BRITISH COLUMBIA DEPARTMENT OF MINES.
Hon. GEORGE S. PEARSON, *Minister;* JOHN F. WALKER, *Deputy Minister.*

Possibilities for the Manufacture of Mineral Wool

IN

BRITISH COLUMBIA

BY

J. M. CUMMINGS

VICTORIA, B.C.:
Printed by CHARLES F. BANFIELD, Printer to the King's Most Excellent Majesty.
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With three accompanying maps.

POSSIBILITIES FOR THE MANUFACTURE OF MINERAL WOOL IN BRITISH COLUMBIA.

INTRODUCTION.

THE USE of insulation in dwelling-houses as a means of decreasing heating costs and increasing comfort is receiving rapidly growing attention. Many excellent insulating media are available for this purpose, differing in properties, composition, and price; one of the most generally satisfactory of all is mineral wool.

The information contained in this report is derived largely from other publications, and it is offered with the hope of stimulating interest in the subject of house insulation and more particularly to point out the possibilities of manufacturing mineral wool in British Columbia.

Acknowledgments are particularly due M. F. Goudge, Bureau of Mines, Department of Mines and Resources, Ottawa, for his help in testing certain samples and in supplying general information on the subject of mineral wool; publications by Goudge form the basis of the following description of the properties and manufacture of mineral wool. Other publications consulted are acknowledged in the text. The section on calcareous and dolomitic deposits is compiled largely from publications of the Geological Survey and Bureau of Mines, Department of Mines and Resources, Canada.

MINERAL WOOL.

Mineral wool is a soft, light, fluffy substance composed of interlaced glassy fibres, ranging from 2 to 15 microns in diameter and from ½ to 3 inches in length. A variable amount of fine glassy shot is usually present as well. The bulk density varies from 8 to 12 lb. per cubic foot for short-fibred wool and from 3 to 6 lb. per cubic foot for long-fibred wool, the weight being due largely to included shot.

The material owes its high efficiency as an insulating medium to the large proportion of "dead" air which it contains (90 to 97 per cent.), this air being entrapped by the fine network of fibres in such small spaces that convection currents are eliminated. A close approach to the insulating value of still air is thus obtained.

A number of other materials, many organic in nature, are available having equal or nearly equal insulating value. Few, however, possess all the other desirable features of mineral wool, outstanding among which are its lightness, cleanliness, freedom from odour, fire- and vermin-proof nature, physical and chemical stability and resistance to moisture. The last may be of importance, not only in preventing the accumulation of moisture within walls, with accompanying dampness and discomfort, but in maintaining the actual insulating value of the material itself. Allcut* has pointed out the serious influence of moisture on the conductivity of construction materials, the ease with which a given material conducts heat increasing with the moisture content.

An outstanding advantage of mineral wool is its resistance to high temperatures, being suitable for use up to 1,200 degrees Fahrenheit. The actual insulating value decreases with increased temperature, but it remains one of the most effective of available media up to the limit of its application.

Mineral wool is marketed in bulk, as rolls, batts, or blankets, and in a granulated form. It is also reinforced with a suitable binder, wire screening, metal lath, or heavy paper, and sold in various shapes, an example being the so-called "rock cork" used for low-temperature insulation.

For house insulation mineral wool is usually applied as batts, blankets, rolls, or in the bulk or granulated form during the process of construction. In the case of houses already constructed, granulated wool may be poured or blown into walls, floors, and ceilings.

Mineral wool is finding a rapidly increasing use as a thermal insulator in industry: In bulk or blanket form for insulating boilers, pipes, furnaces, tanks, etc.; in the form of "rock cork" for cold-storage plants, refrigerators, etc. It is also incorporated into certain insulating bricks and cements.

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* Heat Insulation as Applied to Buildings and Structures—Inst. of Mech. Eng., London, pp. 225–228; December, 1934.

In addition to its value for thermal insulation, mineral wool is one of the most effective materials for sound-insulation purposes, absorbing sounds of great variety of pitch, both reflected and transmitted. For this purpose it is generally applied as blankets, rigid sheets or pads, or in plasters or tiles.

