BRITISH COLUMBIA DEPARTMENT OF MINES

HON. W. A. McKENZIE, Minister

# Non-Metallic Mineral Investigations

REPORT No. 4.

# Some Undeveloped Clay Deposits of British Columbia

By

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*Submitted by*

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Bureau of Mines

Victoria

BUREAU OF MINES

Victoria, B. C.
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To the Honourable W.A. McKenzie,

Minister of Mines.

Sir:-

I beg to submit herewith Report No. 4 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.

# SOME UNDEVELOPED CLAY DEPOSITS OF BRITISH COLUMBIA

By

A.M. Richmond, Non-Metallics Engineer,

Victoria, B. C.

## INTRODUCTION

This report, the fourth of a series on the non-metallic minerals to be issued by the Department of Mines, has as its object the presentation of information pertinent to the clay-working industry of British Columbia with special reports on several of the undeveloped and better quality deposits of clays which are found in widely scattered sections of the Province.

It is manifestly impossible in a short report to give a description of all the clay deposits and clay-working plants of the Province, nor is it necessary as many of them have been well described in various published available reports, but it is felt that a tabulated record of this phase of the industry is desirable, in order to give some idea of the fairly extensive common clay-working business now existent in British Columbia. For detailed descriptions of the many active and abandoned clay plants in the Province the reader is referred to the many excellent reports listed in the short selected bibliography accompanying this report. Many undeveloped common-clay deposits suitable for the manufacture of common red brick are to be found in practically all parts of the country and summarized information concerning them is to be found herein in tabulated form.

The writer gratefully acknowledges the various general treatises on clays which have provided most of the information for the section of this report on the general subject of clays, their composition, occurrence and properties, classification, etc., and in particular the report of Paul M. Tyler of the United States Bureau of Mines, entitled "Clay" published in 1929 as Information Circular 6155 by the United States Department of Commerce, from which much information has been taken verbatim. The assistance and hearty co-operation of the Department of Mines at Ottawa in making the necessary physical tests on many clay samples in the Ceramics Laboratories under the direction of Howells Frechette, were of inestimable value.

## GENERAL NOTES ON CLAYS

A few brief notes on the general subject of clay are included for the information of those who may not have access to the reports listed in the bibliography but who may be interested in better understanding the valuation of clays and clay deposits from an economic viewpoint.

Definition.

Clay is the name applied to those naturally occurring earthy materials which become plastic when wetted. No two clays are exactly alike but practically all of the useful ones exhibit somewhat similar physical characteristics in that they can be moulded when wet and plastic. The moulded mass, in drying, will retain its shape and upon firing (or burning) change into a hard rock-like substance.

Composition and Origin.

Clays are all of secondary origin, resulting principally from the erosion of shales, impure limestones, and igneous rocks containing feldspar. If the clay is found overlying its parent rock, it is known as a "Residual clay", but if transported by glaciers, water or wind, it is known respectively as glacial clay, sedimentary clay and loess. After deposition the beds of clay may be folded, tilted and faulted by movements of the underlying rocks, and erosion may have removed and redeposited clays elsewhere leaving the deposit physically much different than it originally was.

As would naturally be expected, clays consist of a number of different minerals, among the commonest of which are kaolinite, quartz, feldspar, iron oxides, mica, bauxite, limestone and manganese oxides. The exact composition of any clay will depend on the parent rock, or rocks, and the extent to which disintegration and secondary alteration has changed the constituent minerals. While the chemical composition of any clay may indicate to an expert some of its qualities, the best information about the properties of a clay is determined by carefully conducted laboratory physical tests and firings, or by large size semi-commercial tests conducted in an existing clay-working plant under actual operating conditions.

Conclusive testing if properly done involves the expenditure of considerable time and money and this is generally not required nor justified until data respecting the size, uniformity and possible usefulness of the clay deposit has been approximately ascertained in the field. However, much can be learned about the properties of any particular clay by a few simple field tests, but it should be definitely understood that clays which appear to be of possible economic value on preliminary testing must, if other governing factors such as location and markets are favourable, be given either a thorough laboratory testing, both chemical and physical, or a commercial test run in some already existing clay plant, preferably both.

Properties.

The properties of clays which influence their value include colour before and after firing; structure and fineness of grain; visible objectionable impurities, including concretions and nodules of iron, manganese, pyrite or lime; various working properties such as the ease with which the clay can be ground, its plasticity, its tendency to laminate, or moulding and die-forming difficulties. The drying properties after moulding are also important, and the ease and rapidity with which the clay articles air dry, their shrinkage, tendency to crack, warp or scum should be determined. Burning properties such as the ease with which oxidation takes place and in the finished products, porosity, hardness, shrinkage and behavior on overfiring must also be determined. In the case of fire clays, the fusion point is required together with loading tests at high temperatures.

Some of these properties are difficult to describe except in general terms. Plasticity for example depends on producing a mixture with water, having the proper working temper and is usually said to be excellent, fair or poor according to the judgment of the tester. A properly tempered clay will take any required shape with reasonable pressure, will not slump due to its own weight and not be so sticky that it will adhere to the hands or metal parts of the clay machinery. Plasticity may be determined in the field by moistening the clay and working it with the fingers to determine if it can be moulded into a definite shape which is retained without deformation or cracking when the clay is dried.

Slaking, which indicates the ease with which clay can be tempered, may be determined by dropping a lump of dry clay into water and noting the length of time required for it to slake or crumble. Clays which slake in a few minutes are easily tempered and can be rendered plastic without fine grinding.

Shrinkage in drying is undesirable because it tends to make the product warp and crack. It may be reduced very often by mixing the clay with sand or other clays, and in the case of fire clays it is customary to introduce grog (calcined clay or ground brick). Ball clays ordinarily are mixed with ground flint to reduce their shrinkage. For preliminary test purposes a rough brick can be moulded, the dried brick giving a fair idea as to the shrinkage percentage and the deforming characteristics. If the brick cracks, crumbles or warps out of shape the value of the clay is very doubtful and just to be sure of the result a further brick should be made by thoroughly grinding and carefully tempering the clay after which the brick is dried slowly.

The fired colour is often considered the most important single property of clays. Red clays usually burn red, but often blue, grey and even light-coloured clays will burn red or to various shades of buff and brown, depending largely on the iron present as oxides. Unless clays are fairly pure they are likely to be grey, cream or slightly coloured when wet, even though to the untrained eye they may look perfectly white when dry. For field purposes a small piece of clay may be roasted in a blacksmith forge with free access of air (never in a smoky flame) and then cooled. If the clay turns red or brown there is probably a high percentage of iron oxide present (more than 4%). This test is often inconclusive because many clays require to be fired to a high temperature before developing their final colours.

Grit and generally the fineness of a clay may be tested against the teeth, or by separation as with repeated washing and decantation in a glass or beaker. Soluble salts may often be detected by the presence of an efflorescence covering protected sections of the clay beds. Bitter salts like alum and magnesium sulphate are readily recognized by tasting. Such soluble salts are objectionable because they cause white wash coatings or scum on the finished ware.

High lime content will ruin a clay and may be determined by the addition of a few drops of strong hydro-chloric acid to the sample. If lime or dolomite are present the acid will cause effervescence in the clay sample.

The fusibility of clays is measured principally by comparative methods, noting the fusing point of the clay sample in direct comparison with specially prepared test clay cones - called Seger cones after their inventor's name - placed in the kiln with the ware and which fuse at known temperatures. The cones which are made of clay mixtures with various fluxes are so graded that they represent a series of fusion points each a few degrees higher than the one next below it. Representative Seger cones and their melting points are shown in Table I while Table II gives the temperatures at which some of the common clay wares are fired (burned).

