Scientific Editors
Set No. 1

ONTARIO
DEPARTMENT OF MINES

SILICA IN ONTARIO

by

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SILICA IN ONTARIO

INTRODUCTION

In answer to inquiries for information of a general nature on silica, this circular gives a brief summary of the utilization of silica and the occurrence and characteristics of Ontario deposits. Much of the information summarized here has been drawn from M. L. Keith's report entitled "Sandstone as a Source of Silica Sand, in Southeastern Ontario" (1) and L. H. Cole's report, "Silica in Canada: Its Occurrence, Exploitation, and Uses." (2) During June, 1949, as part of a programme of investigation of silica resources in Ontario, the writer examined a number of occurrences of Lorrain quartzite along the north shore of Lake Huron. Brief preliminary descriptions of some of the principal silica deposits in the area from Sault Ste. Marie to North Bay are included in this report.

Silica occurs commonly as pegmatitic and vein quartz, quartzite, sandstone, and unconsolidated sand. Deposits of these four types have been worked in Ontario. Silica finds wide use as raw material in many industries, but specifications regarding the form of silica, chemical purity, and physical characteristics vary greatly according to the consumers' requirements.

In point of tonnage one of the largest markets for silica in Ontario is for metallurgical flux. In 1942 the International Nickel Company opened the Lawson quarry, near Whitefish Falls, district of Sudbury, to supply quartzite for flux, and this single operation currently produces nearly half a million tons a year. Quartzite is quarried near Killarney and Sheguiandah for the production of ferrosilicon. Silica brick is being manufactured by the Algoma Steel Corporation from quartzite quarried in Deroche township, district of Algoma, 20 miles north of Sault Ste. Marie.

Silica sand and fused silica are used in plastic refractories and mortars. Furnace bottoms and linings for certain metallurgical processes are made of rammed silica sand or silica grits. Silica sand is an important raw material for the production of silicon carbide and other abrasives. In the ceramic industry the manufacture of glass requires large tonnages of high purity silica sand. It is also used in other ceramic bodies and in enamels. Silica is a constituent of the batch for Fiberglass and some types of rock wool. When ground fine it forms an inert filler for paints, rubber goods, scouring powders, and cleansers. Silica sand is used in foundries for casting metals and for sand blasting. Sandstone is one of the most widely used building stones.

In 1949 production of quartzite and silica sand in Ontario amounted to 1,404,140 tons, having a value of $1,020,411, making it one of the major industrial minerals of Ontario. Nevertheless, a large part of the Canadian market for high purity silica and silica products is supplied by imports from the United States. In 1948 Canada imported 584,019 tons of silica sand having a value of $1,446,624. The cost of this silica to the consumers, chiefly the glass industry, was approximately $4,500,000, (3) delivered to their plants. Production of silica brick in Ontario in 1948 amounted to 1,266,000 brick, valued at $133,424. During the same period imports of silica brick into Canada, chiefly from the United States, amounted to $1,211,511.

Silica constitutes one of the important non-metallic minerals resources of Ontario, but full use is not being made of the available deposits. Large tonnages of Lorrain quartzite are suitable for the manufacture of silica brick. A large Canadian market for high-grade silica sands exists, and investigations being carried out by the Industrial Mineral Division of the Mines Branch at Ottawa (3) suggests that it may be possible to beneficiate Potsdam sandstone and Lorrain quartzite to produce a product suitable for the requirements of the glass and ceramic industries.

TYPES OF SILICA DEPOSITS

Workable deposits of silica in Ontario are of four types: unconsolidated silica sand, sandstone, quartzite and pegmatitic quartz.

Unconsolidated Silica Sand

Mineralogically, sand deposits found in Ontario consist predominantly of grains of silica and feldspar with varying percentages of carbonate, rock fragments, ferromagnesian minerals such as hornblende, pyroxene, biotite, and olivine, and accessory minerals such as zircon, garnet, tourmaline, apatite, epidote, pyrite, magnetite, and rutile. In examining a sand deposit with a view to its commercial utilization, specifications may require that the following features be investigated:-

1. Mineralogy of the sand; what percentage of silica grains; what accessory minerals.
2. Chemical purity, including analysis of silica, alumina, iron, lime, magnesia, and alkalis.

3. Grain size: sizing, fineness number, and sorting of the grains (checked by sieve analyses).
4. Roundness or angularity of the grains.
5. Toughness of the grains.
6. Cleanliness and percentage of fines present.

Most of the sand deposits in Ontario are of glacial origin or are Recent deposits derived by reworking glacial material. For this reason high purity silica sands are scarce. The sands derived from glacial debris usually consist of extremely heterogeneous material. Glacial and Recent fluvial and lacustrine deposits furnish large tonnages of sand suitable for silica flux, foundry sand, and other uses not requiring a high degree of purity.

Sandstone

Sandstones, consisting of aggregates of sand grains bonded by a mineral cement, usually silica or calcareous material, are the most widely used sources of silica sand. Sandstones, such as the St. Peter sandstone quarried at Ottawa, Ill., may be of high chemical purity and break down easily into sands with very little fracturing of the individual grains. The same specifications as to chemical purity, grain size, angularity and toughness of grains apply to silica sand originating from a sandstone as to silica sand from unconsolidated deposits.

Well-cemented sandstones may be suitable for making ferrosilicon. For building stone the sandstone must be strongly cemented.

In Ontario the most important sandstone formations are the Potsdam or Nepean sandstone of Eastern Ontario, the Medina sandstone of the Niagara escarpment, the Oriskany sandstone of the Niagara peninsula, and the Sylvanian sandstone of the Windsor area.

Quartzite

When the quartz grains of a sandstone are recrystallized by metamorphism the rock becomes a quartzite and loses the granular texture of the original sandstone. On crushing, the quartzite fractures across the original sand grains, and sands produced by grinding quartzite are characteristically sharp and angular. Quartzite is rarely crushed and ground to produce a silica sand, because, owing to its hardness, compactness, and coherence, the cost of crushing and grinding adds greatly to the processing costs.

Most of the silica sandstones of Precambrian age in Ontario are now metamorphosed to quartzite. The Lorrain quartzite, a member of the Cobalt series, which outcrops in a wide area from Sault Ste. Marie to Cobalt, is one of our most important reserves of high-grade silica. Other quartzites occur in the Huronian and Grenville series of Precambrian sedimentary rocks.

Pegmatitic Quartz

During the course of operation of many granite pegmatites for feldspar, considerable tonnages of quartz must also be mined. This massive pegmatitic quartz is sometimes sold as lump silica for use as flux or ground to produce pottery flint. The quantity produced is relatively small and frequently the feldspar operations are situated so far from markets that it is not economical to ship such a low-priced commodity as quartz to the consumers.

SPECIFICATIONS AND USES OF SILICA

Silica Flux

Massive quartz, sandstone, quartzite, and silica sand are used for flux in smelting base metal ores where iron and basic oxides in the ore are slagged as silicates. Since free silica is the active slagging ingredient, the free silica content of the flux should be as high as possible. Impurities of iron, alumina, and bases are not objectionable except that they reduce the percentage of available silica. Therefore, if a cheap local source of lower grade silica is available, it may be used in preference to higher-cost high-purity silica which must be hauled from some distance.

The largest users of silica flux in Ontario are the copper-nickel smelters of the Sudbury area; the International Nickel Company uses more than 1,000,000 tons annually: In the roasting plant of the nickel circuit at Copper Cliff, silica flux consisting of seven-eighths sand and one-eighth fine quartzite is mixed with nickel concentrates, in the proportion of approximately 1 ton flux to 5 tons concentrates, for feed to the Nichols-Herreschoff roasters. The sand is obtained from Pleistocene deposits in nearby Garson township, and quartzite is quarried at the Lawson quarry near Whitefish Falls.

Quartzite crushed to minus 3/4-inch size is used as flux in the Pierce-Smith converters. The quartzite, running about 96 per cent. SiO_2, is fed into the converter by the Garr silica gun. In the copper circuit sand flux is used in the reverberatory furnaces, and flux for the converters consists of a 50-50 mixture of low-grade ore and quartzite.

Sands running as low as 80 per cent. silica are used for rammed furnace bottoms in some open hearth furnaces in the steel industry.