The following table gives a comparison of the conductivity of mineral wool with a number of other common insulating materials:—

Material.	Description.	Ref.	Density.	Temp.	Conductivity.
				Deg.	
Rock Wool	Short fibre, loose	(1)	7.9	54 F.	0.23
Rock Wool	Long fibre, loose	(1)	3.0	53 F.	0.27
Rock Wool	Granulated	(1)	8.7	53 F.	0.28
Rock Wool	Pad with small amount of bonding material	(1)	5.0	54 F.	0.240
Rock Wool	Pad with small amount of bonding material	(1)	11.3	54 F.	0.248
Rock Cork	Rock wool with binder	(3)	14.5	77 F.	0.33
Mineral Wool	Cement	(4)	35.0	......	0.60
Glass Wool	Loose	(2)	6.0	20 F.	0.196
Diatomite	Powdered	(5)	10.0	100 F.	0.30
Diatomite	Powdered	(5)	18.0	100 F.	0.46
Diatomite	Block	(5)	12.0	100 F.	0.37
Diatomite	Block	(5)	16.0	100 F.	0.41
Zonolite	Vermiculite	(4)	6.0–8.0	......	0.48
Aerocrete	Cellular concrete	(6)	40.0	75 F.	1.06
Aerocrete	Cellular concrete	(6)	70.0	75 F.	2.18
Asbestos	Sheet	(7)	48.3	110 F.	0.29
Asbestos	Millboard, pressed	(3)	60.5	86 F.	0.84
Balsam Wool	Chemically-treated fibre between paper	(3)	2.2	90 F.	0.27
Cabots Quilt	Eel-grass between paper	(3)	3.4	90 F.	0.25
Dry Zero	Blanket made from ceiba fibre	(6)	1.6	75 F.	0.24
Flaxinum	Flax fibre	(3)	13.0	90 F.	0.31
Torfolum	Compressed peat-moss	(3)	10.2	92 F.	0.29
Kork-o-board	Peat-moss	(2)	14.9	100 F.	0.31
Linofelt	Flax fibres between paper	(3)	4.9	90 F.	0.28
Thermofill	Dry, fluffy, flake gypsum	(3)	19.8	90 F.	0.35
Thermofill	Dry, fluffy, flake gypsum	(3)	34.0	90 F.	0.60
Thermofelt	Hair and asbestos fibres felted	(3)	7.8	90 F.	0.28
Cork	Loose, granulated	(3)	8.1	90 F.	0.31
Corkboard	No binder	(3)	7.0	90 F.	0.27
Corkboard	No binder	(3)	14.0	90 F.	0.34
Beaverboard	Rigid insulation made from sugar-cane fibre	(6)	13.8	75 F.	0.33
Celotex	Rigid insulation made from sugar-cane fibre	(3)	13.2	90 F.	0.34
Aluminum Foil	Various forms	(8)	1.5–4.5	70 F.	0.2–0.3
Thermax	Shredded wood and cement	(6)	24.2	72 F.	0.46
Ten Test	Rigid, wood fibre	(9)	12.0	48 F.	0.36
Shavings	Ordinary	(3)	......	86 F.	0.71
Sawdust	Ordinary	(3)	......	86 F.	1.04
Masonite	Rigid, exploded wood fibre	(6)	19.8	75 F.	0.33
Magnesia	85% mag., 15% asbestos, rigid	(3)	19.3	86 F.	0.51
Insulex	Cellular gypsum	(3)	8.0	90 F.	0.33
Insulex	Cellular gypsum	(3)	30.0	90 F.	1.00
Gypsum	Plaster	(3)	46.2	86 F.	2.32
Gypsum	Solid tile	(10)	75.6	76 F.	2.96
Still Air		(1)	......	Ord.	0.175
Fir	Across grain	(7)	33.4	......	1.00
Yellow Pine	Across grain	(6)	......	......	1.00
Brickwork	Mortar bond	(7)	132.0	100 F.	4.0–5.0
Plaster	Cement	(7)	......	......	8.00
Concrete	1–2–4 mix	(7)	140.0	110 F.	8.30
Stucco		(7)	......	......	8.00
Stone	Building	(11)	......	......	12.50

References:

(1) National Research Council, Canada.
(2) Mellon Institute.
(3) U.S. Bureau of Standards.
(4) Schaeffer—Ind. and Eng. Chem.; Nov., 1935.
(5) Ind. and Eng. Chem.; May, 1924.
(6) Armour Institute of Technology.
(7) University of Illinois.
(8) Ind. and Eng. Chem., p. 245; Mar., 1933.
(9) University of Toronto.
(10) University of Minnesota.
(11) A.S.H.V.E. Guide, 1934.

Conductivity is the amount of heat (in B.T.U.'s) transmitted through a unit area (per square foot) of unit thickness (per inch) with unit difference of temperature (per degree Fahrenheit) in unit time (per hour). The lower the conductivity of a substance, therefore, the less heat transmitted by it in a given time and consequently the greater its insulating value.