TABLE I. REPRESENTATIVE SOFTENING POINTS OF SEGER CONES
Heat raised 20°C and 150°C per hour.

| | 20°C | 150°C | | 20°C | 150°C |
|---|---|---|---|---|---|
| Cone 022 | 585°C | 605°C | Cone 5 | 1180°C | 1205°C |
| 019 | 630°C | 660°C | 7 | 1210°C | 1250°C |
| 016 | 735°C | 795°C | 10 | 1260°C | 1305°C |
| 013 | 825°C | 860°C | 15 | 1410°C | 1435°C |
| 010 | 890°C | 895°C | 20 | 1520°C | 1530°C |
| 07 | 975°C | 990°C | 26 | --- | 1595°C |
| 05 | 1030°C | 1040°C | 28 | --- | 1615°C |
| 03 | 1080°C | 1115°C | 30 | --- | 1650°C |
| 02 | 1095°C | 1125°C | 32 | --- | 1700°C |
| 01 | 1110°C | 1145°C | 34 | --- | 1760°C |
| 1 | 1125°C | 1160°C | 36 | --- | 1810°C |
| 3 | 1145°C | 1170°C | 42 | --- | 2015°C |

TABLE II. TEMPERATURES TO WHICH COMMON CLAY WARES ARE BURNED.

| Product. | Seger Cone No. | Degrees Centrigrade (approx.) |
|---|---|---|
| Common brick, | 012 - 02 | 875 - 1125 |
| Buff face brick, | 02 - 9 | 1125 - 1285 |
| Fire proofing, | 03 - 4 | 1115 - 1190 |
| Terra Cotta, | 02 - 8 | 1125 - 1260 |
| White earthenware, | 8 - 9 | 1260 - 1285 |
| Firebrick, | 5 - 15 | 1205 - 1435 |
| Porcelain, | 11 - 18 | 1325 - 1490 |
| Sewer Pipe, | 02 - 7 | 1125 - 1250 |

Note: To change Centigrade temperatures to Fahrenheit temperatures in the above table, multiply by 1.80 and add 32°.

Varieties of Clays and their Uses.

Clays are generally named according to their leading uses and since one clay may be suitable for several purposes it may be called by two or more names, or conversely, one name may be applied to widely different clays, all of which has resulted in much misunderstanding. The clay business is conducted largely on an empirical basis, often by hit or miss methods, and until research has extended the present knowledge to a better understanding of the physical and chemical characteristics of clays the following nomenclature will probably continue to be used.

CHINA CLAY. This is the commercial name for kaolin which, since it rarely occurs naturally in deposits of sufficient purity, is obtained by washing out more or less accompanying sand, mica, and other impurities. It burns white, is highly refractory, not particularly plastic and is the chief constituent of chinaware and porcelain and often is used with other clays or alone for the manufacturing of whiteware, floor tile, electrical semi-porcelain, and as a filler in textiles, paper, and cold water paints. China clays are sometimes used as fillers in rubber goods, patent roofings, oilcloths, and, depending on the natural dried color, for different grades of paper fillers (known as paper clays).

BALL CLAYS. These are highly plastic clays with a tendency to ball when wet into large ball-like masses of clay. They are strong clays and burn white or light cream, vitrifying between cones 5 and 10. They are used mixed with china clays to give the body-plasticity and bending strength; such articles as white earthenware, porcelain, floor and wall tile, electrical porcelain, and glass refractories are made from the clay mix.

SLIP CLAYS. These are fine-grained clays which, due to a high percentage of fluxes, melt to a brown or greenish glass at or below about cone 5 (see table for corresponding temperatures). They should be free from lumps, have small drying shrinkage and generally being made into a slip by mixing with water. The slip is applied to the surface of inferior clay wares by dipping or spraying. Formerly slip clays were used for glazing stoneware but now find their principal market as a binder in the making of artificial abrasives.

FIRE CLAYS. Clays which will withstand high temperatures and which will not fuse (or melt) below about cone 28 are called fireclays. This looseness in definition has resulted in practically all plastic clays found in association with coal seams being erroneously called fireclays whether refractory or not. The American Society for Testing Materials makes the following distinctions, dividing the fireclay products into four classes:-

(1) High heat duty firebrick fusing above cone 30-33 (divided according to composition into clay firebrick and siliceous-clay firebrick.)

(2) Intermediate heat duty brick fusing at cone 28-30.

(3) Moderate heat duty brick fusing at cone 26-28 and

(4) Low heat duty brick fusing at or above cone 19.

Fire-clays are used for making fire-brick, refractory cements, retorts, furnace linings, crucibles, coke oven brick, saggers and a wide range of miscellaneous refractory products. Special types of fire-clays include flint fire-clays, refractory bond clays and nodular fire-clays.

STONEWARE CLAYS. These clays are often as refractory as fire-clays but they must fire to a dense body at a relatively low burning temperature for use as stoneware clay. Good plasticity, toughness, good bonding strength, low shrinkage and low firing range are all essential requirements which often may only be attained by making mixtures of different clays. They should burn to a cream or light tan color with low porosity at from cone 5 to cone 9, without yielding soluble salts. As the name implies, they are used for making stoneware, also being used for making yellow ware, art ware, earthenware and terra cotta. Generally speaking, however, terra cotta clays are semi-fire clays or mixtures of such clays with less pure clays and shale.

ROOFING TILE CLAYS. These clays must be plastic and strong, the resulting product drying and burning without warping or cracking to give a flat tile. If the tile is unglazed it should fire to a hard dense body.

SEWER PIPE CLAYS. These clays should, according to H. Ries, be sufficiently plastic to mould in the pipe press, dry and burn without cracking, have good transverse strength when dry, and show freedom from soluble salts, as well as from lumpy fusible impurities. They should be siliceous clays to permit the application of salt glazes Sometimes a fire-clay - impure clay mixture is used for sewer pipe manufacture.

COMMON BRICK CLAYS. Almost any clay which will mould easily, dry without excess shrinkage or deformation, and burn hard at a low temperature (below cone 1) can be used for making common brick. They are usually red burning and almost always a low-grade clay. Excessive drying and fire shrinkage may often be reduced by mixing with the other clays or sand (called tempering).

FACE BRICK CLAYS. To be satisfactory for face brick purposes clay must be of better quality than for common brick. The resulting bricks must be of uniform color on burning with freedom from warping and splitting, have no soluble salts in their composition, have sufficient strength and hardness, show low absorption and have a good range of vitrification to avoid loss in firing due to hard burning. Face brick clays are red burning, white burning and buff burning. Semi-refractory clays are often used for this purpose.

FIRE-PROOFING AND HOLLOW BRICK OR TILE CLAYS. These are often similar to clays used for common face-brick. They need be only slightly stronger in order to flow through the forming die in thinner sections.

PAVING BRICK CLAYS. Mixtures similar to those from which sewer pipe is made are used for paving bricks. Toughness of clay is the essential qualification for this type of ware.

Other clays than those listed above include chemical stoneware clays, sagger clays, enamel brick clays, colloidal clays, high alumina clays, boulder clays and cement clays, all being used for the purposes indicated and being similar in most instances to clays already described.

Uses.

Brief mention has been made of the more important uses of various clays, such as; for structural bricks, tiles, terra cotta, fire and refractory bricks, porcelain and chinaware, etc., but a few additional uses for clay products are listed here as a matter of interest. Special clays, such as bentonite, are used for face and beauty clays and as food adulterants, while others are used for modelling and oil filtering. Ordinary burned and crushed bricks are being extensively used for railroad ballast and for granules used in the colouring of patented roofing materials.

Economics of Clay Deposits.

It should be remembered that it takes more than just a useful clay suitably located to provide the basis for a clay or brick industry. Suitable clays for making the common types of brick are fairly common in British Columbia and it is absolutely essential that a market close to the clay deposit be available or the enterprise will be doomed to failure before it is properly started. Generally speaking, a thousand bricks will weigh from $2\frac{1}{2}$ to $3\frac{1}{2}$ tons or more and for the more common varieties will sell for $14 to $18 per thousand. Obviously there is small leeway between cost and selling price allowable for freight rates and it might properly be concluded that a poor clay deposit close to market is generally more valuable than a good clay deposit situated at some distance from the point of consumption. Firebrick, sewer pipe, pressed brick and stoneware command better prices and consequently can be shipped greater distances to market. Also deposits of clay suitable for the manufacture of better quality clay-products are scarcer giving less chance of competition in any given market area.

After preliminary testing has indicated a useful clay, the size and uniformity of the beds must be determined and the deposit sampled by either test pits or drill holes at uniform spaced intervals. For regular deposits, test holes on the corners of 100-foot squares are sufficient; on irregular deposits, 50-foot squares should be used as the base plan. Samples are taken from every one, two or five feet of the bed thickness, according to the thickness and uniformity of the deposit, it always being remembered that testing subsequent to sampling can only refer to the samples taken.

Following sampling and detailed chemical and physical testing in a properly equipped ceramic laboratory at least one or two commercial test runs should be made in an existing clay plant as a final check on the testing experiments.

