CANADA
DEPARTMENT OF MINES
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MINES BRANCH
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Silica in Canada

Its Occurrence, Exploitation, and Uses

Part II—Western Canada

BY

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CONTENTS

ILLUSTRATIONS

Photographs

Drawings

Silica in Canada

Its Occurrence, Exploitation, and Uses

PART II

WESTERN CANADA

INTRODUCTION

The report on Silica in Eastern Canada, which forms Part I[1] of the series, was issued in 1923 and deals with occurrences in eastern Canada as far west as Fort William, Ont.[2] Part II of the series covers the territory from Fort William, Ont., to the Pacific coast of British Columbia. The field work in connexion with the present report was carried on in conjunction with other work during parts of the field seasons of 1925 and 1926. It will be understood that in a report of this nature only typical deposits can be dealt with, and descriptions of many occurrences are necessarily omitted. It is hoped, however, that the results given will add to the knowledge not only of the deposits described but also of the other known occurrences, as well as those which may be discovered later.

Since writing Part I, many changes have taken place in the silica industry in eastern Canada. In order to bring the information up to date in published form an article, "Recent Developments in the Silica Industry in Eastern Canada," is attached to this report as Appendix I.

Acknowledgments

The thanks of the writer are extended to the owners of the many properties examined for courtesies shown; also to Messrs. Ommanney and Lumsden of the Canadian Pacific Railway Development Branch, for valuable data furnished. Mr. W. Hastings, Mining Engineer of the Saskatchewan Government, has kindly furnished samples and information concerning the sand in northern Saskatchewan. A number of the tests on sands and pebbles referred to in this report have been carried out in the Ore Dressing Laboratories of the Mines Branch in co-operation with R. K. Carnochan. The section on the bituminous sands of northern Alberta is a compilation of extracts from S. C. Ells' report[3] on that subject, while data and samples on the quartzite and silica sands of Nova Scotia were furnished by M. F. Goudge of this Department.

The cordial co-operation of these gentlemen is greatly appreciated.

[1] "Silica in Canada: Part I, Eastern Canada"; Mines Branch, Dept. of Mines, Rept. 555 (1923).

[2] This report also includes chapters on the mineralogy, technology, methods of exploitation, and uses of the various forms of silica.

[3] Ells, S. C.: Bituminous Sands of Northern Alberta, Mines Branch, Dept. of Mines, Canada, Rept. No. 632 (1926).

CHAPTER I.

STRUCTURAL AND GEOLOGICAL FEATURES OF THE VARIOUS FORMATIONS IN WESTERN CANADA IN WHICH POSSIBLE COMMERCIAL DEPOSITS OF SILICA OCCUR

Silica occurs in western Canada in the form of quartz, quartzites, sandstones, quartz or quartzite pebbles, sand, and diatomite. The more important localities were visited and representative samples obtained. It should be remembered, when reading this chapter, that the individual deposit described is not necessarily the best to be found in a district. In covering such an extensive territory as western Canada in which the silica deposits are so widely separated it was only possible to select certain typical deposits which might reasonably be expected to be representative of the different formations. A general description is therefore given of the several formations in each province in which commercial types of silica occur before referring to the individual localities from which the samples were taken.

MANITOBA

Deposits of silica in various forms are known to occur in Manitoba, some of which have already been worked to a small extent. The geological formations in which these deposits are found will be briefly described.

Recent Sands

Sands of Recent age, such as beach sands, occur in many parts of the province. Some of these run high in silica, although it is doubtful if any of those so far known are of sufficient purity to be utilized for glass-making. The purest of these sands are found mainly in the vicinity of the sandstone outcrops which occur on Black island, Punk island, and Grindstone point in lake Winnipeg, from which sandstone they are undoubtedly derived. The available quantity in such deposits is seldom very large and it is doubtful if they will ever be utilized. The possibility, however, exists of finding a deposit in which the sand has been so intermixed with small quantities of refractory clay as to make it suitable for a natural-bonded moulding sand, and this point should not be overlooked in examining sands of this nature. These sands, where examined, showed well-rounded quartz grains of fine texture with a large quantity of fines.

Pleistocene Sands

Many fluvioglacial sands and gravel deposits (eskers), formed by subglacial rivers as they emerged from the ice-sheet, contain sands of high silica content. However, the sands are liable to be also high in lime, and unless some cheap method of beneficiating them can be employed they are not likely to be extensively utilized. These sands show diagonal bedding in places and as they may rapidly change from sand to gravel, it is hard to make definite estimates as to quantities available. A good example of such a deposit is the one at Beauséjour, the sand from which was at one time employed in the manufacture of cheap grades of green, bottle glass as well as sand-lime brick.

"Dakota" Sandstone

According to Wallace[1] "Dakota" [so-called[2]] sandstone is exposed on the banks of the Red Deer, Armit, Kamatch, Swan, and Carrot rivers, and at Kettle hill on Swan lake. It was laid down on an eroded and irregular floor of Devonian rocks (Manitoban limestone) and its thickness varies to a marked degree. The estimate given (200 feet) is probably the upper thickness of this formation. It consists of white or reddish sand grading up into green sandstone and shale, the lower sands in several exposures being quite unconsolidated. The sandstone may weather, as on Kettle hill, into round boulder-like masses. It is very friable, but not easily accessible and is of no immediate importance, the most promising locality, namely that at Swan lake, being far from present rail transportation.

Winnipeg Sandstone

Probably the most promising sources of high-grade silica in the province are the Winnipeg sandstones of Ordovician age which outcrop on a number of islands in lake Winnipeg, notably Elk, Black, Deer, and Punk islands; on Grindstone point; and along the shore of Washow bay west of Anderson point; as well as on the shores of Simonhouse lake, south of the Cranberry lakes on Grass river. The formation is an unconsolidated, or loosely consolidated, sand, in many places heavily stained to a red or chocolate colour by iron with a little clay, but otherwise practically pure. Many exposures contain sand very white in colour which could be excavated without much danger of contamination from the heavily iron-stained beds. The sandstone grades upwards into a more argillaceous phase, and clay bands, up to 3 feet in thickness, are encountered in places towards the top of the formation. According to Wallace[3] the sandstone varies in thickness from 100 feet to a few inches, the thickness depending to a great degree on the inequalities of the Precambrian floor. In some exposures, notably at Grindstone point, the sandstone is overlain by massive beds of limestone. The sand is in most cases very fine in texture, a large percentage (probably as high as 30 per cent in some cases) being finer than the 100 mesh. In no case was a conglomerate base noted and the texture seems to be very uniform throughout the deposits.

Precambrian Quartz and Quartzite

Quartz veins and quartzites are known in many parts of the Precambrian areas of the province and these may possibly become a source of silica in the future. In this connexion the numerous pegmatite dykes are of interest since in many of them the constituent minerals are usually so coarsely crystallized as to allow hand-sorting of the different minerals. From this source therefore it is possible that appreciable tonnages of clean quartz of a high degree of purity may be obtained.

[1] Wallace, R.C.: "The Geological Formations of Manitoba"; Natural History Society of Manitoba, 1925, p. 29.
[2] It is now known that the formations in Canada formerly called Dakota are of more recent age.
[3] Op. cit., p. 16.

SASKATCHEWAN

Pleistocene Sands

The retreat of the ice-sheet during late Pleistocene times left many deposits of sand and gravel in the form of huge morainic areas and an examination of some of the sand hills in these morainic belts show that they are largely composed of silica. However, they are seldom pure white, ranging in colour from reddish to yellowish and often grey. Impurities are present in the form of hornblende, garnet, feldspar, and both white and black micas. The Great Sand hills, to the north of the main line of the Canadian Pacific railway, between Gull Lake and Maple Creek, are good examples of such deposits. It is improbable that they will ever furnish high-grade silica sand.

Whitemud Beds

In the southern part of Saskatchewan white sands and sandy clays were noted by Davis[1] during his investigation of the clay resources of the province. These sands are associated with refractory clays. Dyer[2] who examined these beds during the summer of 1926 refers to them as follows:—

> The Whitemud beds consist of light grey clays and sands which on exposure weather pure white. They contain the refractory clays which have been used with success to make firebrick at Claybank. The typical white part of the beds is not as a rule more than 20 feet thick, but if certain grey clay beds overlying them be included the thickness in places would be 50 feet. The white beds are always of sand in their lower part and of clay in their upper part; at certain localities the two parts grade into each other, and at others they are separated by a carbonaceous band 6 inches to 1 foot thick. The Whitemud formation is probably of Lance age as Sternberg has reported finding the remains of "Triceratops," a typical Lance dinosaur, in beds which he considered Whitemud. The Whitemud beds are found at many points in Cypress hills and Wood Mountain plateau where they can be very quickly detected on account of their pure white colour.

Localities may be found where the sand in this formation will have a high silica content, but judging from the several samples examined they are liable to contain rather high percentages of impurities. For example, a typical argillaceous sand from township 8, range 29, west of the 2nd meridian, after having the clayey bond removed by washing, was dirty grey in colour due to the presence of an appreciable number of dark green and black grains of hornblende and pyroxene. It also contained a considerable percentage of pink feldspar, both fresh and partly kaolinized, and was non-calcareous. The sand particles were all angular and fine in texture, the greater percentage of them passing through a 65-mesh screen.

"Dakota" Sandstone

Beds of sandstone of "Dakota" age have been noted in the northern part of Saskatchewan. According to McInnes[3] these Cretaceous beds, notably along the south shore of Wapawekka lake, are made up mainly of white quartz sands and sandstones, very free of impurities.

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[1] Davis, N. B.: "Clay Resources of Southern Saskatchewan"; Mines Branch, Dept. of Mines, Canada, Rept. No. 468 (1918).
[2] Geol. Surv., Canada, Sum. Rept., 1926, pt. B, p. 33.
[3] Geol. Surv., Canada, Sum. Rept., 1909, pp. 151–157.

ALBERTA

Conglomerate and Pebble Beds

A conglomerate bed of Oligocene age occurs in a number of localities in the western part of Saskatchewan and also in certain parts of Alberta. The most notable occurrence is on the top of the Cypress hills at their western end. The beds consist of great quantities of well-rounded water-worn pebbles mostly hard, greyish quartzites ranging in size from ½ inch up to 6 inches and more in diameter. In places these are well cemented but occasional beds are found in which the pebbles are distributed irregularly or arranged in layers and lenticular beds in the sands and sandstones.[1] That these beds were at one time of considerably greater extent is evidenced by the fact that unconsolidated layers of pebbles, undoubtedly derived from this formation, are widely scattered throughout the drift of the western part of the province.

Bituminous Sands of the McMurray Formation

Bituminous sands underlie a large area in the vicinity of McMurray, the northern terminal of the Alberta and Great Waterways railway, approximately 300 miles north of Edmonton. These beds are in some places of considerable thickness and the sand, which is of high silica content, is impregnated with bitumen, in some places as much as 20 per cent. Ells[2], who has made an extensive study of these sands, considers that there is a possibility of employing the waste sand, after the bitumen has been extracted, as a high-grade silica sand.

Pipestone River Sandstone

Sandstone of a high degree of purity occurs on the mountain range to the north of Pipestone river, approximately 22 miles north of Lake Louise station on the main line of the Canadian Pacific railway. The material is a fine-grained sandstone interbedded with a dolomitic limestone, probably of Upper Ordovician age. There is a great thickness of this sandstone, but no detailed examination has been made of this district to determine the extent of the beds or whether they are to be found at any point closer to the railway.

Blairmore Quartzites and Sandstones

Another locality which may possibly furnish material suitable for silica refractories is the district in the neighbourhood of Blairmore, Alberta. Leach[3] mentions Palæozoic rocks, including thin beds of quartzites, as forming the backbone of the Livingstone range and of Bluff and Turtle

[1] McConnell, R. G.: Report on Cypress Hills-Wood Mountain"; Geol. Surv., Canada, Ann. Rept., vol. I, pt. C., p. 69 (1885).
[2] Ells, S. C.: "Bituminous Sands of Northern Alberta"; Mines Branch, Dept. of Mines, Canada, Rept. No. 632 (1926).
[3] Geol. Surv., Canada, Sum. Rept., 1911, pp. 193–198 inc.

mountains. He also measured a section in the Kootenay formation on York creek near the fan house of the International Coal and Coke Company—

(Descending order)	Feet
1. Hard, siliceous cherty conglomerate	19
2. Hard, dark grey, thin-bedded sandstone	12
3. Partly covered, shaly sandstone and dark shale	36
4. Coal	16
5. Carbonaceous shale, thin beds of shaly sandstone and two thin coal seams (8 inches and 14 inches)	30
6. Coal	10
7. Thin-bedded shaly sandstone and grey and carbonaceous shale	55
8. Grey and brown shale	20
9. Hard, siliceous dark grey sandstone	38
10. Partly covered, carbonaceous shale, thin beds of shaly sandstone, and thin seams of coal (a 3-foot seam 50 feet from top)	165
11. Coal	8
12. Massive, rather coarse, greenish sandstone	41
13. Covered	40
14. Greenish, crumbly, thin-bedded sandstone	75
Total	565

Other sandstones were also noted by Leach[1] in the "Dakota" formation to which he gave the name "Allison Creek sandstones." The lower beds of these can be seen on York creek, about half a mile below the fan house, where about 150 feet are exposed. These sandstones are somewhat similar in appearance to the lower members of the Dakota, but are usually lighter in colour, more massive, and do not disintegrate so readily into crumbly, angular fragments.

BRITISH COLUMBIA

Diatomite

The only known deposits of diatomite in western Canada are in British Columbia and are of freshwater origin. These deposits occur either as dry massive beds high above the present water-levels, or on the bottoms of existent lakes or swamps. The former which are typical of the Quesnel deposits in central British Columbia extend over many square miles and are in places at least 60 feet thick. These diatomite deposits, which are by far the largest known in the Dominion of Canada, were laid down in the Tertiary period, and are underlain by tuffs and gravels, and overlain by porous basalt. In numerous places along the Fraser river in the Quesnel region, these beds have been disturbed by landslides, or are exposed on the steep banks of the rivers and creeks. The more recent deposits are found in numerous lakes and creeks in various parts of the province, particularly on Vancouver island and in the vicinity of Kamloops and Ashcroft.

A detailed monograph on diatomite describing the diatoms, Canadian and world's occurrences, uses and preparation, has been prepared by V. L. Eardley-Wilmot.[2]

[1] Op. cit p. 198.
[2] "Diatomite: Its Occurrence, Preparation, and Uses"; Mines Branch, Dept. of Mines, Canada, Rept. No. 691.

Flathead Quartzites

In the Flathead district of southeastern British Columbia, Mackenzie has mapped and described a sandstone formation which he has tentatively classified as Triassic, and which may possibly contain beds of material suitable for use as a silica refractory. Sufficient detailed examination, however, has not been made of these beds to enable their value to be definitely stated and they are only mentioned here as a possible locality for further investigation.

Mackenzie, in describing this formation, says in part as follows:—[1]

This formation is strikingly homogeneous wherever it has been observed; and it consists throughout of white or pale grey, very fine, even, compact sandstone....Where unweathered, the rock is pale grey, with a sub-vitreous lustre, simulating a quartzite. Weathering changes the colour to white or whitish-grey, streaked with rusty yellow; and some boulders are stained bright red and brilliant yellow. The rock is extremely hard and tough when fresh; but when weathered is softer, and in places is crumbly and friable, with a pitted surface as if from solution. The fragments observed by the unaided eye, or through a hand lens, are wholly quartz, and the cement is calcite. This is indicated by its manner of weathering and also by its general, slight effervescence in acid. A hand specimen held so that light is reflected from its surface reveals that the calcitic cement, where present, is in the shape of single, irregular crystals up to one-fourth of an inch across, enclosing a great number of clastic quartz grains.