From the above table it is evident that mineral wool is one of the most effective, at ordinary temperatures, of the inorganic insulating media listed, and is equalled by few of the organic materials. It is interesting to note that the short-fibred wool, in the above table, with a bulk density of 7.9 lb. per cubic foot has lower conductivity than the long, with bulk density of 3 lb. per cubic foot. On the other hand, however, the long-fibred material is resistant to mechanical vibration, while the short-fibred variety tends to " pack."

Because of its acid-proof property mineral wool is commonly used as packing for acid carboys, and as a filter medium for acids and corrosive liquids and gases.

MANUFACTURE OF MINERAL WOOL.

Mineral wool is divided into two types—rock wool and slag wool—on the basis of the raw material used for its manufacture. The properties of rock and slag wool are similar, although, in general, the best-quality wools are produced from rock.

Rock wool and slag wool are not new products; slag wool was made in Germany in 1870 and rock wool in the United States in 1897. There has been little change in the method of manufacture since the early days of the industry.

In general mineral wool is made by subjecting a thin stream of molten rock or slag to a blast of steam or air. The following excerpt by Goudge* outlines the common method employed:—

" The usual type of cupola furnace used in the making of rock wool in the United States is the vertical, water-jacketed, cylindrical variety constructed of steel. It is unlined and has a removable base. Inside diameters vary from 4 to 6 feet, and the height from 8 to 15 feet. A bustle pipe with 8 small tuyeres, which enter the furnace about 18 inches above the base, supplies the air for combustion. Rock and coke are charged through a trap door near the top of the furnace. A fuel ratio as low as 1 part coke to 6 of rock is reported in one instance where preheated air is used for combustion, but the average is 1 to 3.5. The molten rock comes from the base of the furnace in a stream about the thickness of a lead pencil and falls just in front of a nozzle of special shape from which steam or air issues at a pressure of about 90 pounds. The blast of steam, inclined upwards at an angle of 50 degrees from the horizontal, blows the molten rock stream into myriads of tiny globules which are directed into a chamber known as the wool room, the bottom of which is usually a wide belt conveyor. The fibres form behind the molten globules as they are propelled through the air. The fibres fall on the moving floor in a fluffy mass and are transported from the wool room. The capacity of the average size cupola is 900 pounds of wool per hour. A certain proportion of glassy globules (shot) is always present in the raw wool. In order to make a dustless product a tiny stream of high-flash paraffin oil is run on to the stream of molten rock globules just after they begin their flight from the steam jet. This gives what is known as oiled wool."

Where the rock or slag is of uniform composition it may be charged in pieces ranging from 8 inches down to dust, provided that the fine material is not present in sufficient quantity to choke the draught. Where a mixture is used it is preferable to have the more infusible material in a finer state of division than the remainder.

Various refractory-lined furnaces have been employed, but the high operating temperature (up to 3,000 degrees Fahrenheit) and the intense slagging action of the charge necessitate frequent relining (as often as daily) no matter what refractory is used. The result is a constantly recurring interruption to production, whereas the water-jacketed cupola may be kept in blast continuously for long periods of time.

Within recent years an increasing number of electrical furnaces have been used for the melting of woolrock and slag. A recent innovation† by which an exceptionally long-fibred,

*Raw Materials for the Manufacture of Rock Wool in the Niagara Peninsula of Ontario—Mem. Series No. 80 (Aug., 1931, p. 17), Mines Branch, Canada.

†Spun Rock Wools, Ltd., Thorold, Ontario—ref. in Rock Products for January, 1937, p. 75.

light-weight wool is produced involves the mechanical production of fibres by means of a rapidly rotating disk upon which the molten material impinges, melting being done electrically.

RAW MATERIALS FOR THE MANUFACTURE OF MINERAL WOOL.

