundries for moulding purposes.

St. Canut

The Potsdam sandstone deposit at St. Canut, west of St. Jerome, Quebec, is owned and operated by Canadian Silica Corporation Limited of Toronto. Sandstone from this deposit is reduced to flour at St. Canut and sold for use in the manufacture of cement and asbestos-cement products. Company plans call for the production of sized silica sand for silicon carbide manufacture and other industrial uses.

Ste. Clothilde de Chateauguay

Silica is quarried from a flat-lying bed of Potsdam sandstone at Ste. Clothilde, 30 miles south of Montreal, by Radius Exploration Limited of Montreal. Sandstone from this deposit is crushed, sized, and sold for a variety of uses including the manufacture of light-weight cement. The sandstone at Ste. Clothilde is white in colour and of good quality.

Manitoba

Black Island, Lake Winnipeg

Winnipeg - Selkirk Sand Company, Limited, obtains sand from a silica deposit located on the north shore of Black Island. This company, incorporated in July 1955, employs dredging methods for the recovery of sand from the Black Island deposit. The sand is loaded into barges which are towed to Selkirk where the sand is stockpiled for further processing. A sand-washing plant, being erected at Selkirk, will supply a washed, sized product to sand consumers in southern Manitoba, Saskatchewan , and Alberta.

Nova Scotia

Chegoggin Point, Yarmouth County

Dominion Steel and Coal Corporation, Limited, obtains quartzite from a deposit at Chegoggin Point, near Yarmouth. Rock from this deposit is shipped by rail to Sydney, where it is used in the manufacture of silica brick.

Other Operating Deposits

Silica for metallurgical flux is obtained near Noranda, Buckingham, and Howick, Quebec; Sudbury, Ontario; Flin Flon, Manitoba; and Trail, British Columbia.

Numerous deposits of low-grade silica sand and gravel are operated throughout Canada for foundry sand, sand-blast sand, sand for concrete, etc.

Deposits Under Investigation

Ontario

Gananoque

Active interest has been shown in a deposit of Potsdam sandstone on the north shore of the St. Lawrence, about 6 miles south of the town of Gananoque. This sandstone is creamy-white to grey and brown, medium to fine grained, and fairly pure. Recent laboratory tests conducted at the Mines Branch, Ottawa, indicate that sandstone from this deposit can be beneficiated to produce a sand that would be suitable for steel foundries, sand blasting, etc., and when acid leached, suitable for use in the manufacture of glass and silicon carbide.

Bell's Corners

The silica deposit at Bell's Corners near Ottawa occurs as a 10-foot bed of sandstone 110 feet below the surface. This deposit has been under active investigation as a source of silica sand during the last few years. Test results indicate that this sandstone is a potential source of high quality silica.

Alberta

Peace River

Large deposits of fine to coarse-grained sandstone occur along the banks of Peace River north of Peace River town. The main occurrence is about 7 miles below Peace River. Here, a large deposit of fairly clean, fine to coarse-grained silica sand is found. Peace River Glass Company, Limited, of Edmonton is investigating the possibility of utilizing sand from this deposit for use in the production of glass fibre in its recently completed plant at Fort Saskatchewan. Small tonnages of sand from the Peace River deposits have been used for foundry purposes and for oil-well fracturing.

Miscellaneous Silica Deposits

Beach sand deposits occur along the coasts of the Maritime Provinces and Newfoundland, along the shores of the Great Lakes and Lake Winnipeg, and along the banks and shores of inland rivers and other lakes. Deposits of sand, sandstone, quartz and quartzite occur at numerous locations throughout Canada. However most of these silica deposits are either too impure or too far from existing markets to warrant their development at the present time. A number of these deposits are described in the following table.

Principal Silica Deposits in Canada

Location	Type and Description of Deposit		Typical Chemical Analysis[1]						
			Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L. O. I.
Prince Edward Island northeastern shore	Beach sand -	Principal occurrence at Souris. Large deposits of clean, uniform, well-rounded grains of silica sand. Fairly pure, low iron content but contain small amounts of feldspar.	Souris	95.7	2.66	0.10	Trace	0.10	0.24
Nova Scotia southeastern shore	Beach sand -	Principal occurrences at Barrington Bay and Port Mouton. Large deposits of fine-grained, white sand. Silica content rather low, chief impurities iron, alumina and lime.	Barrington Bay	81.0	11.68	0.90	2.28	0.44	0.74
			Port Mouton	80.2	14.45	0.97	1.80	0.25	0.60
Various locations	Sand -	Deposits at Truro, Ingonish, River Denys. Generally low-quality sand high in iron, alumina and other impurities.	Truro	96.7	0.64	0.15			
			Ingonish	83.2	7.86	0.39			0.28
Sable Island	Sand -	Coarse, brown sand. Contains feldspar and other impurities.	Sable Island	96.5	1.64	0.08			
Fall Brook Hants county	Sandstone -	Fine-grained, grey in colour, high in iron and alumina.	Fall Brook	96.0	3.06	0.40			