Thin sections cut from two specimens typical of the formation were examined, and found to be so similar that one description suffices for both.

The minerals observed forming the fragments were almost wholly quartz, with very small amounts of chert, tourmaline, zircon, and muscovite; the cement is calcite and small amounts of impregnating pyrite are present.

The quartz, which forms about 98 per cent of the fragments, is mostly subangular, a few grains are rounded, and a very few well rounded. This is to be expected from the size of the grains which average 0·123 mm. The quartz is clear, and for the most part extinguishes sharply, though a few grains have a shadowy extinction.

It is possible that material from some of the siliceous beds of this formation may be suitable for silica refractories, but at present they are far from transportation.

Precambrian and Other Deposits

Many other formations in British Columbia, from the Precambrian up, contain silica beds or deposits in the form of quartzites, quartzes, and sandstones of varying degrees of purity. None of these have been operated as yet on any extensive scale.

[1] Mackenzie, J. D.: "Geology of a Portion of the Flathead Coal Area, British Columbia"; Geol. Surv., Canada Mem. 87 (1916).

CHAPTER II

OCCURRENCES OF SILICA IN WESTERN CANADA

Silica in many forms, such as quartz, quartzite, sandstone, sands, and diatomites, is found in western Canada. A few typical deposits will be described.

MANITOBA

Beauséjour Sand Deposit

LOCATION

An extensive deposit of sand occurs in the E. ½ sec. 35 and W. ½ sec. 36, tp. 12, range 7, east of the Principal Meridian, south of the Canadian Pacific Railway tracks at Beauséjour, and approximately 36 miles northeast of Winnipeg. A spur line connects the deposit with the railway. (*See* sketch map, Figure 1.) The village of Beauséjour and the station are less than half a mile from the pit.

TOPOGRAPHY

The country in the vicinity of the deposit is very flat-lying and most of the area is under cultivation. An interesting feature is the lack of surface contours which might indicate the presence of sand, there being little difference in elevation. It is not at all unlikely, therefore, that other deposits of a similar nature are buried beneath the drift which covers such large areas of the province. The deposit is probably of fluvioglacial origin (esker). There is very little overburden to be stripped, never more than 3 feet at the most.

DESCRIPTION OF DEPOSIT

The deposit was operated a number of years ago but at present it is closed down and is owned by the town of Beauséjour. A number of buildings are on the property together with some machinery but everything is in need of repair.

The pit is approximately 300 feet by 600 feet and excavated to a depth of 30 feet in places. The railway siding runs right down the centre of the pit.

The material is of fairly uniform grade throughout the pit on the faces exposed and consists of a well-rounded sand composed mostly of silica grains with an appreciable amount of other mineral grains, such as limestone, feldspar, hornblende, pyroxene, etc. Most of the grains are the natural grains and only a few particles were noticed which were conglomeratic. Although the banks stand up fairly well when first exposed, the sand is not in the least consolidated and can be excavated readily by shovel.

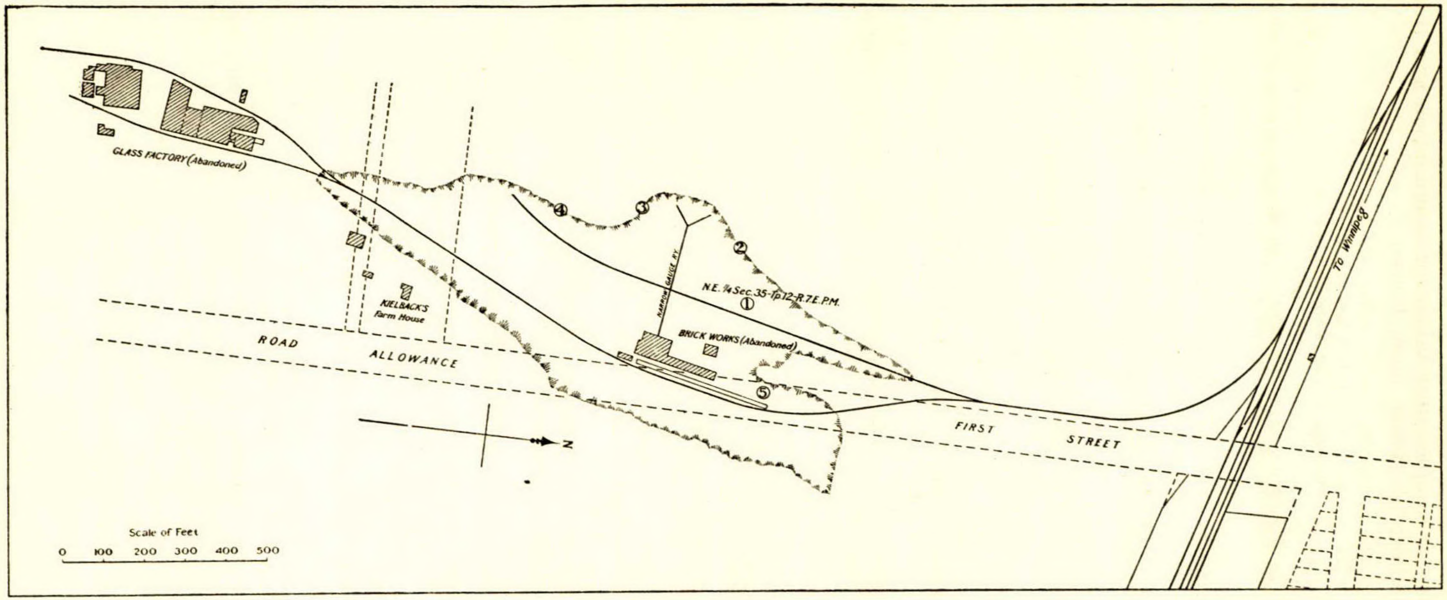

Figure 1. Sketch map of the Beauséjour sand deposit, Beauséjour, Man.

A number of samples were taken for examination and tests, from the localities as shown on sketch map, Figure 1.

Sample No. 1. Bottom of pit, 2 feet thick.
" 2. On edge of pit, near top.
" 3. " "
" 4. Half way down slope of bank.
" 5. On edge of pit at top.

When examined in the laboratory there was found to be very little difference in the character of the samples, so that the contents of the five bags were thoroughly mixed to make an average sample. This large sample (600 pounds) furnished the material on which all the tests were made. A sample of the original sand was prepared for analysis.

Test No. 1

In the first test 73 pounds were put through a small Richards classifier and the following products obtained:—

—		Per cent
Coarse (+ 12 mesh)	= 1·75 lb.	2·4
Coarse (− 12 mesh)	= 36·25 "	49·7
Fines	= 32·50 "	44·5
Loss (probably slimes)	= 2·50 "	3·4
	73·00 lb.	100·0

Screen analyses were made with the following results:—

Mesh	Original sand		Coarse—12 mesh		Fines	
	Per cent	Cumulative per cent	Per cent	Cumulative per cent	Per cent	Cumulative per cent
Retained on 14	2·92	2·92	1·64	1·64		
" 20	2·00	4·92	3·76	5·40		
" 28	4·22	9·14	7·94	13·34	0·20	0·20
" 35	15·06	24·20	31·56	44·90	1·02	1·22
" 48	28·26	52·46	36·82	81·72	20·14	21·36
" 65	25·42	77·88	12·34	94·06	42·76	64·12
" 100	12·78	90·66	2·30	96·36	16·62	80·74
" 150	5·24	95·90	3·30	99·66	13·22	93·96
" 200	1·70	97·60	0·20	99·86	2·90	96·86
Through 200	2·40		0·14		3·14	
Totals	100·00		100·00		100·00	

The chemical analyses were as follows:—

—	1	2	3	4	5
Silica (SiO_2)	78·51	86·12	76·30	89·34	89·60
Iron oxide (Fe_2O_3)	0·57	0·43	0·55	0·88	0·57
Alumina (Al_2O_3)	3·41	4·16	4·67	3·62	4·31
Lime (CaO)	7·84	3·69	8·84	2·88	2·32
Magnesia (MgO)	0·75	0·56	0·74	0·51	0·18
Alkalis (K_2O and Na_2O)	n.d.	n.d.	n.d.	0·77	n.d.
Loss on ignition	5·86	2·63	6·83	2·00	2·80
	96·94	97·59	97·93	100·00	99·78

1. Crude sand from 600-pound sample.
2. Coarse material, Test No. 1—12 mesh.
3. Fine material, Test No. 1.
4. Sample from sand sent to Dominion Glass Co., Redcliff, Alberta, March 10, 1914.
5. Sample from sand sent to Dominion Glass Co., Redcliff, Alberta, March 10, 1921.

These analyses show high percentages of lime, alumina, and iron. A microscopic examination of the original sand shows the presence of appreciable percentages of limestone, feldspar, and black iron-bearing minerals. Although washing, therefore, in a classifier removes a certain proportion of the lime in the fines, it does not decrease the iron or alumina content to an appreciable extent.

Test No. 2

To see whether the iron content could be lowered by removing some of the iron-bearing minerals, a small proportion of the sand, after removing all coarser than 20 mesh, was passed over a Wilfley table and the products examined under the microscope. While a small proportion of the heavier minerals was removed a considerable number of black grains were still left in the sand and considering the high cost of tabling it was thought unnecessary to carry this test any further.

Test No. 3

In order to determine whether violent washing would decrease the lime content, 1,013 grammes, together with pebbles and 3,000 c.c. water, were washed in a pebble mill for ½ hour, after which the sand was washed in a pail till clear by decantation.

Washed sand	=	902·0 grammes.
Washings	=	104·5 "
Loss in slimes	=	6·5 "
		1,013·0 "
CaO in washed sand	=	5·49 per cent.

Test No. 4

A weighed quantity (902·4 grammes) was calcined at a temperature of 990° C. There was a loss after calcining of 55·1 grammes.

The calcined material was slaked in boiling water and the lime washed out, after which the sand remaining weighed 740·5 grammes. The lime content of the sand, after calcining and slaking, was determined and found to be 0·80 per cent. This method materially reduced the percentage of lime in the original sample. A screen test on the calcined and washed material was run with the following results:—

Mesh	Per cent	Cumulative per cent
Retained on 14	0·46	0·46
20	0·80	1·26
28	2·70	3·96
35	15·20	19·16
48	30·51	49·67
65	26·13	75·80
100	13·65	89·45
150	9·05	98·50
200	1·04	99·54
Through 200	0·46	.....
Total	100·00	

Test No. 5

It was thought possible that a reduction in the lime content might be made by selective screening after washing. A sample of 1,000 grammes was washed in a manner similar to that used in test No. 3 and a screen analysis made, the lime being determined in the material retained on each screen.

Mesh	Per cent	Cumulative per cent	Per cent CaO
Retained on 28	2·03	2·03	39·11
35	0·90	2·93	1·72
48	16·60	19·53	1·95
65	39·81	59·34	2·52
100	23·11	82·45	5·39
150	9·19	91·64	6·43
200	4·33	95·97	8·45
Through 200	4·03	....	5·39
Total	100·00		

These results are interesting inasmuch as by selective screening, the lime content can be materially reduced. Thus, if the material, after washing, were passed through a 28-mesh screen and all finer than 100 mesh discarded, approximately 80 per cent of the sand would be recovered with a lime content of 3·21 per cent.

The results of these tests show that the sand can be improved to a certain extent by washing and selective screening, but that even after such treatment it still contains too high an iron content for any use in the glass industry, except for the manufacture of the cheapest grades of dark green bottles.

Black Island Sandstone

LOCATION

Black island is situated in lake Winnipeg, approximately 60 miles north of the southern end of the lake. It occupies portions of townships 25 and 26, ranges 7 and 8, east of the Principal Meridian.

TRANSPORTATION

Water transportation is the only means by which the sandstone can be placed on the market. The distance from the sandstone on the southeast shore of lake Winnipeg to Riverton, the terminal of the Winnipeg Beach branch of the Canadian Pacific railway, is 36 miles, while the water haul to Selkirk, on the Red river, is 80 miles.

TOPOGRAPHY

Black island is a narrow island 12 miles long and over 4 miles wide at its widest point. Its longest axis runs northeasterly and southwesterly. Its area is a little over 33 square miles.

The island is low-lying, probably no point being over 200 feet above the level of the lake. It is well wooded with spruce and is, in places, well covered with drift material consisting of loam, sand, and clay. In some places in the interior of the island it is swampy, the interior of the eastern half of the island being all swamp as indicated on Figure 2. Two small lakes occur in this swampy area. The rock outcrops on the eastern end of the island are all Precambrian. Towards the centre the sandstone outcrops along both shores; the western end is heavily drift-covered, but is believed to be underlain by Ordovician limestone.

Along the southeastern shore the banks rise gradually from the lake-level, but in many places where the sandstone is exposed the banks are quite steep, rising vertically from the shore at one place to a height of 70 feet. The ground on the top of these cliffs rises gradually for about one-half mile back from the shore.

Along the northwestern shore the banks are not so steep, rarely rising more than 25 or 30 feet above the lake-level. At most places the sandstone bank is from 100 to 150 feet back from the water-level, leaving a gradually sloping beach of fine white sand. Towards the western part of the sandstone exposure the shore is heavily strewn with chocolate-coloured sandstone blocks.

DESCRIPTION OF DEPOSITS

Sandstone outcrops occur in the banks and cliffs along both the southeastern and northwestern shores of the island. In places the sandstone is pure white, but many of the beds are heavily iron-stained, so that there is a great range of colours, from white, through all the shades of reddish brown to a deep chocolate-coloured band. These various phases grade one into another with no definite line of demarcation. An exception to this is the deep chocolate band, which is well marked and considerably harder than the rest of the beds.

