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Geology of the Peace River Glass Sand Deposit

by

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TABLE OF CONTENTS

MAPS, FIGURES AND TABLES

MAPS, FIGURES AND TABLES (continued)

GEOLOGY OF THE PEACE RIVER GLASS SAND DEPOSIT

INTRODUCTION

Importance of Glass Sands to Alberta

There are many types of glass, but in general glass is made from a mixture of silica (quartz), various alkalies, alkali earths and metals. These substances are mixed in certain definite proportions depending on the kind of glass desired. Silica comprises 50 to 75 per cent of the batch. The batch is mixed by heating it until all the ingredients are melted together; consequently cheap fuel is a prime requisite for the establishment of a glass industry.

Natural gas provides a cheap source of heat for glass making, and consequently the widespread occurrence of this fuel in Alberta serves as the basis of the glass industry of the Province. Glass sand is brought to the factory at Redcliff, Alberta, from Illinois, so that the discovery of deposits of this material in Alberta would make the industry not only independent of foreign sources, but could lead to its expansion. Consumption runs from 10,000 to 15,000 tons annually. During the late war the uncertainty and high cost of transporation led to a search for local supplies of glass sand. Two possible sources of sand were investigated, namely the quartzitic sandstones occurring in the Rocky Mountains, and sands occurring on the beaches of several of the larger lakes. Neither of these sources has as yet proved worthy of development, the sandstones proving too hard for working profitably, and the beach sand deposits too impure or too small.

In 1946 a deposit of sandstone was found near the town of Peace River, and is the subject of this report, since it offers good prospects as a source of glass sand.

Explanations of Terms.

A glass sand is a sand that is high enough in silica for use in the manufacture of glass. Usually the silica content is over 90 percent, and the sand such that it can be cheaply treated to raise this percentage. Very few sandstone deposits meet these requirements.

Silica is silicon dioxide, and occurs in nature as the mineral quartz, which is a prominent constituent of many rocks. The quartz grains in a glass sand deposit are most often cemented together and as such the rock is a sandstone; but when the sandstone disintegrates the loose grains are collectively known as sand.

Origin of Glass Sand.

Sand is formed from rock which has disintegrated due to the action of temperature changes, erosion, chemical action and other agencies. If the rocks contain free quartz, as do granite, gneiss and many others the resulting sand will show a higher percentage of silica than the parent rock. This is because quartz is more resistant to chemical action than most other minerals, and also so tough that it is better able to withstand the rubbing and bumping together to which sand grains are subjected by wind, waves and water currents. Thus as time goes by the percentage of silica in the sand will slowly increase due to the gradual removal of the other minerals by solution and their destruction by abrasion. However, the quartz grains themselves do suffer from these processes for sharp corners are worn away, and the grains become rounded.

Occasionally the sand deposit becomes consolidated due to the cementing together of the grains. While in this state the percentage of silica will remain static and will not increase until the agents of erosion and weathering attack the sandstone, disintegrating it. Consolidation of the sand may take place several times, and each time the proportion of quartz to the other minerals increases. Eventually the sand may be almost wholly quartz, with minor amounts of zircon, titanite, feldspars, etc., and as such may become a glass sand. A deposit of this type may run as high as 97 per cent silica, and this may be raised to over 99 per cent by washing out impurities with water.

REQUIREMENTS OF A GLASS SAND

Chemical Properties.

Sand for glass must be almost pure silica (quartz), and contain very little iron. Table 1 gives the different grades of glass that can be made from silica sand of varying purity.

Table 1.