Mineral wool is composed essentially of calcium-magnesium-aluminium silicates. The following table gives analyses of a number of typical commercial wools:—

Material.	Ref.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Misc.	A/B.
Rock Wool	(1)	37.20	10.96	3.68	31.52	14.48	2.44	0.8
Rock Wool	(1)	36.98	13.05	2.45	32.27	14.13	2.52	0.8
Rock Wool	(1)	38.11	13.25	1.75	28.20	16.29	3.22	0.9
Rock Wool	(1)	38.36	9.56	1.10	41.24	10.06	1.72	0.8
Rock Wool	(1)	40.50	11.17	1.75	30.07	11.64	3.44	1.0
Rock Wool	(2)	42.80	1.40	......	51.70	2.80	1.3	0.7
Rock Wool	(3)	49.20	2.46	0.64	44.30	2.68	0.80	1.0
Slag Wool	(2)	38.0	11.0	1.0	28.0	19.0	3.0	0.8
Slag Wool	(2)	38.4	10.5	0.7	31.5	15.3	3.6	0.8
Slag Wool	(4)	30.9	24.7	0.5	35.6	....	8.3	1.1
Slag Wool	(5)	32.3	19.0	0.7	39.7	5.0	3.3	1.0
Slag Wool	(5)	34.0	9.1	2.7	38.7	6.2	9.3	0.7

REFERENCES:

(1) Rock Wool—C.I.M.M.; Sept., 1936.

(2) Mineral Wool—Inf. Circ. 6142, U.S. Bureau of Mines; June, 1929—Thoenen.

(3) Mineral Wool from Wollastonite—Min. and Met.; March, 1936.

(4) Gas J. (Lond.), Sup. 23–27; July 22, 1925—Green and Edwards.

(5) Stahl und Eisen, 49, 97; Jan. 24, 1929—Guttman.

A—weighted percentage of SiO_2 and Al_2O_3 (if in excess of 8 per cent.).

B—weighted percentage of CaO, MgO, Fe_2O_3, and alkalis.

The four major components entering into the composition of mineral wool are silica (SiO_2), alumina (Al_2O_3), lime (CaO), and magnesia (MgO). The following table compares* the calculated minimum and maximum limits of composition of mineral wool according to four different authorities:—

	Thoenen.	Goudge.	Logan.	Ill. Geo. Sur.
SiO_2	39.3–46.5	33.7–44.3	22.5–49.2	35–65
R_2O_3†	13.5–16.1	13.7–21.6	5.4–15.4	0–33
CaO	21.3–32.5	21.4–30.6	21.0–68.1	5–50
MgO	11.6–16.8	13.3–18.9	4.0–18.8	0–32

† Al_2O_3 and Fe_2O_3.

As illustrated by the composition of several of the commercial wools listed above, alumina and magnesia are not essential for the manufacture of satisfactory wool, one plant‡ utilizing a mixture of silica and limestone, and another§ using wollastonite. Aluminium and magnesium, however, are desirable constituents in adding to the viscosity range and fluidity of the melt above 2,500 degrees Fahrenheit.

Apart from other considerations, the material, rock or slag, must be self-fluxing; this is assured if the proportion of weighted acidic and basic constituents is nearly equal. Goudge‖ sets the limits of the acid-base ratio at from 0.8 to 1.5, but points out that mineral wool can be made from materials in which the components are not so evenly balanced, provided sufficiently high furnace temperature can be obtained to ensure fluidity. Under stable temperature conditions the result of increasing the acid-base ratio is to produce a more viscous melt, which in turn yields a coarser-fibred wool. Viscosity may be reduced by adding certain fluxes such as soda or fluorspar, but in general the most economic operation

*Rock Wool from Illinois Mineral Resources—Bull. 61, Ill. State Geol. Survey, 1934.

‡Mineral Wool—Inf. Circ. 6142, U.S. Dept. Commerce Bur. of Mines, 1929—Thoenen.

§Mineral Wool from Wollastonite—Min. and Met.; March, 1936—Thorndyke.

‖Raw Materials for the Manufacture of Rock Wool in the Niagara Peninsula of Ontario—Mem. Ser. No. 50, Mines Branch, Dept. Mines, Canada, 1931.

results from the use of a material in which the acidic and basic constituents are roughly equal in amount. An excess of basic constituents produces either a short dusty wool or fails to yield fibres. In referring to the manufacture of slag wool Lang* points out that a slag too rich in iron blows into dust and not fibre, but does not specify the limits.

A quick and approximate criterion† of the suitability of an impure limestone for the manufacture of rock wool is given by the percentage of CO_2 which it contains; a rock in which the CO_2 content lies between 20 and 30 per cent. is a potential woolrock, otherwise additions of other material must be made.

Rocks within the following limits‡ will yield a good grade of wool without the necessity of using excessive temperatures or admixture of other materials:—

	Minimum. Per Cent.	Maximum. Per Cent.
SiO_2	24	32
Fe_2O_3	2	3
Al_2O_3	8	12
CaO	16	21
MgO	10	13
Volatile matter	26	29

Many rocks and slags outside of these limits will produce satisfactory wool, however, with proper adjustment of manufacturing conditions and the possible addition of other materials.