Knowing the variety of wares it is possible to make from the clay it is next essential that an exhaustive study be made of production costs and possible market demand for the products at any price above the actual cost of production. This market demand must consider not only cost of production, selling and transportation but also consider possible cut-rate competition from other companies.

Other considerations which enter into the final analysis of the worth of any clay property include sources of fuel, miscellaneous supplies, labour, and financial arrangements for plant construction and working capital.

It should be remembered that the manufacture of clay products is no business for the unexperienced. Brick-making and allied clay product manufacturing processes appear quite simple to the uninformed but the large number of abandoned clay-product plants in such a comparatively young country as British Columbia is ample evidence of either an improper understanding of the properties of clays and their working, or the difficulties of excessive transportation costs and competition. The plant and machinery necessary for clay-working costs a great deal of money and the risks of adopting the wrong process or making the fatal mistake in trying to make certain products from the wrong type of clay raw material are so real and many that money spent for an ounce of prevention in the form of reliable disinterested professional advice is money well spent.

In this connection the work of the Department of Mines, Ceramics Division, at Ottawa, under Mr. Howells Frechette renders a very valuable service to those interested in making preliminary and, if justified, exhaustive tests on Canadian clays. An excellent staff in a thoroughly modern ceramic laboratory are available to those desiring detailed knowledge of Canadian clay samples.

## BRITISH COLUMBIA CLAY PRODUCTION

Since the first records of production were kept in 1905 when approximately $360,000 worth of red brick and drain tile were manufactured, there has been a total production of $12,861,415 worth of clay products made in the sixteen active and twenty-two inactive or abandoned clay-working plants of British Columbia. Production figures by classes of product for this period are shown in Table III, the 1931 production of $495,786 being considerably smaller than the normal production of approximately $750,000.

TABLE III. TOTAL PRODUCTION OF CLAY PRODUCTS IN BRITISH COLUMBIA SINCE 1905 AND FOR 1931.

| Product. | 1905-1931. | 1931. | Approx. normal production |
|---|---|---|---|
| Common red brick, | $ 3,234,778 | $ 130,438 | $ 185,000 |
| Face, paving and sewer brick, | 3,720,718 | 56,419 | 80,000 |
| Fire-brick, | 1,720,935 | 99,762 | 200,000 |
| Pottery and tile, | 4,083,147 | 205,294 | 250,000 |
| Clay and miscellaneous products, | 97,458 | 10,184 | 14,500 |
| Special clays, bentonite, | 4,379 | 3,779 | 500 |
| | $12,861,415 | $495,786 | $750,000 |

In addition to the local production consumed almost entirely within the Province, considerable quantities of sewer pipe from Redcliff, Alberta, and special refractory clays and fire-bricks from the United States and Great Britain are annually sold in British Columbia. The following figures kindly compiled by the Department of National Revenue, Customs Branch, Ottawa, show the clay products imported into this Province for the twelve-month period ending March 31st, 1931.

TABLE IV. IMPORTS OF CLAY PRODUCTS INTO BRITISH COLUMBIA FOR TWELVE-MONTH PERIOD ENDED MARCH 31st, 1931.

| Commodity imported. | Value. | Commodity imported. | Value. |
|---|---|---|---|
| China clay, unmanf. | $ 685 | Furnace repair firebrick, | $27,283 |
| Fire clay, " | 10,312 | Firebrick, n.o.p. | 2,945 |
| Other clay n.o.p. " | 1,949 | Paving brick, | 1,995 |
| Building brick, | 15,149 | Building blocks and hollow tile, | 75,739 |
| Chrome firebrick, | 5,112 | Drain, sewer pipes, glazed or unglazed, | 6,921 |
| Magnesite firebrick, | 5,377 | Tiles, blocks earthenware, | 17,109 |
| Plus 90% silica brick, | 1,331 | Earthenware tiles, | 65,837 |
| Firebrick worth over $100 / M, | 16,515 | Clay or sand crucibles, | 5,195 |
| | | | $259,454 |

In addition to the above total of $259,454 worth of the better clay products, large amounts of porcelain, chinaware, stoneware, earthenware, plumbing fixtures, such as basins, baths, etc., electrical porcelain, etc. for which figures are not available, were brought in and sold in British Columbia. The figures showing local imports indicate possibilities for the development of at least one or two of the high-grade clays found in British Columbia.

## TARIFF

Canadian.

Clay products entering Canada are subject to the following duties in addition to the prevailing special Excise taxes:

| | General. | British Preference |
|---|---|---|
| 1. Clays including china clay, fire-clay and pipe clay not further manufactured than ground, | Free | Free |
| 2. Crucibles of clay, | Free | Free |
| 3. Building brick, paving brick and manufactured n.o.p. | 22½% | 12½% |

| | General, | British Preference |
|---|---|---|
| 4. Drain tile, unglazed, | 20% | 15% |
| 5. Drain pipes and sewer pipes, | 35% | 25% |

United States.

Clays and products entering the United States must pay to the American Customs the following tariff:-

1. Clays unwrought or unmanufactured, including blue common clay and gross Almerode glass pot clay, not specially provided for ...... $1.00 per ton.

2. Wrought or manufactured, not specially provided for...$2.00 per ton.

3. China clay or kaolin...... $2.50 per ton.

## BRITISH COLUMBIA CLAY WORKING PLANTS PAST AND PRESENT

The production of clay products listed in Table III was made in 39 clay-working plants situated at many points throughout the Province, but principally at those near the centres of population on the lower mainland and Vancouver island. Of this total number of companies only three, the Clayburn Company, the B. C. Refractories, and the B.C. Pottery Company, the latter long since out of business, produced firebrick and special refractory brick. The production in the case of the Clayburn and B.C. Pottery Companies was in addition to a wide range of building brick, sewer pipe and tile. The other 36 companies produced drain tile, common red brick, together with, in some instances, facing and building brick. At the present time only 16 companies or 40% of the total number which have operated are capable of making clay products, and these are mostly of the lowest grade of common brick and tile. Competition and the unfavourable situation of manufacturing plants with respect to markets have eliminated over half the clay enterprises which have been started, giving ample proof of the statement that a good clay remote from a market is practically valueless.

Many of the 16 active plants are of small capacity and only exist to supply a limited local demand for common red brick, trading as they do on the margin of profit made possible by high transportation charges on distant competing producers' ware.

The active plants and their locations are given in Table V and where possible, references to more detailed information are given. For those properties about which complete information is desired and which have not been previously reported on, the reader may obtain information by writing to the Bureau of Mines, Victoria, B. C.

The once active but now dormant or abandoned clay plants, together with references, are tabulated in Table VI.

TABLE V. ACTIVE CLAY-WORKING PLANTS OF BRITISH COLUMBIA.

1. Clayburn Company, Limited, plants at Clayburn and Kilgard, of 100 and 200 tons daily capacity respectively. J. W. Ball, Manager. Manufactures of vitrified sewer pipe, firebrick and special refractories, acid resisting and structural brick. Ref. G.S.C. Memoir 24E pp 126-131; G.S.C. Memoir 25, pp 76, and Minister of Mines Reports for 1908, p.186;1926,p.326.

2. Port Haney Brick and Tile Company, plant of 50 tons daily capacity at Port Haney. B.B. Baynes, President. Manufacturers of structural and common brick, hollow tile and drain tile. Ref. G.S.C. Memoir 24E, pp. 141. Minister of Mines Report 1908, p. 186.

3. Baker Brick and Tile Company (with which is associated the Victoria Brick Company) plants on Douglas Street, Victoria. W.A. Luney, Manager. Manufacturers of structural brick, pottery, drain and hollow tile, crushed brick and common red brick. Ref. Minister of Mines Report 1908, p. 184.

4. Gabriola Shale Products, Limited, plant at Gabriola island, about 8 miles from Nanaimo. Manufacturers of common red brick, capacity of 17,000 per working day.

5. B.C. Refractories, Limited. L.T. Fairey, Manager. Plant at 660 Taylor street, Vancouver. Manufacturers of plastic fire clays, high temperature cements and refractory linings, bentonite clays, etc.

6. Vancouver Brick and Tile Company. W. Ayling, Manager. 24,000 to 32,000 common bricks per day capacity. The plant is located at Sullivan, near Cloverdale.

7. Pacific Brick Company - New Westminster. Red brick.

8. B.C. Clay Products, Foot Crompton Road, Vancouver. P. A. Seidel, Manager. Manufacturers of clay flower pots. 500,000 capacity per year.