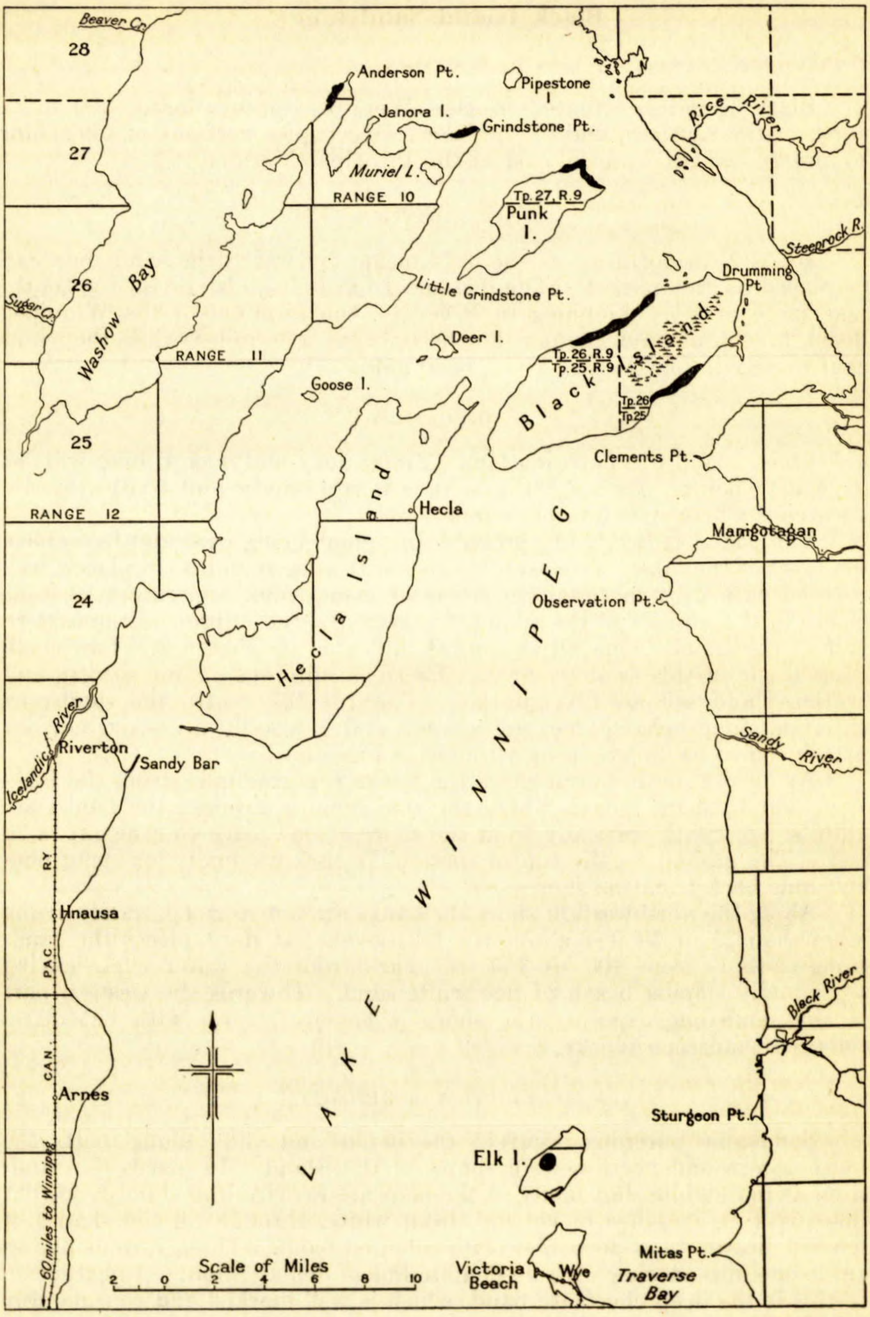

Figure 2. Index map showing principal occurrences of Winnipeg sandstone in the Lake Winnipeg district, Man.

On the southeastern shore the sandstone is exposed except for a few spots which are drift-covered, almost continuously for a distance of over 7,000 feet. At the northern end of the sandstone outcrops on the White claim (*see* Figure 3) the section of the bank is as follows, in descending order:—

27 ft. Sandy loam and sand (Recent).
3 " Blue sandy clay.
25 " White sandstone with few iron stains (Sample B).
5 " Golden brown, iron-stained, soft sandstone.
Water-level.

Going southwest along the shore, the exposure of sandstone becomes thicker, and at station 1 the following section was measured, in descending order:—

18 ft. Fine-grained angular, yellowish quartz sand with occasional grains of tourmaline and feldspar.
1 " Smooth brown clay, highly plastic, in thin bands or layers in sand.
6 " Fine-grained sand, same as top 18 feet.
1 " Clayey silt.
3 " Sandy blue clay, becoming stiffer at depth, with small pebbles of white sandstone embedded in it.
30 " White sandstone with occasional iron stains (Lot 2, 40 sacks).
Water-level.

Following along the section in the same direction the sandstone gradually becomes more iron-stained and there is a 3-foot bed of orange-coloured sand directly underlying the clay band before the first of the two gullies between stations 2 and 3 is reached. The sandstone also appears to be dipping to the southwest and disappears beneath the drift at station 3. There is also a small outcropping of the golden brown, iron-stained sandstone appearing above water-level just south of station 2.

Between station 3 and station 6, the section is heavily drift-covered and there are no sandstone outcrops visible. In places the bank is steep, while in others the slope is gradual. The shore along this section is heavily strewn with Archæan boulders.

One hundred yards northeast of station 6 the sandstone again appears together with the clay capping and the beds thicken toward the southwest. Two large gullies have been eroded in the sandstone, one on each side of station 6. In the south branch of the larger gully, out of which a stream flows, the sandstone is observed 100 yards back from the face of the cliff along the shore. Sample A was taken from this exposure.

On the south side of this large gully the sand in the cliff is very white and few iron stains are noticed. Lot No. 1, consisting of 86 sacks, was taken from the face of this exposure, which is 40 feet high, capped by the clay band on top of which there is 8 to 10 feet of overburden drift.

Farther along the section the sandstone passes from the white phase to a section heavily iron-stained in patches with occasional clay parting-planes or lenses. The colour is yellow to brown and occasionally pink. An orange-coloured band similar to that noted near station 2 occurs under the clay band. At the top of the section directly beneath the clay band at station 7, a chocolate-coloured band of harder sandstone appears which can be followed along the section to 200 yards south of station 9. This dark band reaches a thickness of nearly 6 feet in places and where it occurs it generally overhangs on account of its greater hardness. The shore in the vicinity where this band is exposed, carries heavy slabs of the chocolate-coloured sandstone. Some of these blocks are 3 feet thick and 10 feet square. Sample C was taken from the whiter sandstone opposite station 7, and sample D was from the same bed opposite station 8.

To the south of station 8 another phase of the sandstone makes its appearance just beneath the chocolate band. This might well be called an argillaceous phase, since it consists of iron-stained, reddish sandstone with considerable clayey lenses and clay bands. This bed becomes thicker to the south and at a point 100 yards south of station 9 it is 20 feet thick. Sample E was taken at this point, and includes the cleaner sand as well.

The whiter sand gradually dips to the south, and at station 10 disappears beneath talus material. Sample G was taken from argillaceous band at station 10.

To the south of station 10 the clay band thickens materially, the sandstone becoming thinner till finally it is completely drift-covered.

On the northwest shore similar sandstone outcrops in the banks, although in no places are the exposures as thick as on the southeastern shore.

Where the sandstone first occurs at the north end of the section there is a bed of clay capping it and the bank is not more than 10 feet high. Following along the section the sandstone thickens and at a point in the centre of the Ross claim the bank is 21 feet above the water-level. The section at this point is as follows, in desending order:—

1	ft.	6	in.	Ochreous loam.
1	"	4	"	Fine-grained sand stained golden yellow in patches.
3	"	6	"	Fine, white sandstone with yellow patches.
2	"	0	"	Fine, white sand only occasional iron stains (sample J).
12	"	8	"	Talus-covered.
				Water-level.

The sand exposed in this section continues southwestward for a distance of nearly 3 miles and then becomes drift-covered. As one goes south along the section the sand rapidly becomes badly iron-stained, so much so that it probably would be extremely difficult to wash it to a clean white product.

On the Cope claim, to the southwest of the section given above, a drill hole was put down a quarter of a mile back from the edge of the bank. This encountered 3 feet of loam on top of white, loosely compacted sand from which sample O was taken. At a depth of 10 feet the drill hole was still in sand.

Chocolate-coloured slabs of sandstone appear on the shore towards the southwestern end of the beds, although the banks at this point are very low.

Opposite the northern part of the section the shore is sandy, and the sand extends out under the water for an undetermined distance. Sample H was taken 100 yards off shore, where the water was only one foot deep.

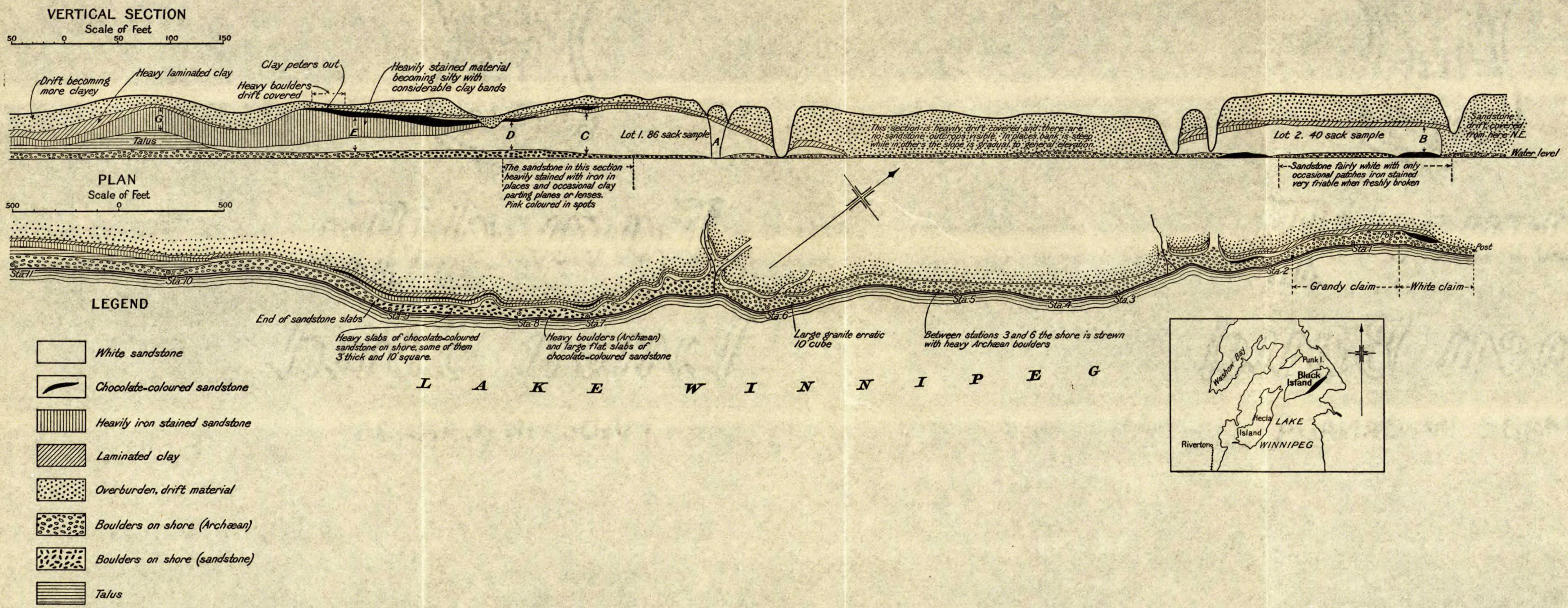

Figure 3. Section through sandstone outcrops along southeast shore, Black island, lake Winnipeg, Man.

On the shore opposite where this sample was taken there is a small creek entering the lake, and the sandstone outcrops in the bed of this creek at lake-level.

Two other samples, L and M, were taken along this section as representative of the material.

CHARACTER OF THE SAND

The sandstone is composed of fine-grained quartz grains fairly well rounded and only loosely bonded. In places it is a pure white, but grades off into reddish brown and even to a chocolate-coloured phase due to the presence of iron. The iron seems to be present rather as a stain or in the bonding material, and in no cases were iron-bearing minerals found to be included in the sand grains. Very few grains of other minerals appear to be present in the sand.

SAMPLES

In order to obtain a definite idea of the commercial possibilities of the sand from these deposits two large lots were obtained. Lot No. 1 consisted of 86 sacks holding approximately 150 pounds each, while Lot No. 2 contained 40 sacks. The points from which these samples were taken are indicated on the map (Figure 3). In addition to these large samples a number of other smaller samples were taken from points already referred to, in order to see what variation there was in the deposit both as regards grain size and impurities. These were shipped to Ottawa for testing.

RESULTS OF TESTS

Both lots as received in Ottawa were sampled and an analysis made on each of them as a basis for comparison. The following results were obtained:—

	Lot No. 1	Lot No. 2
Silica (SiO_2)	95·52	97·48
Iron oxide (Fe_2O_3)	0·192	0·096
Alumina (Al_2O_3)	2·20	1·36
Lime (CaO)	0·27	0·14
Magnesia (MgO)	0·16	0·10
Loss on ignition	0·91	0·53
	99·25	99·71

R. A. Rogers, Analyst, Ore Dressing Division, Mines Branch, Dept. of Mines, Canada.

A number of tests were run on tonnage lots in order to determine whether the sand could be improved by removing the fines and decreasing the impurities present.

Lot No. 1

Test No. 1

As a preliminary test 2 bags were put through a hammer mill and then through a Gayco air separator set at its coarsest setting. The following results were obtained:—

—	Weight	SiO_2	Fe_2O_3	Al_2O_3
	lb.	%	%	%
Gayco oversize	256	97·42	0·10	1·82
" fines	8	77·86	0·99	13·47
Clean-up, sweepings loss	3½	....	....	....
Original sample	267½	....	0·192	2·20

The sandstone crushes very readily and results of this test show that a part of the iron and alumina present in the crude rock is in the bonding material. The test was carried out on the dry material.

Test No. 2

Run No. 1.—A washing test on 2,000 pounds of sandstone was made by grinding in a Chilean chaser mill to pass through a 20-mesh, revolving drum screen; it was then elevated by a Wilfley pump into an Akins revolving screw classifier. The sand was fed at the rate of approximately 600 pounds per hour and water was added in the Chilean mill as well as at other points in the circuit. The oversize material was caught in a tank and the overflow was collected in a Dorr thickener.

Run No. 2.—The oversize from Run No. 1 was fed into the Wilfley pump and then through the Akins classifier for a second scrubbing. Time of feeding, 2 hours. The oversize from this run was collected as before and the overflow added to that from first.

Run No. 3.—Oversize from second run re-fed to Wilfley pump and then to Akins for a third washing. Time of feed 1 hour, 50 minutes. The oversize was collected, dried, and weighed, while the overflow material was passed through a filter press, dried, and weighed.

Products of Test No. 2.

Samples: Akins oversize Run No.	1	=	6 lb.	Fe_2O_3	=	0·13%
" "	2	=	21 "	"	=	0·088%
" "	3	=	11 "	"	=	0·14%
Clean-ups: "	1	=	132 "			
"	2	=	66 "			
"	3	=	71 "			
Akins oversize final			1,414 "			
" overflow			125¾ "			

Summary.

Oversize (samples, clean-ups, etc.)	=1,621 lb.
Overflow (fines, slimes, losses)	= 379 "
Original sample	2,000 "
Loss on washing	= 18·9%

Test No. 3

This test was similar in all ways to the preceding test (Test No. 2) with the exception that the Akins classifier was tilted at higher angle and run at a faster speed while more spray water was added. The oversize was run through the Akins a second and a third time.

Products of Test No. 3.

Samples: Akins oversize Run No. 1	=	7½ lb.	Fe_2O_3	=	0·031%
" " 2	=	5½ "	"	=	0·04%
" " 3	=	3½ "	"	=	0·032%
Clean-ups: " 1	=	125 "			
" 2	=	107 "			
" 3	=	130 "			
Akins oversize final............	=	607 "			
" overflow.................	=	830 "			

Summary.

Oversize (samples, clean-ups, etc.)	=	985½ lb.
Overflow (fines, slimes, losses)	=	1,014½ "
Original sample	=	2,000 "
Loss on washing	=	50·7%

While a high-grade sand was produced from this test there was too great a percentage of oversize (+100) material washed away with the overflow.

Test No. 4

Since the rock is very friable and breaks up readily it was thought possible that by putting it through the Chilean mill too much crushing of the sand was taking place, resulting in an excessive amount of fines. A test was therefore run on the crude sandstone after passing it all through a ¼-inch mesh by feeding directly into the Wilfley pump, and then to the Akins classifier. The oversize was re-fed to the Wilfley pump five times after the first washing.

Products of Test No. 4.