The rapid expansion in the demand for mineral wool in recent years, coupled with the exceedingly high freight rates on materials of this type, has led to the establishment of many plants in localities where true woolrock was not available. The difficulty is met by mixing different rocks, or slag with rocks, in suitable proportions. If possible, however, it is preferable to use a single rock of uniform composition and definite melting-point, because, with mixtures of rocks having diverse melting-points, trouble is often encountered in cupola-furnace operations owing to a gradual accumulation of the more infusible rock on the bottom of the cupola.

In general the quality of slag wool is inferior to rock wool. In using an argillaceous limestone or dolomite, however, there is a loss of from 20 to 30 per cent. of the raw material charged to the furnace, owing to the carbon dioxide being driven off during melting; this loss does not occur when using slag, with the result that the production of mineral wool per ton of slag is greater than that for rock.

The mineral-wool industry is young and much remains to be done in investigating the effects of chemical composition and operating conditions upon the properties of the wool produced.

RAW MATERIALS FOR THE MANUFACTURE OF MINERAL WOOL IN BRITISH COLUMBIA.

WOOLROCK AND SUB-WOOLROCK.

An actual search for suitable woolrock in the Province has not, as yet, been undertaken. The following section, however, based upon available information, is intended to direct attention to certain possible occurrences along major lines of transportation and within easy reach of tide-water.

Silica and alumina are important constituents of most common rocks; lime and magnesia, however, are in most cases but minor constituents and concentrations are of relatively restricted occurrence. Since lime is an essential and magnesia a desirable constituent of mineral wool, limestone and dolomite form the basis of the following notes in the hope that either impure portions of certain deposits will yield true woolrock, or that given abundant

*Some Problems Encountered in Designing and Operating a Slag Wool Plant—Chem. and Met. Eng., No. 9, 1923.

†Rock Wool from Illinois Mineral Resources—Bull. 61, Ill. State Geol. Sur., Urbana, Ill., 1934.

‡Raw Materials for the Manufacture of Rock Wool in the Niagara Peninsula of Ont.—Mem. Ser. No. 50, Mines Branch, Dept. Mines, Canada, 1931.

lime, or lime and magnesia, suitable mixtures can be prepared from adjacent rocks. Unfortunately nearly all the information available on limestone and dolomite in the Province is concerned with only the purer deposits, whereas for the present purposes impure material is of greater interest.

COASTAL AREA.

Calcareous and dolomitic rocks in the coastal area are essentially restricted to Triassic and Jurassic formations, in which they usually occur associated with basic volcanic flow-rocks and their tuffaceous equivalents, or less commonly with argillites and quartzites. In general, metamorphism has altered the purer limestone-beds to marbles and the associated host-rocks to their metamorphic equivalents.

In themselves the limestone deposits of the Coast are for the most part too pure to be suitable for the manufacture of rock wool. In many cases, however, the associated rocks contain a relatively high proportion of lime, and again certain of the limestone-beds have been converted to a complex of garnet, epidote, and diopside which approximates the desired composition. It is possible that a detailed investigation of the following deposits would discover suitable woolrock. Nearly every listed deposit may be considered a potential source of material if admixture with adjacent rocks is contemplated.

Apart from the calcarenite-beds at Nanaimo and on Lasqueti Island, the sandstones and shales of the Upper Cretaceous series are non-calcareous and from the point of view of mineral-wool manufacture are of interest only for admixture with limestone or dolomite.

1. Quatsino Sound.

Limestone outcrops continuously along the east shore of Neroutsos Inlet of Quatsino Sound, through the narrows, and as far east as Marble Creek on Rupert Arm, also appearing on the west shore of Neroutsos Inlet and on Holberg Inlet.

The limestone, where unaltered, is fine-grained and very pure, but in places is interbedded with argillites and tuffs. The B.C. Pulp and Paper Company obtains limestone from the vicinity of Port Alice.

2. Nootka Sound.

Granular crystalline limestone is exposed for more than a mile on Tlupana Arm. A medium-greyish type is most common, but variations to white and bluish types are present as well as argillaceous phases. In places the deposit is cut by numerous basic dykes. A marble-quarry was formerly opened up on this deposit at Deserted Creek. Similar deposits up to 2,000 feet thick, in places interbedded with tuffs, occur on Kennedy Lake, Kokshittle Inlet, Herbert Arm, Bedwell Sound, and Sidney Inlet.

