Silica Sands—Glass

BRITISH COLUMBIA DEPARTMENT OF MINES

HON. W. A. McKENZIE, Minister

Non-Metallic Mineral Investigations

REPORT No. 3.

Possibilities of Manufacturing Bottles and Glassware in British Columbia

By

A. M. RICHMOND

Submitted by

JOHN D. GALLOWAY, Provincial Mineralogist

Bureau of Mines

Victoria

BUREAU OF MINES

Victoria, B. C.

May, 1932.

To the Honourable W.A. McKenzie,

Minister of Mines.

Sir: -

I beg to submit herewith Report No. 3 of a series on Non-Metallic Investigations by A. M. Richmond.

In accordance with your instructions, Mr. Richmond commenced this investigation in June, 1931, and has been continuously engaged since that time. The objective is to investigate primarily many non-metallic mineral deposits to see if they can be utilized in British Columbia manufactures and industries. It involves field examination, a study of imports of non-metallics, specifications of purchase and many intricate factors in non-metallic trade.

It is hoped that the facts obtained and inferences drawn therefrom will stimulate the use of Provincial deposits of certain non-metallic minerals.

Further reports in the series will be issued from time to time as completed.

I have the honour to be,
Sir,
Your obedient servant,

JOHN D. GALLOWAY,

Provincial Mineralogist.

POSSIBILITIES OF MANUFACTURING BOTTLES AND GLASSWARE

IN BRITISH COLUMBIA

By

A.M. Richmond, Non-Metallics Engineer.

Victoria, B. C.

INTRODUCTION

Millions of bottles of many sizes and shapes are used annually by the people of British Columbia. Hundreds of thousands of the bottles purchased each year are broken; several millions more are exported out of the Province by the distilleries, beverage and food preserving and manufacturing companies who pack British Columbia products; many more are used over and over again as in the dairy business, the brewery business and in the home canning of fruits, jams, and jellies; but by far the largest part of the new jars and bottles which are used each year are discarded after they have once served their original purpose as merchandising containers.

From the results of a recently completed survey among the bottle and glassware consumers of the Province, who are located principally at or near Vancouver, New Westminster, and Victoria, it is conservatively estimated that approximately 17.5 millions of new bottles, with a delivered value of $686,290, are purchased annually by the distilleries, breweries, wineries, soft drink manufacturers, canning and preserving factories, pickle and vinegar companies, and various smaller companies such as dairies, druggists, ink and paste makers, polish and miscellaneous toilet preparation manufacturers.

It is the purpose of this Report, No. 3 of the Non-Metallic Mineral Investigations Series, to indicate where this large number of glassware containers is bought; to discuss briefly some of the economic factors which enter into the delivered price of the imported supply; to give information concerning the raw materials used in the manufacture of pressed and blown glassware, such as specifications, available reserves within the Province, or, in the absence of a suitable reserve of raw material, to indicate favourable areas where the same might be found, in the hope that the assembled data will sufficiently interest those who are technically and financially able to make further investigations, with the ultimate result of establishing a British Columbia glassware manufacturing industry.

The selected bibliography at the end of this report has provided much of the general information given in the report and is gratefully acknowledged by the writer.

ECONOMICS OF THE PRESENT SITUATION

There is no glass manufacturing factory in the Province at the present time. Many years ago there was a small bottle factory in the vicinity of New Westminster and another plant in the city of Victoria, both of which made bottles from cullet (broken glass waste) by hand methods. More recently, in 1929, it was announced in the press that a glassware plant would be built in New Westminster. A special civic by-law granting the company a factory site free of taxes for a period of ten years was approved by the people of New Westminster but for unexplained reasons the project was not completed, though a start was made to clear the land and the company was apparently well financed.

The following tabulation gives in summarized form the approximate size and distribution of the local bottle market, as obtained by personal contacts and circular letter enquiries to possible glassware consumers. A limited amount of estimation was found necessary to take care of those manufacturers who will always neglect to return forms sent to them, but it is believed that the consumption estimates presented are below rather than above the actual consumption figures. No attempt has been made in the table to gauge the normal business consumption, the figures given representing the consumption for the year 1931. Only new bottle and glassware purchases are compiled in Table No. 1 and no account is taken of the large number of used bottles which are annually rebought by the breweries from junkmen, small collectors and second-hand bottle companies.