Qualities of Glass that Can be Produced from Sands of Varying Chemical Composition

(Based on ignited samples)

QUALITY		% SiO_2 Min.	% Al_2O_3 Max.	% Fe_2O_3 Max.	% CaO MgO Max.
First quality	optical glass	99.8	0.1	0.02	0.1
Second "	flint glass containers	98.5	0.5	.035	0.2
Third "	flint glass	95.0	4.0	.035	0.5
Fourth "	sheet glass, rolled & polished plate	98.5	0.5	.06	0.5
Fifth "	sheet glass, rolled & polished plate	95.0	4.0	.06	0.5
Sixth "	green glass containers and window glass	98.0	0.5	.3	0.5
Seventh "	green glass	95.0	4.0	.3	0.5
Eighth "	amber glass	98.0	0.5	1.0	0.5
Ninth "	amber glass	95.0	4.0	1.0	0.5

The requirements for each quality of glass in the above table may vary slightly. It is to be noted that for most qualities the silica content should be not less than 98 per cent, and the iron not over 0.3 per cent. Iron gives the glass a green, yellow or red colour, depending on the amount present. To a certain extent this colour can be neutralized by the addition of manganese to the batch, the resulting colour being a faint shade of purple. The content of titanium should be very low, for it also colours glass. Aluminum oxide, or calcium oxide plus magnesium oxide is permissible up to 2 or 3 per cent provided that these, together with the silica, total over 99 per cent of the sand. The sand should be free from mica as it causes spots and blow holes in the glass.

Physical Properties.

Grain size of the sand is important. If the grains are too large they are not completely mixed with or dissolved in the other ingredients in the batch, and the glass is stringy. On the other hand, sand that is too fine-grained traps air which appears as bubbles in the glass. General requirements as to screen size are: all material to be less than 20 mesh (0.84 mm.) and not more than 2 per cent to be under 100 mesh (0.149 mm.); 50 per cent to be around 40 mesh (0.42 mm.).

In addition the sand should be free from clay or pebbles, which are often insoluble in glass. These impurities may be introduced during stripping operations or in shipping. Screening and washing before shipment, and care in loading for shipment should eliminate them.

Economic Considerations.

Besides possessing favourable chemical and physical properties, a glass sand deposit must be large enough to supply the demand for many years; in addition the overburden must be thin in order that stripping costs may not be excessive. Proximity to transportation facilities is another important factor that requires consideration. The low cost of glass sand, $1.50 to $2.00 a ton, as compared to the cost of transporting it by rail demands that it be cheaply quarried, and also that ample facilities for washing and drying it afterwards be present.

The high cost of glass sand laid down in Alberta would tend to make the development of any local supplies very attractive.

GEOLOGY OF THE PEACE RIVER GLASS SAND DEPOSIT

Location of the Deposit.

The deposit is located principally in section 4, township 85, range 21, west of the 5th meridian and in section 33, township 84, range 21, west of the 5th meridian. It occurs on both sides of the Peace River, though the most continuous outcrops are on the west side. Its position, about seven miles in a direct line, and ten miles by road from Peace River town, places it within easy reach of the railroad. Position of the deposit is shown in Figure 1.

Exploration of the Sand Deposit.

The sand occurrence was first brought to the attention of the Research Council of Alberta in 1946. In that year this organization conducted a water supply survey in the eastern part of the Peace River district. Among the rock samples collected by S. J. Kidd, geologist, there was a small specimen of quartz sandstone which, on account of its purity, appeared to have possibilities as a glass sand. Conditions did not permit more than a superficial examination of the sandstone beds, consequently a preliminary survey of the deposit was not made until 1947. In that year outcrops of the sand were examined, and a number of samples secured for analysis. Tests and analysis of these samples indicated that the sand had commercial possibilities as a glass sand. Further data and more samples were secured in 1948. The present report embodies all the important data collected in the years 1946 to 1948.

Local Areal Stratigraphy.

The distribution of the rock formations comprising bedrock in the vicinity of the glass sand deposit is shown on Map 1, page 7 , and is given in the following table:

Upper Cretaceous	-	Dunvegan formation - sandstone and shale
Lower Cretaceous	-	Fort St. John formation - marine shale
	-	Peace River formation - massive sandstone and shale

All exposed bedrock in the area is either lower Upper Cretaceous or upper Lower Cretaceous in age and belong to the three formations listed above. A brief description of each formation follows.