3. Nitinat Lake.

Massive beds of light-grey to white marble outcrop at the southern end of Nitinat Lake on the west shore. The deposit is a member of the Nitinat formation, exposed typically along the shores of Nitinat Lake. The formation underlies a belt 10 to 12 miles wide extending west from the mouth of Gordon River to Barkley Sound. The marbles are sometimes thick-bedded, but more commonly are thin-bedded and greatly jointed and fractured. Shear-zones are frequent, along which alteration has taken place, producing dark-weathering rocks in which quartz, diopside, and plagioclase occur. Amphibolites are well developed along contact-zones with large bodies of intrusive rocks.

Other limestone members of the series occur near the head of Pipestem Inlet, in Effingham Inlet, on Tzartus Island in Barkley Sound, on the north side of Uchucklesit Harbour, at Smith's Landing nearly opposite the mouth of Nahmint River, and a short distance up Gordon River from Port Renfrew.

4. Rosebank, Esquimalt Harbour.

A deposit of light-blue crystalline limestone, highly fractured, and traversed by numerous dykes, occurs at Rosebank, enclosed in volcanic rock. A quarry was operated on this deposit by the Rosebank Lime Company for the manufacture of lime.

5. Bamberton.

A vertical lens of crystalline limestone, in places intimately associated with volcanic material, occurs on the west shore of Saanich Inlet at Bamberton. The B.C. Cement Company obtains limestone from this deposit for the manufacture of cement.

6. SOUTHERN VANCOUVER ISLAND.

Other easily accessible deposits of limestone, occurring as lens-like bodies in volcanics, are found near Cobble Hill, near Parson's Bridge, in the Highland District 2½ miles north of Goldstream, and near the 17-Mile Post, Esquimalt & Nanaimo Railway. Although in general very pure, portions of these deposits are siliceous or intimately intermingled with volcanic material.

7. NANAIMO.

Beds of impure limestone or calcarenite outcrop along the north shore of Departure Bay, immediately west of the Dominion Government Biological Experimental Station.

Similar rocks are found at the north end of Lasqueti Island and on Sangster Island.

8. NANOOSE.

A highly siliceous deposit of limestone outcrops along the north shore of Nanoose Harbour.

9. HORNE LAKE.

Extensive beds of limestone are exposed at the foot and along the northern side of Horne Lake. The formation varies from white to dark grey, the most common type, as exposed along the logging-railroad at the foot of the lake, being crystalline and bluish-grey in colour.

10. TEXADA ISLAND.

One of the best deposits of limestone on the Pacific Coast occurs on Texada Island as a belt 2 miles wide extending along the north-east coast for 6 miles from the northern tip of the island, then crossing in a southerly direction to within one-quarter of a mile of the south-west coast. The formation is enclosed in, and invaded by, igneous rocks which have converted what was once a fine-grained, dark-blue limestone to a light-grey medium-grained marble. Although high-calcium limestone predominates, numerous interbeds of dolomite occur in places up to 8 feet wide. Quarries are operated at Blubber Bay by the Pacific Lime Company and the B.C. Cement Company, and at Vananda by F. J. Beale. The Powell River Company formerly obtained limestone for their own consumption from a quarry at the head of Marble Bay.

About half-way down the south-west coast is a separate deposit of comparatively unaltered, fine-grained, grey to blue, high-calcium limestone. At the southern end of this area, limestone cliffs rise to a height of 900 feet, 1 mile from the shore.

At the south end of the island within one-quarter of a mile of the head of Anderson Bay, red and white crinoidal marble was quarried at two places from a bed over 70 feet thick, inter-stratified with schists and slates. The slates and schists exposed at the head of Anderson Bay are somewhat calcareous.

11. QUADRA ISLAND.

A large deposit of dark-blue, fine-grained limestone outcrops along the shore of Open Bay; argillites and quartzites appear to the east and volcanic material to the west.

12. REDONDA ISLAND.

A band of white to grey crystalline limestone appears on the northern side of Redonda Island. A quarry was formerly operated on this deposit.

13. DINNER ROCK.

A vertical band of crystalline limestone, 65 feet wide, outcrops a short distance south of Dinner Rock, 8 miles north of Powell River. The marble is associated with argillite and greenstone.

14. NELSON ISLAND.

A vertical band of white crystalline limestone, 60 to 90 feet wide, is exposed near the head of Blind Bay, and continues uphill to an elevation of at least 500 feet. In places the limestone is intersected by a network of dykes. The deposit is being quarried by the International Lime Corporation, Limited.