TABLE I. NUMBER AND VALUE OF NEW BOTTLES AND GLASSWARE CONTAINERS USED IN BRITISH COLUMBIA IN 1931.

Industry using Glassware	Gross Bottles.	Delivered Value.	Percentage of Total Value.
1. Distilleries and Wineries.	61,000	$ 397,900	58.0%
2. Canning, pickling, preserving and jam factories.	14,340	98,600	14.4
3. Breweries.	25,000	92,000	13.4
4. Dairies.	5,820	40,490	5.9
5. Druggists, wholesale.	9,790	34,500	5.0
6. Soft drink and other beverage companies.	1,500	7,800	1.1
7. Miscellaneous.	4,000	15,000	2.2
TOTALS:	121,450	$686,290	100.0%

It will be noted that the average value per gross (144 bottles) varies considerably, but it should be realized that a wide variety of sizes and shapes of containers (possibly 1,000 variations) are required to meet the above listed consumption. Also the quantity of bottles purchased at any one time and consequently the size of the shipment has a considerable effect on the delivered price, due to increased factory costs for the manufacture of small lots, and to freight charges, which constitute an important part of the total delivered cost.

The nearest glassware factory to British Columbia is situated at Seattle, Puget sound, but the tariff of 32½ per cent on bottles and other forms of pressed and blown glassware entering Canada from the United States makes this an expensive place to purchase supplies. The closest Canadian factory is that of the Dominion Glass Company, situated at Redcliffe, Alberta. Other Canadian factories are located at Winnipeg, Wallaceburg, Hamilton, Montreal, and Lachine, Quebec. Four of the six plants in Canada are controlled by the Dominion Glass Company. Considerable glassware is also imported from the Eastern United States and some is brought from England, Belgium, and France.

It is interesting to note that the delivered price of milk bottles from Redcliffe to Vancouver, or Victoria, in carload lots requires that approximately 29% of the total cost be paid out as freight. On beer bottles shipped similarly between the same points, the freight amounts to approximately 20% of the total cost as delivered. From Eastern glass factories the freight rates into British Columbia are even higher and it simply means that the British Columbia manufacturer of foodstuffs, etc. is handicapped to the extent that he cannot possibly compete in the prairie markets with Eastern manufacturers of similar products who buy their glassware containers close to their packing establishments. The minimum freight rates for carloadings from Redcliffe and Montreal to Vancouver and Victoria are as follows:-

> Redcliffe to Vancouver 75¢ per 100 pounds, for a 45,000 pound minimum load, or $337.50 per carload, minimum.
>
> Redcliffe to Vancouver 83¢ per 100 pounds for a 36,000 pound minimum load, or $298.50 per carload, minimum.
>
> Montreal to Vancouver $1.35 per 100 pounds for a 30,000 pound minimum load, or $405.00 per carload, minimum.
>
> (Same rates apply to Victoria shipments)

Beer and milk bottles are comparatively strong and can be packed with somewhat less care than many of the larger, or more fragile bottles, so it can be readily understood that the percentage of cost which must be paid out as freight by the purchaser will depend largely on how many bottles can be packed into a carload. However, with any way of packing, the freight charges amount to a large share of the total cost and would provide a margin of safety for a local glass plant which would have its market located largely within trucking distance. According to figures presented by representatives of the Consumers Glass Company, Montreal, before the Advisory Board on Tariff and Taxation, Ottawa, October 29th, 1929, the freight on all shipments of glass for a year from their Montreal factory amounted to 21% of the total factory cost of glass, which figure included local truck deliveries in Montreal. The railway freight taken alone (omitting the quantity and cost of trucking in Montreal) amounted to 24% of the total factory cost of the glass containers manufactured.

The same could be said with regard to foreign glassware purchases but with more emphasis, because in addition to the extra packing required to safeguard against higher breakage losses on long shipments, the purchaser, and ultimately the consumer, has to pay freight and duty charges. Glassware and bottles imported from countries favoured by the British Preferential Tariff are subject to an import duty of 20% while imports from countries under the General Tariff regulations are subject to a $32\frac{1}{2}$% import duty, in addition to the prevailing Special Excise duties on all imports. The above rates apply to the importation of glass demijohns or carboys, bottles, n.o.p., decanters, flasks, phials, glass jars, and glass balls, lamp chimneys, glass shades or globes; cut, pressed, moulded or crystal glass tableware, decorated or not; blown glass tableware and other cut glass ware.