Samples: Akins oversize Run No. 1	=	9 lb.	Fe_2O_3	=	0·030%
" " 2	=	9 "	"	=	0·024%
" " 3	=	7 "	"	=	0·020%
" " 4	=	4 "	"	=	0·016%
" " 5	=	3 "	"	=	0·020%
" " 6	=	3 "	"	=	0·020%
Clean-ups: " 6	=	153·5 lb.			
Akins oversize final...........	=	1,104 lb.			
" overflow...............	=	595 "			

Summary.

Oversize (samples, clean-ups, etc.)	=	1,293 lb.
Overflow (fines, slimes, losses)	=	707 "
Original sample	=	2,000 "
Loss on washing	=	35·3%

Lot No. 2

Test No. 1

This was a washing test similar to Test No. 2, Lot No. 1, except that for the third run, the incline and speed of the Akins was increased and additional water was added.

Products of Test No. 1.

Samples: Akins overflow Run No.	1	=	14	lb.	Fe_2O_3	= 0·072%
" "	2	=	8½	"	"	= 0·064%
" "	3	=	7	"	"	= 0·092%
Clean-ups: "	1	=	60	"		
"	2	=	77	"		
"	3	=	98½	"		
Akins oversize..................		=	1,328	"		
" overflow..................		=	294	"		

Summary.

Oversize (samples, clean-ups, etc.)	=	1,564 lb.
Overflow (fines, slimes, losses)	=	436 "
Original sample	=	2,000 "
Loss on washing	=	21·8%

GRANULOMETRIC ANALYSES

Screen tests were made on a number of the products obtained from the several tests and the results tabulated.

In addition to the two large lot samples a number of other samples were taken and screen tests made on them with the following results:—

Lot No.	1		2		1		1		1		1		1		1	
Test No.	Head sample		Head sample		2		2		2		3		3		3	
Run No.	Crude		Crude		1		2		3		1		2		3	
Per cent.	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %		Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 10 mesh	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
" 14 "	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
" 20 "	0·3	0·3	0·6	0·6	......	......	......	......	......	......	0·1	0·1	0·1	0·1	0·1	0·1
" 28 "	1·7	2·0	2·3	2·9	0·8	0·8	0·5	0·5	0·5	0·5	0·8	0·9	0·8	0·9	1·2	1·3
" 35 "	12·1	14·1	10·4	13·3	9·0	9·8	5·9	6·4	5·8	6·3	8·4	9·3	9·0	9·9	11·7	13·0
" 48 "	22·3	36·4	21·4	34·7	19·9	29·7	16·2	22·6	15·4	21·7	26·7	36·0	29·5	39·4	32·9	45·9
" 65 "	30·8	67·2	39·1	73·8	34·8	64·5	33·6	56·2	37·8	59·5	42·3	78·3	41·3	80·7	40·5	86·4
" 100 "	10·0	77·2	10·3	84·1	14·1	78·6	18·2	74·4	23·6	83·1	18·5	96·8	17·4	98·1	12·6	99·0
" 150 "	13·3	90·5	8·9	93·0	14·2	92·8	10·2	84·6	5·7	88·8	2·8	99·6	1·8	99·9	0·9	99·9
" 200 "	7·5	98·0	6·2	99·2	5·5	98·3	14·3	98·9	10·5	99·3	0·3	99·9	0·1	100·0	0·1	100·0
Through 200 "	2·0	......	0·8	......	1·7	......	1·1	......	0·7	......	0·1	......	......	......	......	......

Lot No.	1		1		1		1		1		1		2		2		2	
Test No.	4		4		4		4		4		4		1		1		1	
Run No.	1		2		3		4		5		6		1		2		3	
Per cent.	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 10 mesh	0·3	0·3	0·2	0·2	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4	......	......	......	......	......	......
" 14 "	0·2	0·5	0·2	0·4	0·3	0·7	0·3	0·7	0·2	0·6	0·3	0·7	......	......	......	......	......	......
" 20 "	0·6	1·1	0·4	0·8	0·5	1·2	0·7	1·4	0·6	1·2	0·7	1·4	......	......	......	......	......	......
" 28	1·9	3·0	2·1	2·9	2·3	3·5	2·7	4·1	2·4	3·6	2·6	4·0	1·7	1·7	1·1	1·1	1·4	1·4
" 35 "	11·0	14·0	11·1	14·0	12·0	15·5	14·5	18·6	13·2	16·8	13·3	17·3	8·1	9·8	6·7	7·8	7·8	9·2
" 48 "	22·3	36·3	24·4	38·4	24·7	40·2	26·6	45·2	27·0	48·8	26·3	43·6	20·0	29·8	18·8	26·6	22·1	31·3
" 65 "	36·6	72·9	36·0	74·4	35·8	76·0	34·3	79·5	35·4	79·2	35·4	79·0	41·1	70·9	44·4	71·0	43·2	74·5
" 100 "	17·6	90·5	20·7	95·1	19·1	95·1	16·2	95·7	16·7	95·9	17·5	96·5	12·1	83·0	11·8	82·8	8·8	83·3
" 150 "	8·7	99·2	4·4	99·5	4·6	99·7	4·2	99·9	4·0	99·9	3·4	99·9	6·0	89·0	10·8	93·6	5·8	89·1
" 200 "	0·5	99·7	0·4	99·9	0·2	99·9	0·1	100·0	0·1	100·0	0·1	100·0	9·9	98·9	5·8	99·4	10·9	100·0
Through 200 "	0·3	......	0·1	......	0·1	......	......	......	......	......	......	......	1·1	......	0·6	......	......	......

Sample No.	A				B				C			
	Unwashed		Washed		Unwashed		Washed		Unwashed		Washed	
	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 20 mesh	0·05	0·05	....	....	....	....	0·06	0·06	....	....	....	....
" 28 "	0·01	0·06	0·01	0·01	....	....	0·01	0·07	0·01	0·01	0·13	0·13
" 35 "	11·70	11·76	9·27	9·28	11·70	11·70	7·66	7·73	12·20	12·21	9·70	9·83
" 48 "	24·75	36·51	20·97	30·25	17·37	29·07	13·50	21·23	20·17	32·38	17·82	27·65
" 65 "	34·75	71·26	38·19	68·44	25·17	54·24	23·50	44·73	26·88	59·26	26·68	54·33
" 100 "	19·95	91·21	24·92	93·36	11·45	65·69	23·53	68·26	20·77	80·03	24·45	77·78
" 150 "	6·08	97·29	4·90	98·26	25·80	91·49	24·87	93·13	12·37	92·40	15·55	94·38
" 200 "	2·12	99·41	1·67	99·93	7·10	98·59	6·62	99·75	5·15	97·55	5·20	99·53
Through 200 "	0·59	....	0·07	....	1·41	....	0·25	....	2·45	....	0·47	....
Loss on washing	4·4 %				11·0 %				10·0 %			

Sample No.	D				E				G			
	Unwashed		Washed		Unwashed		Washed		Unwashed		Washed	
	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 20 mesh	....	....	....	....	....	....	....	....	....	....	....	....
" 28 "	....	....	0·12	0·12	0·12	0·12	0·05	0·05	1·45	1·45	0·13	0·13
" 35 "	13·55	13·55	11·07	11·19	21·04	21·16	17·22	17·27	14·03	15·48	16·10	16·23
" 48 "	18·00	31·55	15·20	26·39	22·15	43·31	23·37	40·64	15·25	30·73	19·61	35·84
" 65 "	25·31	56·86	26·37	52·76	25·27	68·58	29·03	69·67	21·39	52·12	28·71	64·55
" 100 "	29·30	86·16	28·37	81·13	7·27	75·85	18·65	88·32	17·24	69·36	14·30	78·85
" 150 "	7·89	94·05	15·47	96·60	16·70	92·55	9·65	97·97	6·47	75·83	18·95	97·80
" 200 "	4·45	98·50	3·30	99·90	3·67	96·22	1·68	99·65	7·45	83·28	1·95	99·75
Through 200 "	1·50	....	0·10	....	3·78	....	0·35	....	16·72	....	0·25	....
Loss on washing	8·4 %				16·0 %				39·2 %			

Sample No.	H				I				J			
	Unwashed		Washed		Unwashed		Washed		Unwashed		Washed	
	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 20 mesh	......	......	......	......	......	......	......	......	......	......	......	......
" 28 "	......	......	0·04	0·04	......	......	0·10	0·10	0·10	0·10	0·07	0·07
" 35 "	11·66	11·66	16·75	16·79	5·44	5·44	2·85	2·95	14·65	14·75	12·64	12·71
" 48 "	36·94	48·60	39·70	56·49	23·60	29·04	19·31	22·26	19·89	34·64	17·67	30·38
" 65 "	22·13	70·73	21·76	78·25	39·65	68·69	39·12	61·38	31·26	65·90	33·39	63·77
" 100 "	20·39	91·12	4·90	83·15	22·90	91·59	28·90	90·28	22·20	88·10	21·27	85·04
" 150 "	6·80	97·92	16·20	99·35	4·37	95·96	6·82	97·10	8·17	96·27	12·62	97·66
" 200 "	2·07	99·99	0·65	100·00	3·25	99·21	2·73	99·83	2·80	99·07	2·32	99·98
Through 200 "	0·01	......	......	......	0·79	......	0·17	......	0·93	......	0·02	......
Loss on washing	6·6 %				6·6 %				7·4 %			

Sample No.	L				M				N			
	Unwashed		Washed		Unwashed		Washed		Unwashed		Washed	
	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %	%	Cumulative %
Retained on 20 mesh	......	......	0·15	0·15	......	......	......	......	1·34	1·34	2·53	2·53
" 28 "	......	......	0·62	0·77	0·08	0·08	......	......	2·56	3·90	0·04	2·57
" 35 "	19·25	19·25	10·95	11·72	17·45	17·53	13·66	13·66	12·33	16·23	11·93	14·50
" 48 "	23·02	42·27	22·77	34·49	20·50	38·03	16·59	30·25	18·72	34·95	16·87	31·37
" 65 "	22·38	64·65	26·52	61·01	30·81	68·84	30·76	61·01	20·71	55·66	22·34	53·71
" 100 "	23·15	87·80	27·20	82·21	23·92	92·76	31·12	92·13	27·32	82·98	29·76	83·47
" 150 "	5·15	92·95	10·55	98·76	4·70	97·46	6·32	98·45	7·00	89·98	11·94	95·41
" 200 "	4·65	97·60	1·16	99·92	2·07	99·53	1·54	99·99	7·47	97·45	4·40	99·81
Through 200 "	2·40	......	0·08	......	0·47	......	0·01	......	2·55	......	0·19	......
Loss on washing	19·0 %				8·4 %				16·8%			

Sample No.	O*			
	Unwashed		Washed	
	%	Cumulative %	%	Cumulative %
Retained on 20 mesh	......	......	......	......
" 28 "	......	......	......	......
" 35 "	6·89	6·89	7·65	7·65
" 48 "	15·98	22·87	16·46	24·11
" 65 "	32·03	54·90	34·37	58·48
" 100 "	22·97	77·87	33·15	91·63
" 150 "	14·47	92·34	6·20	97·83
" 200 "	6·35	98·69	2·17	100·00
Through 200 "	1·31	......	......	......
Loss on washing	14·0 %			

* The sample letters refer to letters used in text.

SUMMARY

The sand in this deposit is a fine-grained, silica sand loosely bonded with an argillaceous, and in some places, a ferruginous bond. It breaks readily into its natural grain, the greater part being between 48 and 150 mesh. There are few grains of other minerals outside of quartz. The impurities are chiefly iron oxide and argillaceous material which is either present in the bond, or as a coating on the quartz grains. The grains are fairly well rounded and when washed are white in colour, although in places the iron stain is so deep that it is difficult to remove entirely.

The purity of the sand is indicated by the several analyses given throughout the text. The possibility of removing part of the impurities by washing is shown by the tests, although, due to the fineness of the grain, there is rather an excessive loss on washing.

The development of this deposit should not present any great problem. On account of the softness of the rock it could readily be broken down into its natural grain size by hydraulicking, thus eliminating crushing at the plant. The overburden in places is fairly thick but a large tonnage could be obtained with only a small amount of stripping. Shipping offers a more serious difficulty since at both exposures the water is shallow along the shore and as there are no harbours, long piers and breakwaters would have to be built to enable scows to be loaded with safety. The nearest market is at Winnipeg, 100 miles distant.

Punk Island Sandstone[1]

Loosely consolidated sandstone of Precambrian age outcrops on the northeast shore of Punk island about 5 miles north of Black island in lake Winnipeg. The sand is fine-grained and in places the banks are 20 feet high. A sample was taken from the top 3 feet of the bank adjacent to the northern exposure of the white clay described in the report referred to.

Screen Analysis

—	Crude		Washed	
	Per cent	Cumulative per cent	Per cent	Cumulative per cent
Retained on 14 mesh	....	....	....	....
" 20 "	0·18	0·18	0·21	0·21
" 28 "	1·12	1·30	1·41	1·62
" 35 "	9·44	10·74	10·41	12·03
" 48 "	18·78	29·52	20·65	32·68
" 65 "	31·35	60·87	37·43	70·11
" 100 "	27·72	88·59	21·23	91·34
" 150 "	7·65	96·24	7·58	98·92
" 200 "	1·79	98·03	0·91	99·83
Through 200 "	1·97	....	0·17	....
Total	100·00	....	....	....

Loss on washing = 9·4 per cent.

The sand is in every way similar to that on Black island.

[1] A map of the northeast shore of this island together with a brief note of the occurrence of the sandstone is given in "Clay and Kaolin on Punk Island"; Investigations in Ceramics and Road Materials, Mines Branch, Dept. of Mines, 1926.

Grindstone Point Sandstone

At Grindstone point, in township 27, range 6, east of the Principal Meridian, on the west shore of lake Winnipeg, sandstone occurs underlying flat-lying limestone of probable Ordovician age. The cliff, where examined about 1 mile west of the point (*see* Plate III A), is about 60 feet high, the top 20 feet being limestone beneath which occurs the sandstone dipping 20 degrees to the west. The sandstone is interbanded with argillaceous layers up to 3 and 4 inches thick. In places the sandstone is highly iron-stained giving a reddish tone to the whole cliff, but there are numerous areas of fairly white material. An average sample of the white material was tested and gave the following results.

Screen Analysis

—	Crude		Washed	
	Per cent	Cumulative per cent	Per cent	Cumulative per cent
Retained on 14 mesh	....	....	....	....
" 20 "	....	....	....	....
" 28 "	0·21	0·21	0·32	0·32
" 35 "	2·94	3·15	3·33	3·65
" 48 "	9·36	12·51	10·69	14·34
" 65 "	45·52	58·03	50·67	65·01
" 100 "	36·16	94·19	31·90	96·91
" 150	5·27	99·46	3·01	99·92
" 200 "	0·41	99·87	0·08	100·00
Through 200 "	0·13	....	....	....
Total	100·00	....	....	....

Loss on washing = 8·6 per cent.

These results show that this sandstone is very similar to the material found on Black island. However, on account of its heavy capping of limestone it is improbable that this deposit will be developed until the more readily accessible material on Black island is exhausted.

Washow Bay Sandstone

On the shore of Washow bay, a quarter of a mile southwest of Anderson point in sec. 29, tp. 27, range 6, east of the Principal Meridian, another outcrop of sandstone occurs underlying limestone. The bank at this point is 6 feet high, the top 2 feet being limestone with 4 feet of white sandstone exposed underneath. The outcrop forms a small local anticline about 200 yards long, the greatest height exposed being 6 feet at its centre. A sample was taken for testing.