Ferrosilicon

In the manufacture of ferrosilicon, lump silica of 3/4-inch to 5-inch diameter, derived by crushing quartzite or compact, well-cemented sandstone, is used. Chemically this material must be of high purity, within the following limits: silica, over 97.5 per cent. (quartzite now being mined in Ontario averages 98 to 99 per cent.); alumina, not over 1.0 per cent.; iron should be uniform and total iron plus alumina not over 1.5 per cent., (iron in the Killarney quartzite runs from 0.2 to 0.4 per cent.); MgO and CaO each less than 0.2 per cent.; phosphorus and arsenic are particularly objectionable and should not be present.

Silicon Carbide

Keith [1] (p.4) gives the following specifications for silica sand for the manufacture of silicon carbide: "The silica content is generally specified as 99.25 per cent. minimum. Lime, magnesia, and phosphorus are objectionable. Small amounts of iron and alumina are tolerated but should be constant from one shipment to another. Canadian manufacturers are using a sand with A. F. A. fineness No. 35."

Silica Brick

Quartzite of medium to fine grain size, ranging in composition from 96 to 98 per cent. silica, has proved to be the best raw material for silica brick. Much of the Lorrain quartzite of the Sault Ste. Marie-Sudbury area is suitable for the manufacture of silica brick, comparing favourably with Pennsylvanian and Wisconsin quartzites.

Silica, which melts at 1728° C, has the ability to sustain loads even when temperatures approach the melting point; therefore it is an extremely useful refractory material in the metallurgical industry. Silica brick is widely used in steel furnaces where operating temperatures may be in the neighbourhood of 1680° C.

Examination of the phase relations of the systems silica-iron oxide and silica-lime, indicates that considerable amounts of iron and lime can be tolerated with little effect on the melting point of silica, because these oxides are immiscible with silica at high temperatures in the high silica range. Nevertheless, alumina and alkalis present in the SiO_2- FeO- CaO system act as fluxes and materially reduce the refractoriness of the silica brick. It has been found, therefore, that the best range of chemical composition for raw material is as follows:-

Silica . . . . 96 to 98 per cent., or over.
Alumina . . . . less than 1.0 per cent.
Iron oxides . . . . less than 1.0 per cent.
(combined iron and alumina under 1.5 per cent.).
Alkalis, magnesia, and lime should be low.

Quartz is the stable form of silica under normal conditions of temperature and pressure. On heating, however, quartz inverts at 870° C to tridymite, which in turn inverts at 1470° C to cristobalite, both of which are the forms of silica stable in these high temperature ranges. This inversion of quartz is accompanied by expansion and resultant decrease in specific gravity.

Silica bricks are manufactured by grinding the quartzite to a suitable mesh size, usually about 55 per cent. between 4 and 28 mesh, 20 per cent. between 28 and 65 mesh, and 25 per cent. under 65 mesh; bonding with 1 to 2 per cent. lime; moulding into bricks; drying and firing in a kiln. On firing, the quartz converts to tridymite and cristobalite with resultant expansion. The extent of the conversion has an important bearing on the behaviour of the brick in service.

Texturally, the most suitable quartzites are those with fine-grained, closely interlocking texture or those with both fine and medium grain size, because the inversion from quartz to the higher temperature forms occurs more rapidly and is more complete in the finer-grained material.

To determine the suitability of a quartzite as a raw material for silica brick, tests should be carried out on brick made from samples of several hundred pounds of quartzite.

Glass Sand

For the manufacture of glass, silica sand of high purity is needed. The following table gives specifications for glass sand approved by the glass division of the American Ceramic Society and the U. S. Bureau of Standards:

	Min. SiO_2	Max. Al_2O_3	Max. Fe_2O_3	Max. $CaO + MgO$
First quality, optical glass	99.8	0.1	0.02	0.1
Second quality, flint glass containers and tableware	98.5	0.5	.035	.2
Third quality, flint glass	95.0	4.0	.035	.5
Fourth quality, sheet glass rolled, polished plate, and window glass	98.5	.5	.06	.5
Fifth quality, sheet glass rolled, polished plate, and window glass	95.0	4.0	.06	.5
Sixth quality, green glass containers	98.0	0.5	.3	.5
Seventh quality, green glass	95.0	4.0	.3	.5
Eighth quality, amber glass containers	98.0	.5	1.0	.5
Ninth quality, amber glass	95.0	4.0	1.0	.5

Moisture in delivered sand should not exceed 2.5 per cent. Uniformity of grain size is important. A glass sand should all pass 20 mesh and not more than 3 per cent. should pass 80 mesh. Angular grains are preferred by some manufacturers owing to their larger surface area and more rapid reaction in the melt, but this feature does not appear to be a necessary requisite of good glass sand.

Enamels

For enamel frits a good grade of fine glass sand is used. Iron content should be less than 0.2 per cent.; alumina, less than 0.5 per cent.; and silica, over 97.5 per cent.

Pottery Flint

Finely ground silica is used for pottery flint in ceramic bodies. The chief requirement as to purity is that the iron content should be low when a white colour is desired.

Sodium Silicate

In the manufacture of sodium silicate a high-grade glass sand is used. Weigel (4) (p.157) gives the following specifications: "The sand must contain at least 99 per cent. silica, with not over 1 per cent. alumina, not over 0.5 per cent. lime and magnesia combined, and less than 0.1 per cent. iron." Grain size is minus 20, plus 100 mesh.

Paint Filler

Finely ground pottery flint is used in the paint industry as a filler. For this use, white colour, fineness, and freedom from impurities are the main requirements.

Foundry Sands

For foundry sand a highly refractory, tough silica sand having rounded grains with rough surfaces is preferred. Depending on the size and type of casting, various size grades of sand are used, graded according to the American Foundrymen's Association specifications. The silica sands are bonded with clay, and rough grain surfaces improve the bonding power. Rounded grains are preferred to angular grains owing to the increase in the permeability of the sand, which allows the escape of gases during casting. Both naturally bonded and artifically bonded sands are used.

Miscellaneous Uses

Silica is also an ingredient in some Fiberglas and rock wool batches and is used in cleansing and scouring powders, matches, fertilizer filler, and roofing paper.

ORIGIN AND OCCURRENCE OF HIGH-GRADE SILICA DEPOSITS

All high-grade silica deposits of detrital origin, including silica sand, sandstone, and quartzite, are composed essentially of the mineral quartz, which was originally derived through the weathering of a quartz-bearing igneous rock, such as granite. When a granite breaks down into a sand under normal weathering conditions, the sand will be composed of the constituent minerals of the granite: quartz, feldspar, mica, and hornblende, with accessories such as zircon, tourmaline, garnet, magnetite, and pyrite possibly present. The result is an impure, low silica sand.

Quartz is a very stable mineral and does not break down easily, either chemically or physically, during the weathering cycle. Most of the pure silica sand deposits, such as the well-known St. Peter sandstone of Ottawa, Ill., and the Oriskany sandstone of Pennsylvania, have resulted from the cumulative concentration of quartz grains, which persisted as a very stable mineral through several cycles of weathering and lengthy transportation, while other less stable minerals were destroyed. These sandstones are usually derived from the weathering of a sandstone; with each cycle the resulting product becomes purer.

The evidence that many of these deposits are the product of several cycles of weathering is found in the well-rounded, worn character of the quartz grains and the paucity of associated accessory minerals. Probably the purest silica sand deposits recently formed in Ontario are those in the Sault Ste. Marie area that are derived from the weathering of the Lake Superior sandstone. Ancient silica sands, such as the Potsdam sandstone of Eastern Ontario and the Sylvania sandstone of Southwestern Ontario, probably represent fossil beach deposits of a transgressive epicontinental sea.

SILICA DEPOSITS IN ONTARIO

The chief silica resources in Ontario are the Lorrain quartzite of Precambrian age, the Potsdam sandstone of Cambrian age, the Medina sandstone of Silurian age, the Sylvania sandstone of Devonian age, and the unconsolidated sands of Quaternary and Recent age. The silica deposits are discussed in the following order:-

- Precambrian quartzites:
  - Lorrain quartzite
  - Grenville quartzite
- Paleozoic sandstones:
  - Potsdam or Nepean sandstone
  - Medina sandstone
  - Oriskany sandstone
  - Sylvania sandstone
- Unconsolidated sands:
  - Sault Ste. Marie area
- Pegmatitic and vein quartz.

Lorrain Quartzite

The Cobalt series of Middle Huronian age is made up of a lower formation, the Gowganda, consisting predominantly of conglomerate, arkose, and greywacke, and an upper formation, the Lorrain quartzite. The latter has a thickness ranging from 5,500 to 6,500 feet, of which the upper third is silica of high purity, being composed almost entirely of quartz. Chemically analyses of these high purity deposits indicate a silica content ranging from 95 to more than 99 per cent.