In addition to freight and duty charges above mentioned it is interesting to note for one year's business by the Consumers Glass Company of Montreal that 21.5% of their factory cost was for materials used in the construction of crates and containers used in packing the finished glassware for shipment to purchasers throughout the country.

The use of glass containers for display and distribution of foodstuffs, more especially preserved fruits, jams, pickles, catsup, etc., is noticeably greater now than it was but a few years ago. This is due in no small measure to the energy of the glass manufacturing companies and their sales agents, and also to the increasing demand on the part of the purchasing public who are attracted by the cleanliness of the container and the wholesome appearance of foods put up in glass. Glass containers enable the food to be at least visually inspected before it is purchased, and many of them have a secondary value as useful household utensils after their original purpose as a container has been served. As a result of enquiries sent to the various canning companies, it would appear that the added advantages of packing in glass are being rapidly appreciated and no doubt if it were possible to obtain glass jars and bottles from a local manufacturer at prices approximating the existing prices paid by the Eastern manufacturers and packers of food products, the market for this type of ware could be greatly extended in British Columbia. It is estimated that the present local market for glass food containers would be at least doubled.

Breweries annually purchase a large number of second-hand bottles at a discount of approximately 20% on the purchase price of new bottles. The used bottles have to be very carefully washed before they can be used and the additional care and consequently extra cost of washing old bottles as compared with the cost of washing new bottles before use almost offsets the saving in the original cost. The breweries would be ready to buy new bottles rather than old bottles if new bottles could be obtained slightly cheaper than is at present paid for them.

RAW MATERIALS USED IN MAKING BOTTLES AND GLASSWARE

The raw materials used in the manufacture of bottles and pressed and blown glassware are: coal or natural gas for fuel; silica as sand, friable sandstone, or crushed quartz; lime as limestone, burned or hydrated lime; soda in the form of soda ash or sodium sulphate; and small amounts of manganese dioxide, selenium, coloring agents, etc., used in the glass to obtain special results.

In order to give some idea of the proportions in which the above-mentioned non-metallic minerals are used, the following table of batch mixtures has been compiled from several sources of information.

TABLE 2. TABLE TO SHOW THE PROPORTIONS OF RAW MATERIALS IN BOTTLES AND GLASSWARE BATCH MIXTURES.

Batch No.		1.	2.	3.	4.	5.	6.
Sand	(parts)	1000	1000	1000	1000	1000	1000
Limestone	"	320	340	175	170	180	180
Soda Ash	"	350	---	375	375	380	400
Salt Cake	"	---	380	---	---	8	---
Carbon	"	---	50	---	---	10	---
Borax	"	---	---	---	1	---	---
Arsenous oxide	"	---	---	---	1	---	1
Selenium	"	---	---	---	0.03	---	0.03
Manganese Dioxide, (parts)		---	---	---	0.06	---	---

Batches 1 and 2 are for common hand-worked bottle glass, and are taken from an article on Glass, by Robert Linton, which was published in the 1899 Volume of The Mineral Industry. Batch 3 is for use in an Owen's bottle-making machine. Batch 4 is for colourless bottles of machine manufacture, while batches 5 and 6 are for cheap grades of amber and tumbler glass. The last four glass batch proportions are taken from an article by

W.E.S. Turner, published in Volume III, pp. 377-401, of the Dictionary of Applied Chemistry, 1928.

In order to give some idea of the consumption of various non-metallic minerals and supplies used in the manufacture of blown and pressed glassware in Canada, the following figures for 1928 and 1929 have been taken from the Dominion Bureau of Statistics publications for the year 1929. The figures summarize operations at six glass manufacturing plants in mid-western and Eastern Canada. Figures are not available for individual plants.

TABLE 3. CANADIAN GLASS BOTTLES AND PRESSED GLASSWARE MANUFACTURING STATISTICS FOR 1928 AND 1929 IN CANADA.