Screen Analysis

—	Crude		Washed	
	Per cent	Cumulative per cent	Per cent	Cumulative per cent
Retained on 14 mesh	....	....	....	....
" 20 "	....	....	....	....
" 28 "	....	....	....	....
" 35 "	....	....	0·51	0·51
" 48 "	1·38	1·38	4·31	4·82
" 65 "	41·98	43·36	52·13	56·95
" 100 "	42·39	85·75	29·25	86·20
" 150 "	12·69	98·44	13·05	99·25
" 200 "	1·33	99·77	0·75	100·00
Through 200 "	0·23	....	....	....
Total	100·00	....	100·00	....

Loss on washing = 11·3 per cent.

The sandstone from this locality was very friable and when taken from the sample bag was practically all in the form of a sand. It is very similar to the Black Island material in texture and appearance.

SASKATCHEWAN

Great Sand Hills

In that area of Saskatchewan lying to the northeast of Maple Creek, on the main line of the Canadian Pacific railway, there is an extensive morainic belt of sand hills, in many cases in dune formation. The belt is 7 or 8 miles wide and 15 miles or more long. Many of the dunes are 100 feet high and extensive patches of drifting sand devoid of vegetation occur.

The sand is a light brownish-red in colour and the grains are well rounded to sub-angular.

A sample, taken from one of these dunes, obtained by a post-hole auger through a depth of 10 feet, was submitted to a screen analysis to obtain the grain size.

Mesh	Per cent	Cumulative per cent
Retained on 35	0·30	0·30
" 48	6·60	6·90
" 65	33·35	40·25
" 100	43·72	83·97
" 150	7·58	91·55
" 200	7·88	99·43
Through 200	0·57	....
Total	100·00	....

A microscopic examination of this sand shows it to contain an appreciable percentage of the black iron-bearing minerals, as well as some grains of feldspar. It is improbable that such sand will be a source of high-grade silica.

Medalta Clay Pit, Willows

In secs. 1 and 12, tp. 8, range 29, west of the 2nd meridian, a clay deposit has been opened up in which the lower strata of clays contain a considerable proportion of sand. A sample of this material was obtained, and after it was washed to remove the clay the sand was found to be so contaminated with mica, hornblende, feldspar, etc., as to make it unsuitable for use as a high-grade silica. The grains are subangular to angular and the greater proportion will be finer than 65 mesh.

Wapawekka Lake Sandstone and Sand

A deposit of sandstone and unconsolidated sand occurs on the south shore of Wapawekka lake, approximately 125 miles to the north of Prince Albert. Although this sand is not of commercial importance at present due to its remoteness from railway transportation, it is of interest on account of its high degree of purity, and should the district be tapped by a railway the deposit will, doubtless, be of economic value.

McInnes[1], who made an exploratory survey of the district in 1909, refers to the occurrence of the sandstone as follows:—

The white quartz sand and loosely coherent sandstone, occurring as thick beds in the Dakota formation, on the south shore of Wapawekka lake, seem to be well adapted for glass. The quartz grains are subangular and are fairly uniform in size, about 93 per cent passing through a 60-mesh sieve. An unwashed sample of the sand, collected from the face of a scarped bank, was analysed by H. A. Leverin of the Mines Branch. It gave the following result:—

SiO_2 (silica)	98·60
Fe_2O_3 (iron oxide) Al_2O_3 (alumina)	1·20
Other impurities	0·20
	100·00

As neither the iron oxide nor the alumina occur in the grains of quartz, but rather as coating and cementing materials, this sand after washing should be very pure indeed. The sands occur in cliffs 30 to 40 feet high, facing the lake, and are so loosely coherent as to be easily reduced and collected by the hydraulic method. Certain bands in the crystalline limestone of Lac LaRonge seem to be well adapted to furnish the lime and limestone that would be necessary in glass making. Though now inaccessible by reason of distance, these sands are commercially interesting from their close association with the lignite already referred to, and from the probability of their occurrence elsewhere in the west, in close proximity to a supply of natural gas.

Prof. W. G. Worcester, of the Ceramic Department of the University of Saskatchewan, examined these sandstones in 1921, and his description is contained in an unpublished report made to the Minister of Labour and Industries, Saskatchewan, entitled "Reconnaissance Survey of Part of Northern Saskatchewan, 1921." Referring to these sands from Wapawekka lake, he says:—

Analyses made at the University of Saskatchewan of samples of sand secured in northern Saskatchewan gave the following results:—

	No. 12	No. 13	No. 14
	%	%	%
Total silica	97·94	97·558	98·27
Iron and alumina	2·123	1·230	1·652
Calcium	Trace	0·934	Trace
Magnesium	Trace	Trace	Trace

[1] Geol. Surv., Canada, Sum. Rept., 1909, p. 157.

The value of such high-grade glass sands, as a natural resource, to Saskatchewan, cannot be computed in dollars and cents. It will take generations to even partially exhaust these vast deposits. Their value is further enhanced by the fact that the necessary flux (limestone) is known to occur in the Lac LaRonge Series of rocks; furthermore, there is good reason to assume that fuel will be found in close proximity.

W. H. Hastings, Mining Engineer of the Saskatchewan Government, who visited northern Saskatchewan, during the summer of 1926, has kindly furnished a small sample of the sand which he collected near Sandstone point, Wapawekka lake. The sample submitted weighed 955 grammes and was a very clean, white sand with partly rounded grains. As none of the analyses given by previous writers showed the iron and alumina separately, an analysis was made to determine the relative proportions of these two constituents as they occurred in the sample submitted.

Silica (SiO_2)	98·50 per cent.
Iron oxide (Fe_2O_3)	0·008 "
Alumina (Al_2O_3)	0·21 "

It is probable that the iron content of the sand and sandstone, as shown in the previous analyses, is quite low and that the greater portion of the amount credited to iron and alumina can be placed as alumina.

A screen analysis was made on the sample, with the following results:

Mesh	Per cent	Cumulative per cent
Retained on 28	1·0	1·0
" 35	51·4	52·4
" 48	39·7	92·1
" 65	4·1	96·2
" 100	1·1	97·3
" 150	2·3	99·6
" 200	0·2	99·8
Through 200	0·2	....
	100·00	....

This is a well-graded sand suitable for many of the uses of a high-grade silica sand, and if the sample is representative of any large proportion of the available material the deposit may be regarded as a source of high-grade silica.

ALBERTA

Cypress Hills Pebbles

A large deposit of well-rounded pebbles occurs on the northwestern end of the Cypress hills, near the top of the escarpment. The nearest shipping point is at Irving on the Canadian Pacific railway, 22 miles north.

The best exposure is in sec. 15, tp. 8, range 3, west of the 4th meridian. At this point there is a bank of these pebbles, 30 feet high and 200 yards long.

The pebbles are mostly quartzite and range in size from ½ inch up to 6 inches and larger. They vary in shape from almost perfect spheres to oval or flattened disks.

Six bags of the smaller sizes were collected for testing purposes to see if they were suitable for use as grinding pebbles.

In order to determine the value of these pebbles for use as grinding pebbles, tests were run in comparison with commercial Danish pebbles of the same size, and under similar conditions.

—	Test No. 1	Test No. 2
	Canadian Pebbles	Danish Pebbles
Weight of pebbles (53½ lb.—2″+1″) (46½ lb.—3″+2″)	100 lb.	100 lb.
Weight of charge (granite chips)	100 lb.	100 lb.
Time of run in pebble mill	1 hour	1 hour
Weight of pebbles after run	99 lb. 15 oz.	99 lb. 15 oz.
Loss	1 oz.	1 oz.

—	Test No. 3	Test No. 4
	Canadian Pebbles	Danish Pebbles
Weight of pebbles (same pebbles as in Tests 1 and 2)	99 lb. 15 oz.	99 lb. 15 oz.
Weight of charge (granite chips)	100 lb.	100 lb.
Time of run in pebble mill	3 hours	3 hours
Weight of pebbles after run	99 lb. 13 oz.	99 lb. 13 oz.
Loss	2 oz.	2 oz.

NOTE.—1 cracked pebble and 4 broken pebbles among the Canadian pebbles.

—	Test No. 5	Test No. 6
	Canadian Pebbles	Danish Pebbles
Weight of pebbles (45 lb.—3″+2″) (55 lb.—2″+1″)	100 lb.	100 lb.
Weight of charge (granite chips)	100 lb.	100 lb.
Time of run in pebble mill	6 hours	6 hours
Weight of pebbles after run	99 lb. 9½ oz.	99 lb. 14½ oz.
Loss	6½ oz.	1½ oz.

NOTE.—1 cracked pebble in Test No. 5 after run.

—	Test No. 7	Test No. 8
	Canadian Pebbles	Danish Pebbles
Weight of pebbles	99 lb. 6 oz.	99 lb. 14½ oz.
Weight of charge (limestone chips)	100 lb.	100 lb.
Time of run in pebble mill	6 hours	6 hours
Weight of pebbles after run	99 lb. 5¼ oz.	99 lb. 14½ oz.
Loss	¾ oz.	No loss

NOTE.—The charge for Test No. 7 was made up from pebbles from Test No. 5 after removing cracked pebble. There were 2 broken and 2 cracked pebbles after Test No. 7. Pebbles used in Test No. 8 were those after Test No. 6.

—	Test No. 9	Test No. 10
	Canadian Pebbles	Danish Pebbles
Weight of pebbles (−3″+2″)	66 lb. 11¾ oz.	67 lb. 8¼ oz.
(−2″+1″)	33 lb. 4¼ oz.	32 lb. 7¾ oz.
Weight of charge (granite chips)	100 lb.	100 lb.
Time of run in pebble mill	6 hours	6 hours
Weight of pebbles after run	99 lb. 11¼ oz.	99 lb. 12 oz.
Loss	4¾ oz.	4 oz.

NOTE.—For Test No. 9 the pebbles were hand-picked to remove all defective pebbles.

—	Test No. 11	Test No. 12
	Canadian Pebbles	Danish Pebbles
Weight of pebbles (pebbles from Tests 9 and 10)	99 lb 11¼ oz.	99 lb. 12 oz.
Weight of charge (granite chips)	100 lb.	100 lb.
Time of run in pebble mill	6 hours	6 hours
Weight of pebbles after run	99 lb. 7 oz.	99 lb. 8½ oz.
Loss	4¼ oz.	3½ oz.
Broken pebbles	2	

Screen analyses were made on the ground material after each run and the amount of work done in each case was calculated according to Rittinger's theory.[1] The results obtained from these calculations show that the amount of work done by the Canadian pebbles in each comparative test was practically the same as that for the Danish pebbles.

It is possible, therefore, that by selective screening and careful grading, pebbles suitable for grinding may be obtained from this deposit.

Bituminous Sands, McMurray District

The bituminous sands of northern Alberta contain a large proportion of sand consisting mainly of quartz grains, which when freed from the bitumen are a possible source of silica.

[1] Richards, R.H.: Text Book of Ore Dressing, p. 167 (1909).

Ells[1] has made an extensive study of these deposits and for details as to the locations of the numerous outcrops the reader is referred to his report. The following notes on the character and composition of the sands are extracts from his report:—

Character of Bituminous Sand

In 1913 and 1914 a number of core samples of bituminous sand were secured from representative outcrops, at a number of points throughout the McMurray area. These samples were analysed and the percentage and character of associated bitumen and grading of mineral aggregate determined In considering the following abridged results it should be remembered that the average depth from the face at which samples were taken did not exceed 4 feet, and that different results (see table following) may be obtained from samples taken at points removed from actual exposures It is considered, however, that the analyses given, furnish a fair indication of the general character and degree of enrichment of a large tonnage of bituminous sand. Other analyses, not quoted, have shown a bitumen content in excess of 20 per cent, but pending further investigation these are considered as indicating local enrichment only.

Abridged Analyses of Samples of Bituminous Sand from the McMurray Area

Test No.	—	Passing mesh								Per cent contained bitumen
		200	100	80	50	40	30	20	10	
11	Athabaska river..........	2	11	54	16	10	5	2	......	14
12	"	6	54	25	13	......	......	......	......	15
12	"	7	77	14	2	......	......	......	......	16
15	"	24	64	9	3	......	......	......	......	17
15	"	3	38	19	40	......	......	......	......	9
16	"	9	33	11	47	......	......	......	......	12
21	"	3	5	1	8	7	15	33	27	15
21	"	4	26	11	48	3	2	3	3	20
22	"	11	70	14	5	......	......	......	......	12
47	Christina river............	3	6	8	12	14	45	12	......	11
49	"	3	15	11	70	1	......	......	......	14
52	"	2	35	12	51	......	......	......	......	17
52	"	4	34	16	46	......	......	......	......	15
39	Clearwater river..........	4	14	14	48	9	7	4	......	14
43	Hangingstone river........	3	22	9	51	9	4	2	......	15
31	Horse river..............	5	38	8	47	2	......	......	......	16
32	"	5	47	16	32	......	......	......	......	16
33	"	5	36	14	45	......	......	......	......	15
34	"	10	33	19	37	1	......	......	......	17
35	"	4	27	11	56	2	......	......	......	9
35	"	7	77	5	11	......	......	......	......	17
36	"	4	40	5	51	......	......	......	......	16
36	"	5	39	27	29	......	......	......	......	11
37	"	3	35	15	57	......	......	......	......	18
38	"	5	42	18	35	......	......	......	......	11
38	"	4	30	18	47	1	......	......	......	16
73	McKay river.............	2	49	26	22	......	......	......	......	16
74	"	6	25	16	40	4	9	......	......	18
64	Ells river................	6	75	18	1	......	......	......	......	15
67	"	6	53	19	20	......	......	......	......	16
63	Muskeg river.............	7	10	1	27	20	16	10	6	9
54	Steepbank river..........	3	8	2	25	16	20	15	9	14
55	"	7	4	1	12	10	17	27	22	16
56	"	2	4	1	42	22	13	9	4	17
58	"	5	33	2	43	7	4	2	3	16
59	"	3	14	2	72	5	5	1	......	16
61	"	7	10	1	27	20	16	10	6	8

[1] Ells, S. C.: "Bituminous Sands of Northern Alberta"; Mines Branch, Dept. of Mines, Canada, Rept. No. 632 (1926).

The physical characteristics of a representative sample of the bituminous sand, and of the bitumen itself may be briefly summarized thus:

	Per cent
Crude bituminous sand—	
Specific gravity 25° C/25° C	1·75
Moisture	1·3
Bitumen soluble in CS_2	15·5
Sand	83·2

The sand consists, for the most part, of clear quartz grains. In form the grains are most irregular, varying from sharply angular to oval, waterworn shapes. Judging from the grading of the sand, the bulk of which ranges from 40 to 80 mesh, the greater part may be considered as originating as shore deposits.

The following is an analysis of sand combined from samples taken from six representative outcrops:—

	Per cent
SiO_2	95·50
Al_2O_3	2·25
CaO	0·50
Fe_2O_3	0·35
MgO	0·23
Less loss on ignition	1·50
	100·33

* * * * *

In order to determine the manner in which the iron content was associated, sand tailings from Alberta bituminous sand were examined microscopically. Samples were also treated with solutions of caustic soda and of hydrochloric acid. From this examination it appears that, by washing, the iron content of the sand can be reduced to possibly 0·15 per cent......

From a consideration of the above data, it is evident that the sand tailings as derived from a successful extraction process, will be found satisfactory for the production of the cheaper grades of green glass (bottles, etc.), or if the sand is washed, for the production of white glass (window, plate, etc.).