Dunvegan Formation

Rocks of this formation are interbedded sandstones and shales and are of brackish water origin. It apparently caps the higher parts of the hills, which are brush-covered, and consequently no outcrops of it were observed in the area.

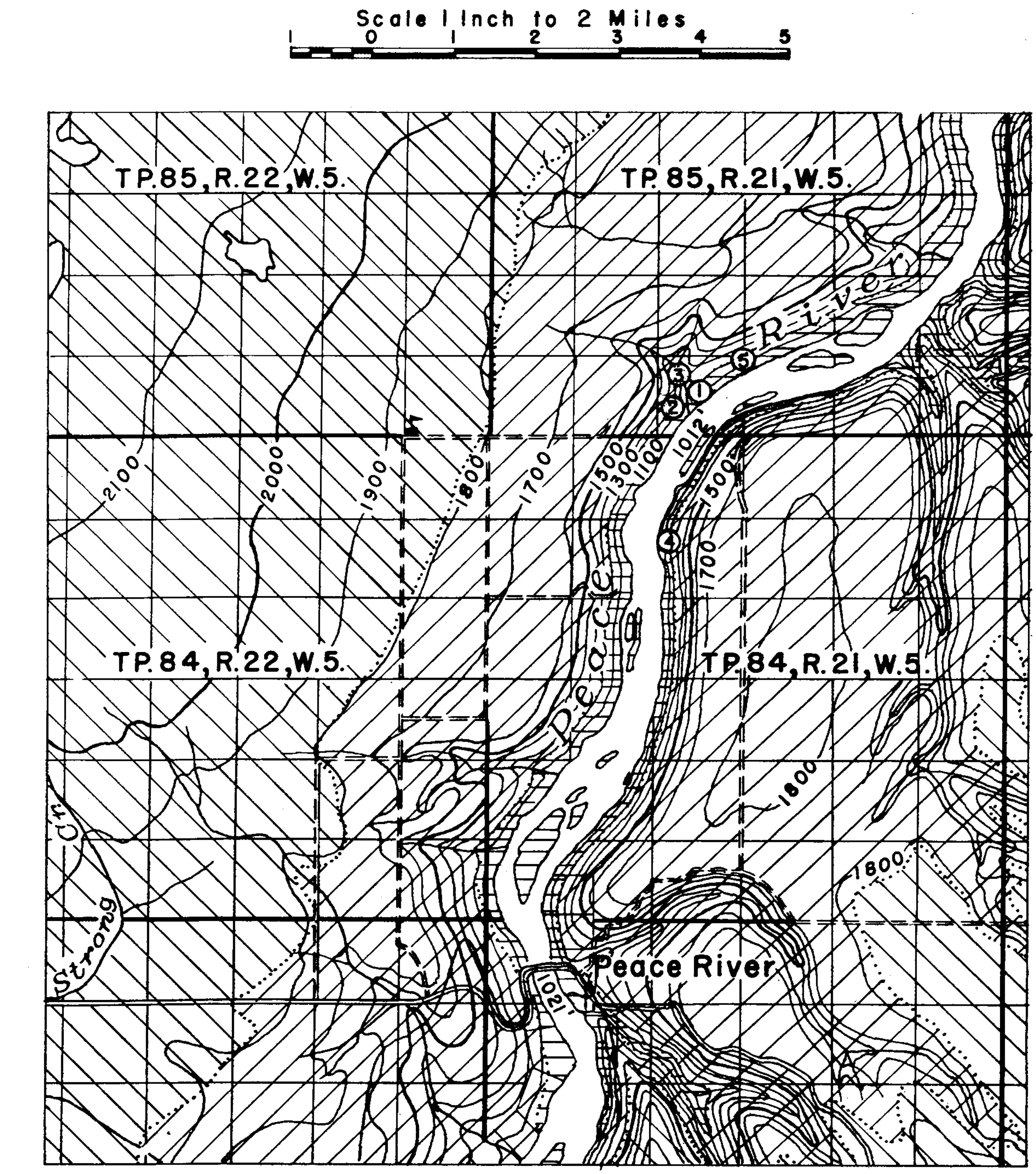
St. John Formation

This formation is about 600 feet thick and consists essentially of dark gray marine shale. Brown-weathering concretions occur sporadically throughout this shale. The rocks of this formation are prone to slump. Fish remains are abundant at the base. Bright yellow, ocherous material is usually present in the shale.