	1928	1929
Value of pressed and blown glass output,	$8,466,382	$11,197,382
Silica sand used, tons,	78,915	97,298
Value of sand per ton,	$4.70	$4.73
Soda ash used, tons,	29,656	36,511
Value of soda ash per ton,	$33.12	$31.16
Lime used (CaO) tons,	---	10,013
Value of lime per ton,	---	$10.90
Value of miscellaneous supplies,	$905,959	$876,521
Values of boxes, lumber, etc.	$557,760	$767,307

Glass, an amorphous solidified solution of various acid and basic chemical substances, is valued chiefly for its strength, its transparency, its insolubility when placed in contact with practically all liquids and solids, its low co-efficient of expansion, and the comparative cheapness and ease with which it is manufactured. Many different substances could be used in the manufacture of glass but due either to their excessive cost, their unfavourable influence on the glass working temperatures, or to the unstable condition of some of the resulting glasses, it is customary practise to use only those materials which will give a glass good enough for the purpose required and with a minimum of cost. Obviously the better the quality of the raw materials used, the better will be the resulting product. Such glasses as optical glass and first quality plate and tableware glass are made of the best procurable materials, whereas considerable quantities of detrimental impurities such as iron and alumina are permitted in the cheaper forms of glass bottles and containers. As the detrimental impurities cannot be removed in the course of manufacture certain specifications limiting the amounts of impurities permitted have been established by usage, and in the case of silica sand, by the American Ceramic Society and United States Bureau of Standards. Due to the transparency of most glasses small variations in the purity of the raw materials used, can be readily detected, and for this reason the specifications covering such raw materials entering the glass melt are very rigid.

The raw materials used in the manufacture of bottles and glassware containers, as stated before, are silica, lime and soda. Small quantities of other chemical materials such as barium oxide, lead oxide, alumina, manganese dioxide, arsenous oxide, or selenium, etc. are sometimes added to the glass batch to overcome impurities in the silica sand, or for the special qualities they impart to the finished glass products, such as hardness, brilliancy of lustre, transparency, etc.

Silica. A reference to Table 2 shows the importance of silica to the glass manufacturer. Most common types of glassware contain from 60 to 75% silica, derived mostly from exceptionally pure silica sand. While silica is a common mineral in nature and many varied forms might be utilized in glass-making, due to economic reasons such as cost, purity of product and constancy of quantity and quality of supply, it is found that all of the silica consumed in glass-making in America is derived from deposits of very pure quartz sand or deposits of easily crushed friable quartz sandstone. The cost of crushing massive quartz, or quartzite, in addition to the cost of screening and washing operations required to produce a clean, uniform product, prohibits the utilization of this source of silica at the present time. Attempts to use crushed quartz by the manufacturers of glass in California had to be abandoned recently in favour of imported Belgian glass sand supplies.

The ideal sand for glass-making would consist entirely of small quartz grains of uniform size. However, absolutely pure silica sands are unknown, though the French Fontainbleau sands from near Paris and some of the German sands contain over 99.98% silica. Many deposits of sand have been found in Europe and America which contain over 99% silica with but small amounts of detrimental impurities. It is not essential that sand for all glass-making be of first quality, although optical glass and first quality cut and plate glass require the best washed sand procurable. The cheaper grades of window glass, glass containers and bottles generally can be made with sands containing appreciable amounts of impurities. The impurities consist of small amounts of alumina in the form of clay, or more rarely as muscovite or feldspar; iron, the most detrimental of all the impurities, as ferrous or ferric oxides in the form of limonite, magnetite, etc.; and lime, magnesia, alkalies, and small amounts of organic matter. No definite standards have been universally accepted by the glass manufacturers as to what maximum quantities of impurities should be permitted in silica sands used for various qualities of glass but the following Table No. 4 prepared by the American Ceramic Society in co-operation with the United States Bureau of Standards serves to indicate the accepted range of specifications and has been generally adopted by the trade with but slight modifications by some individual glass makers. The limiting tolerances, or variations permitted from the Standards are set forth in Table No. 5.

TABLE 4. PERCENTAGE OF COMPOSITION ALLOWED IN GLASS SANDS OF VARIOUS QUALITIES. (Based on ignited samples).