9. Mainland Tile Company. W. Ponsford, Manager. Plant one mile

north of Cloverdale. 1,000 tiles per day capacity - makers of drain tile and common brick.

10. Jennings and Son operate a common red brick plant at Somenos.

11. Christian Community of Universal Brotherhood (Douhkabors). Plants in vicinity of Grand Forks. Makers of common red brick.

12. Wm. Haug and Son operate a plant at Kelowna. 10,000 to 12,000 daily capacity common red brick.

13. Enderby Brick Company. P.A. Gorse, proprietor (Salmon Arm). Plant capacity 10,000 per day common brick or 10,000 per day drain tile. Ref. G.S.C. Memoir 24E, pp. 118.

14. Prince George Brick Company - J. Reifenrath, Manager. Plant capacity 3,000 common red brick daily.

15. Smithers Brick Company - L.B. Warner, Secretary. Capacity of 5,000 common red brick per day.

16. Terrace Brick Company. Manufacturers of common red brick.

TABLE VI. INACTIVE OR ABANDONED CLAY-WORKING PLANTS IN BRITISH COLUMBIA

1. B.C. Pottery Company, Ltd. - abandoned plant at Victoria. Ref. Minister of Mines Report 1908, pp. 185.

2. North Saanich Brick and Tile Company at Sidney - inactive.

3. Victoria Brick Company, now associated with Baker Brick and Tile Company.

4. Humber Brick Company, Victoria. Ref. Minister of Mines Report, 1908, pp. 184.

5. Mayne Island Brick Company has abandoned plant.

6. Small plant at Somenos, formerly owned and operated by Chinamen; now abandoned.

7. Hillbank deposits of clay near Koksilah; partially developed but not now worked.

8. Abandoned brick plant of Wellington Collieries, Ltd. at Union Bay.

9. Brick plant at Pender Harbour long since abandoned.

10. Vancouver Clay Products, Vancouver; inactive.

11. Anvil Island Brick Company, Anvil island; abandoned. Ref. G.S.C. Memoir 24E, pp. 142.

12. Columbia Clay Company, Ltd., Anvil island, abandoned. Ref. G.S.C. Memoir 24E, pp. 142.

13. Coughlan and Sons, New Westminster; inactive. Ref. G.S.C. Memoir 24E, pp. 123.

14. Fraser River Brick Company - 2 miles below New Westminster; inactive. Ref. G.S.C. 24E, pp. 123.

15. Clayburn property at Clayburn - not worked, the Company centering its operations at the Kilgard plant. Ref. Minister of Mines Report 1908, pp. 186.

16. Heaps Brick Company at Ruskin; inactive. Ref. G.S.C. Memoir 47, pp. 55.

17 to 23.

Small common red brick-making plants located at (17) Kamloops (18) Nelson (19) Cranbrook (20) Kimberley (21) Windermere (22) Merritt (23) Quesnel, and possibly other localities about which there is no record, have been unworked for several seasons or have been abandoned due principally to lack of local markets.

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SOME UNDEVELOPED CLAY DEPOSITS OF BRITISH COLUMBIA

Throughout the Province are to be found many undeveloped clay deposits. In most of these the clays are suitable only for the manufacture of poor quality red common brick and, in some instances, drain tile and pressed brick. The development of these deposits cannot be expected, nor would it be justified until markets close to the deposits have been created by a large increase in the population of the district. Clays suitable for the manufacture of high-grade refractories, structural brick, sewer pipe, and, in one or two instances, stoneware and porcelain, have been discovered, and it is believed that the existing markets for this class of ware now being supplied largely by imported goods are sufficient to justify further development of one or two of the deposits of such clays. Bentonite clays have been discovered at several localities in the southern interior in the vicinity of Nicola and Princeton.

In this section of the report are given notes on the better quality clays occurring near Prince George, Quesnel, Chimney creek, on the Fraser river, Williams Lake at Blue Mountain, and Kilgard in the Sumas area, and at Kyuquot on the west coast of Vancouver island. Notes are also given on the occurrences of bentonite clays in the Nicola-Princeton area.

Table VII has been compiled from several sources and shows the location of deposits of common clay suitable for common brick and drain tile manufacture, and references to where more detailed information may be secured. In addition to those in this short list there are undoubtedly many undiscovered clay deposits which will be found as the country's population grows and creates markets which will warrant the exploitation of clays now some distance from transportation.

TABLE VII. REFERENCES TO KNOWN UNDEVELOPED CLAY DEPOSITS

NOTE: This list is additional to the clay deposits listed in Table VI, some of which were closed for lack of markets rather than for lack of material.

1. Small clay surface deposit near Fernie suitable for common brick only. Ref. G.S.C. Memoir 25, pp 67.

2. Silty clay for common brick and possibly cheap pottery occurs in the valley plains at Golden. Ref. G.S.C. Memoir 25, pp. 69.

3. Clay for common brick occurs at Field and in the Yoho valley. Ref. G.S.C. Memoir 24E, pp. 117.

4. Clay suitable for common red brick and drain tile occurs on Sixmile creek, 6 miles north of Fort Steele, Ref. G. S. C. Memoir 47, pp. 50.

5. Clays suitable for common brick and possibly drain tile occur along the Columbia river near Ford creek, in the Big Bend area north of Revelstoke. Ref. G.S.C. Memoir 47, pp. 48-50.

6. Deposits of common brick clay occur at Goat canyon and between Goat canyon and Creston. Ref. G.S.C. Memoir 65, pp. 39-40.

7. Clay suitable for common brick and drain tile appears in the Canadian National Railway cuts opposite Silverdale on the Canadian Pacific Railway. Ref. G.S.C. Memoir 47, pp. 56.

8. Common brick clay is found at Guillifords in the Tulameen area. Ref. G.S.C. Memoir 24E, pp. 123.

9 - 15. The report on the Resources of the Pacific Great Railway land blocks which was prepared under the direction of Major Crysdale, contains much information about deposits of common brick clay located at the following places in the Cariboo:- (9) At river level on the Stone Indian reserve, Chilcotin river; (10) On the Fraser river a short distance below the mouth of the Chilcotin river; (11) On the left bank of the Fraser river one-quarter of a mile below Woodpecker island; (12) On Lot No. 4884, on the left bank of the Fraser river about one-quarter of a mile below White's Landing; (13) In the most northerly part of the Big Slide north of Quesnel; (14) On the left bank of the Fraser river and in the Big Slide 8 miles north of Quesnel; and (15) In the Baker Creek canyon opposite Quesnel.

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The following reports on the better quality clay deposits are segregated according to the Mineral Survey Districts, with the reports on bentonite clays similarly segregated but in a section by themselves following the description of the Kyuquot pyrophyllite deposits.

## Mineral Survey District No. 1

Only low-grade clays so far have been discovered in this Mineral Survey District.

## Mineral Survey District No. 2

**J.C. MACLURE DEPOSIT OF CLAY ON LOT 3991.** This deposit, owned by J.C. Maclure of 125-Mile House, Lac La Hache, and associates of Vancouver, is situated on the right bank of the Fraser river, 25 miles above Prince George and approximately 7 miles by river barge above Yellow River, a small station on the Canadian National Railway. The following notes were supplied by Resident Engineer Douglas Lay, who examined and sampled the deposit during the fall of 1931. Mr. Lay states:

"The deposit is reached from the Prince George-Summit Lake road by turning off on a branch road about 22 miles north of Prince George, and following this branch road for about one-half a mile, at which point a blazed line, somewhat difficult to follow, leads to the deposit."

"At this point on the Fraser river, which is just below Giscome rapids, there is an extensive bank on the right bank of the river, about 50 to 60 feet above water-level. Practically no work has been done, and exposures are virtually all by natural agencies, sloughed in. The clay can be seen at various points in the bank of the river from a short distance above water-level upwards over a distance of about 300 feet, and quite possibly search would disclose further exposures. The clay is cream coloured, drying white, in main, and somewhat darker in colour in places doubtless due to organic matter. At one point the exposure of cream-coloured clay indicates a thickness of at least 25 feet, and it is stated that the actual thickness determined by boring at this point was 27 feet. Underlying the clay, it was stated, is a stratum of sand."