Peace River Formation

This formation consists of three members, two of them massive sandstone, separated by a third, a shale member. Total thickness is about 300 feet. The uppermost member, 100 feet or more thick, forms prominent sandstone cliffs for many miles along the Peace River north of Peace River town. The

GEOLOGICAL MAP OF THAT PART OF THE PEACE RIVER DISTRICT IN THE VICINTY OF THE GLASS SAND DEPOSIT



— LEGEND —

CRETACEOUS

UPPER CRETACEOUS

DUNVEGAN FORMATION

LOWER CRETACEOUS

FORT ST. JOHN FORMATION

PEACE FORMATION

GEOLOGICAL BOUNDARY

(1) SAND DEPOSIT

1012' HEIGHT IN FEET ABOVE SEA LEVEL

1700 CONTOURS, INTERVAL 100 FEET

GRAVEL ROAD

DIRT ROAD

RAILWAY

SCHOOL

FIGURE 1

cliffs are more numerous on the west bank of the river (Figure 1.). The light gray sandstone is usually fine-grained, argillaceous and hard; but about 7 miles below the town there occurs in it a lens of easily crumbled, fairly clean, fine- to coarse-grained quartz sand which has possibilities for use in the manufacture of glass. The sandstone lens is the subject of this report.

Local Structural Geology.

The strata form a broad anticline which has its crest a few miles north of the glass sand deposit. Dip of the strata in the vicinity of the deposit is about 15 feet per mile to the southwest. No faults or other dislocations of strata were observed in any of the outcrops. Hence the structure is quite simple, and no complications in this respect should be encountered whenever the deposit is developed.

Detailed Geology of the Deposit

The lens of sandstone suitable for glass extends along Peace River for about two miles. In almost all outcrops it is exposed on vertical faces of the cliffs, thereby making examination of the sand very difficult (Figures 1 and 2). The thickest section of it that was measured is located in legal subdivision 6, section 4, township 81, range 25, west of the fifth meridian (Locality 1 of Map 1), and is as follows:

	Feet
Soil and concealed interval	18.0
Shale - flaky, blue gray (St. John shale)	16.0
Contact of St. John and Peace River formations	
Sandstone - fine-grained, argillaceous	7.0
Sandstone - fine- to coarse-grained, good quartz sand; three yellow, iron-stained bands, 1 inch to 4 inches thick, crumbly	19.0
Sandstone - ledge-forming, fine-grained, argillaceous, hard	7.0
Sandstone - as in 19-foot bed above	12.0
Sandstone - fine-grained, hard, impure	2.0
Sandstone - as in 12-foot bed above, few thin hard bands	8.0
Sandstone - hard, impure, fine-grained, about	50.0
Base of section	139.0

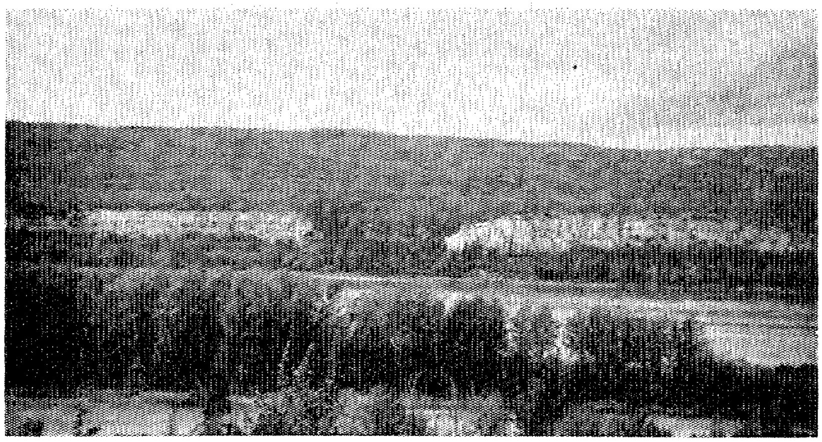


Figure 1—Outcropping of Peace River sandstone on the west bank of Peace River, about seven miles below the town of Peace River. The best exposures of the glass sand occur at the mouth of the stream which has cut the notch in the sandstone cliff.