Location	Type and Description of Deposit	Typical Chemical Analysis[1]						
		Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Nova Scotia (Con't)								
Hantsport	Sandstone - Friable, coarse-grained. Iron and alumina content fairly high.	Hantsport	96.3	1.61	0.92			
Northeastern Cape Breton and southwestern portion of province	Quartzite - Typical occurrences at Leiches Creek, Chegoggin Point, Kentville and Wolfville area. Massive deposits of hard quartz, some white in colour and quite pure, others iron-stained. Usually fine-grained and uniform in texture.	Chegoggin Point	97.1	0.97	0.51	0.28	0.10	
		Kentville - Wolfville area	96.5	1.90	0.60	Trace	0.14	0.76
New Brunswick								
Moncton - Saint John area	Sandstone - Medium-grained sandstone deposits. Some white in colour and fairly pure.	Moncton - Saint John area	98.2	1.38	0.32	Trace	Trace	0.40
Grand Manan Island	Quartzite - Fine-grained, fairly pure quartzite. Low iron and alumina.	Grand Manan Island	98.8	0.35	0.08	0.24	-	0.45
Quebec								
Montreal area	Sandstone - Typical occurrences at St. Canut, Ste. Clothilde, Melocheville, etc. Large deposits of fine-to coarse-grained Potsdam sandstone.	St. Canut	99.0	0.37	0.17			
		St. Clothilde	98.5	0.31	0.08			0.12

Location	Type and Description of Deposit	Typical Chemical Analysis(1)						
		Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Quebec (Con't)	Numerous outcrops in the area south of Montreal. Sandstone area extends northward, passing west of Montreal, towards Ste. Jerome and eastward towards East Templeton. This sandstone is friable and usually quite pure although it may be iron stained in places.	Melocheville	98.0	0.40	0.30			0.20
		East Templeton	98.7	0.24	0.56		0.15	0.20
Kamouraska area	Quartzite - Typical occurrences at St. Pascal and St. Andre. Massive hills of fine-grained quartzite that extend along the south shore of the St. Lawrence River in the vicinity of Kamouraska. The Pilgrim Islands, located above Rivière-du-Loup, form a continuation of the quartzite ridges found on the mainland.	St. Pascal	95.4	1.65	0.35	0.86	0.75	0.30
		Pilgrim Islands	98.2	1.34	0.24	0.14	0.25	0.45
Southern Quebec	Quartz and Quartzite Deposits of quartz and quartzite occur at many locations throughout the whole of the southern section of the province. Many of these deposits are quite pure.	Buckingham	99.0	0.14	0.41	0.15		0.20
		Sherbrooke	99.0	0.80	0.05			

Location	Type and Description of Deposit	Typical Chemical Analysis[1]						
		Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Quebec (Con't)	Numerous occurrences are found in the Ste. Jerome-Mont Laurier-Buckingham area. Large quartz veins occur in the area east of Sherbrooke. Other typical deposits are located at St. Donat de Montcalm, at Lac Bouchette (south of Lake St. John), and at Chute aux Outardes near Baie-Comeau.	St. Donat	98.7	0.60	0.10			
		Lac Bouchette	99.0					
		Chute aux Outardes	98.7					
Ontario Southeastern portion of province	Sandstone - Numerous deposits of sandstone occur in the area extending from Kingston and Brockville northward through Perth and Smiths Falls to Bell's Corners. Most of the sandstone found in this area is quite friable, some areas contain sandstone that is quite white and fairly pure, while other areas contain badly stained, very impure stone. Typical occurrences are found at Joyceville, Gananoque and Bell's Corners.	Joyceville	98.0	1.00	0.26	0.12	0.06	0.36
		Gananoque	96.5	1.42	0.51	0.43	0.09	0.83
		Perth-Smiths Falls area	97.9	0.80	0.19	0.14	0.12	0.35
		Bell's Corners	97.7	0.74	0.20			0.53