Quality of Sand.	Silica (SiO_2) Minimum	Alumina (Al_2O_3) Maximum	Iron Oxide (Fe_2O_3) Maximum	Lime and Magnesia. CaO - MgO Maximum
1st quality: optical glass	99.8%	0.1%	0.2%	.1%
2nd quality: flint glass containers & tableware.	98.5	.5	.035	.2
3rd quality: flint glass.	95.0	4.0	.035	.5
4th quality: sheet glass, rolled & polished plate glass.	98.5	.5	.06	.5
5th quality: sheet, rolled & polished plate glass & glass bottles.	95.0	4.0	.06	.5
6th quality: green glass containers & window glass.	98.0	.5	.3	.5
7th quality: green glass bottles.	95.0	4.0	.3	.5
8th quality: amber glass containers.	98.0	.5	1.0	.5
9th quality: amber glass.	95.0	4.0	1.0	.5

TABLE 5. PERCENTAGES TOLERANCES ALLOWED IN GLASS SANDS OF VARIOUS QUALITIES. (Based on ignited samples).

Quality of Sand.	Tolerance Plus or Minus (Silica)	Tolerance Plus or Minus (Alumina)	Tolerance Plus or Minus (Fe.Oxide)	Tolerance Plus or Minus (CaO & MgO)
1st quality:	0.1%	0.05%	.005%	.05%
2nd quality:	.5	.1	.005	.05
3rd quality:	1.0	.5	.005	.1
4th quality:	.5	.1	.005	.1
5th quality:	1.0	.5	.005	.1
6th quality:	1.0	.5	.05	.1
7th quality:	1.0	.5	.05	.1
8th quality:	1.0	.5	.1	.1
9th quality:	1.0	.5	.1	.1

A study of the table shows that sands of the fifth quality or lower, generally suitable for glassware and bottle manufacture, should contain more than 94% silica, not more than 4.5% alumina, not more than 0.065% to 1.1% iron oxide content and less than 0.6% combined lime and magnesia content.

Alumina in glass sand is usually present as clay and as such can be removed efficiently by washing but if present as feldspar, it cannot be removed economically, nor by washing. It has several beneficial effects in glasses in that it decreases the coefficient of expansion, makes the glass harder, of more brilliant lustre, and gives it better moulding qualities, prevents devitrification, aids the annealing process, but has the disadvantages of increasing the fusibility and viscosity, making the glass more difficult to fuse and work. Over 4.5% alumina (the actual amount must be determined for the individual glass) is usually detrimental to all types of glass.

Iron is the most easily detected impurity in finished glass products, even the best glasses when viewed edgewise generally showing a faint greenish tinge due to ferrous iron content in the original batch mixture. As indicated in the table the amount permitted is dependent on the quality of glass desired but should never be more than 0.3% for any kind of white glass (clear glass). Green and amber bottles owe their color to the iron content, some of the black and dark green bottles being made from sands containing as much as 7% iron oxide. In addition to giving the glass the greenish color, iron in small quantities (0.09 to 0.1%) detracts from its brilliance. Small amounts of iron in the sand may, if present as magnetite, illmenite or metallic iron, be removed by magnetic separators, or if present in the molten glass mix in amounts up to 0.1% may be neutralized by the addition of small amounts of manganese dioxide, or selenium, to the batch. The washing of sands in preparation removes the iron present as limonite associated with clay (alumina) present.

Other impurities such as lime and magnesia are generally found only in small quantities in most glass sands. Lime is not harmful but generally speaking should be present in amounts of less than .5% in the sand and this amount should be a constant factor from shipment to shipment, most manufacturers preferring to add lime as lime rather than account for it in the batch mixture by keeping a close check on the lime content of the sand being used. Magnesia present in sand is usually a negligible quantity, being more frequently found in the lime supply used. It raises the melting point of the glass. Alkalies in small amounts are not detrimental but organic matter such as roots, twigs, etc. are not permitted in glass sands.

Size and Shape of Glass Sand Grains.

Glass sand should be uniform in size and of reasonably definite screen analysis. Coarse sand requires more fuel and a longer time to melt while fine sand melts too rapidly causing the batch to froth and foam due to the accelerated speed of the glass-making reactions. Sands composed of both coarse and fine particles unless carefully melted, will give products containing stone flaws due to unmelted silica grains. Opinion and practice in America, while differing in actual screen sizing limits, is agreed that all sand used in glass-making should pass an 18 or 20 mesh screen and 95% of it should be retained on a 100 mesh screen. The American Ceramic Society in conjunction with the United States Bureau of Standards has suggested the following screen analysis for sand as an ideal to be sought after, rather than required:

All sand to be minus 20 mesh screen.
From 40 to 60% of sand to be minus 20 mesh and plus 40 mesh screen.
From 30 to 40% of sand to be minus 40 mesh and plus 60 mesh screen.
From 10 to 20% of sand to be minus 60 mesh

and plus 100 mesh screen.
Not more than 5% of sand to be minus 100 mesh screen.