Pipestone River Sandstone

LOCATION

A deposit of fine-grained sandstone occurs near the headwaters of the Pipestone river, approximately 22 miles north of Lake Louise, Alberta, a station on the main line of the Canadian Pacific railway. Three claims have been located which, according to the map filed in the Mining Lands Branch of the Department of the Interior, are situated in SE. ¼ sec. 29 and W. ½ sec. 28, tp. 31, range 16, west of the 5th meridian. The claims, each 15 chains wide and approximately 26·5 chains long, are located end to end, so that the southern boundary of the southernmost claim runs parallel to the Pipestone river 47·5 chains southeast of Pipestone falls. The boundary of the north claim is just outside the northern boundary of Rocky Mountains park. The greater portion of these claims, therefore, comes under the jurisdiction of the regulations for mining claims in Federal parks.

The Lake Louise Silica Company,with head office at Calgary, Alberta, has been organized to exploit the property.

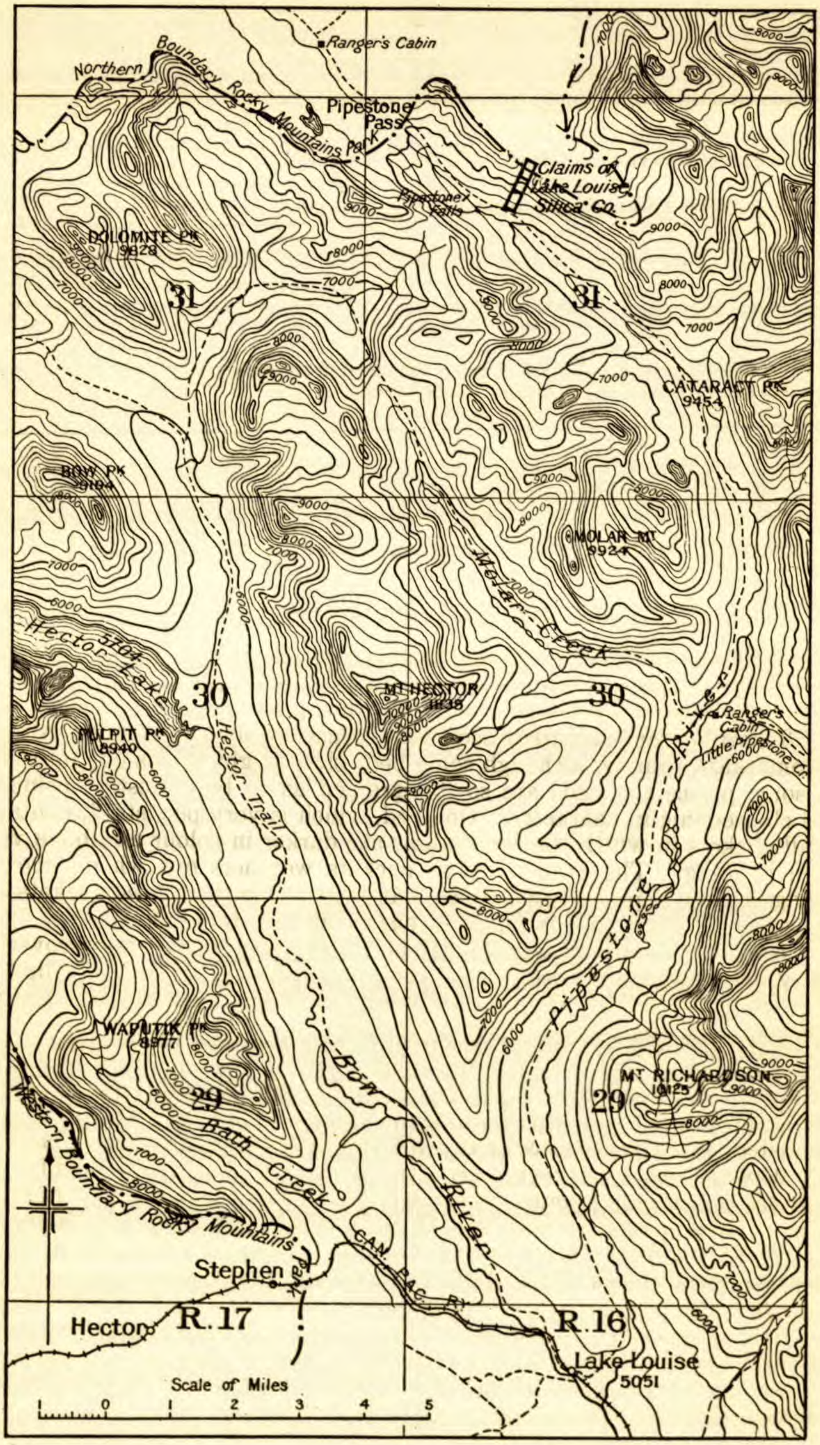

Figure 4. Map showing claims of the Lake Louise Silica Company, on Pipestone river, Alberta.

TRANSPORTATION

At present the deposit is reached by a pack trail which follows the valley of the Pipestone river north from Lake Louise station, crossing the river at several points. Lake Louise station has an elevation of 5,051 feet, and the bottom of the deposit is about 7,050 feet above sea-level, a rise of approximately 100 feet per mile for the 22 miles.

Many difficulties would have to be overcome in building a road to the deposit, including numerous side-hill cuts in loose material and the construction of several bridges, which would have to be placed well above spring flood-level.

TOPOGRAPHY

The sandstone occurs in steep-pitching beds running up the southern slope of a mountain ridge on the north side of the Pipestone river. There is very little level ground, as the valley bottom is very narrow and rises steeply on either side. For the first 1,000 feet on the north side of the creek the slope is about 20 degrees, then it rises to 35 degrees and runs up rapidly, the last 1,000 feet being very steep, in some cases precipitous. The ridge at the north end of the claims is probably 2,500 feet above the creek at the south end of the claims.

DESCRIPTION OF DEPOSIT

The material is a fine-grained sandstone with which is interbedded a dolomitic limestone, probably of Upper Ordovician age. The sandstone beds, measured at right angles to the dip, are about 1,000 feet in thickness.

The different sandstone beds vary considerably in texture. All are of remarkable purity, although some beds show slight traces of iron stain. In some places the beds are so fine-grained as to be almost translucent and chalcedonic in character. One bed, which is very persistent, contains small pockets in which the sand grains are darker in colour and have very little bonding. The sand in these pockets weathers out when exposed, giving the bed a pitted appearance. It is probable that these pockets are the source of sand that is found in nearly all the draws.

At the foot of the steepest part of the escarpment is a talus covering many acres, which consists of blocks and fragments of sandstone broken from the main beds. There is sufficient material in this talus to furnish broken sandstone to a plant for many years.

CHARACTER OF ROCK

The rock is a fine-grained, white sandstone, in some beds loosely cemented with a siliceous cement, while in others it approaches a quartzite. The loosely cemented rock, when freshly quarried, crushes readily but becomes harder on exposure. All the grains in these beds are well rounded most of them being between 0·417 and 0·147 millimetre in diameter. This is slightly finer than is usually found in average sandstone from which glass sand is obtained. The quartzitic beds are very hard, and crush with angular fractures, much of the material being reduced to a powder.

The sample for test purposes was taken from the loosely compacted material found in the talus pile, since this class of material composes by far the greater available part of the deposit. The quartzitic beds, where observed, were in narrow bands of limited extent.

The material was crushed so as to pass through a 10-mesh screen and three granulometric analyses were made with the following results:—

Granulometric Analyses

—	1		2		3	
	Weight, per cent	Cumulative per cent	Weight, per cent	Cumulative per cent	Weight, per cent	Cumulative per cent
Retained on 10 mesh	....	....	....	....	....	....
" 14 "	4·75	4·75	6·22	6·22	....	....
" 20 "	6·56	11·31	9·30	15·52	....	....
" 28 "	7·07	18·38	9·82	25·34	....	....
" 35 "	21·50	39·88	28·88	54·22	2·92	2·92
" 48 "	21·79	61·67	24·94	79·16	32·66	35·58
" 65 "	15·25	76·92	13·20	92·36	37·69	73·27
" 100 "	9·28	86·20	2·12	94·48	16·17	89·44
" 150 "	5·25	91·45	5·00	99·48	5·11	94·55
" 200 "	2·15	93·60	0·24	99·72	2·81	97·36
Through 200 "	6·40	....	0·28	....	2·64	....
Totals	100·00	....	100·00	....	100·00	....
Average fineness	51·07		34·34		55·43	

No. 1. Crude material crushed to pass 10 mesh.
No. 2. Crude material crushed to pass 10 mesh and washed.
No. 3. Crude material crushed to natural grain and washed.

A study of these figures reveals some interesting data. Unwashed crude material yielded 86·20 per cent above 100 mesh, while washed material left 94·48 per cent on the same screen. In the test where the material was crushed to the natural grain and washed, there is 89·44 per cent retained on the 100-mesh screen. The loss in washing in this last test was 10·6 per cent, which is not excessive in general practice. A microscopic examination of the material retained on the several screens showed that the material retained on all the screens up to the 35 mesh is composed of grain aggregates, and it is not until the material is crushed to 35 mesh or finer that these aggregates are disintegrated and the true grains liberated. Therefore, in commercial practice, if this material were crushed to pass the 10-mesh screen and washed, the aggregate grains remaining in the finished product would tend to break down in shipping and cause additional fines in the material by the time it reached its destination. However, by crushing to a finer mesh, the rock would be broken to its natural grain and the fines could be eliminated by washing.

CHEMICAL COMPOSITION

Chemical analyses showed that the material is a very pure silica rock, with few impurities. The iron content is comparatively low, none of the samples tested containing higher than 0·2 per cent. The other impurities, such as lime, alumina, and magnesia are also low and within the limits required for glass sands, so that it is altogether probable that sand produced from this deposit would be suitable for glass manufacture.

The following are the results obtained from the several analyses made:

Chemical Analyses

—	1	2	3	4	5
	per cent	per cent	per cent	per cent	per cent
Silica (SiO_2)	98·42	98·70	98·71	99·08	99·22
Iron oxide (Fe_2O_3)	0·197	0·064	0·053	0·157	0·157
Alumina (Al_2O_3)	0·50	0·41	0·63	0·16	0·10
Lime (CaO)	0·12	0·23	0·13	0·16	0·04
Magnesia (MgO)	0·29	0·37	0·30	0·33	0·28
Loss on ignition	0·38	0·25	0·22	0·19	0·12
	99·907	100·024	100·043	100·077	99·917

No. 1. Crude rock submitted by the Lake Louise Silica Co. (unwashed).
No. 2. Crude rock taken from sample from talus pile (unwashed).
No. 3. Crude rock taken from sample from talus pile (washed).
No. 4. Crude sand from deposit submitted by Lake Louise Silica Co. (unwashed).
No. 5. Crude sand from deposit submitted by Lake Louise Silica Co. (washed).

POTTERY TEST

A sample of the crude material was crushed in an agate mortar, then in a ball mill to pass 150 mesh, and a small quantity burned to cone 12 (1370° C or 2498° F.). The burned sample was fully equal in colour and cohesiveness to standard potter's flint burned under similar conditions.

SUMMARY OF CONDITIONS

This material is a high-grade sandstone from which a good grade of silica sand suitable for industrial use could probably be manufactured. The deposit, however, is remote from transportation and it would be very expensive to build a road to the locality from the nearest railway line at Lake Louise. If such a road were built the cost of haulage to the railway (22 miles) would still amount to a considerable item. The present market for silica in western Canada is small, probably not more than 5,000 tons annually, and in most cases the markets are at a considerable distance from Lake Louise, so that freight charges would be an important factor.

BRITISH COLUMBIA

Kamloops Deposit

A small outcropping of silica (quartz) occurs just to the south of the town of Kamloops in the SE. ¼ sec. 6, tp. 20, range 17, west of the 6th meridian. The distance by road to the railway is only 2 miles.

The quartz is exposed in a narrow draw less than 100 yards from the road and has been stripped for a width of 15 feet across the deposit and about 20 feet up the west side of the gully. Very little work has been done outside of some stripping so that no idea could be obtained as to the extent or the strike and dip of the rock. It is of interest, however, on account of its close proximity to the railway.

The rock is pure white and rather more opaque than vitreous and where exposed showed very few inclusions of impurities.

A surface chip sample was taken, lengthwise of the gully; across the deposit for 25 feet, and analysed with the following results:—

	Per cent
Silica (SiO_2)	85·92
Iron oxide (Fe_2O_3)	1·27
Alumina (Al_2O_3)	0·65
Lime (CaO)	4·03
Magnesia (MgO)	2·18
Loss on ignition	5·27
	99·32

Shuswap Lake Quartz

On the east shore of Shuswap lake, 7 miles north of Sicamous on the main line of the Canadian Pacific railway, a massive deposit of quartz occurs along the shore. This appears to have a strike a little to the west of south and the deposit disappears under the water, as it is followed southwards. The main exposure examined was on subsection 4, lot 34, tp. 22, range 8, west of the 6th meridian. At this point a trench about 10 feet wide and 40 feet long (*see* Plate IIIB) has been excavated, from which a considerable tonnage has been taken in past years.

The rock is very white and massive with only a few places where other included minerals were noted. The adjacent rock is in places heavily iron-stained, but in only a few places was the quartz discoloured.

The extent of the deposit could not be determined as it was covered with drift except where the trench has been made. According to Davis[1] 100 tons from this deposit were mined by Jos. Blais, Kamloops, B.C., and the quartz shipped to the Trail smelter (Consolidated Mining and Smelting Co.) where it was used in connexion with the manufacture of hydrofluosilicic acid.

A representative sample from the trench on this deposit analysed as follows:—

	Per cent
Silica (SiO_2)	98·20
Iron oxide (Fe_2O_3)	0·13
Alumina (Al_2O_3)	0·77
Lime (CaO)	0·57
Magnesia (MgO)	0·34
Loss on ignition	0·17
	100·18

Silica Deposit near Keefer's, B.C.

LOCATION

The deposit is situated on the west bank of the Fraser river, in sec. 32, tp. 11, range 26, and secs. 5 and 8, tp. 12, range 26, west of the 6th meridian, and consists of the following mineral claims, in order from the south:—(*See* accompanying map, Figure 5.)

Mary Ann Fraction	Lot	1106
Mary Ann	"	1081
Gisby Fraction	"	1105
Gisby	"	1098
Madge	"	1079
Salmon River Fraction	"	1104
Salmon River	"	1077
Laura	"	1080

[1] Davis, A. W.: Ann. Rept. Minister of Mines, B.C., 1923, p. A172.