Distribution

The Lorrain quartzite outcrops in many places along the north shore of Lake Huron from Sault Ste. Marie on the west to Killarney on Georgian bay on the east. Fig. 1 shows the distribution of the Lorrain quartzite formation.

There are four belts of high purity quartzite that are readily accessible by rail, road, or water transportation and are, therefore, of particular commercial interest. The most westerly of these is located near Bellevue in Deroche township on the Algoma Central railway, 20 miles north of Sault Ste. Marie. Here a quarry operated by Wright and Company supplies silica to the Algoma Steel Company for the manufacture of silica brick. The second belt of quartzite, outcropping near Echo bay in Macdonald township, district of Algoma, extends southeastward for a distance of about 30 miles to Thessalon and has a maximum width of 10 miles.

The third and largest belt of quartzite outcrops on the mainland across from the east end of Manitoulin island. It is horseshoe-shaped and has a length of 70 miles and a width of from 2 to 3 miles. The north limb outcrops along the shore of the North channel south of the town of Massey, and extends eastward for a distance of 45 miles through Whitefish Falls to Goschen township, district of Sudbury. Here the belt reverses its direction abruptly, and the south arm extends southwest from Goschen township to Lake Huron, just north of Killarney village. The quartzite ridges form three long points jutting out toward Manitoulin island. These two arms of the horseshoe form La Cloche mountains, which stand up in bold relief as snowy white ridges above the surrounding country. On Manitoulin island the southern range of quartzite outcrops at Sheguiandah hill in a monadnock completely surrounded by flat-lying Paleozoic rocks.

There are three quarry operations in this belt: at Whitefish Falls, the International Nickel Company operates the Lawson quarry for silica flux; on Badgeley point, near the village of Killarney, Dominion Mines and Quarries operates the Killarney quarry, producing lump silica for ferrosilicon; at Sheguiandah on Manitoulin island, silica for ferrosilicon is produced by the Canadian Silica Corporation.

The fourth deposit of quartzite is much smaller, having an area of about 5 square miles. It is located in Delamere and Cosby townships, district of Sudbury, on the North channel of the French river. Rutter station, on the Canadian Pacific line from Sudbury to Toronto, lies 5 miles to the west of the deposit.

Lithology

The Lorrain quartzite formation is described as follows by W. H. Collins: (5) "There is an imperceptibily easy gradation in the lowermost one-third to one-fourth of the Lorrain formation from an impure reddish or pale-green quartzite into a purer white variety which continues to the top, and about the middle of the formation there is a zone of indefinite thickness which is distinguished by the presence of numerous thin beds of quartz conglomerate, locally rich in pebbles of red jasper."

The upper high purity section of the formation is the only part with which this report deals.

The quartzite is commonly white or grey in colour, but may be green, pink, or red depending upon impurities. It is completely recrystallized and is composed of interlocking grains of quartz. This recrystallization has rendered the rock extremely hard and coherent, and, on crushing, the rock often breaks with a conchoidal fracture. Texturally, the rock ranges from a coarse-grained glassy quartzite to a fine-grained, cherty, milky white quartzite.

Beds range in thickness from a few inches to 10 feet. The upper part of the formation is extremely uniform, consisting almost entirely of quartz. There are no impure interbeds of arkose or greywacke, and there are thick sections of pure quartzite available for quarrying.

Chemical analyses of 30 samples collected from various deposits by the writer indicate silica content ranging from 97.5 to 99.3 per cent.; alumina, 0.2 to 2 per cent.; iron oxides, 0.04 to 1.1 per cent.; lime, magnesia, and alkalis, less than 1 per cent. Impurities noted on petrographical examination include feldspar, kaolin, sericite, talc, chlorite, and iron oxides.

Structure and Intrusives

The Lorrain quartzite, together with the rest of the Cobalt series, was highly folded during the post-Huronian Killarney orogeny. In most of the area herein described the Lorrain quartzite dips steeply. In the Whitefish Falls- Killarney belt the quartzite of the La Cloche ranges has a synclinal structure. The Gowganda formation of Lower Cobalt age flanks the quartzite ridges on either side. (5)

The quartzite ridges are cut by faults. The shearing is often coincident with bedding planes, and along these zones of intense shearing, talc, chlorite, and sericite are developed. These talc-sericite slips account for a considerable amount of the alumina and alkalis present in the rock, and if a high degree of purity is required, this material should be wasted by selective mining or sorting.

The Lorrain quartzite is cut by numerous narrow diabase dikes, which are tentatively correlated as Keweenawan in age. In the Killarney area there are two main sets of dikes. One set strikes approximately east-west; the other set, northwest-southeast or northeast-southwest. Careful preliminary examination is necessary in choosing a quarry site in order that the occurrence of the diabase dikes will not interfere with quarry development.

Occurrences

The occurrences of Lorrain quartzite in the following six areas, as shown on Fig. 1, are described in more detail:

1. Whitefish Falls area, Mongowin township
2. Killarney area, Killarney township
3. Sheguiandah area, Manitoulin island
4. Cosby township
5. Bar River area, Macdonald township
6. Bellevue area, Deroche township

(1) Whitefish Falls Area

The northern limb of La Cloche mountains runs in an east-west direction through Mongowin and Curtin townships, district of Sudbury, just north of the village of Whitefish Falls on the Espanola-Little Current highway. High purity Lorrain quartzite, which forms the crest of this range of hills, underlies an area of about 20 square miles in the southern parts of Mongowin and Curtin townships. The highest point in this area is the hill just east of No. 68 highway at Willisville, about a mile north of Whitefish Falls. The elevation at the base of the fire tower on the top of the hill is 1,114 feet, giving a relief of 533 feet above the level of Lake Huron (elevation 581 feet.)

The Whitefish Falls area is easily accessible by road and rail, being served by the Espanola-Little Current branch of the Canadian Pacific Railway and by No. 68 highway.

The Lorrain quartzite of the Whitefish Falls area is a fine- to medium-grained, hard, flinty, white quartzite, which occurs in beds from 6 inches to more than 2 feet in thickness. On the Willisville hill the bedding strikes N. 75 - 80 degrees E. and dips steeply to the south. Faint cross-bedding is still discernible in places in the recrystallized quartzite. The rock has strong blocky jointing with fractures at right angles.

In some places the quartzite is cut by narrow zones of faulting, along which the sheared rock is often altered to a sericite-serpentine schist. These fractures may be occupied by diabase dikes with a maximum width of 20 feet. The dikes strike in two predominant directions, east-west conformable with the bedding and northwest-southeast.

Microscopic examination of the fine-grained cherty white quartzite from the Lawson quarry discloses that it is composed of a fine mosaic of interlocking quartz grains of fairly uniform size. The average grain size is 0.15 mm., with a range of 0.05 to 0.2 mm. The grains have sutured interlocking boundaries.

A sample of the medium-grained white quartzite from the Willisville hill shows strong cataclastic structure. The quartz grains, averaging 0.5 mm. in diameter and reaching a maximum size of 2 mm., show evidences of strain and are elongated in one direction. Along intergrain boundaries are aggregates of mylonitic quartz. Sericite and pyroxene are developed in the quartzite in scattered radiating fibrous aggregates.

Lawson Quarry. [6] -In 1942 the International Nickel Company opened a quarry for silica flux in Lorrain quartzite on lot 13, Curtin township (formerely timber berth 11) just north of the villageof Whitefish Falls. The quarry is on the C. P. R. line from Espanola to Little Current; the rail haul to Sudbury via Espanola is approximately 65 miles. The quartzite ridge now being quarried has a length of 2,700 feet between No. 68 highway and the railway line on the west shore of Frood lake and a width of 900 feet. It formerly rose to a height of 200 feet above the yard level. The first bench has now been nearly completed and its floor is 120 feet above the yard level. A second bench with a height of 40 feet is now being worked.

The quartzite is a white, fine-grained, hard, almost cherty rock. A sheared diabase dike about 20 feet wide cuts the west face of the second quarry bench.

For primary breaking, vertical 9-inch diameter holes are drilled by 3 churn-drill rigs. Holes are drilled on 17-foot centres with approximately 22-foot burden. The quartzite is loaded into trucks by a 2-1/2 cubic yard electric shovel. Two 15-ton Euclid and one 30-ton Mack trucks are used for the short haul to the chute that feeds the crusher plant on the side of the hill. The lower part of the slide is inclined at 40 degrees, and the bottom and sides are lined with reinforced concrete and crusher plates.