Figure 2—Exposure of glass sand situated at the mouth of the creek noted in the caption above.

Of the 55 feet of sandstone at the top of the Peace River formation in the above section, the 19-, 12- and 8-foot beds totalling 39 feet are suitable for making glass. The 16 feet of hard, impure sandstone interbeds would have to be discarded. This deposit of clean white sand extends downstream for over one-half mile, but thins in that direction. It is also exposed at Localities 2 and 3, where the sections were measured, and are shown in Figure 3. There is little correlation between the beds in these sections though they are only about 1200 feet apart, and thus the lenticularity of the beds is well shown. It is to be noted that at Localities 2 and 3 there are 22 and 24 feet of glass sand respectively.

The sand extends upstream on the west bank for about one mile above Locality 1, but the sand is coloured a chocolate brown by a coating of iron oxide on the sand grains. It is believed that this iron staining of the sand grains is a surface development only and that the sand a few feet in from the vertical face will be clean and white. The reasons for this conclusion are: (1) the sand deposit consists of clean sand at Localities 1, 2 and 3 where erosion is most active, that is, the layer of brown sand has been eroded; (2) it is reasonable to assume that the iron staining on the grains has been deposited due to evaporation of water in the formation on reaching the air. A few well placed drill-holes would be necessary to prove or disprove this conclusion. Only brown sand occurs on the east side of the river, though in places the amount of iron staining is not great. Iron-free sand may occur there under a cover of rock and brush which conceals most of the sandstone on that side.

A good section of the glass sand was measured in the northwest quarter of section 28, township 84, range 21, west of the fifth meridian (Locality 4). It is as follows:

	Feet
Glacial drift and alluvium	20.0
Gravel	15.0
Silt, light gray clayey streaks	1.3
Sand, loose quartzose, white clean, with coaly streaks	1.7
Coal, powdery	0.9
Sand, white clean, quartzose, medium-grained	2.0
Sand, white, quartzose with streaks of carbonaceous matter	2.6
Coal, lignitic, weathered	1.5
Sandstone, quartzose, purplish colour, cross-bedded	28.0
Sandstone, fine-grained, numberous black specks, argillaceous, at least	50.0
Base concealed	123.0

This section has at least 28 feet of sand that may be suitable for making glass, provided that the discolouration of the grains does not persist. It will be noted too that this locality is about 1 1/2 miles from Locality 1, thereby showing that the sand lens has a lateral extent exceeding that distance. Beyond Localities 1 and 4 the sand lens becomes thinner and fingers out into the fine-grained, impure sandstone common to the Peace River formation. At Locality 5, only 7 feet of glass sand are present.

In developing the deposit, two of the principal problems to be solved are: (1) to determine whether the iron-staining of the sands is confined to the surface of the deposit; (2) to find those places where the overburden is not too great for economic working of the deposit. The overburden is less on the east side of the river, and exploration should probably be commenced there. Moreover outcrops are more accessible on that side, which is another factor favouring initial development there.

Features of the Sand Grains

The grains of sand are almost entirely colourless quartz with a minor amount of smoky quartz. Silica is present also in the form of chalcedony. Accessory minerals are feldspars and titanite. Extra minerals are magnetite, limonite, ilmenite and zircon. Occasionally the sand grains are cemented together by yellowish-brown iron oxides to form pellets, nodular masses, and thin bands from a fraction of an inch to one or two inches across.

The size of the sand grains varies from very fine to very coarse. The proportions of the various screen sizes present are shown in Tables 2, 3 and 6. Screened samples of the sand are shown in Figures 3 and 4.