Location	Type and Description of Deposit	Typical Chemical Analysis[1]						
		Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Amherstburg-Windsor area	Sandstone - A number of beds of Sylvania sandstone averaging 8 to 10 feet in thickness occur at depth in this area. The sandstone is white in colour and quite pure. The chief impurity, limestone-dolomite, is present as a bonding material.	Windsor	97.0	0.04	0.02	0.93	0.63	1.39
Hagersville area	Sandstone - Numersous outcrops of sandstone are found in a narrow section of country running east and west of Hagersville. The sandstone is coarse-grained, white to yellow-brown and quite friable. The chief impurity is lime which usually occurs as a bonding material. Typical occurrences are found at Nelles Corners and Springvale.	Nelles Corners	92.6	0.08	0.18	2.01	0.24	0.27
		Springvale	98.3	0.36	0.24	0.40	Trace	0.20
Port Arthur area	Sandstone - Friable beds of dark brown to creamy-white sandstone. Principal development in the vicinity of Port Arthur and the northwestern shore of Lake Superior. These sandstones usually carry considerable calcareous bonding material.	Port Arthur	92.4	0.16	0.64	2.40	0.61	2.00

Location	Type and Description of Deposit	Typical Chemical Analysis[1]						
		Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Ontario (Con't)								
Georgian Bay-Timiskaming area	Quartzite - Massive deposits of quartzite, extending from Sault Ste. Marie on the west, to Lake Timiskaming on the east. Includes the Manitoulin, Killarney and Bellevue deposits. These quartzites are generally quite pure.	Sheguindah	99.2	0.33	0.05	0.02	0.02	
		Killarney	98.7	0.80	0.08	0.03	0.03	
		Bellevue	98.7	0.63	0.20	0.03	0.05	
East central portion of province	Quartz and Quartzite - Deposit of quartz associated with feldspar. These deposits occur in the area west of Kingston towards Parry Sound and northward towards Arnprior and Renfrew.							
Manitoba								
Lake Winnipeg	Sand - Loosely consolidated sand, heavily iron stained in some places but quite pure in others. Chief impurity is a clay which is easily removed by washing. Main occurrences are on Elk, Black, Deer and Punk Islands in Lake Winnipeg, and at Grindstone and Anderson Points on the mainland.	Black Island	99.0	0.56	0.01	0.01	0.02	0.30

Location	Type and Description of Deposit		Typical Chemical Analysis[1]						
			Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Saskatchewan									
Wapawekka Lake	Sand and Sandstone	Main occurrence on north shore of Wapawekka Lake, 125 miles north of Prince Albert. Thick beds of uniform, white standstone.	Wapawekka Lake	98.6					
Red Deer River	Sand and Sandstone	Chief occurrence on north bank of Red Deer River east of Prince Albert near Manitoba - Saskatchewan boundary. Large deposits of fine- to medium-grained sandstone.	Red Deer River	98.5	0.54	0.14	0.03	0.03	
Alberta									
McMurray District	Bituminous Sands	Large deposits of bituminous sands occur throughout the McMurray District. These sands contain a large percentage of fine-grained silica sand which, freed from the bitumen, is quite pure.	McMurray District	95.5	2.25	0.35	0.50	0.23	1.50
Peace River	Sandstone	Large deposits of fine- to coarse-grained sandstone. Main deposits are along the banks of Peace River north of Peace River town.	Peace River	98.5	0.65	0.25	0.06	Trace	

Location	Type and Description of Deposit		Typical Chemical Analysis[1]						
			Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
Alberta (Con't)									
Pipestone River	Sandstone	Main occurrence is located near the headwaters of Pipestone River, north of Lake Louise. Large deposit of fine-grained sandstone, white in colour and quite pure although iron-stained in places. Cemented with a silicious material.	Pipestone River	98.4	0.20	0.50	0.12	0.29	0.38
Cypress Hills	Quartzite pebbles	Large deposit of well-rounded pebbles, 1/2" to 6" in size and larger, suitable for use in grinding mills. This deposit is located in the Cypress Hills, about 20 miles south of Irvine.							
British Columbia									
Coastal Region	Sand	Numerous deposits of beach and bank sand occur along the coast of British Columbia and Vancouver Island. Some of these deposits are quite pure but most are too impure to be of importance.	Bowser, Vancouver Island	68.7	16.1	1.88	5.36	1.70	0.31

Location	Type and Description of Deposit		Typical Chemical Analysis(1)						
			Sample Location	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
British Columbia (Con't) Miscellaneous Deposits	Quartz -	Typical occurrences located on the eastern shore of Shuswap Lake and along the west bank of Fraser River in the vicinity of Keffer's. Deposits of massive white quartz, generally fairly pure.	Shuswap Lake	98.2	0.77	0.13	0.57	0.34	0.17
			Keffer's	96.3	1.00	0.37	0.80	0.24	0.80

(1) The chemical analyses given here are of typical samples from each of the deposits listed; however, they are not necessarily representative of the quality of a particular deposit as a whole. They were obtained from the publications listed at the end of this report and from test reports and correspondence of the Mines Branch, Ottawa.