"The quartzite is fed from the slide by an 8-foot by 64-inch roll feeder to a 60- by 42-inch jaw crusher set to crush to 2 1/2 inches. A 30-inch belt conveyor carries the crushed product to a 5-by 10-foot double-deck screen. The openings in the upper or scalping screen are 4 by 6 inches and in the lower screen are 2 by 4 inches. The oversize is crushed to 1 3/4 inches in a 4-foot standard Symons cone crusher, this product along with the screen undersize, falls on a 30-inch belt conveyor discharging to a 5 by 10-foot single deck screen with 1 by 6-inch openings. The oversize from this screen is crushed to 7/8-inch in a 4-foot Symons short-head crusher and, along with the screen undersize, is carried on a 30-inch inclined conveyor to a 4 by 8-foot double deck screen above the loading bins with openings 7/8 by 6 inch in the scalping screen and 5/16 by 4 inch in the lower screen. The oversize is discharged into a bin for shipment to the converter plants at Copper Cliff and Coniston; the undersize falls into a separate bin and is shipped to the reverberatory plant at Copper Cliff." [6]

At the present time the upper scalping screen at the bins has openings, 1 by 4 inches, and three products are obtained; plus 1 inch, 1 inch to 5/16 inch, and minus 5/16 inch. Production amounts to about 2,000 tons per 10-hour day. The crushing plant is furnished with an efficient cyclone dust-collection system.

The following table gives the results of analyses of composite chip samples of quartzite from the Whitefish Falls area. All the analyses quoted in this report were carried out by the Laboratories Branch of the Ontario Department of Mines by spectrographic methods. Silica was calculated by difference and K_2O was arbitrarily taken as 0.30 where it is shown as less than 0.50 in the analyses for this calculation.

Analyses of Lorrain Quartzite, Whitefish Falls Area

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
59-4	98.86	0.51	0.08	0.02	0.03	0.04	0.16	<0.50
59-5	98.78	0.64	0.10	0.02	0.02	0.04	0.10	<0.50

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
59-7	98.35	1.04	0.09	0.03	0.02	0.05	0.12	<0.50
76-2A	97.67	1.77	0.05	0.01	0.02	0.08	0.10	<0.50
76-2B	98.13	1.34	0.05	0.01	0.02	0.07	0.08	<0.50
76-6	97.74	1.73	0.05	0.01	0.02	0.06	0.09	<0.50
76-7	97.67	1.81	0.06	0.02	0.02	0.05	0.07	<0.50

Sample 59-4 is a composite chip sample taken as representative of the material at the east end of the first bench at the Lawson quarry.
Sample 59-5 is a composite chip sample representing the quartzite in the muck pile at the west end of the first bench, Lawson quarry.
Sample 59-7 is a composite chip sample taken on the second bench near the chute, Lawson quarry.
Sample 76-2A is a composite chip sample of quartzite taken in a north-south direction across strike over a length of 100 feet on the east end of the fire tower hill at Willisville, Curtin township.
Sample 76-2B is a second analysis of the same sample, indicating the magnitude of sampling error in this case.
Sample 76-6 is a composite chip sample of quartzite taken across strike over a length of 3,00 feet at the west end of the fire tower hill at Willisville, Curtin township.
Sample 76-7 is a composite chip sample of quartzite taken across strike over a length of 300 feet on the quartzite ridge in block A, concession II, Mongowin township, a quarter of a mile west of No. 68 highway.

It is difficult to get a sample adequate to represent an average quartzite over a mineable width, but these analyses give an indication of the probable content of impurities in the rock.

(2) Killarney Area

The south limb of La Cloche mountains forms a series of high ridges running from Goschen township, district of Sudbury, in a southwesterly direction through Killarney township (formerly known as timber berth 10), district of Manitoulin, to Georgian bay, where the quartzite ridges form three long fingers reaching out toward Manitoulin island. These are, from north to south, McGregor point, Fraser point, and Badgeley point. South and west of Badgeley point the quartzite formation outcrops on Haywood, Partridge, Centre, and Badgeley islands. Most of these islands are flanked by Ordovician limestones.

The highest point in the south range of La Cloche hills is in Carlyle township, district of Manitoulin, where the quartzite ridge has a maximum elevation of 1,785 feet, standing 1,204 feet above the level of Lake Huron.

Killarney Quarry.-The Killarney quarry of Dominion Mines and Quarries, Limited, is situated on the south shore of Badgeley point, Killarney township, across from the northeast end of Badgeley island, 4 miles west of Killarney village. Access is by boat from Little Current; the quarry and crushing plant are situated on the shore of Killarney bay.

Badgeley point is composed of white Lorrain quartzite ridges, which stand up from 500 to 1,000 feet above the level of Lake Huron. The fine-grained, completely recrystallized quartzite occurs in steeply dipping beds striking northeast-southwest. At the quarry the strike ranges from N. 40° E. to N. 55° E. On the quartzite ridge immediately west of the quarry, strikes average N. 55° E. and dips range from vertical to 70° S. Cross-bedding indicates poor tops facing south. The quartzite is cut by diabase dikes up to 25 feet in width. One set of diabase dikes appears to run in a northeast-southwest direction conformable with the strike of the quartzite. A second set occupies valleys trending approximately east-west. These diabase dikes have dips ranging from 60 degrees to vertical and appear to occupy sets of joints or faults having a regular structural pattern. Being softer and more easily weathered than the quartzite, these dikes form valleys that are readily visible on aerial photographs of the area.

Fine-grained iron oxide gives the quartzite a reddish colour in some places. Microscopic examination of sections of quartzite from the Killarney quarry discloses that the rock is medium- to fine-grained and that the average grain size is 0.2 mm.

It is made up of an aggregate of equant quartz grains with smooth boundaries. Metamorphism appears to be less intense here than at the Lawson quarry. There is little or no alignment of quartz grains and no evidence of cataclastic structure in the specimens examined.

The Killarney quarry has produced continuously since it was opened by Willmott and Company in 1911. The quarry is now operated by Dominion Mines and Quarries, Limited, on a seasonal basis from May to November each year. The lump silica is shipped by boat to Welland, Ont., Niagara Falls, N. Y., and Ashtabula, Ohio, for manufacture of ferrosilicon.

The present quarry floor has an elevation of 625 feet, 45 feet above lake level. The face averages about 100 feet in height and has a length of about 1,400 feet in an east-west direction. The present face is transected by three diabase dikes having general east-west strikes and steep northerly dips. The face is being advanced to the north.

The coyote method of tunnel-blasting is used for primary breaking. The last blast carried out in November, 1947, using 161,100 pounds of explosives, broke an estimated tonnage of 500,000 tons of rock. Secondary breaking is done by pop-holing and sand-blasting. The quartzite is loaded on 7-ton cars by a 2 1/2-yard shovel. Haulage is by rail to the crusher plant.

The skips are hauled up an incline at the crusher plant and dump into a 25-ton bin. The rock is fed from this bin to a 42-by 40-inch jaw crusher set to 5 inches. The product is conveyed to a double-trommel screen with openings of 4 3/4- and 3/4-inch size. The undersize, minus 3/4-inch material, goes to the waste dump. The oversize, plus 4 3/4-inch material, goes to a gyratory crusher set at 3 inches. The product from this crusher, together with the middlings from the jaw crusher, go to a second set of screens. The fines from these screens are stock-piled with the waste, the middlings, constituting all minus 4 3/4-inch plus 3/4-inch material, go to an 8,000-ton bin at the wharf. Lake freighters are loaded at the wharf by boom conveyers. Oversize from the second set of screens goes to another gyratory crusher in closed circuit with screens. Production is in the neighbourhood of 1,000 tons a day, 80 per cent. of which is minus 5-inch plus 3/4-inch material.

The following table gives analyses of composite chip samples of quartzite from the Killarney quarry area:-

Analyses of Lorrain Quartzite- Killarney Quarry

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
64-1	99.05	0.49	0.04	0.01	0.03	0.04	0.04	<0.50
64-2	98.66	0.86	0.04	0.01	0.03	0.04	0.06	<0.50
69	98.67	0.80	0.08	0.03	0.03	0.04	0.05	<0.50
67-3	98.19	0.94	0.36	0.06	0.03	0.05	0.07	<0.50
67-2A	97.72	0.98	0.76	0.07	0.04	0.06	0.07	<0.50
67-2B	98.28	1.01	0.22	0.07	0.02	0.05	0.05	<0.50

Samples 64-1 and 64-2 are composite chip samples taken across a high quartzite ridge immediately west of the Killarney quarry. Sample 64-1 was taken across a length of 700 feet in an east-west direction eastward from the west boundary of claim S. 38,001 at a point 500 feet south of No. 4 post. Sample 64-2 was taken across strike in a north-south direction for a width of 1,100 feet along the west boundary of claim S. 38,001.