Generally speaking, if the sand is chemically suitable the disadvantages of improper size classification are of minor importance and can be readily and cheaply changed by screening. The shape of the individual sand grains in glass sand would seem to be a matter of personal opinion, some manufacturers preferring the rounded smooth grains, others preferring the angular shaped sharp grains.

Lime.

Lime, an important raw material in the manufacture of most glasses can be added to the batch as crushed limestone ($CaCO_3$); as burned and crushed lime (CaO), or as hydrated lime ($CaOH$). Formerly, most glass makers used lime in the crushed burned state in their batch mixtures but recent practise has been towards using crushed limestone because of its lower cost; and because of the more constant and easily controlled furnace reactions which are possible and which result in the production of glass free of stone flaws, strains, blisters and laminations, etc. The raw limestone used should be as pure calcium carbonate as it is possible to obtain economically, containing less than 0.3% iron oxide (Fe_2O_3), not more than 5 to 6% magnesia (MgO) and only very small amounts of silica and alumina.

Lime is used to increase the fusibility of glass and for the production of easier working melts and it imparts smoothness and brilliance to the product. Up to limiting amounts of 12% combined lime and soda the chemical resistance of glass is increased.

Soda.

Glass makers prefer to introduce soda into the glass batch mixture as soda ash (sodium carbonate) because of the fuel saving (up to 30% according to some authorities) due to the lower melting and working temperatures obtained. Also a regular clearing action takes place on the glass melt surface and the furnace linings last longer when soda ash is used. However, when sodium sulphate sells for half the price of soda ash, or less, it is used because of the saving in glass cost which results. Sodium sulphate (salt cake) is at present the most common form used in the American plants. Small amounts of carbon, as coke or anthracite coal, must be used with sodium sulphate to give a reducing action and prevent the formation of glass scum or gall on the surface of the molten glass.

The sodium sulphate specifications, like those for silica and lime are not fixed definitely, though general practise calls for material containing at least 97% anhydrous sodium sulphate with less than 1% sodium chloride or sulphuric acid, under 0.5% insoluble content and less than 0.02% iron oxide.

Miscellaneous Chemicals.

The small amounts of special chemicals sometimes required for purification or neutralizing reactions are obtained from chemical firms. Alumina is added as kaolin, more rarely as orthoclase feldspar. Manganese dioxide used for an iron neutralizer is only required in proportions of 1 to 1600 and is only effective when the iron content is less than 0.1% of the total batch.

BRITISH COLUMBIA RESERVES OF RAW MATERIALS SUITABLE FOR GLASS MANUFACTURE.

Silica.

While several samples of sands have been submitted to the Bureau of Mines from points on Vancouver island and the lower mainland, so far none have been received which would be suitable for glass-making purposes. It is quite possible that excellent deposits of glass sand are existent within the Province, though so far no such deposits are known to the writer, and in order to assist in their possible discovery notes on prospecting, sampling and the general economics of glass sand deposits are briefly presented in a succeeding section of this paper.

There are, however, several deposits of silica, as massive quartz, which would require quarrying or underground mining, crushing and screening before they could be utilized, situated in areas adjacent to the lower mainland; and undoubtedly many others as yet unprospected or unsampled could be discovered with very little effort. It should be noted that past experience has been unfavourable for the development of massive quartz silica sources for use in glass manufacturing processes.

The Gisby group of claims, near Keefers and 140 miles east of Vancouver on the Canadian Pacific Railway, described in detail by L. H. Cole of the Mines Branch, Department of Mines, Ottawa, in his Bulletin No. 686 on "Silica in Western Canada, 1928," contains an immense reserve of quartz in slaty mica schist country rocks. Representative samples show the following analysis: Silica, 96.26%; Iron oxide, 0.37%; Alumina, 1.00%;

Lime, 0.80%; Magnesia, 0.24%, with 0.80% loss on ignition of the sample. The property, which has been idle for several years, is equipped with a small crushing mill.