Examination of the individual grains shows them to vary greatly in degree of roundness. Some are subangular, having only the sharp corners rounded off, whereas other grains have been worn almost spherical (Figures 3, and 4). Some of the grains have dull pitted surfaces.

Origin of the Peace River Glass Sand.

Since the sandstone members of the Peace River formation thin from southwest to northeast, the source of the sediments lay somewhere west of the present site of the Rocky Mountains, and was probably the Selkirk Mountains. Rocks in the upper sandstone member of the Peace River formation were laid down close to a shore-line, as is attested by the presence in them of coaly beds. The fact that they underlie marine shales also shows that the sea was not far away. The lens of glass sand was probably deposited as part of a delta, for the sand in places is cross-bedded indicating strong current action. Furthermore, the glass sands feather out within a few miles, a feature to be expected in a delta. The sands in the lens are so high in silica that they must be a reworked sand deposit that was tapped by the stream and deposited as beneficiated sands.

TESTS AND ANALYSES

Channel samples of the glass sands, each weighing about 40 pounds were taken at Localities 1, 2 and 3, and submitted for analysis. At Locality 2, there are two sand beds, a lower 7 feet thick and an upper 9.5 feet thick, separated by 14 feet of hard fine-grained sandstone and 2.5 feet of coal and carbonaceous shale. These two beds were sampled and tested individually, and are herein called Samples 2A and 2B respectively. Sample 1 represents 39 feet of sands taken at Locality 1, and Sample 3 represents 24 feet of glass sands taken at Locality 3 (see Map 1). The samples were screened to remove all the + 20 mesh, with the results shown in Table 2.

Table 2.

Size Analyses of Original Samples

Field Sample	Weight %	
	+ 20 mesh	- 20 mesh
Sample 1	12.0	88.0
Sample 2A	23.9	76.1
Sample 2B	17.6	82.4
Sample 3	48.0	52.0

The oversize fraction (+ 20 mesh) consists of large grains and lumps and would be discarded. The abnormal percentage of oversize material in Sample 3 is largely due to the presence of lumps of sand in which the cementing material is sap from the roots of trees. This condition is local and the normal percentage of waste will probably not exceed 20 per cent.

The - 20 mesh fractions of the samples were screened for grain size distribution with the results shown in Table 3.

Table 3.

Size Analyses of - 20 Mesh of Original Feed

Sample	1	2A	2B	3
% of total	88.0	76.1	82.4	52
Mesh	Weight %	Weight %	Weight %	Weight %
+ 28	5.0	10.2	14.2	12.4
+ 35	13.6	13.6	18.1	25.9
+ 48	34.8	22.4	40.5	34.0
+ 65	17.9	31.4	18.5	18.6
+ 100	18.3	15.3	5.3	6.3
+ 150	8.9	6.6	2.4	2.3
+ 200	0.9	0.3	0.7	0.3
- 200	0.6	0.2	0.3	0.2
	100.0	100.0	100.0	100.0

The grain size requirements of a glass sand can be met in all the above samples with a minimum of loss. Since about 50 per cent of a glass sand should be around 40 mesh, the addition of the + 35 and + 48 mesh fractions gives approximately this amount. All the samples contain from one to eight per cent of sand too fine for use, that is, the amount by which the sum of those fractions smaller than 100 mesh exceeds the allowable maximum of two per cent.

Chemical analyses were run on the untreated screened sand, and indicate that the sand could be used in that state to make sixth quality glass (Table 1). Chemical analyses are given in Table 4.

Table 4.

Assay of Original - 20 Mesh Feed

Sample No.	% Assay								
	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	Total
1	98.50	0.252	0.65	0.047	0.06	Tr.	0.17	0.14	99.819
2A	91.11	0.111	0.97	0.036	0.05	Tr.	0.15	0.34	99.767
2B	98.39	0.147	0.69	0.110	0.03	Tr.	0.15	0.22	99.737
3	98.47	0.103	0.82	0.064	0.02	Tr.	0.18	0.22	99.877

In order to reduce the amount of iron in the sand, cuts of the samples were tabled on a Wilfley table under a variety of conditions. By this procedure the proportions of iron and titanium were reduced by one-half to one-third. The best results obtained in these tests are set forth in Table 5.