Sample 69 is a composite grab sample from the muck-pile in the quarry.

Samples 67-2A, 67-2B, and 67-3 are representative composite samples from the stock-pile of minus 3/4-inch fines at the Killarney quarry. Sample 67-2B which is from the same 20-pound sample as 67-2A, was screened and the plus 1/4-inch fraction washed and analysed. There appears to be no significant difference between these three samples. The high iron content is thought be to largely due to iron introduced during the crushing operation.

(3) Sheguiandah Area, Manitoulin Island

The hills of Lorrain quartzite outcropping as monadnocks are surrounded by flat-lying younger Paleozoic rocks in Howland and Sheguiandah townships, Manitoulin island, 6 miles south of Little Current, and are a continuation of the south range of the La Cloche Mountains. There are five areas of outcrop in the southern part of Howland township and the northern part of Sheguiandah township. The area is easily accessible by road and water.

Sheguiandah Quarry.-The Sheguiandah or Trotter quarry, which is operated by the Canadian Silica Corporation, is located on lot 2, concession XII, Howland township, on the shore of Sheguiandah bay about 1 mile north of Sheguiandah village. The quartzite ridge trends N. 80° E. and rises to a maximum height of 180 feet above the level of Lake Huron. The quartzite formation strikes east-west and has a dip ranging from 75 to 80 degrees to the north. The very fine-grained, almost cherty, white quartzite is very similar to the material from the Lawson quarry.

There is strongly developed blocky jointing at right angles to the bedding. Strong zones of shearing strike N. 70° E. and dip steeply to the north. Along these shear zones sericite and soapstone are developed in bands from 4 to 6 inches wide.

The present quarry face has a length of 1,600 feet and a height ranging from 30 to 50 feet. The face trends N. 80° E. and dips 75° N. parallel to the strongly developed bedding shears. The face is being advanced to the south across the structure. Primary breaking is done by drilling four sets of flatly dipping holes into the face by means of wagon drills operating on the quarry floor. Secondary breaking is done largely by a 4,300-pound drop ball on a boom-derrick. Haulage from the quarry to the primary crusher is by trucks loaded by a 2-cubic yard shovel. Primary crushing is done by a gyratory crusher. The product is conveyed to a set of triple deck screens having openings of 4 inches, 1 inch, and 1/4 inch. The minus 4-inch plus 1-inch material is stock-piled over a tunnel conveyor fed by nine chutes. Soapstone is picked out on the conveyor belt and discarded in order to lower the alumina in the commercial product. Freighters are loaded by boom conveyor feeding from the stock-pile. This lump silica is used for ferrosilicon. The minus 1-inch plus 1/4-inch and the minus 1/4-inch materials are stock-piled separately. The operation is seasonal, and production depends largely on market conditions. The present production of lump silica ranges from 65,000 to 85,000 tons annually. Quarrying operations began in 1945.

The following table gives analyses of composite chip samples from the Sheguiandah quarry:-

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
60-1	99.09	0.37	0.07	0.02	0.02	0.08	0.05	< 0.50
60-3	98.05	0.97	0.32	0.12	0.09	0.10	0.05	< 0.50
61-1	99.17	0.37	0.05	0.02	0.02	0.03	0.04	< 0.50
61-2	98.46	0.92	0.10	0.08	0.04	0.06	0.04	< 0.50
61-3	99.27	0.26	0.05	0.02	0.02	0.04	0.04	< 0.50
61-4	99.20	0.33	0.05	0.02	0.02	0.04	0.04	< 0.50

Sample 60-1 is a composite sample of the minus 1-inch plus 1/4-inch material in the stock-pile at the water's edge.
Sample 60-3 is a composite sample of the minus 1/4-inch material from the stock-pile.
Sample 61-1 is a composite grab sample from an inactive quarry 500 feet west of the present operation.
Sample 61-2 is a composite chip sample taken across a 70-foot width in a north-south direction at the west end of the present quarry. This composite sample includes some of the soapstone from a a sheared zone exposed in the west wall.
Sample 61-3 is a composite chip sample across a 125-foot width in a north-south direction at the east end of the present quarry operation.
Sample 61-4 is a composite chip sample taken over a length of 1,000 feet along the hill top behind the quarry face being worked at present.

(4) Cosby and Delamere Townships, Sudbury District

Hills of white quartzite standing up from 100 to 300 feet in relief above the surrounding country occupy an area of approximately 5 square miles in the western part of Cosby township and the eastern part of Delamere township, district of Sudbury. The quartzite outcrops on the road from Noelville to French River station. Rutter station on the C. P. R. line to Sudbury lies 5 miles to the west.

This area of quartzite, tentatively correlated as Lorrain in age by T. T. Quirke, differs from the other Lorrain quartzites examined in its very coarse texture. The rock is a glassy, coarse-grained, recrystallized, white to pink quartzite with grains up to 5 mm. in diameter. Secondary sericite and specularite are developed in many places throughout the formation. The bedding is nearly vertical in most places examined.

A small quarry was opened half a mile north of the Noelville road on the east side of the quartzite range, but only test shipments were made.

Three analyses of quartzite from Cosby township gave the following results:-

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
42	98.07	1.00	0.40	0.05	0.06	0.06	0.06	< 0.50
44	96.98	1.76	0.75	0.05	0.03	0.09	0.04	< 0.50
45	98.09	0.37	1.09	0.01	0.02	0.08	0.04	< 0.50

Sample 42 is a composite chip sample taken over a 350-foot width across the strike of the quartzite just north of the Noelville road in the southern part of Cosby township.
Sample 44 is a composite chip sample taken over a 700-foot width across structure on a quartzite ridge immediately north of the schoolhouse in Cosby township on the Noelville road.
Sample 45 is a composite grab sample from the small quartzite quarry half a mile north of the main road, Cosby township.

(5) Bar River Area, Laird Township

The belt of Lorrain quartzite previously mentioned as running from Echo bay to Thessalon, district of Algoma, has been quarried near Bar River station on lots 2 and 3, concession VI, in Laird township. The quarry, which was operated in 1941-43, is located 1 mile east of Bar River station. The rock is a greyish-white, fine-grained, sugary quartzite occurring in massive beds from 8 inches to 4 feet in thickness. The formation strikes N. 55° to 75° E. and dips 20° N. The quarry face has a height of approximately 40 feet and was opened on the north face of a ridge rising more than 100 feet above the present quarry floor. The crest of the quartzite ridge lies about 800 feet south of the present quarry face.

Some iron-staining, specularite, and soapstone were noted in the rock, but no diabase dikes are present. Microscopic examination shows that the rock is composed of inter-locking grains of quartz averaging about 0.8 mm. in size, but showing a considerable variation in grain size from 0.1 to 2.0 mm. Dusty inclusions outline the original rounded quartz grains. The quartz shows little or no evidence of strain.

An analysis of a chip sample taken across the 40-foot section exposed in the south face of the quarry gives the following results:-

SiO_2	98.89
Al_2O_3	0.59
Fe_2O_3	0.08
CaO	0.02
MgO	0.01
TiO_2	0.05
Na_2O	0.06
K_2O	0.50

(6) Bellevue Area, Deroche Township

Hard white quartzite, which is correlated by McConnell as Lorrain in age, forms several ridges in the Sault Ste. Marie area. The most important of these is the Bellevue ridge, a narrow, 6-mile, closely folded syncline of Lorrain quartzite, which extends in an east-west direction across the southern part of Deroche township and westward for a mile into Van Koughnet township.

The quartzite is intruded by granite and diabase and is completely recrystallized.

Bellevue Quarry.-Wright and Company operated a small quarry in the Lorrain formation of the Bellevue ridge at mileage 19.8 on the Algoma Central railway. This quarry supplies crude mine-run quartzite to the Algoma Steel Corporation for the manufacture of silica brick.

At the quarry the quartzite strikes northeast and dips 50 degrees to the north west. The rock is grey or pink in colour and contains scattered patches of specularite. Ripple marks and cross-bedding can be seen on the ridge above the face of the opening. Quartzite breccias and quartz conglomerates were also noted. At the east side of the quarry, sericite soapstone is developed along a sheared zone striking N. 10° W. and dipping 50° W.