Another deposit of quartz, situated 7 miles north of the Canadian Pacific Railway at Sicamous on an arm of Shuswap lake and 335 miles by rail from Vancouver has also been described by the same author. A representative sample from a 10' x 40' trench on the property close to the lake shore, (the only working place on the ground and from which 100 tons of quartz has been shipped) contained: Silica, 98.20%; Iron oxide, 0.13%; Alumina, 0.77%; Lime, 0.57%; Magnesia, 0.34%, with 0.17% loss on ignition of the sample. It is owned by J. Blais of Kamloops, B.C.

As previously indicated, it would probably be cheaper to import the few thousand tons of glass sand that would be consumed annually in a local glass factory than it would be to prepare such a limited quantity of silica from deposits of massive quartz. The average delivered value of the sand used by the glass manufacturing industry of Canada in 1928 and 1929, from Table 3, was $4.70 and $4.73 per ton respectively. This is a low valuation to cover mining, milling, freight, depreciation and miscellaneous general charges on a small yearly production of ground quartz.

Lime.

Scattered along the Coast on water transportation and within easy reach of centres of population are many deposits of limestone suitable for glass manufactures. The high calcium limestones of Texada island and other nearby deposits assure ample supplies of this necessary raw material to any future producer of local glassware. In his "Preliminary Report on the Limestones of British Columbia," which appeared in the 1929 Investigations of the Mineral Resources and the Mining Industry, M. F. Goudge of the Department of Mines, Ottawa, gives a comprehensive general description of the many available limestone deposits in the Province. This publication can be obtained from the Mines Branch, Department of Mines, Ottawa. It is planned to issue in the near future supplementary data to that contained in the above report in the form of a mimeographed report on some of the British Columbia limestones as one of the series of Non-Metallic Investigations.

Soda.

British Columbia is adequately supplied with resources of sodium carbonate and sodium sulphate. The carbonate lakes, situated a few miles north of Clinton and adjacent to the

Pacific Great Eastern Railway, have been known and intermittently worked for several years. In two instances plants for the production of soda ash were erected but due to financial and technical difficulties at both properties the past operations were not the commercial success anticipated. Recent developments and the satisfactory solution of the technical difficulties would enable the properties, with re-designed equipment, to function should a satisfactory market for the soda ash product be procured.

Near Kamloops a deposit of sodium sulphate was discovered in 1930 by C. W. Austin and W. Knowles. Indications are that possibly 200,000 tons of sodium sulphate crystal are contained in the lake bed, 9 acres in area, which is conveniently located to the main line of the Canadian Pacific Railway. Samples taken from several points on the lake surface and from a test pit indicate material suitable for glass making.

Sodium sulphate is also produced as a by-product in the manufacture of explosives at the James Island plant of the Canadian Industries, Limited.

More detailed information respecting the various deposits of sodium salts in the Province is to be issued shortly as a report in this series of Non-Metallic Investigations.

Fuel.

Many coal sources suitable for the production of producer gas for firing glass melting furnaces are available within British Columbia as a study of available published coal statistics and literature will show.

PROSPECTING FOR, SAMPLING AND VALUATION OF SAND DEPOSITS

Sand, the fine disintegration production of weathering forces such as changes in temperature, frost, rain, abrasion by running water and various chemical actions on many kinds of rock, is usually found as bedded deposits in old and new stream channels and on, or close to, shores of lakes and oceans. Deposits resulting from wave action or water transportation are partially classified as to size, generally the finest sand being furthest from the rock shore line, on the inside of the river bends or on the downstream side of river gravel-sand bars. Sands disturbed or resulting from glacial action show no classification, often containing heterogeneous mixtures of rock, gravel and clay with sand.

Sand prospecting, like placer prospecting in many respects, can be confined to favourable areas indicated on the many excellent general geologic maps issued by the Geological Survey of Canada. Sand, however, unlike gold is valueless when situated but a short distance from the point of consumption or marketing, and this fact should never be forgotten.

Many, in fact most of our present building sand deposits, were located by a study of surface outcrops, examination of road and railway cuts, river banks, lake and sea-shore beaches. Similar methods can be applied to the search for any sand if it is remembered that the valuable deposits were originally formed by water transportation.