A sample (2095B) taken at this point, about the middle of the exposure, was tested in the Ceramics Laboratory of the Department of Mines, Ottawa. The sample proved to be a very fine working plastic clay which dried satisfactorily and showed an average drying shrinkage of 6.6%. The burning tests gave the following results:-

| Cone | Fire Shrinkage. | Absorption. | Colour. | Remarks. |
|---|---|---|---|---|
| 03 | 3.0% | 17.9% | Clean white. | Hard |
| 3 | 4.7% | 16.0% | Clean white. | Very hard |
| 10 | 7.4% | 10.2% | A very good white but slightly iron stained. | Very hard |

The softening point was above Cone 30 (1650°C) but could not be accurately determined as the furnace could not be carried to a higher temperature. Thirty-three per cent (33%) water was required to temper the clay to a stiff plastic state.

The Investigator, J.G. Phillips, of the Mines Branch staff, states that "This is a very high-grade clay of the china-clay type. It has possibilities for the following commercial uses: the manufacture of high-grade refractories; as the china-clay ingredient in the manufacture of certain grades of white-ware, porcelain, and floor and wall tile, and other purposes where a high-grade china clay is required. While this clay is not considered to be of as good quality as English china clay, from the indications of the tests this clay is judged as comparing favorably with the higher grades of clay found on the North American continent."

Sample 2096B taken of another exposure of the white clay 300 feet downstream from the first sample was similarly tested at Ottawa. Twenty-six per cent (26%) water was required for tempering. The clay sample was plastic, worked well and on satisfactory drying showed a shrinkage of 5.8%. The firing test showed the following results:-

| Cone | Fire Shrinkage | Absorption. | Colour. | Remarks. |
|---|---|---|---|---|
| 03 | 1.3% | 17.0% | Good white | Hard |
| 3 | 2.0% | 16.0% | Good white | Hard |
| 10 | 3.1% | 12.7% | Good white but with slight iron stain. | Very hard |

The fusion point was Cone 28 and the Investigator, J. G. Phillips, makes the following remarks concerning the economic possibilities of the clay:

"The clay was observed to contain an appreciable quantity of sandy material, probably silica, and is not as pure as sample 2095B, which results in its having a lower fusion point. It has possibilities for the manufacture of third-grade refractories, sewer-pipe and stoneware."

Sample 2097B representing a thickness of 8 feet near where sample 2096B was taken, required 24% water for tempering. The clay was fairly plastic, worked well and dried with a shrinkage of 5.3%. The firing behavior is shown in the following table:-

| Cone | Fire Shrinkage | Absorption. | Colour. | Remarks. |
|---|---|---|---|---|
| 03 | 0.7% | 17.1% | Good white | Fairly hard |
| 3 | 1.0% | 16.2% | Good white | Hard |

This clay is of the same grade as sample 2096B and could be used for the same purposes, namely, third-grade refractories, sewer-pipe and stoneware.

The apparent extent and excellent quality of at least sections of this deposit of clay offset to a large extent the very adverse location. It is considered possible that barge transportation from the clay deposit to the railway, either at Yellow River or Prince George, would be economical and permit the development of this excellent clay. Detailed work is certainly justified in making an exhaustive study of the market conditions for this type of material, both in the raw and manufactured forms.

**QUESNEL STONEWARE CLAY DEPOSITS.** Apparently 8 miles north of Quesnel by wagon-road up the west bank of the Fraser river, there occurs a deposit of grey-white, bedded sedimentary clay in association with the diatomite found on Lot No. 8642. Quesnel is the northern terminus of the Pacific Great Eastern Railway. The clay and diatomite occur near the top of steep bluffs overlooking the river from an elevation of about 500 feet and apparently have been subjected to sliding, the beds lying in detached masses. A sample taken across a bed of 10 feet of clay and exposed along a length of 100 feet was tested in the Ceramics Laboratory at Ottawa. J.G. Phillips did the testing and reported that the clay, which is a soft, grey-white coloured material, required 25% water to make it plastic. This wet clay worked well and dried satisfactorily with a shrinkage of 5.3%. The firing behavior was as follows:-

| Cone | Fire Shrinkage | Absorption | Colour | Remarks |
|---|---|---|---|---|
| 03 | 0.0% | 18.8% | Almost pure white, clean. | Fairly hard |
| 3 | 0.4% | 17.6% | Almost pure white slightly iron-stained. | Hard |
| 10 | 0.6% | 16.3% | Almost pure white slightly iron-stained. Clean. | Very hard |

The clay fused at Cone 19 and as indicated by the tests, would be suitable as a binder in the production of diatomite shapes of white colour. While the clay works well in the plastic state, its plasticity is not of a high degree, and the amount of diatomite it would carry would have to be determined by additional tests, preferably on a large scale. It is rather a high-grade clay, has a fairly high fusion point and fires to a good white colour. Should large scale working tests prove its working qualities to be satisfactory, it would probably be suitable for making sewer-pipe and stoneware. While the clay has not been found in its original position it is very likely that search to the west would result in finding the outcrops. A fairly large tonnage can be seen in the detached masses which have come to rest to form a bench about 100 feet below the original position.

L. Reinecke, in Memoir 118 of the Geological Survey of Canada, reports sampling a bed 20 feet thick by 50 feet long, and the existence of adjoining beds 20 feet thick which were overlain by diatomite. The results of sampling by Reinecke indicate that if the clay is mixed with the lower grade clays from Baker Creek canyon, 9 miles south, semi-refractory clays can be manufactured from the mixture.

CHIMNEY CREEK BRIDGE RESIDUAL CLAY DEPOSIT. The following notes covering the occurrence of a No. 1 residual fire-clay near the Chimney Creek bridge are from the report by L. Reinecke, in Memoir 118 of the Geological Survey of Canada, pages 67 - 69:-

"Samples 1 to 4 were taken from a point 1,400 feet in elevation above Chimney Creek bridge, west of the Fraser river and within sight of the bridge. The bridge is about 26 miles by road from 150-Mile House and 15 to 16 miles over a high grade from the Pacific Great Eastern Railway at Williams Lake. The clays occur as residual masses produced by the alteration of a series of Cache Creek fine-grained quartzites and argillites. The clay-bearing zone is much crumpled and faulted, whereas the undisturbed beds below and to the side are hard, fresh, and free from clay. Over the clay there are silts and basalts of Tertiary age. A section of the deposit from the top down is as follows:-

| | Thickness in Feet. |
|---|---|
| (a) Black basalt nearly flat-lying and forming the summit of the slope. The lower 15 feet is broken up and consists of broken basalt fragments mixed with the clay .......................... | 40 |
| (b) Fine silt, unconsolidated and well bedded, probably of Tertiary age ........................ | 10 |
| (c) Fine-grained argillite or quartzite, yellowish white and partly altered to clay .................. | 30 |
| (d) Bluish, fine-grained quartzite, the bed much crumpled and apparently wholly altered to clay, although the sample No. 1 tested carried 50% non-slaking material .................................. | 2 to 4 |
| (e) Silty argillite or quartzite changed to yellowish white clay, 15 to 20% of fresh rock present. ...... (Sample No. 2) | 25 |
| (f) Seam of white clay with pinkish streaks, showing in places only, in a much crumpled and faulted bed. This is the best clay in the bank.(Sample No. 3)... | 2 to 3 |
| (g) Resembles (e) with seams of white clay through it, percentage of fresh rock about the same as in (e) (Sample No. 4) ...................................... | 25 |
| (h) Alternate beds of silty argillite or quartzite varying slightly in texture and colour, largely altered to clay but with more rock present than in (d), (e), (f), and (g). ............................ | 85 |

(j) Black, carbonaceous argillite somewhat altered to clay.

(k) Alternations of argillite and quartzite exposed for 800 feet down the slope. These beds are not changed to clay."

"The beds from (k) downward strike along the slope and are practically undisturbed; those from (c) to (g) are very much crumpled, twisted, and appear in all attitudes, and the bed from (h) is less disturbed. The alteration to clay of beds (c) to (g) is very pronounced; (h) is partly altered to clay and from (k) down the beds are quite fresh."

The results of testing on the samples taken were as follows:

"Sample No. 1. Semi-refractory. A white, residual clay. Washing and screening through 80-mesh sieve yields 50% of plastic clay resembling stoneware clay. This burns to a light grey hard body. The crude clay, ground to pass a 16-mesh screen, has low plasticity, but is easily moulded, burns to a dark grey, hard body at Cone 5. Total shrinkage at Cone 5, 8%, absorption at the same temperature 6%. The washed clay fuses at Cone 15 and the crude clay at Cone 18.