ECONOMIC CONSIDERATIONS

The economics of the production and sale of the many types of silica is governed by many factors. The production of silica is a low-priced, high-tonnage, very competitive operation. Successful operation of a particular silica deposit is dependent upon the ability of the operator to supply consumers with suitable grades of silica at competitive prices.

Three factors should be carefully considered before embarking on a program for developing a new-found silica deposit, namely, the nature and extent of the orebody, production methods and costs, and the location with respect to markets

The Nature and Extent of the Orebody

The orebody in question should contain a sufficient quantity of uniform high-quality silica to meet the needs of industry for many years. It should lend itself to a fairly simple and inexpensive method of mining and beneficiation. Sand deposits may be exploited very economically since little equipment is required for quarrying and milling. However, most of these are generally too impure for use in industry. Deposits of quartz and quartzite are usually quite pure but require heavy equipment for mining and milling. The best types of silica deposits are those composedof friable sandstone or quartzite. Deposits of this nature are usually quite pure and lend themselves to economical methods of processing.

Production Methods and Production Costs

Silica may be obtained from river, lake, or sea-side sand deposits by dredging; however, it is generally obtained by open-pit operation of inland deposits. Sandstone, quartz and quartzite deposits are usually operated by quarrying methods although underground mining methods are also used. The open-pit or quarry method is by far the simplest and most economical method of operating a silica deposit.

Crushing and beneficiation costs are naturally dependent upon the hardness and purity of the ore being treated. Quartz and quartzite are harder than sandstone and therefore require heavier, more expensive equipment for mining and reduction to size. Sandstone is reduced more readily, but generally contains more impurity which must be removed by suitable methods of beneficiation, such as magnetic separation, washing, etc. This might raise costs to a prohibitive level.

The Location With Respect To Market

The location of a silica deposit with respect to existing or potential markets is an important factor governing the success of any operation. Most types of silica are valued at 50 cents to $3.00 a ton, f.o.b. quarry. Trans-

portation costs may add up to $5.00 or more a ton to the price of the silica delivered to the consumer. To be competitive, low-quality silica must be shipped in large quantities over relatively short distances. Most shipments are made by boat since water transportation is cheaper than rail. Silica sand of glass-sand quality sells for $7.00 to $8.00 a ton, while silica flour costs from $15.00 to $25.00 per ton in the Toronto - Montreal area.

MINING, MILLING AND BENEFICIATION

Most of the silica produced in Canada is obtained by open-pit operation of deposits of sandstone, quartz and quartzite. The quarries are usually operated by benching. Benches vary from 15 to 25 feet or more in width whereas the quarry face averages 10 to 25 feet in height. The face is drilled by air-operated, hand or wagon-drills. The rock is blasted and conveyed by truck or train to a milling plant where it is crushed to size. Primary crushing is usually accomplished by large jaw or gyratory crushers. Secondary crushers include smaller jaw or gyratory crushers and various types of impact crushers. Beneficiation methods include hand sorting, sizing, and washing for the coarser, (-6, +1 inch), grades of silica and sizing, magnetic separation, and sometimes washing for silica sand. Extreme caution must be exercised during the processing of the finer grades of high-purity silica sand to prevent contamination of the finished product. Silica rock is very abrasive and iron contamination from mining and milling equipment must be watched closely. The iron content of sands for use in glass, ceramic and other industries using high-purity silica must be very low. Quality control is an important feature of all plants producing high-purity silica sand and flour.

SUMMARY

The Canadian demand for high-quality silica has been increasing during the last 10 years or more and will continue to do so with increased production of glass and other commodities made with silica.

Domestic production of high-purity silica has never reached a very high level owing to the lack of suitable deposits, and Canada at all times has had to import large quantities to meet her requirements. However, recent investigation by the Department of Mines in Ottawa and by various interested persons, indicates that there is, in Canada, a number of deposits of silica which, by suitable methods of beneficiation, may be economically upgraded to supply high-purity silica sand to Canadian consumers. Interest in these and other Canadian silica deposits is keen and it is hoped that their early development will make Canada self-sufficient with respect to high-purity silica.

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