Once found, a few preliminary samples carefully taken, will indicate the possible value of any sand deposit for glass manufacturing purposes. Should the chemical qualities of the sand deposit be satisfactory, detailed testing and thorough systematic sampling is then required to definitely establish tonnages and variations in the purity of the deposit. Simply taking small quantities of sand from the open-cuts or bank exposures in a haphazard fashion is not sampling, nor is a large sample from one location of any value in determining the variations in grade found in most sand beds.

Computations of tonnage and analyses for grade are preferably made from a systematically mapped and regularly laid out scheme of either auger test pits, test shafts, or drill holes. Frequently the bank exposures are such that much detailed information as to the thickness of the sand bed, its general geologic attitude such as dip and strike, its quality and mining possibilities can readily be obtained. Wherever possible, drilling results should be periodically checked by small shafts put down to bedrock or through the valuable beds of sand. Deposits with light overburdens are best prospected with post-hole augers or hand-operated drills, while more deeply buried deposits may be prospected and sampled with churn and percussion drilling machines. Uniform deposits can be quickly tested by wide spacing of test pits but when irregularity is found in the percentages of impurities present or in the sand grain size, it is absolutely essential that a uniform spacing of the test pits and drill holes on not more than 100 foot centres be used if accurate sampling results are to be obtained. Samples must properly represent the bed sampled and uniform amounts of materials should be taken from every foot of the bed to give truly representative results. All tests made subsequent to sampling can refer only to the actual samples taken so that they must be representative to be of any value.

It is customary to assume that 1 cubic yard of sand in place will weigh, from 2,500 to 3,000 pounds, depending on the compactness of the deposit. Most estimates of tonnage are based on a figure of 2,500 pounds per cubic yard in place, though some estimators prefer the figure of 100 pounds per cubic foot of sand in place.

Preliminary screening and washing tests should be made at the property to determine the approximate screen analysis and clay content of the sand. Inspection of the samples with a pocket lens will detect minute quantities of iron, but only accurate chemical analyses should be relied on to measure the quantities of this and other impurities such as alumina, lime, and magnesia, present. As the ultimate success or failure of many sand companies can often be traced to poor sampling and testing, it is imperative that only experienced competent men be employed to do the final sampling and give the last analysis and opinion on any sand-mining problem.

Other important factors entering into the valuation of any sand deposit include:

1. Available markets, their value, and the possibility of competition from other sand producers.

2. The available transportation facilities for the transport of supplies into, and finished product out of the property to markets, including the detailed costs of such transportation.

3. The mining and preparation methods, together with detailed estimates of cost necessary to prepare suitable products for marketing which would depend on:-

   (a) The physical characterics of the deposit.

   (b) The sources of water for washing and the source of fuel for drying the sand.

   (c) The local climate and labour supply.

4. The possibilities of producing and marketing other sand products, such for example as filter sands, engine sands, blast sands, furnace sands, wire saw sand and abrasive sands from the glass sand screening waste oversize and undersize products.

CONCLUSIONS

Evidence submitted in this brief report indicates a yearly market in British Columbia for 17.5 million bottles valued at $686,290. This supply is obtained from manufacturing plants situated outside the Province and the cost of containers, crates, freight, and in some instances, duty charges, represent a very large proportion of the delivered cost of the glassware purchased.

Deposits of fuel, lime and sodium salts suitable for glass manufacturing are existent within British Columbia and in some cases are already developed and ready to supply such a market at reasonable prices. The undeveloped deposits only require the assurance of a moderate-sized market to encourage their owners to equip, and produce satisfactory materials for glass making.

Deposits of silica sand suitable for glass making have not been found in the Province to date though several deposits of particularly pure silica rock are known to exist close to main transcontinental railway lines. Silica sand it is hoped may be discovered as a result of information presented herein, but should it not be discovered locally in economic quantities, a local glass-manufacturing plant situated on tidewater would be able to import glass sand (on which there is no import duty) at more favourable prices than it is possible for the interior glass factories of Canada to import.

The above information is presented in the belief that an opportunity does exist in British Columbia for the establishment of a glassware manufacturing industry, and in the hope that those technically capable and financially responsible will pursue this investigation further and ultimately supply British Columbia's growing consumption of glassware containers with bottles and glassware made in a British Columbia factory.

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