Sample No. 2. A No. 3 fire-clay. A white and pink residual clay. Plasticity low. Burns to a hard, buff body at Cone 5 with total shrinkage of 11% and absorption 11%. Twenty-five per cent of the crude is clay.

Sample No. 3. No. 1 fire-clay or kaolin. White and pink residual clay. Ground to pass 16-mesh screen. Plasticity low. As all the particles do not slake the clay is granular when wetted. Burns to a cream-coloured body at Cone 5 with total shrinkage of 15 and absorption of 17%. Portion ground to pass an 80 mesh screen; plasticity good, clay smooth when wetted. Floor tile burnt to Cone 5 slightly off white colour and not vitrified. Clay makes a good casting slip when poured into plaster moulds, but needs the addition of potter's flint because of high shrinkage. Clay not affected when heated to Cone 30, hence highly refractory.

Sample No. 4. Semi-refractory clay. Light buff, residual clay. Ground to pass 150-mesh screen; plasticity fair but short in texture. Burns to drab grey vitrified body at Cone 5 with a total shrinkage of 14%. Fuses at Cone 17."

"Mr. Keele remarks on the results as follows: 'These tests show that the deposit is uneven in quality, that the clay-forming processes are not completed, as plasticity is generally low and fluxing impurities are rather high in certain portions. The clays of this deposit as a whole might be worked for the manufacture of a low grade of firebrick, or as a mixture with a more plastic clay for making sewer-pipe. If the material was crushed and washed it would yield a certain amount of fine clay which could be used in the manufacture of stoneware goods, but the yield of washed clay would probably be too small to repay that operation. As the material is not fine-grained and is not white in either the raw or burned state, it cannot be classed as a commercial kaolin or china clay.'"

G.H. TURNER'S WILLIAMS LAKE CLAY DEPOSIT. This property, comprising Lots Nos. 5177, 5178 and 5180, is situated 4.3 miles by road in a south-westerly direction from Williams Lake station on the Pacific Great Eastern Railway. According to G.H. Turner, he is the owner of the last two mentioned lots while the first one is held jointly by B. A. Cunliffe and himself.

A series of altered argillites has been exposed along the roadside and by open-cuts some 300 feet to the west of the road. Samples of residual clayey material similar to that said to have been shipped to the plant of the B.C. Refractories Company in Vancouver were taken from the roadside pit, and from a 30-foot open-cut to the west of the road, and 20 feet above it.

The sample from the roadside pit required 27% moisture to temper to a stiff plastic state and was worked with difficulty due to the shortness of the clay. The drying was satisfactory and was accompanied by a shrinkage of 1.7%. On firing the product to Cone 10 it was found that the shrinkage was 0.0%, the absorption was 23.6%, the colour was a dirty buff, full of specks, and soft and friable. J.G. Phillips, the ceramist conducting the tests, notes that the clay fuses at Cone 18 and due to the poor working and firing properties, concludes that the clay is of little or no value as a raw material in the ceramic industry.

The sample from the 30-foot open-cut tested similarily in the Ceramic Laboratory of the Department of Mines, Ottawa, required 23% water to temper the clay, and while it was inclined to be short it was found to work fairly well. The material dried with satisfactory results and showed a shrinkage of 4.7%. On firing, the results were as follows:-

| Cone | Fire Shrinkage | Absorption | Colour | Remarks |
|---|---|---|---|---|
| 03 | 0.0% | 19.4% | White, clean | Fairly hard |
| 3 | 0.0% | 19.0% | " " | " " |
| 10 | 0.0% | 19.0% | " " | " " |

Clay fused at Cone 19

The heavily wooded mountain slopes show a few outcrops below 2,500 feet elevation. The best section of sedimentary sandstones, shales, and red and blue shales may be seen in a ravine tributary to Gold stream. The section was 250 feet thick, the lower 150 feet being largely red shale. At the junction of the main stream with its tributary there is a heavy bed of red shale exposed on a 25-foot face. Above the red shale is a blue shale, and similar material is found outcropping up the tributary ravine near an old tunnel. Five samples were taken by Ries and the following results were obtained:-

Sample No. 1942. Red shale from the junction of the two creeks above referred to. On being tested this clay proved to be adapted to the making of good quality common red brick and showed possibilities when mixed with more plastic clay for the manufacture of sewer-pipe and paving-brick.

Sample No. 1943. This sample was taken from the blue shale overlying the red shale beds and may properly be classed as a fire-clay. It is the best clay on the property. It is fine-grained and dense like the other shales on the property, and worked best with wet pan grinding, its plasticity being good and the air-dried product showing a shrinkage of approximately 8%. Its fusion point was Cone 30, the following firing tests showing the behavior of the shale when fired from Cone 010 to Cone 15:-

| Cone | Fire Shrinkage | Absorption | Colour and Remarks |
|---|---|---|---|
| 010 | 2.8% | 17.60% | Soft body though not very porous. |
| 05 | 4.4% | 15.55% | Buff colour and steel hard. |
| 1 | 5.6% | 10.35% | Buff and fairly dense body. |
| 7 | 7.0% | 7.00% | |
| 9 | 7.4% | 5.1 % | |
| 15 | 11.5% | 2.6% | |
| 30 | Fused | | |

This shale in its plastic condition could be used for making pressed brick and, with the use of grog, for making fire-brick. It is almost as refractory as the Sumas fireclays.

Sample No. 1944. This sample, taken from the tunnel on the tributary stream, showed good plasticity, worked well, and on firing burned to a dense brick steel hard at Cone 05. Fusion point was Cone 27.

<u>Sample No. 1945.</u> This sample was taken from an irregular deposit of white clay of unknown dimensions. It is a very plastic clay, tempering with 18% water, drying with an air shrinkage of 5% and burning to a cream or bright buff colour at Cone 010, at which temperature it is nearly steel hard.

In general, Ries concludes that the Blue Mountain shales are softer and more easily ground than the Sumas shales, but have a higher shrinkage when fired at lower cones. The blue shale, sample No. 1943, is a fire-clay and it seems that these materials might be successfully used for the manufacture of terra cotta, sewer-pipe, and fire-proofing.

ATLAS CLAY PRODUCTS, LTD. <u>(Sumas Mountain Property)</u> This property, comprising 130 acres of the Fooks ranch, is situated north of the old Great Northern Railway tracks at Kilgard, being separated on the east boundary from the Clayburn property by a narrow strip of Indian Reserve land. It is owned by the Atlas Clay Products, Limited, the authorized capital being $150,000 divided equally into common and 7% preference shares.

The clay and shale measures outcrop along the railway track and up the south side of Sumas mountain and are the westerly continuation of the regular clay and shale measures now being worked by the Clayburn Company. Access is by means of the Great Northern Railway and road. The best exposures are 50 miles east of Vancouver and within half a mile of the main Fraser Valley south road.

Test work has been limited, but there is sufficient evidence in the form of naturally opened cuts and outcrops to indicate a regular series of sandstones, blue clays and shales, dipping at approximately 10 degrees to the S.W. with a strike of about S. 40 degrees E. The regularity of the outcrops and the thickness of the individual beds of shale would indicate beds of considerable extent, information which would have to be determined by drilling. Surface development work, confined to the more favourable sections of the property near the south-east end along the railway tracks, would also be necessary.

Seven samples in all were taken and sent to the Ceramics Laboratory of the Mines Branch, Ottawa, where tests were conducted by J. G. Phillips. The results were as follows:-

<u>Sample No. 1.</u> This sample was taken across a width of 12 feet of fresh clayey shale on the east end of the lower, or so-called No. 1 seam, and from a point about 150 feet from the eastern boundary of the property. It was a grey soft shale, required 22% moisture for tempering, being plastic and working well, and dried with an air shrinkage of 7.2%. The firing

behavior was as follows:-

| Cone | Fire Shrinkage | Absorption | Colour and Remarks. |
|---|---|---|---|
| 010 | 1.0% | 15.5% | Light buff, fairly hard |
| 03 | 3.2% | 12.7% | Good light buff, hard |
| 3 | 4.1% | 10.4% | Good light buff, hard |
| 12 | Fused. | | |

This clay has good working and firing properties, has a long firing range with indications of generally good firing qualities, firing to a good buff colour. It could be used for making common brick, hollow building tile, drain tile, buff facing-brick, sewer-pipe and roofing tile.