Table 5.

Wilfley Table Products from Various Tests

Sample No.	Wt. % of - 20 mesh	Wt. % of total feed	% Assay	
			Fe_2O_3	TiO_2
1	69.0	60.6	0.123	0.029
2A	64.4	49.0	0.077	0.025
2B	73.7	60.7	0.048	0.028
3	52.2	27.2	0.062	0.038

The iron content of Sample 1 is still rather high, and may resist further beneficiation since iron oxide coats many of the sand grains. The higher iron content in this sample is probably due to less of the iron-stained

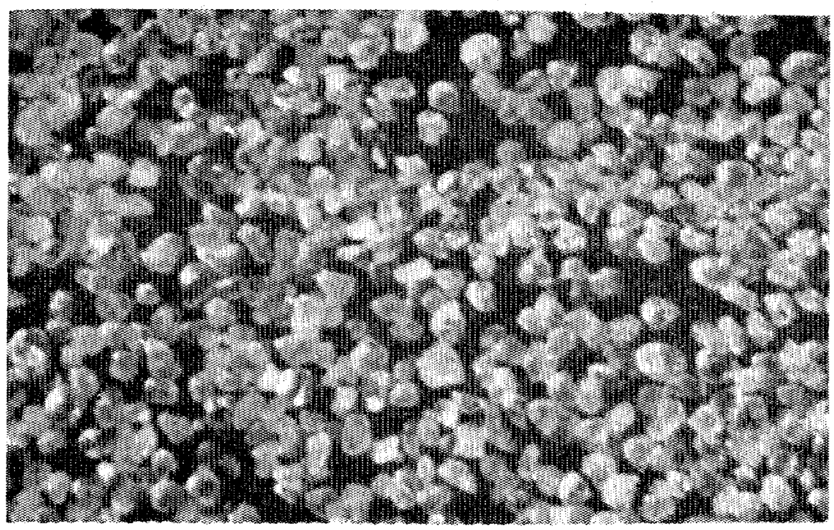


Figure 3—Photograph of the glass sand from Locality 1 after screening and tabling; enlarged 20 times. See Tables 5 and 6 for chemical and size analyses.

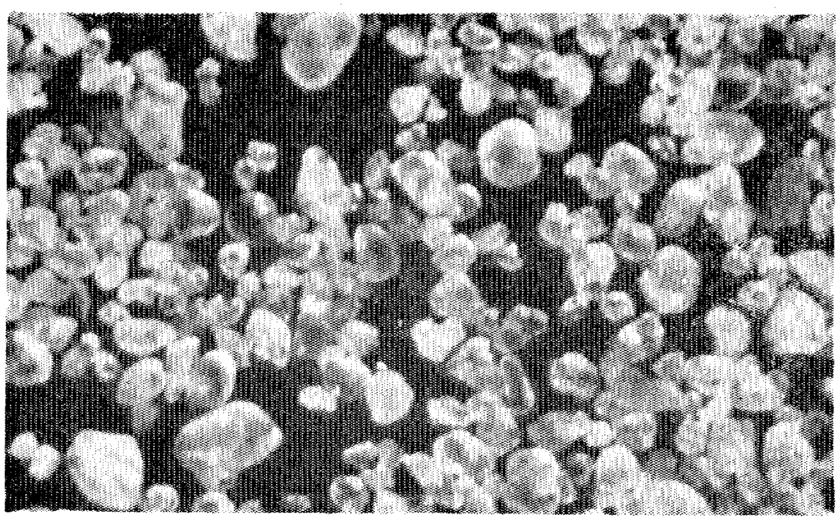


Figure 4—Photograph of glass sand from Locality 2 after screening and tabling; enlarged 20 times. See Tables 5 and 6 for chemical and size analyses.

sand being eroded from this outcrop than from the other two outcrops sampled. Removal of more of the surface material should reveal a sand having less iron in it.