15. Salmon Arm, Jervis Inlet.

A large body of white crystalline limestone is reported to occur a short distance from tide-water on Salmon Arm.

16. Harbledown Island.

Greyish crystalline limestone, much broken and mixed with igneous material, outcrops for 300 yards along the south shore, half a mile from the east end of the island. An exposure of argillaceous limestone, interbedded with argillites and quartzites, is reported to occur at Parsons Bay on the west coast of the island.

17. Beaver Cove.

A large deposit of white to blue, high-calcium marble outcrops along Sultan Creek a short distance from the shore of Beaver Cove. A quarry was commenced on this deposit at one time for the recovery of building-stone.

18. Northern Vancouver Island and Vicinity.

Blue limestone, more or less altered to marble, outcrops for 100 yards near the entrance to Frederick Arm and appears on the west side of Fanny Bay in Phillips Arm and on the southerly shore of Loughborough Inlet, 1 mile beyond Campbell Point. To the south the limestone crosses the northern corner of Maurelle Island and appears along the southern shore of Cordero Channel a short distance south-east of Hall Point. The limestone is somewhat argillaceous in places.

Extensive beds of massive, argillaceous limestone appear on the north-east coast of Vancouver Island 10 miles east of Cape Scott.

19. Smith Inlet.

A very large body of white, coarse-grained, crystalline limestone occurs along the shore of Smith Inlet, 3 miles from the head. The deposit consists largely of an intimate mixture of high-calcium and dolomitic limestone traversed by numerous dykes of trap-rock. A quarry was operated on this deposit by the Coast Calcite Company.

20. Rivers Inlet.

Limestone is reported to occur at the mouth of False Inlet and at Kilbella Bay in Rivers Inlet.

21. Koeye River.

Limestone appears on the south side of Koeye River, one-half mile from its mouth on Fitzhugh Sound and 7 miles south of Namu. The rock is quarried for use at Ocean Falls by P. Christensen.

22. Cunningham Island.

A wide band of white, coarsely crystalline, high-calcium limestone outcrops on the south shore of Cunningham Island, off Gunboat Passage, 22 miles from Ocean Falls, and extends inland for 3 miles. Dolomite is practically absent and dykes are rare. The deposit was formerly quarried by F. J. Beale.

23. King Island.

A large deposit of pure limestone, operated at one time by F. J. Beale, occurs at the south-east end of King Island.

24. Aristazable Island.

Limestone interbedded with volcanics outcrops along the east shore of Aristazabal Island on Laredo Channel.

25. Princess Royal Island.

A band of limestone is reported to occur on the east coast of Princess Royal Island approximately opposite Swanson Bay. A series of white to grey limestones alternating with schist and siliceous beds is exposed on Sarah Island, between Finlayson and Tolmie Channels.

26. Banks Island.

Several extensive beds of dolomite associated with metamorphosed volcanics appear on the east coast of Banks Island just opposite Anger Island.

27. OTHER LIMESTONE DEPOSITS.

Other limestone deposits of this area are reported to occur at the head of Kumealon Inlet off Grenville Channel; on Porcher Island; and on Gurd Island.

28. SMITH ISLAND.

Limestone-beds several hundred feet thick outcrop for 3 miles along the shores of a narrow inlet at the north-west corner of Smith Island. The deposit is reported to be of good quality.

29. DIGBY ISLAND.

Beds of bluish-grey crystalline limestone 200 yards wide and bordered by schists are exposed at the south end of Digby Island.

30. WHITE CLIFF ISLAND.

White to light grey crystalline limestone forms cliffs 75 feet high on the coast of White Cliff Island. The limestone is highly shattered and cut by dykes and shows in places a laminated structure due to the incorporation of schist.

31. CLAXTON.

A large deposit of dolomite is reported to occur about 1,000 feet from the Skeena River at Claxton, 15 miles from Prince Rupert.

32. SWAMP POINT.

Blue siliceous, low-magnesian limestone occurs at Swamp Point in Portland Canal. This material was quarried at one time by the Granby Company for flux-rock.

33. GRAHAM ISLAND.

Massive beds of light-grey, partly crystalline, bituminous limestone are exposed on the south end of South Island.

Thin bands of buff and grey limestone are interbedded with argillites on the south shore of Maude Island.

Calcareous argillites occur in the Maude formation.

34. MORESBY ISLAND.

Massive grey limestones, usually more or less crystalline, occur along the east coast of Moresby Island from Carpenter Bay north to Lockeport, largely as inclusions in later intrusive rocks. Dolomitic limestones are reported to occur along the northerly end of the east coast of the island.