Sample No. 2. This sample from the same locality as sample No. 1, was taken across 4 feet of a 4-foot bed of shale known locally as seam No. 2, and lying a short distance vertically above seam No. 1. Its working and drying properties were similar to those of sample No. 1, the shrinkage, however, being but 6%. The firing properties were as follows:-

| Cone | Fire Shrinkage | Absorption | Colour and Remarks. |
|---|---|---|---|
| 08 | 0.6% | 18.1% | Salmon holour, fairly hard |
| 06 | 2.0% | 15.5% | Salmon, hard |
| 03 | 5.0% | 12.7% | Dark salmon and very hard. |
| 12 | Fused | | |

The unfavourable fired colour would possibly limit the usefulness of this clay for face brick, but it could be used for common wares and possibly for sewer-pipe.

Sample No. 3. This sample, from the same locality as the first two samples but from a 7-foot bed of grey soft shale overlying seam No. 2, called locally seam No. 3, tempered with 21% moisture to a plastic mass which worked well and dried with a shrinkage of 5.6%. Its firing qualities at Cones 08, 03, were similar to those for sample No. 2. The fusion point was reached at Cone 3. The clay could be used for common brick, hollow building tile and drain tile, the unfavourable dark salmon colour when fired limiting its use for facing brick.

Sample No. 4. This sample was taken from a 20-foot exposure of blue clay, situated in a small ravine, approximately 400 yards west of the three previous samples. The working qualities were satisfactory, the drying shrinkage being 6.7%. The firing behavior was as follows:-

| Cone | Fire Shrinkage | Absorption | Colour and Remarks |
|---|---|---|---|
| 03 | 1.2% | 9.3% | Dark buff, hard |
| 3 | 4.8% | 8.3% | Brown and very hard |
| 10 | 6.8% | 3.1% | Dark brown, mottled from iron spots and almost vitrified. |
| 23 | Fused | | |

The clay was found to be slightly lacking in desired plasticity, but to have merit in having a rather high fusion point, a long firing range, and a gradual increase in shrinkage and approach to vitrification. Its fired colour was judged only fair, and it could be used for common clay products, face brick, sewer-pipe and roofing tile.

Sample No. 5. One hundred and fifty yards west of sample 4, a sample was taken across a 5-foot width of a 10-foot bed of clay exposed in the railway embankment. It is fairly plastic, and cracked during moderately rapid drying, the shrinkage being 5.9%. The fired properties were only fair, but as it fires to a rather good red colour at Cone 03 and does not fuse until Cone 5, it has possibilities for the making of face-brick.

Sample No. 6. This sample was taken across 6 feet of clay at a point 150 feet west of sample No. 5. It is only suitable for the manufacture of common brick, hollow building tile and drain tile. At Cone 03 the product showed a fire shrinkage of 6.0%, the absorption of 4.0% and a dark salmon colour and vitrification. Fusion point was Cone 1.

Sample No. 7. This sample was taken from a 20-foot bed of blue shale and clay situated above the road and near the centre of the property. It was found to be somewhat lacking in plasticity, had a short firing range and a low fusion point, the firing behavior being as follows:-

| Cone | Fire Shrinkage | Absorption | Colour and Remarks |
|---|---|---|---|
| 08 | 0.3% | 16.8% | Brownish salmon, fairly hard |
| 06 | 1.7% | 14.5% | do do do |
| 03 | 5.6% | 8.3% | Good red and very hard. |
| 1 | Fused | | |

The clay could be used for the making of common brick hollow building-tile, drain tile, etc., if its working properties were proved satisfactory in large-scale working tests.

It is considered very probable that very little depth would be required at the south-east corner of the property to reach the geological horizon from which the fire-clay is being mined on the adjoining Clayburn property. If such fire-clay beds were encountered the value of the property would be materially enhanced. Provided sufficient market can be obtained for the face and pressed brick products, it may be concluded that the property is well located for economical working, and moderately well situated with respect to the Vancouver and Fraser Valley markets.

KYUQUOT SOUND PYROPHYLLITE DEPOSITS. Vancouver Island. For a complete description of the occurrence of quartz-pyrophyllite, which is found on the Monteith and Deartrail claims located on the peninsula between Easy creek and Kokshittle arm of Kyuquot sound (one of the larger inlets on the north-west coast of Vancouver island), the reader is referred to the exhaustive report by C.H. Clapp which appeared in the 1913 Summary Report of the Geological Survey of Canada, pages 109-126.

The quartz-pyrophyllite, an alteration product of feldspathic andesites and dacites, was used by the old B.C. Pottery Company of Victoria as a "fire-clay." The property is situated on tidewater within a few feet of the shore. According to Clapp, approximately 500,000 tons of material can be conservatively estimated as being in reserve.

Heinrich Ries, in the Geological Survey of Canada Memoir 24E, page 140, makes the following remarks about a sample of the pyrophyllite taken from the stock pile at the B.C. Pottery Company's plant in Victoria: "The stuff consists of a mixture of clay and lumps of partially decomposed rock, and turned out to be one of the most refractory clays found in western Canada. A sample lot from the stock pile at the factory showed the clay to be of rather low plasticity for the reason that much of it represents but partly kaolinized rock."

"It was worked up with 20% water, and had an air shrinkage of 3%, with a tensile strength of 84 pounds per square inch."

"The burning tests were carried out in some detail because of the refractory character of the material:-

| Cone | Fire Shrinkage | Absorption | Colour |
|---|---|---|---|
| 010 | Slightly swelled | 15.50% | Salmon |
| 03 | " " | 14.22% | Pink |
| 1 | " " | 11.7 % | Pink |
| 5 | 0.6% | 9.23% | Drab |
| 9 | 1.7% | 7.92% | Grey |
| 13 | Not vitrified | | |
| 30 | Fused | | |

It burns steel hard at Cone 1 and shows good refractoriness."

It is understood that samples of the more altered rock were tested by several ceramists in Great Britain. The general result of their tests showed that the clay was of poor plasticity but of excellent quality for use in pottery, porcelain, china-ware and high-grade tile and paper manufacture.

## BENTONITE CLAYS

Bentonite is the name given to a very plastic (when wet) clay-like group of materials consisting mainly of the mineral montmorillionite. When dry, bentonite is rock and wax-like in appearance and feel, some varieties becoming powdered on long exposure. It is creamy white to olive green in colour, exhibiting conchoidal fracture and when wet is extremely smooth feeling and plastic. It resembles soft soap when soaked in water, and some types of bentonite are capable of absorbing as much as five times their own weight of water and coincidently increasing their bulk to several times their original dry size. It usually occurs in bedded deposits of varying thickness and geological research has indicated its formation by the devitrification and partial decomposition of beds of volcanic ash. The outcrops are always barren of vegetation and generally exhibit a peculiar crinkled coral-like appearance when dry.

Bentonite is used principally for oil-refining as a filter to remove impurities, the British Columbia varieties being particularly well adapted for this use. It is also used as a bonding ingredient in foundry work, and in a wide variety of uses such as for: de-inking of newsprint; as a bonding medium in fire-brick, asbestos cements, insulating and accoustic plasters; for increasing the workability of cement mortars; as a thickening and suspending agent in the heavy-mud system of rotary, oil-well drilling; and for soaps, cosmetics, antiphlogistine, hoof-packing, etc.

Bentonite is generally sold as a finely powdered product and should be free from objectionable amounts of sand, gypsum, carbonaceous matter and soluble salts. Prices are from about

$8 per ton for the dried and crushed Wyoming crude and $25 per ton for selected air-floated bentonite, f.o.b. Chicago, as at recent quotations.

## BRITISH COLUMBIA OCCURRENCES OF BENTONITE

There are no reported occurrences of bentonite in Mineral Survey Districts Nos. 1, 2, 5 and 6.

### Mineral Survey District No. 3

Keele reported the discovery of bentonite from the vicinity of 17-Mile House on the Cariboo road and also from the mouth of Gorge creek in the Deadman River valley, northwest of Kamloops lake. These deposits were not examined as their distance from railway transportation precludes commercial development until such time as the more conveniently situated Nicola and Princeton deposits have been utilized.

**J. GUICHON RANCH BENTONITE DEPOSIT.** This deposit, situated $2\frac{1}{4}$ miles east of Quilchena by road and 10 miles northeast of the railway at Nicola by road, outcrops as an 8-foot bed of bentonite overlying conformably a 5-foot bed of shaly lignite coal. The rocks in the area surrounding the deposit are Tertiary volcanics, the immediate vicinity of the outcroppings being covered with clayey detritus.