This quarry has recently been taken over by Algoma Steel Corporation.

The following table gives the results of analyses of composite chip samples of quartzite from the Bellevue quarry:-

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
70-1	97.87	1.36	0.22	0.02	0.03	0.14	0.06	<0.50
70-4	98.69	0.63	0.20	0.05	0.03	0.05	0.05	<0.50
706-1	97.69	1.32	0.46	0.10	0.03	0.05	0.05	<0.50
706-2	98.43	0.51	0.60	0.04	0.02	0.05	0.05	<0.50

Sample 70-1 is a chip sample taken over a width of 300 feet across structure on the quartzite ridge overlooking the quarry.
Sample 70-4 is a chip sample across the top of the quarry face.
Samples 706-1 and 706-2 are composite grab samples from the muck-pile in the quarry.

Grenville Quartzite

The Grenville series of Southeastern Ontario contains a number of quartzite members. Very little quantitative date is available on these quartzites, but in general they are too impure to be used as a source of high-grade silica.

Quartzite from the Actinolite-Cloyne area is reported by Miller and Knight [7] to "be made up of interlocking grains of quartz, together with subordinate sericite, iron oxides and a little iron pyrites." A chemical analysis of this rock indicates 87.05 per cent. silica; 3,28 per cent. iron oxides; 5.52 per cent. alumina; 0.10 per cent. lime; 0.34 per cent. magnesia; 0.83 per cent. soda; 1.50 per cent. potash; 0.10 per cent. sulphur; and 1.55 per cent. water.

In a report on the geology of Leeds county, M. B. Baker [8] describes the Grenville quartzites and gives an analysis of the quartzite as follows:-

SiO_2	98.14
CaO	0.35
Al_2O_3	0.88
Fe_2O_3	0.41
	99.78

He remarks that this quartzite would be suitable for the manufacture of silica refractories.

Potsdam Sandstone

Fig. 2 shows the distribution of Paleozoic sandstones in southern Ontario.

The Potsdam sandstone has recently been described by M. L. Keith [1] in a report entitled "Sandstone as a Source of Silica Sands in Southeastern Ontario," and the following information on the Potsdam sandstone is largely taken from Keith's report, to which the reader is referred for further details.

The Potsdam sandstone is the lowermost Paleozoic rock in Southeastern Ontario and rests with unconformity on the eroded surface of the underlying Precambrian. It outcrops in numerous places in the Kingston-Perth area (see map No. 1946-9, accompanying Keith's report) and in the Ottawa area (Alice E. Wilson, Geol. Surv. Can., map No. 588A, 1940). In the Ottawa area Alice E. Wilson, of the Geological Survey of Canada, uses the term "Nepean" for this formation. In this report the term Potsdam is used to refer to all these sandstones, following the nomenclature of M. L. Keith.

The Potsdam formation is a buff to white, sugary-textured, flat-bedded sandstone of high purity. Texturally it consists of an aggregate of subrounded to angular individual grains of quartz poorly cemented together by silica cement. Owing to its lack of coherence in most occurrences it is easily broken down on milling into a silica sand with very little crushing of the individual grains. Some of the Potsdam sandstone is hard, compact, and quartzitic and is unsuitable for the production of silica sand.

In some areas the sand has a calcareous or argillaceous bond instead of silica. In other places the sandstone contains black carbonaceous material.

Chemically the sandstone runs from 98 to more than 99 per cent. silica; the following analyses of the Potsdam sandstone are taken from Keith's report [1] (pp. 14, 16, 19, 23, 24, 26).

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	S	Loss on Ignition
Average of 12	98.61	0.47	0.15	0.10	0.13	0.05	0.02	0.35
Kingston Silica	98.03	1.00	0.26	0.06	0.12	0.06	0.01	0.36
Hart Road	99.40	0.30	0.13	0.13	0.00	0.00	0.01	0.07
Charleston Lake	99.07	0.32	0.10	0.07	0.12	0.07	0.03	0.24
Newboro	99.19	0.33	0.04	0.08	0.04	0.05	0.03	0.22
"	99.00	0.29	0.13	0.08	0.06	0.05	0.02	0.16
"	98.41	0.54	0.19	0.06	0.39	0.07	0.03	0.53
Battersea	98.21	0.50	0.14	0.07	0.11	0.02	0.05	0.46
Opinicon lake	99.04	0.65	0.03	0.04	0.07	0.03	trace	0.22

Alumina ranges from 0.3 to 1.0 per cent.; total iron, from zero to 0.4 per cent.; lime is low; and alkalis are generally absent. The iron is usually present as hematite or limonite coating the quartz grains or in the intergranular cement, and much of it can be removed during disaggregation and washing of the sand.

On disaggregation the bulk of the grains (80 to 98 per cent.) are between 28 and 100 mesh with an average A. F. A. fineness number of 56.

As quarried at the property of Kingston Silica Mines, Limited, at Joyceville, the sand is too high in iron for the glass trade.

Beneficiation tests, however, which were conducted by the Industrial Minerals Division of the Mines Branch at Ottawa have indicated that the iron content could probably be reduced from 0.32 to 0.06 per cent. by a process of dry milling.

Kingston Silica Mines, Limited.

Kingston Silica Mines, Limited, operates a sandstone quarry and plant on lots 13 and 14, concession V, Pittsburgh township, Frontenac county, near the village of Joyceville on the Rideau canal, 12 miles northeast of Kingston.

The Potsdam sandstone quarry has a 15-foot face. Eighteen-foot holes are drilled vertically by wagon drill. The rock is loaded by a 1-cubic-yard gasoline shovel into trucks and hauled to a 30- by 30-inch impact crusher in closed circuit with a 1-inch screen. This crusher produces minus 1-inch material which is stock-piled at the mill. Owing to the poor coherence of this sandstone much of the material is reduced to a sand in this initial crushing stage.

The flow sheet for the mill is given in Keith's report [1] (p. 28). This scheme is now somewhat modified, the impact crusher replacing the jaw crusher, and a rod-mill replacing the rolls. After screening, the sand is classified in two hydraulic classifiers. The sand is dewatered in a Rotascoop dewatering cone, drained, and stored in bins.

During the summer of 1950, Kingston Silica Mines opened a new quarry 10 miles east of Kingston on No. 2 highway on the north shore of the St. Lawrence river, lots 29 and 30, concession III, Pittsburgh township. This sandstone contains more carbonaceous material, but the grains appear to be better rounded and less pitted than the Joyceville material.

Nepean Township, Carleton County

The Nepean sandstone outcropping near Bell's Corners in Nepean township, Carleton county, has long been worked as a building stone, Campbell Sandstone Quarries operate a quarry on lot 3, concession II, Nepean township, for the production of building stone and silica rock for cement.

In December, 1950, a test shaft was sunk to a depth of 100 feet on lot 5, concession II; Nepean township, to test the very pure basal beds of the Nepean sandstone as a possible source of glass sand. A bulk sample was taken in January, 1951, and is being tested. This work is being carried out under the direction of F. W. Huggins, of Ottawa.

Medina Sandstone

The Medina sandstone of lower Silurian age outcrops near the base of the Niagara escarpment in Lincoln, Wentworth, Halton, and Peel counties from Lewiston on the Niagara river westward to Dundas, thence northward to Orangeville. The Whirlpool sandstone member ranges in thickness from 8 to 25 feet and is a medium- to fine-grained, grey, white, red, or gray and red mottled sandstone. Bedding is often irregular, and the cross-bedding and lensing of the sandstone make quarrying difficult in many places.

The Medina sandstone is not of sufficient purity to constitute an important source of high-grade silica sand. It is an attractive building stone, and a number of quarries are operated for building stone near Inglewood and Georgetown in Halton and Peel counties. The William R. Barnes Company, Limited, of Waterdown, quarries this sandstone for use as silica grits and silica ganister for lining cupolas and ladles in grey iron foundries.

Cole [2] gives an analysis of Medina sandstone from the Milton area as follows:-

SiO_2	91.9
Fe_2O_3	0.45
Al_2O_3	3.65
CaO	1.70
MgO	0.22
Loss on Ignition	0.90

Oriskany Sandstone

The only sizable deposit of Oriskany sandstone in Ontario is located in North Cayuga and Oneida townships, Haldimand county, 4 miles west of the town of Cayuga. The sandstone underlies an area of approximately 1 1/2 square miles and has a maximum thickness of about 20 feet.