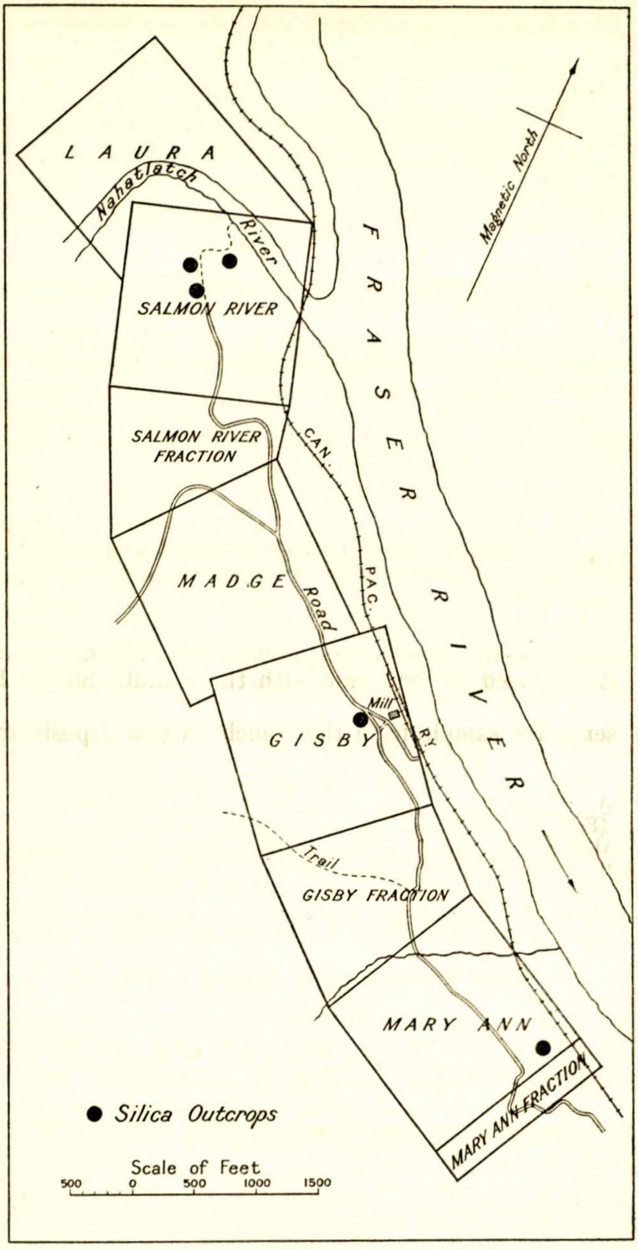

Figure 5. Sketch map showing claims on silica deposit near Keefer's, B.C.

TRANSPORTATION

A wagon road runs through all of the claims paralleling the river to a point on the top of the bank on the south side of the Nahatlatch river, approximately in the centre of the Salmon River claim. The Canadian Pacific Railway main line runs parallel to the claims between the claims and the Fraser river. A siding is located on the railway at the southeast corner of the Gisby claim.

TOPOGRAPHY

The claims are all situated on a steep slope on the west side of the Fraser river, there being but a few places where any considerable level ground is encountered. The river is from 300 to 500 feet below the claims. Second-growth timber covers practically all of the claims and there is a light overburden over most of the area.

DESCRIPTION OF THE DEPOSITS

The silica outcrops are all so similar in character and geological associations that they may be considered, for descriptive purposes, to be one and the same deposit. While only three localities were examined there were indications that the intervening areas were underlain by silica, so that it is probable that the deposit is continuous or practically continuous for approximately 1½ miles.

The three localities examined were a quarry just on the south edge of the Mary Ann claim, between the road and the river; the long crosscut near the mill on the Gisby claim; and on the Salmon River claim between the hoist at the end of the wagon road and the Nahatlatch river.

These three localities are in line with one another and with the general trend of the enclosing rocks which are principally slaty sediments. The dip of the quartz is about 60 degrees to the southwest.

In referring to the character of the enclosing rocks Cairns[1] says:

> This ledge (quartz) dips to the southwest at a high angle. Above it lies a belt of micaceous slaty schists and underneath dip other slaty rocks which, in part, have a rather talcose feel, and, in part, are less altered in appearance. A specimen of the latter was examined under the microscope and found to be a graphitic biotite schist containing a large percentage of clear plagioclase and quartz crystals and much reddish biotite. The latter is partly altered to a greenish chlorite and there is some calcite in the slide. These sediments are intersected both above and below the quartz ledge by a number of narrow sills mostly of felsitic texture and uncertain composition. The largest of these, about 3 feet wide, outcrops 50 feet above the ledge and has the composition of a hornblende diorite porphyry. It is likely that these intrusives are related to the period of silica deposition and to the metamorphism and alteration of the enclosed sediments.

The full width of the ledge has not been exposed so far. The largest exposure noted was 50 feet. A sample taken a number of years ago from the ledge on the Salmon River claim contained 98·24 per cent silica.

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[1] Unpublished manuscript. An extensive description of this deposit, together with the associated talc, is given in "Talc Deposits of Canada," Geol. Surv., Canada, Pub. No. 2092, 1926, pp. 41–49 inc.

A sample of the quartz was obtained from the quarry on the south edge of the Mary Ann claims. An analysis of this material gave the following results:—

	Per cent
Silica (SiO_2)	96·26
Iron oxide (Fe_2O_3)	0·37
Alumina (Al_2O_3)	1·00
Lime (CaO)	0·80
Magnesia (MgO)	0·24
Loss on ignition	0·80
	99·47

MILL

A small mill has been erected on the southeast corner of the Gisby claim to treat the silica and talc encountered in the crosscut nearby.

This mill consists of two units, one for silica and the other for talc grinding. A 40 h.p. Diesel oil engine operates the plant which consists of crushers, screens, elevators, pulverizers, and an air separator.

Shipment was made in sacks from the Canadian Pacific Railway siding nearby.

Products prepared were chicken grit, ground silica, and ground talc of several different grades.

The property is idle at present.

APPENDIX I

RECENT DEVELOPMENTS IN THE SILICA INDUSTRY IN EASTERN CANADA

INTRODUCTION

Since the publication in 1923 of Silica in Canada Part I (Eastern Canada), a number of important changes and developments in the silica industry have taken place. Several new deposits have been opened up on which plants have been erected, and the products from these deposits are finding a ready market. It is too soon to say whether such development will eventually result in the imported material from Belgium and the United States being replaced in eastern Canada, but, judging from the results so far achieved, important progress has already been made.

The increasing stringency of the specifications for high-grade silica sands for use in the glass industry, especially in the low percentage of iron (Fe_2O_3) allowable (not greater than 0·06 per cent), has made it more and more difficult for sand producers in Canada to meet the requirements of the glass companies. While these strict specifications on the part of the glass companies are perfectly justifiable, since they have to meet an ever-increasing demand for a clearer and whiter product, it means that the sand producers must take the utmost care, not only in selecting the purest rock obtainable from their quarries, but they also must keep the closest checks on their washing and screening plants.

Unlike the producers of gold or silver, the value of whose product depends on the precious metal content, if a silica sand does not fulfil the specifications it is not marketable and the material is generally a dead loss. The success of the silica industry in Canada depends entirely on whether the producers are able to place materials on the market which meet all the requirements of the different consuming industries.

During the past five years there have been several deposits in eastern Canada on which considerable development work has been done, with varying degrees of success, mainly in the localities noted below.

BUCKINGHAM AREA

In the Buckingham area, Quebec[1], the Scarf property and a part of the Bilsky property have been purchased by the Canada Glass Products, Ltd., with head office in Hull. The company has opened up an extensive quarry on the Scarf property and erected an up-to-date mill for crushing, washing, drying, and screening their product. The quarry is situated at the west end of a lake on the property, and a narrow-gauge railway, a quarter of a mile long, connects the quarry with the mill. The rock is drilled by power drills and loaded into 1-ton cars, from which it is dumped

[1] "Silica in Canada: Part I—Eastern Canada"; Mines Branch, Dept. of Mines, Canada, Rept. 555, p. 55.

into larger cars on the narrow-guage railway. A small locomotive hauls train-loads of these larger cars to the foot of the incline leading up to the top of the mill. The following flow-sheet (Figure 6) shows the operation of the mill.

Electric power is employed in the mill, steam for the drier being generated by a boiler. The mill has a capacity of 300 tons per 24 hours. The product is used for the manufacture of carborundum and glass, and in the steel foundries.

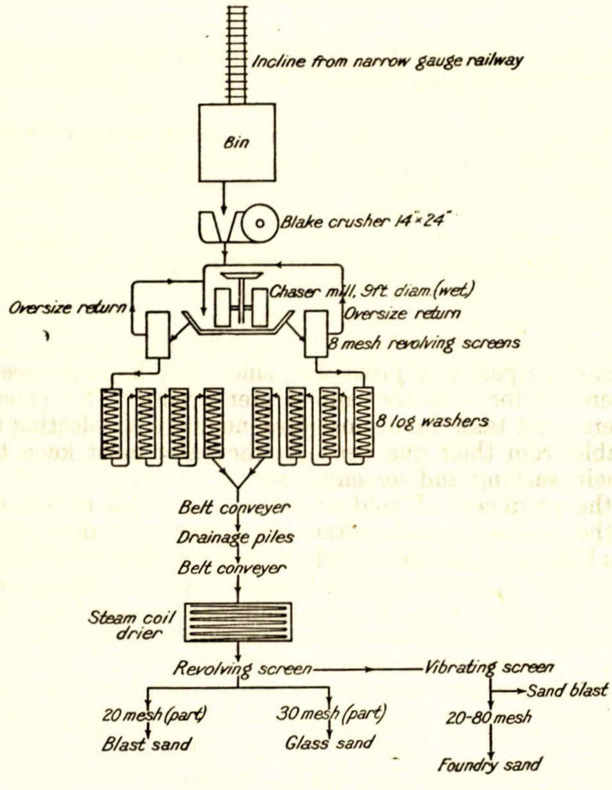


Figure 6. Flow-sheet of the Canada Glass Products Company, East Templeton, Que.

KINGSTON DISTRICT

On the Gates property,[1] 9 miles east of Kingston on the St. Lawrence river, a deposit of sandstone is being opened up by the same company operating the Scarf property. Plans are made for the erection of

[1]Op. cit., pp. 44 and 45.

another modern mill and it is hoped to have this in full operation by the end of 1928. A sample, taken recently from this property, and after washing in the laboratory, analysed as follows[1]:—

	Per cent
Silica (SiO_2)	99·39
Iron oxide (Fe_2O_3)	0·06
Alumina (Al_2O_3)	0·14
Lime (CaO)	0·15
Magnesia (MgO)	Trace
Loss on ignition	0·18

ST. CANUTE, QUE.

The Cascades Silica Products Co., Ltd., owners of a deposit at St. Canute,[2] have been reorganized under the name of Silico, Ltd., with head office at 254 Ontario St. West, Montreal. Their mill at St. Canute was entirely destroyed by fire within the past two years, but has been replaced by a modern mill of larger capacity. Within the past year a sand-lime brick plant has been built to utilize the white sand in making a dead-white brick for the building trade.

The operations at this property are as follows:—

1. Blasting and quarrying to man size.
2. Carting to mill elevator.
3. Preliminary crushing (jaw crusher).
4. Secondary crushing (Symons pulverizer).
5. Reduction into sand in a chaser mill.
6. Washing in a battery of log washers.
7. Draining in drainage piles.
8. Drying in a steam tube drier.
9. Division by screening into several grades to suit:
   (a) Sundry markets for sand.
   (b) Needs of sand-lime brick plant.
   (c) For grinding in a pebble mill into various grades of fineness —ground silica. (This fine-grinding plant is in course of erection.)

SILICA SAND IN CAPE BRETON, N.S.

M. F. Goudge

Deposit of the River Dennis Sand and Clay Company, Ltd.

LOCATION

The property is about one mile northeast of the settlement known as River Dennis Road, and about 4 miles by road west of Melford.

[1] J. T. Donald and Co.—Analysts.
[2] "Silica in Canada: Part I—Eastern Canada"; Mines Branch, Dept. of Mines, Canada, Rept. 555, pp. 53-55.

TRANSPORTATION

The sand is hauled in Ford motor trucks 9 miles to the Canadian National railway at Cummings Siding near River Denys station. About 3½ miles of the wagon road have been constructed by the company. It is proposed to build a light railway from the sand pit to the Canadian National railway.

TOPOGRAPHY

The sand occurs in the depression at the junction of the east and west branches of Diogenes brook. Steep, wooded hills rise almost from the water's edge. The sand occurs for a short distance up the steep slopes, as well as under the more level ground at the junction of the brooks. The brooks follow a steep slope to their junction, but from there onwards the gradient is very gentle.

ROCK FORMATION

The rocks along the upper waters of the brooks have been mapped by Fletcher as being of George River age and consist of syenites, impure quartzites, and crystalline limestones. Outcrops of dolomitic and high-calcium limestone are to be seen in the immediate vicinity of the sand deposits.

THE SAND DEPOSIT

The sand, which varies in colour from light yellow-brown to nearly white, is composed of grains of semi-transparent, white and yellowish white quartz, which vary in size from one-half inch in diameter down to a very fine sand, almost a rock flour. The various sizes are not intermingled, but occur in well-defined strata. The brown tint, which is most pronounced when the sand is wet, is due to a clayey coating on the sand grains.

The impurities consist of minor amounts of white mica and of dark-coloured rock minerals. Another impurity which, however, renders the sand the more desirable for moulding purposes, is clay, which occurs to a greater or less extent through all the sand. In the main sand pit there has been exposed a bed of blue clay, 4 to 8 feet in thickness, dipping at the same angle as are the sand beds. This clay contains nodules of pyrite. In the upper 12 feet of the sand, especially the medium-coarse grades, are numerous nodules varying in diameter from that of a pea to over 2 inches. These nodules consist of sand grains firmly cemented by iron oxides. In the larger nodules the hard outer shell, about ⅛ inch thick, is composed of sand cemented by a purplish brown hematite; the remainder of the nodule is cemented by an earthy-brown limonite (?). The small nodules are entirely cemented by hematite. The surrounding sand is stained a deep purple for an inch or so away from the nodules. These nodules are not found at a greater depth than about 12 feet from the surface.

The property has not been developed to any extent as yet (July, 1926), but the sand has been uncovered at several places over an area 800 feet long (north and south) and 450 feet broad. Not all of the area is underlain by sand. A depth of 80 feet of sand is said to have been proved by a boring near the brook, and the bottom of the deposit was not reached. The property is densely wooded and the overburden of gravelly soil varies from 2 to 12 feet.

Seven grades of sand classified according to fineness are at present available at the deposit. The various grades occur in seams which, as exposed in the pit, dip in a southeasterly direction at an angle of 50 degrees. The relation of the various strata to one another is shown in Figure 7. In

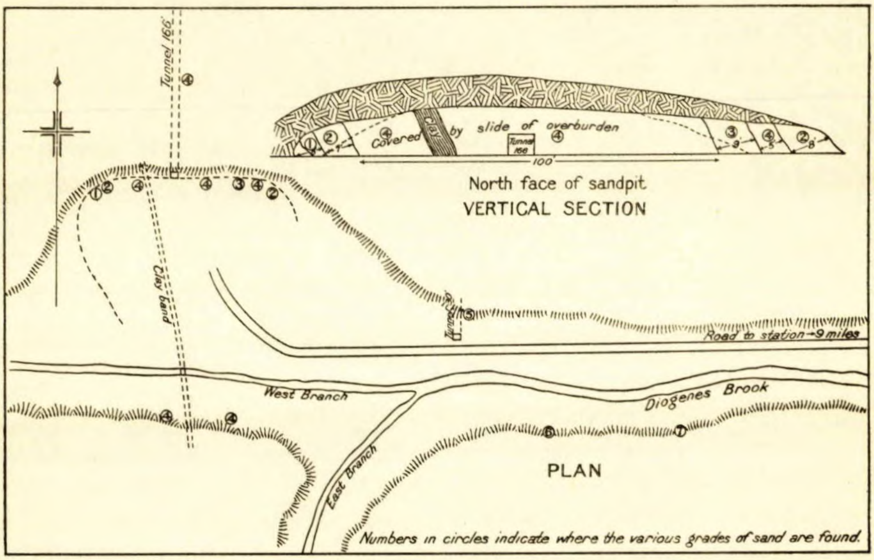


Figure 7. Sketch of property of the River Dennis Sand and Clay Company, Ltd., Melford, N.S.

other places the stratified nature is not so much in evidence and the sand is overlain by horizontal beds of white clay. A brief description of the seven grades follows:

Grade No. 1.—A silica gravel mixed with considerable clay. The grains vary from moderately coarse up to ½ inch in diameter. This material is used for "banking."