The only development on the bentonite outcrop is a 30-foot shaft put down from the characteristically crinkled surface in order to obtain samples of the clay for testing. The beds strike approximately north and south, dipping into the hill at an angle of 30° to the horizontal. The bentonite is further exposed by the development of the lignite seam which is used locally for domestic fuel. Several short tunnels have indicated the continuity of the bed, with a thickness of 8 feet, for some distance underground. The material is a dense, fine-grained, greasy-appearing, rock-like, clay of creamy yellow to olive green in colour, and exhibiting conchoidal fracture.

Three samples were taken: No. 1 sample being across 8 feet of bentonite near the portal of the upper or No. 1 tunnel; No. 2 being across 7 feet of impure sandy clay 130 feet in from the portal of No. 1 tunnel; and No. 3 from across 6 feet of bentonite exposed in an open-cut directly above and to the right of the 30-foot shaft. These samples were tested in the Chemical Division Laboratory of the Department of Mines, Ottawa, by A. Sadler. The following physical test results were obtained:-

| | No. 1 | No. 2. | No. 3 |
|---|---|---|---|
| Specific Gravity determined by pycnometer. Clay dried at 105°C. | 2.54 | 2.29 | 2.55 |
| Fusion point by Seger cones | 12 | 11 | 14 |
| Refractive Index | 1.548 | 1.556 | 1.548 |
| Moisture of clay dried at 105°C | 3.55% | 5.05% | - |
| Moisture after heating to 400oC. | 2.42% | * 3.07% | - |
| Moisture after " " 500°C. | * 2.11% | 1.96% | - |
| Moisture " " " 600°C. | 1.64% | 1.38% | - |
| Moisture " " " 700°C. | .68 % | .75% | - |

* Colloidal properties competely destroyed at these Temps.

| | | | |
|---|---|---|---|
| Water absorbed by 1 gramme of bentonite clay | 1.8 gr. | 1.0 gr. | - |

Tests were also made to determine how the degree of dilution of a bentonite-water suspension and the time of standing affected the clay in suspension. Four 10-gram samples were disintegrated in 350 cc of distilled water and diluted to 500 cc, 1,000 cc, 1,500 cc, and 2,000 cc. The amount of clay in suspension was determined after 1, 4, 6 and 10 days. Results showed that Sample No. 1 was the most colloidal of all those tests, there being 17.90 per cent of the clay in suspension at the end of 10 days (in the 500 cc beaker) as compared to 6.37% and 7.02% for samples No. 2 and No. 3. Complete results from this test, as well as from tests showing the coagulating effect of various reagents upon the samples are quite lengthy, but those interested may obtain them by writing to the Bureau of Mines.

There is available at this Guichon Ranch deposit a large indicated supply of bentonite which it would be possible to mine with relatively cheap underground methods, should sufficient demand for bentonite be found to more than tax the capacity of the more favourably located Princeton deposits.

Other occurrences of bentonite in the Merritt-Nicola area are indicated by samples received from Murdoch McIntyre of Merritt, and H. Stumbles and J.S. Morgan of Lower Nicola, all of whom report substantial quantities of the material available.

## Mineral Survey District No. 4

Several deposits of bentonite occur in the Princeton area of the Similkameen Mining Division. The majority of these are exceptionally well situated with respect to railway transportation, two of them being in railway cuts on the Princeton-Copper Mountain branch line of the Canadian Pacific Railway.

PRINCETON PROPERTIES, LTD. Bentonite Deposits. An 18-inch bed of creamy white bentonite is found in the now flooded colliery of the former Princeton Coal and Land Company. The material occurs between the lower coal seam and the shale floor and it is doubtful if such a thin bed could be worked economically in conjunction with the mining of the coal

Bentonite beds of good quality and thickness outcrop on the south side of the first railway cut east from the railway bridge crossing the Similkameen river on the Copper Mountain-Princeton branch of the Canadian Pacific Railway, the main portion of the deposit being on lands owned by Princeton Properties Limited. The outcrop shows a 14-foot bed of bentonite. The upper three feet are slightly yellowish-brown in colour and below this is 7 to 8 feet of yellow clay. Next below is a 4-foot bed of clay, then a thin seam of lignite coal and, lastly, shale. About 500 yards to the east of this outcrop the bentonite beds are found outcropping at slightly higher elevations along the south wall of the railway cut, and here a small open-cut quarry and short adit have been made on the bed of clay which at this point is about 12 feet thick. Shipments of clay have been made from both exposures to the plant of the B.C. Refractories Company, Limited, 660 Taylor Street, Vancouver, B.C., and during the summer of 1931 several carloads were sold for oil-refining purposes.

Two samples were taken in the eastern exposure, the No. 1 sample being across the centre 4 feet of the bed and the No. 2 sample being from the top $3\frac{1}{2}$ feet of the bed at the same point. These samples were tested by A. Sadler of the Chemical Division, Department of Mines, Ottawa, and the following results were obtained:-

| | No. 1 | No. 2 |
|---|---|---|
| Specific Gravity after dried at 105 C | 2.55 | 2.54 |
| Fusion point by Seger Cones | 14 | 14 |
| Refractive Index | 1.549 | 1.547 |
| Moisture of clay dried at 105°C | 4.92 | 4.35 |
| Moisture after heating to 400°C | * 4.12 | * 3.47 |
| " " " " 500°C | 2.57 | 3.25 |
| " " " " 600°C | 1.48 | 1.44 |
| " " " " 700°C | .78 | .64 |
| Water absorbed by 1 gr. of sample: | 1.6 gr. | 1.6 gr. |

* Colloidal properties completely destroyed at these Temps.

Bentonite water suspension tests showed that at the end of 10 days, 7.8% and 13.81% of the clay respectively for samples No. 1 and No. 2 was still in suspension in the 500 cc beaker. These figures compare with figures of 17.9%, 6.37% and 7.02% for the No. 1, No. 2 and No. 3 samples from the Guichon deposit. Full data respecting this test and the coagulation tests may be obtained from the Bureau of Mines, Victoria.

This Princeton deposit, dipping as it does at a slight angle into the hill, and situated on the railway, is most favourably situated for cheap mining. No testing of the ground by trenching or drilling has been necessary as large quantities of bentonite are exposed along the railway cuts.

Half a mile east of the above occurrence there is an outcrop of light-coloured bentonite which has been partially developed by a short adit. The bentonite as exposed is 5 to 6 feet thick, is half a mile by wagon-road from the railway, and could be cheaply worked by pits. This and the other Princeton deposits are owned by Princeton Properties, Limited, Princeton, B. C., P.W. Gregory, agent.

## CONCLUSIONS

The foregoing notes are intended to cover in a comparatively short space much information regarding the clay industry of British Columbia, with particular references to some of the better and as yet undeveloped deposits of clays, which are found, unfortunately, at some considerable distances from the centres of consumption. It is worthy of note that certain high-grade clays are available, and it is probable that in time they can be properly adapted to fill British Columbia's growing demand for high-grade refractory, structural and ceramic wares. The results of testing the clays from the Prince George deposit show it to be well adapted to the manufacture of high-grade wares. The unfavourable market conditions and somewhat difficult transportation problems, however, hinder the further development of this deposit. The clays of the Cariboo, while not of as good quality as the more northern clay, are of fair quality and have been used to a limited extent for high-grade refractory wares. The pyrophyllite deposits of Kyuquot sound have also been used successfully for refractory (semi) wares, while the slightly lower-grade clays at the Blue Mountain and Atlas Clay properties can be used successfully for a wide range of the more common structural products. Their development will only be justified, however, when a far larger market is available for these products.

The numerous instances of abandoned and inactive common clay-working plants in British Columbia, it is hoped, will serve as a warning to those proposing to begin other operations which would have a very small chance of commercial success.

The brief resumé given on the bentonite deposits of the Province is sufficient to show that the supply of this clay is plentiful and that the development of the industry, as in the case of all the special clay deposits of the Province, is dependent on finding a market for the product. Further details may be found in Bulletin No. 626 on "Bentonite" by H.S. Spence, Mines Branch, Ottawa.

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# SOME UNDEVELOPED CLAY DEPOSITS OF BRITISH COLUMBIA

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