It is a medium to coarse-grained, well-rounded, friable white sandstone poorly bonded by a lime cement. Cole [2] gives analyses of this sandstone: silica ranges from 79.2 to 98.78 per cent.; alumina, from 0.08 to 0.61 per cent.; iron oxide, from 0.15 to 0.49 per cent.; lime, from 0.04 to 10.20 per cent.; magnesia, from 0.10 to 1.16 per cent.

The Oneida Lime Company operated a quarry on lot 49, concession I, Oneida township, from 1912 to 1918 and produced glass and foundry sand. Pilkington Brothers produced some glass sand from this Oriskany deposit during the same period.

Springvale Sandstone

A sandstone deposit in lot 6, concession XIV, Walpole township, Haldimand county, near the village of Springvale, consists of flat-lying, thin-bedded, white, sugary, medium-grained sandstone bonded with a lime cement. A small quarry was opened in this formation by the William R. Barnes Company, Limited, for foundry sand. The upper surface material is leached of lime cement and provided a good silica sand. Fresh, unleached material proved to be much less friable than the surface material and the quarry was closed.

Sylvania Sandstone (9)

The Sylvania sandstone of Devonian age, which is the silica sand horizon quarried at Rockwood, Mich., is a pure white incoherent aggregate of quartz grains. From the outcrop in Michigan this formation dips eastward and is present in Ontario in the subsurface but does not outcrop.

Information from drilling indicates that the Sylvania sandstone underlies part of the north-western part of Essex county but pinches out to the east, south of Lake St. Clair. Other sandstones occur at various places in the Detroit River-Onondaga section in Southwestern Ontario but are probably not correlated with the Sylvania.

In Anderdon and the Sandwich townships, Essex county, the Sylvania sandstone has a thickness of from 60 to 75 feet. A well in Anderdon township located the top of this sandstone at a depth of 150 feet.

This potential glass sand horizon would require under-ground mining, and the prospects for its economic development are poor at present.

Unconsolidated Sands

Most of the unconsolidated sand deposits in Ontario are of Pleistocene and Recent age and are usually impure.

Campement d'Ours Island.

A small deposit of coarse-grained silica sand occurs on the southwest shore of Campement d'Ours island near Sault Ste. Marie. It was probably derived by the weathering of the Lake Superior sandstone of the Sault area. Analyses of this sand by the Provincial Assayer show the following results:-

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
1	99.26	0.24	0.06	0.02	0.02	0.05	0.05	< 0.50
2	99.09	0.34	0.09	0.02	0.02	0.09	0.05	< 0.50

Unconsolidated beds of silica sand are associated with Cretaceous fire clay in the James Bay lowland.

Pegmatitic and Vein Quartz

Granite pegmatites mined for feldspar usually have considerable tonnages of quartz mined as waste. Owing to the low price for quartz, which is commonly in the neighbourhood of $2.50 to $3.50 per ton f. o. b. plant, it is not usually economically feasible to market the quartz at a profit. Some quartz is sold as flux.

For similar reasons vein quartz cannot be mined at a profit as a source of silica.

GRADE AND EVALUATION OF SILICA DEPOSITS

As pointed out in a previous section the specifications for silica vary greatly depending on the consumers' requirements. But one of the most important factors in evaluation of a silica deposit is its location. Being a low-priced, high-tonnage type of operation, the deposit must be located where cheap transportation to large markets is available.

The ease of mining, type of mining to be employed (i. e. underground as against open pit), and the size of the deposit, its uniformity and potential reserves, merit initial consideration. Other determining factors are the character of the rock, whether sandstone or quartzite, its texture, grain size, grain shape, grain size distribution, toughness of grains, and coherence of grains.

Most consumers have very definite limits of tolerance for impurities. In the glass and ceramic industries, for example, the percentage of iron oxide is important. If this is too high it may be possible to reduce the iron content to the permissible range by processes of beneficiation, such as air classification, washing, acid leach, etc. If beneficiation is necessary, however, a close examination of costs must be made to ensure that the price of the final product is still within a competitive range for the proposed market.

MINING, MILLING, AND BENEFICIATION

All the silica deposits being worked in Ontario at the present time employ open pit quarry methods. The length and height of quarry face depend upon the size of the deposit, the size of the operation, the lithological character of the rock, the attitude of the bedding, and the mining methods to by employed. Wagon drills drilling vertical holes with a 15- to 20-foot quarry face are used at the Kingston Silica operation. At Sheguiandah, where the quarry face is a nearly vertical bedding plane, wagon drills drill flat-holes from the quarry floor. Churn drills are used to break large tonnages very economically at the Lawson quarry, where a 40- to 50-foot face is worked. At the Killarney quarry, the Coyote method of tunnel-blasing is used to break very large tonnages of rock on an 80- to 100-foot face. Better control of fragmentation and low costs for secondary breaking are obtained when breaking is done on faces of low to moderate height. Secondary breaking is done in some cases by a heavy steel drop ball on a boom-derrick. At the St. Lawrence Alloys and Metals quarry near Beauharnois, Que., jet-piercing is being used for "drilling" holes.

Loading is done by gasoline, Diesel, or electric shovels. Rail haulage is employed in one quarry, truck haulage in all others. Primary crushing is done by jaw or gyratory crushers. Since the silica rock is extremely abrasive, wear is rapid and consideration should be given in choosing a primary crusher to the costs of changing the crushing surfaces. Surfaces can be built up by surface welding.

Where the material is a sandstone of poor coherence, as at the Kingston Silica Mines property, an impact crusher of the hammer mill type will reduce much of the rock to a sand product in one stage.

Where fine grinding is necessary to produce a sand or flour product, dust becomes a serious problem. The Aerofall mill, which may employ the rock itself as the grinding medium, offers encouraging results for fine grinding. Air classification is employed in this dry-milling circuit.

Where the silica sand is beneficiated by washing, hydraulic classification is frequently used. Further removal of iron oxides may be accomplished by acid leaching. When wet milling is employed, the cost of drying, particularly in the fine sizes, will be appreciable.

MARKETING SILICA

The following companies produced silica in Ontario in 1950:-

Canadian Silica Corporation, 100 Adelaide Street West, Toronto,
Dominion Mines and Quarries, Ltd., Little Current.
International Nickel Company (Lawson quarry), Willisville.
Kingston Silica Mines, Limited, R. R. 6, Kingston.
Algoma Steel Corporation (Bellevue quarry), Sault Ste. Marie.
William R. Barnes Company, Ltd., Waterdown.

Sand for flux was also produced by the International Nickel Company and the Falconbridge Nickel Company for their own use.

The total production 1949 amounted to 1,404,140 tons, valued at $1,020,411.

Imports and exports of silica into Canada in 1948 were as follows:-

Material	Tons	Value
IMPORTS		
Ground flint stone	739	$ 25,749
Ganister	230	1,312
Silica sand for manufacturing	584,019	1,446,624
Silex or crystallized quartz	17,473	168,827
Silica firebrick		1,211,511
EXPORTS		
Quartzite	228,100	494,284

Available statistics on the consumption of silica sand and ground quartz in Canada in 1947 supplied by the Dominion Bureau of Statistics are as follows:-

By Industry	Tons
Paints, pigments and varnishes	1,886
Soaps and cleansers	4,396
Clay products	5,861
Asbestos products	87
Miscellaneous non-metallics	6,260
Roofing paper	1,710
Glass	172,859
Artificial abrasives	90,716
Fertilizers	69,669
Iron castings	4,603
Cooking and heating apparatus	2,111
Boilers, tanks, and plate work	65
Farm implements	1,324
Railway rolling stock	1,763
Matches	471
Disinfectants	12
Sweeping compounds	63
Primary iron and steel	51,986
Heavy chemicals	30,152
Miscellaneous chemicals	166
Stone products	549
Machinery	1,324
Electrical apparatus	550
Cement manufacturing	36,223
Cement products	701
Misc. iron and steel	33
Total	485,540

Current prices for silica products quoted from Metal and Mineral Markets, of December 7, 1950, are as follows: Water-ground and floated, in bags. f. o. b. Illinois: 325 mesh, 92 to 99 1/2 per cent. SiO_2, $21 to $40 per ton.
Dry ground, air-floated, in bags, f. o. b. Illinois: 325 mesh, 92 to 99 1/2 per cent. SiO_2, $18 to $30 per ton.
Glass sand, f. o. b. plant, $1.25 to $5.00 per ton.