Grade No. 2.—A mixture of clay and coarse sand, which is used for "bonding."

Grade No. 3.—A medium-grained, tan-coloured sand, which is comparatively free from clay and contains practically no mica. It is used in making heavy castings.

Grade No. 4.—Very similar to No. 3 but is slightly finer grained and of lighter colour. It is used in foundries.

Grade No. 5.—A light-grey, medium-fine-grained sand containing a considerable amount of clay and some flakes of white mica. It is used in foundry work.

Grade No. 6.—A fine-grained, greyish white sand which contains a quantity of white mica as well as clay. It is used in foundry work.

Grade No. 7.—This is the finest grained sand yet found in the deposit. There is much clay mixed with it and also considerable white mica. It is used for brass moulding.

DEVELOPMENT

The property is still in the initial stages of development. The overburden has been stripped from an area about 125 feet in diameter and a low working-face of from 12 to 15 feet of sand exposed. A tunnel has been driven into the north side of the pit for a distance of 166 feet (July, 1926), the whole distance being in Grade No. 4 sand. This grade forms the bulk of the shipments to date. The sand, after being trammed from the tunnel face, is dumped into an elevated hopper which loads it into motor trucks. Another tunnel has been started in Grade No. 5 sand some distance east of the main pit. The other grades of sand are practically undeveloped, only a small amount of overburden being cleaned off in order to disclose the nature of the sand.

PRODUCTION AND USES

No data on production were obtainable, but a fair market seems assured and considerable material was being shipped. The chief consumers at present are the British Empire Steel Corporation, Sydney and New Glasgow; and Cummings Foundry at New Glasgow. The sand, owing to its clay content is particularly adapted for moulding and casting purposes. Doubtless, this clay could easily be removed by washing if a pure silica sand were desired.

SILICA ROCK IN CAPE BRETON, N.S.

M. F. Goudge

Leitches Creek Quarry of the British Empire Steel Corporation

LOCATION

The quarry is located in the Boisdale hills about 5½ miles west of Leitches Creek station, Cape Breton county.

TRANSPORTATION

The stone is hauled by team over a fairly good road to Leitches Creek station and from there shipped by Canadian National railway to the plant of the British Empire Steel Corporation, Sydney.

TOPOGRAPHY

The quartzite occurs in the valley of George brook, which flows obliquely down the southeast flank of the Boisdale hills. The sides of the valley are steep and heavily wooded.

ROCK FORMATION

The quartzite and the associated rocks have been mapped as belonging to the George River formation by Robb and Fletcher of the Geological Survey. This formation, which is classed as Precambrian, consists largely of altered limestones and siliceous sediments.

THE QUARRY

The quarry has been opened at the base of the steep hillside on the southeast side of George brook, about a quarter of a mile south of the road from Leitches Creek to Barachois. The quartzite quarried is fine-grained, brittle, and greyish white with blue and brown tints in places. It is much fractured and tends to break easily into small angular fragments. Aside from what is exposed in the quarry, this type of stone is to be seen outcropping to the south and west in the valley of a small tributary stream. The white quartzite is also to be seen farther east.

Associated with the white quartzite in the district are impure, blue quartzites, masses of dark-coloured basic rocks and light-coloured granite dykes. A few small veins and masses of milky quartz are noticeable both in the pure and in the impure quartzites. Iron stains are to be seen along many of the joints in the stone, particularly near the surface.

The quarry face (August, 1926) is about 215 feet long, 20 feet high, and has been carried in about 70 feet from the original starting point. On top of the working-face is about 10 to 15 feet of impure, blue quartzite, and on top of this again there is from 7 to 9 feet of gravelly soil which supports a heavy forest growth. Near the contact of the white and the blue quartzite is a tongue of light-coloured granite varying in thickness from 6 feet, near the western end of the quarry, to 2 inches near the eastern end. It apparently dips into the hill at an angle of about 10 degrees. The impure rock and granite are stripped off ahead of the quarrying operations. The floor of the quarry is in white stone.

What seems to be the strongest set of joints trends 152 degrees and is vertical. There are three large fractures, apparently fault-planes, in the quarry face, at intervals of 120 feet, 175 feet, and 195 feet from the western end of the quarry. These fractures trend 15 degrees and dip 70 degrees westerly. The two nearest the western end are each about 6 inches wide and contain serpentine and chlorite. The fracture near the eastern end of the quarry terminates the white quartzite, blue quartzite occurring on the east of the fracture. There is a small showing of white quartzite about 20 feet farther east, but its extent could not be determined.

Higher up the hillside, about 700 feet northeast of the operating quarry, is another small quarry. This was the first to be opened up but was abandoned because of the large quantity of undesirable stone that had to be removed in proportion to the amount of good stone obtained.

Between the two quarries the greater part of the stone exposed is impure quartzite with some hornblende schist. Northeastward from the abandoned quarry the quartzite exposed on the surface is all impure.

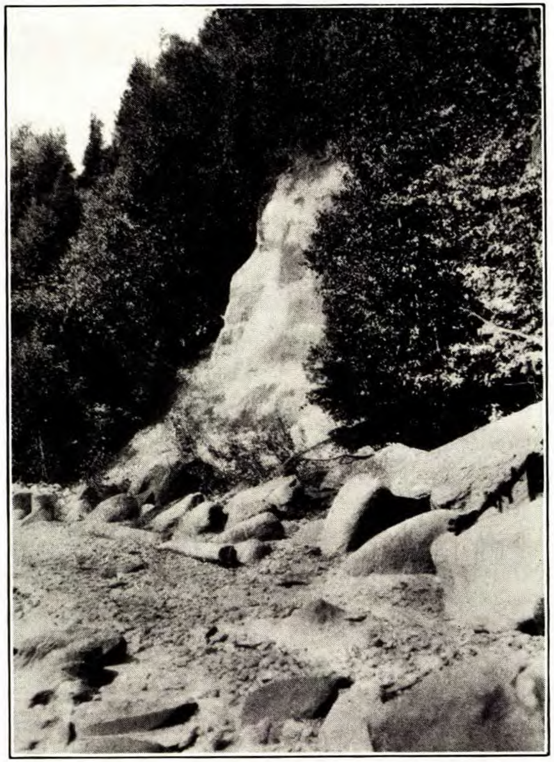
QUARRY METHODS

The overburden of gravel and impure rock is first removed, the remaining solid quartzite is then blasted out and loaded on wagons.

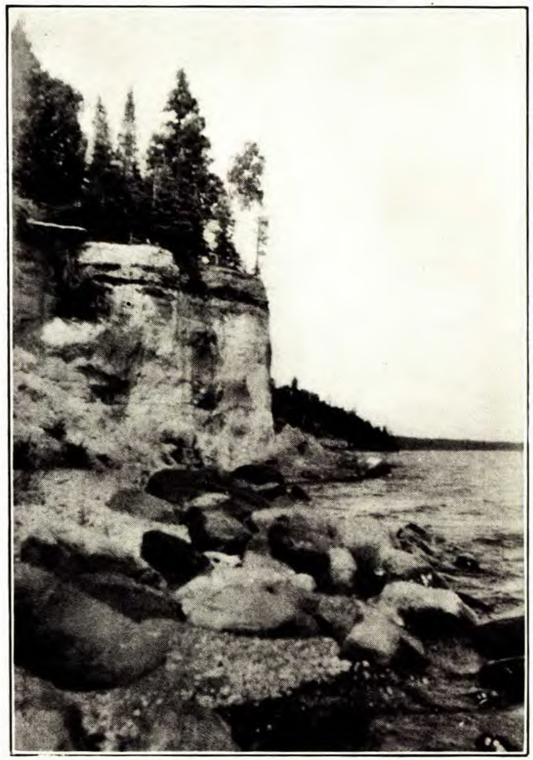
The drilling is done with an Ingersoll, steam, tripod drill. A single line of holes which slope downward at an angle of 10 degrees is drilled into the bottom of the working-face to a depth of from 10 to 14 feet. The holes are commenced with a 3-inch bit and finished with a $1\frac{1}{4}$-inch bit. They are loaded with 40 per cent dynamite, from 15 to 25 sticks being used per hole depending on whether the rock is much fractured or fairly solid. The spacing of the holes is also very irregular depending on the nature of the stone.

PRODUCTION AND USES

The production is intermittent, depending entirely on the company's immediate requirements. The material is all used in the manufacture of silica brick for their own furnaces.



A. Sandstone cliff on southeast shore of Black island, lake Winnipeg, Man.

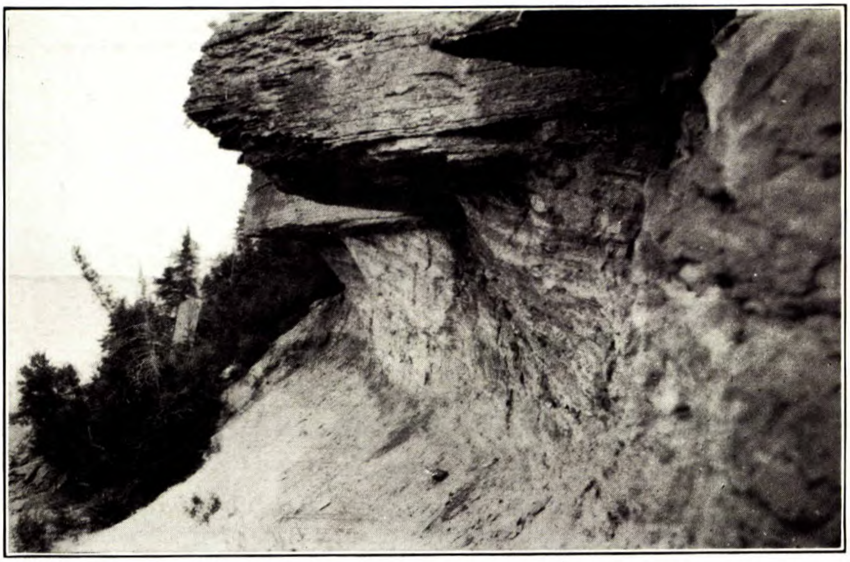


B. General view along southeast shore of Black island, lake Winnipeg. The cliff at this point is 70 feet high.

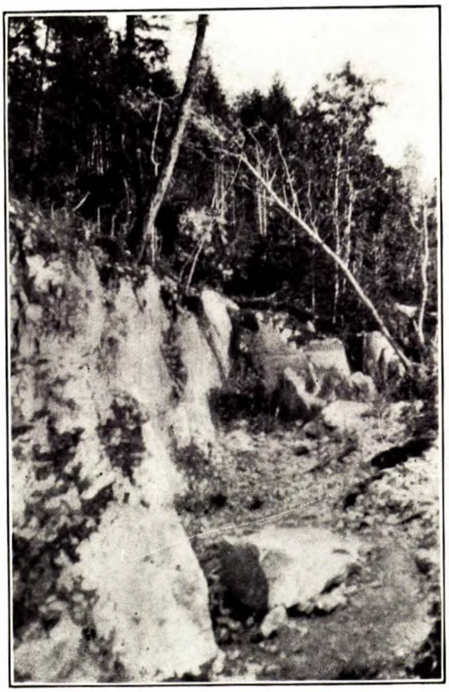
A. Southeast shore of Black island, lake Winnipeg, Man., showing large blocks of chocolate-coloured sandstone fallen from hard bands in cliff.

B. Southeast shore of Black island, lake Winnipeg, Man., showing sandstone cliffs and large blocks of white sandstone broken down from escarpment.

PLATE III



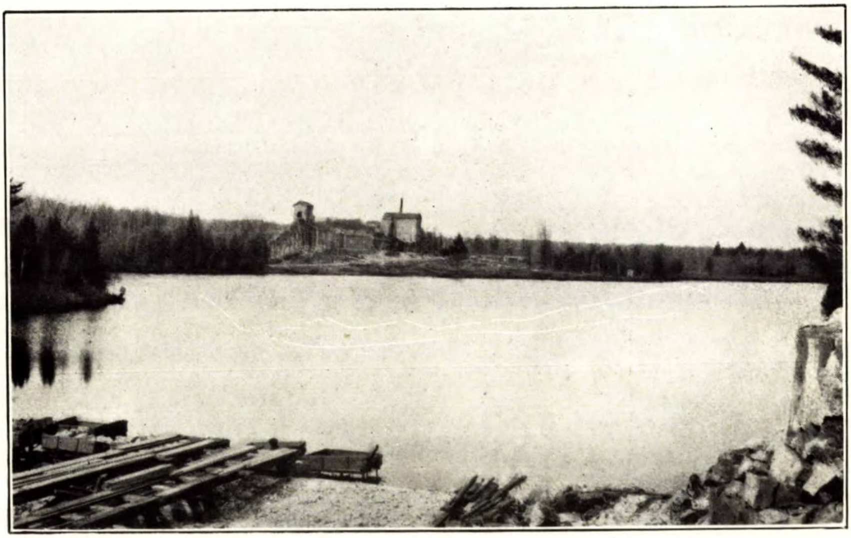
A. Grindstone point, lake Winnipeg, Man., showing limestone capping cross-bedded sandstone.



B. Side of trench in quartz deposit on Shuswap lake, 7 miles north of Sicamous, B.C.

PLATE IV

A. Quarry of Canada Glass Products Co., Ltd., on Scarf property, East Templeton, Que.

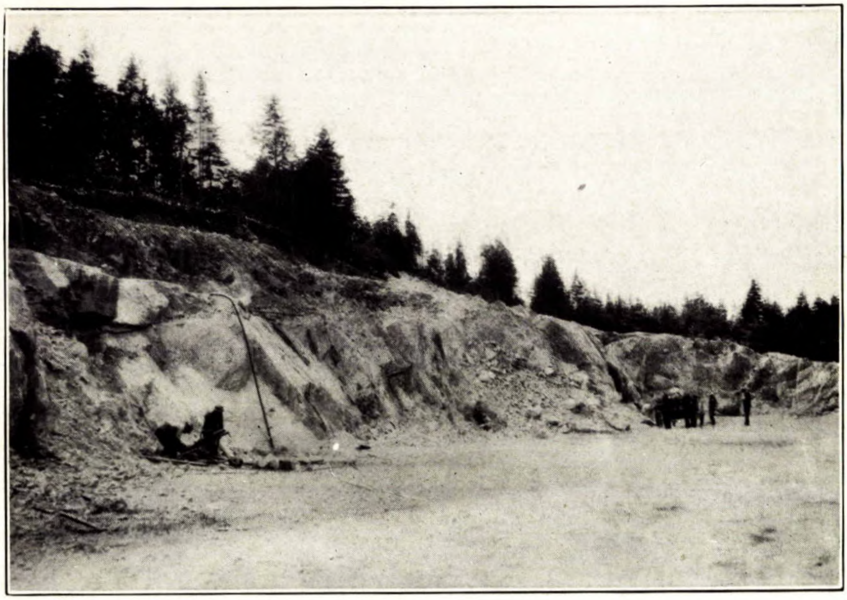


B. Mill of Canada Glass Products Co., Ltd., East Templeton, Que.

PLATE V

A. Quarry of Silico Ltd., at St. Canute, Que.

B. Mill of Silico Ltd., at St. Canute, Que.



A. Quartzite quarry, Leitches Creek, Cape Breton county, N.S. View showing method of drilling, transportation, and general conditions affecting development.

B. Quartzite quarry, Leitches Creek, Cape Breton county, N.S. Close-up view of the white quartzite showing the shattered condition of the stone.

INDEX