The weight per cent of total feed shown in column 3 of Table 5 gives the percentage of the original sample that is left after screening and tabling. For example, for every 100 pounds of Sample 1 in the raw state, 60.6 pounds remain after beneficiating the sand. This 60.6 pounds is not all potential glass sand, since it contains a small percentage of material too fine to be used. The percentages of sand too fine-grained to be used can be determined from Table 6, in which is given a screen analysis of the table products represented by column 3 in Table 5.

Table 6.

Size Analyses of Table Products

Mesh	Sample 1	Sample 2A	Sample 2B	Sample 3
	Weight %	Weight %	Weight %	Weight %
- 20				
+ 28	1.7	10.3	4.3	9.3
+ 35	13.6	16.4	18.4	34.3
+ 48	33.1	26.0	47.0	41.6
+ 65	25.5	31.2	18.5	11.2
+ 100	15.9	13.9	8.1	2.6
+ 150	9.3	2.0	2.7	0.5
+ 200	0.6	0.1	0.6	0.4
- 200	0.3	0.1	0.4	0.1
	100.0	100.0	100.0	100.0

Since not more than two per cent of a glass sand should be finer than 100 mesh, small percentages of the table products would have to be discarded. About eight per cent of Sample 1, and two per cent of Sample 2B are undersize (Table 6), but the fines are not excessive in the other two samples. Correcting the amounts shown in column 3 of Table 5 for excess of fines, it appears that the usable percentages of Samples 1, 2A, 2B and 3 are 56, 49, 58 and 27 respectively. These products can probably be increased by five to ten per cent in actual practice.

SUMMARY AND CONCLUSIONS

1. A glass sand occurs in the uppermost 40 to 60 feet of the Peace River formation along the banks of the Peace River from section 28, township 84, range 21 to section 4, township 85, range 21, both west of the fifth Meridian. Of the foregoing thicknesses, about 60 per cent is a glass sand.

2. Four samples of the sand were tested, and all will yield a product having a size distribution suitable for glass making.

3. All samples except Sample 1 lend themselves to Wilfley table beneficiation, and will yield a silica sand product of suitable chemical composition for glass making.

4. The glass sand was beneficiated at a loss of 40 to 50 per cent of the raw material. In actual practice this loss could probably be reduced to 30 to 40 per cent.

5. The amount of available glass sand appears large enough to attract development, for it may exceed 1,000,000 tons. Accurate estimates of reserves cannot be made without test drilling since the deposit is concealed in many places.

6. The glass sand occurs in the upper part of a sandstone cliff 50 to 100 feet high in many places. Hence the overburden and waste material could be easily disposed of by dumping them over the cliff.

7. The overburden is 25 feet or more thick, and economic recovery of the sand would in most instances require the judicious location of sand pits.

8. Water for beneficiating the sand would be available at all times of the year in the nearby Peace River. Another source is a stream that flows down the west bank of the Peace River near Localities 1, 2 and 3, and a dam placed across it high up the bank could possibly produce a head of water strong enough for hydraulicking the sands.

9. Transportation to the railway at the town of Peace River may be accomplished by river barge or motor truck. The distance by barge is about seven miles and by truck ten miles. Another alternative is that beneficiated sand could be stockpiled at the plant during the summer, and trucked over the river ice in winter to Peace River.

10. Whereas this sand may be used primarily for making glass, there are other uses which might expand the market. Some of these are: the manufacture of asbestos shingles and asbestos pavement; the manufacture of silica brick used to line furnaces; sand for cuspidors and waste receptacles used in some public buildings; engine sand to give traction to locomotives; filter sand to remove foreign matter from water reservoirs; horticultural sand used in experiments with plants; molding sand used in making castings of steel, iron, brass, aluminum, etc; sand for paint manufacture; blast sand for cleaning or dulling hard surfaces; sand and flint for pottery manufacture; sand for poultry and bird grit; and sand for sand tables and sand piles.

Acknowledgements.

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