With the current freight rate of $5.71 per ton from Ottawa, Ill., the price of glass sand laid down in Toronto would therefore range from $6.96 to $10.71 per ton depending on grade.

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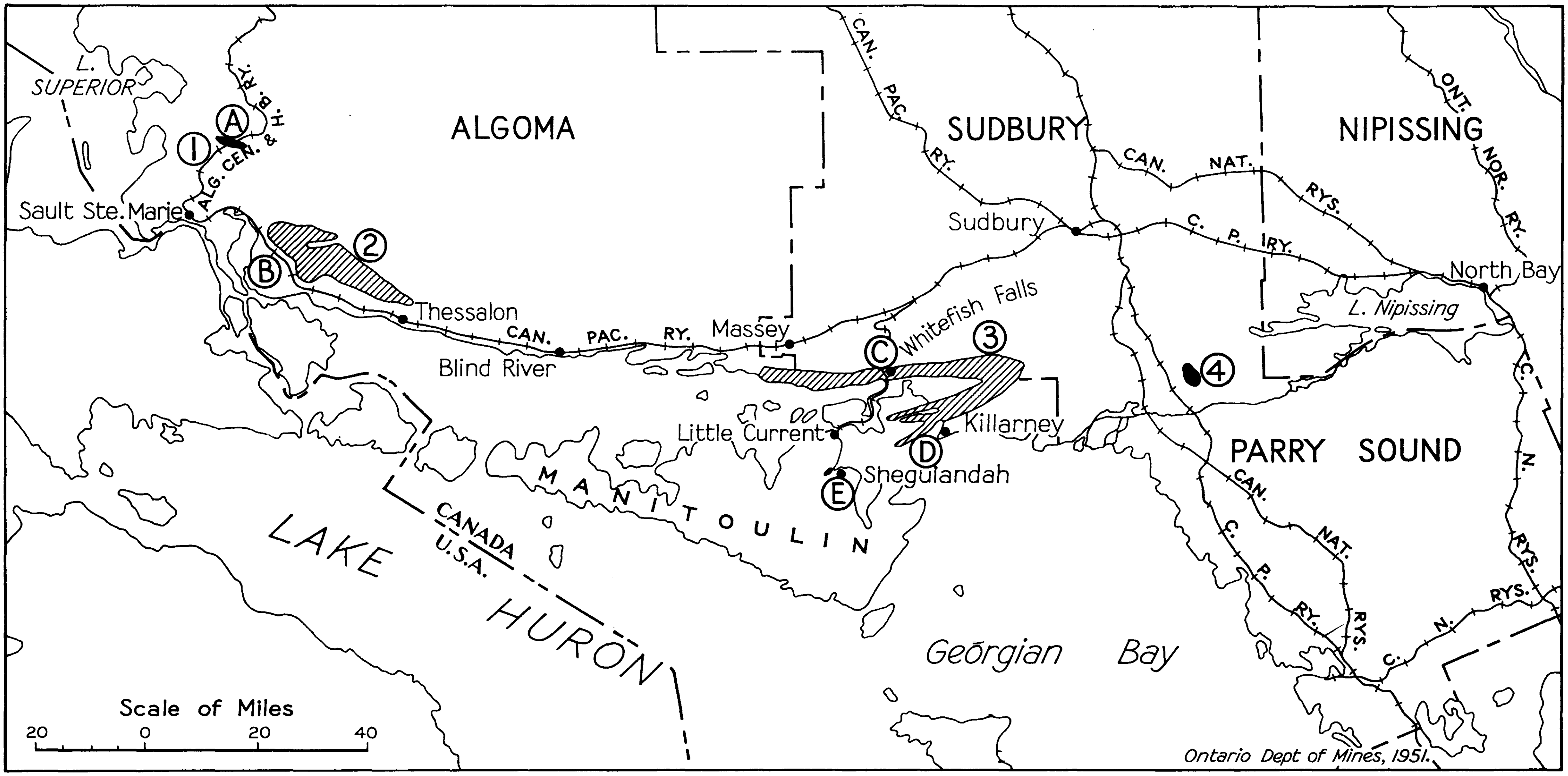

① Bellevue area, Deroche township.
Ⓐ Bellevue quarry.
② Bar River, Thessalon area.
Ⓑ Bar River quarry.
③ Whitefish Falls – Killarney – Sheguiandah area.
Ⓒ Lawson quarry.
Ⓓ Killarney quarry.
Ⓔ Sheguiandah quarry.
④ Cosby – Delamere area.

Fig. 1.

DISTRIBUTION OF LORRAIN QUARTZITE

Along the north shore of LAKE HURON, ONTARIO.

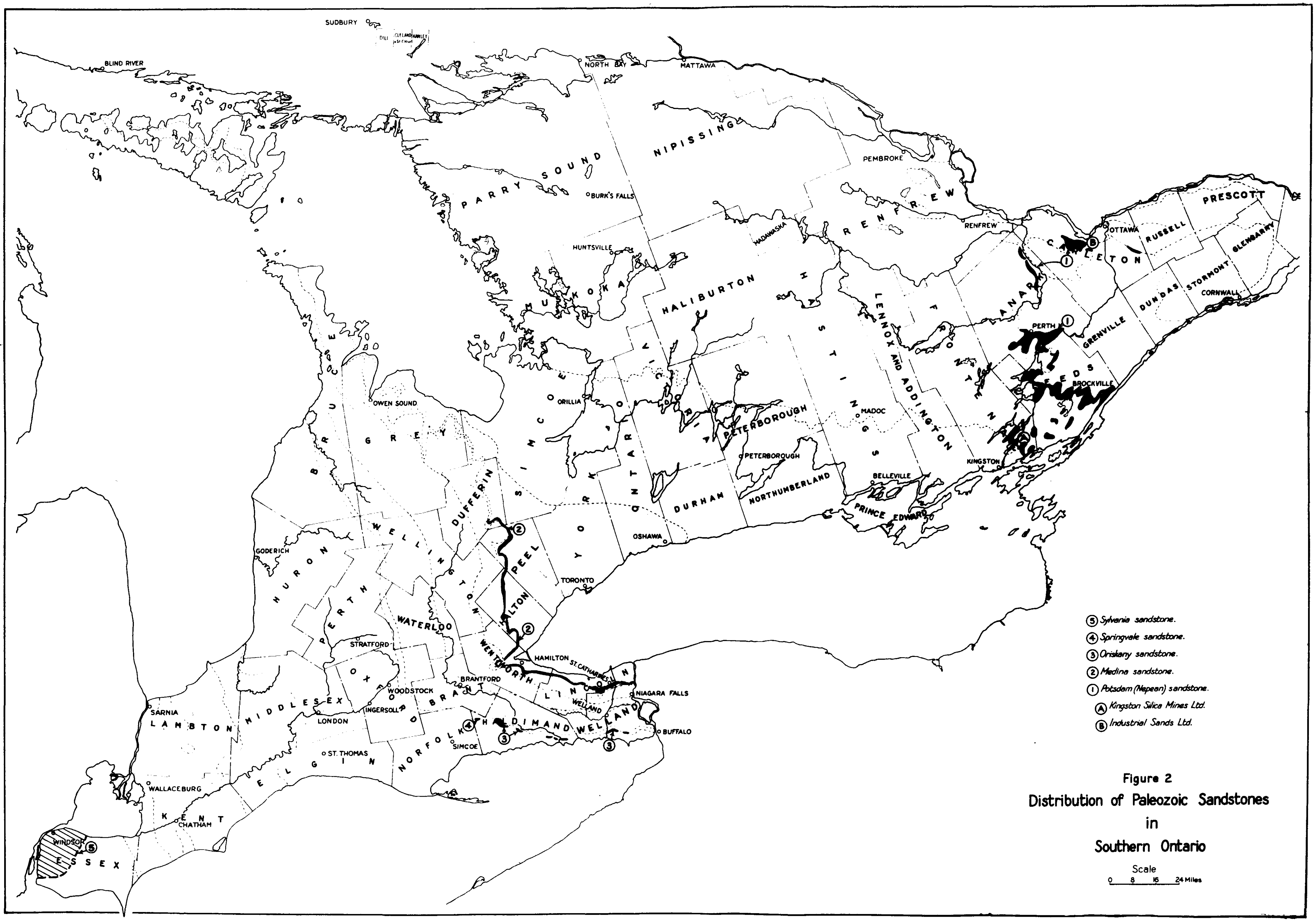

Figure 2
Distribution of Paleozoic Sandstones
in
Southern Ontario