ANALYSES, COAST LIMESTONE DEPOSITS.

	(1)	(2A)	(2B)	(2C)	(3A)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	1.30	1.26	0.30	0.10	2.64
Fe and Al oxides	0.60	0.17	0.10	Trace	0.40
$CaCO_3$	92.10	95.50	97.90	99.80	96.85 }
$MgCO_3$	6.00	2.34	0.92	None	0.42 }

REFERENCES:

(1) Mines Branch No. 719—Analysis of typical material by Port Alice Co.
(2A) Mines Branch No. 452—white marble from old marble-quarry.
(2B) Mines Branch No. 452—grey marble from old marble-quarry.
(2C) B.C. Minister of Mines' Report, 1911.
(3A) G.S.C. Mem. 13—white crystalline marble from west shore, south end of Nitinat Lake.

ANALYSES, COAST LIMESTONE DEPOSITS—*Continued.*

	(3B)	(4A)	(4B)	(4C)	(6A)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	45.00	0.95	1.95	1.50	1.80
Fe and Al oxides	27.00	0.29	0.16	0.20	2.00
$CaCO_3$	28.00	98.65	95.35	98.00	93.12
$MgCO_3$		0.40	2.85	Trace	0.96

	(6B)	(6C)	(6D)	(6E)	(7)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	0.40	1.10	7.80	8.00	15.42
Fe and Al oxides	Trace	0.80	Trace	Trace	5.40
$CaCO_3$	99.50	97.50	92.00	91.50	75.80
$MgCO_3$	None	Trace	None	None	1.97

	(8)	(9)	(10A)	(10B)	(10C)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	14.80	8.59	4.26	0.52	0.20
Fe and Al oxides	Trace	1.10	0.29	0.38	0.21
$CaCO_3$	85.00	84.50	93.40	95.07	99.09
$MgCO_3$	None	6.45	0.98	4.16	0.56

	(10D)	(10E)	(10F)	(10G)	(10H)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	0.76	0.54	2.30	0.72	0.88
Fe and Al oxides	0.54	0.35	0.67	0.65	0.36
$CaCO_3$	92.82	97.96	84.11	62.48	98.50
$MgCO_3$	6.41	0.38	14.64	36.15	0.30

	(10I)	(10J)	(11)	(14A)	(14B)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	0.60	0.30	3.71	0.83	15.00
Fe and Al oxides	Trace	Trace	0.84	0.50	0.50
$CaCO_3$	99.00	93.60	95.00	97.78	84.00
$MgCO_3$	0.20	5.10	1.28	0.10	None

REFERENCES—*Continued.*

(3B) G.S.C. Mem. 13—typical garnet-epidote-diopside rock.
(4A) Mines Branch No. 719.
(4B) Mem. 13, G.S.C.
(4C) B.C. Minister of Mines' Report, 1911.
(6A) G.S.C. Mem. 13—Raymond Crossing, near Cobble Hill.
(6B) G.S.C. Mem. 96—Wriglesworth property, west of 17-Mile Post.
(6C) G.S.C. Mem. 13—Tod Inlet.
(6D) B.C. Minister of Mines' Report, 1911—Parsons Bridge.
(6E) B.C. Minister of Mines' Report, 1911—Bamberton.
(7) G.S.C. Mem. 51—calcarenite at Nanaimo.
(8) B.C. Minister of Mines' Report, 1911.
(9) Provincial Analyst—sample collected by writer of typical light-grey crystalline limestone.
(10A) Mines Branch No. 452—red crinoidal marble from Anderson Bay.
(10B) Mines Branch No. 719—Pacific Lime Co., top 17 feet of quarry.
(10C) Mines Branch No. 719—Pacific Lime Co., middle section of quarry.
(10D) Mines Branch No. 719—Western Lime Products, across 30 feet.
(10E) Mines Branch No. 719—Western Lime Products, typical sample of white crystalline limestone.
(10F) Mines Branch No. 719—Powell River Co., average sample across 60 feet.
(10G) Mines Branch No. 719—Powell River Co., dolomitic beds.
(10H) Mines Branch No. 719—Powell River Co., high-calcium beds.
(10I) B.C. Minister of Mines' Report, 1911—old quarry.
(10J) B.C. Minister of Mines' Report, 1911—new quarry.
(11) Provincial Analyst—sample collected by writer of typical limestone as exposed along Open Bay.
(14A) Mines Branch No. 719.
(14B) B.C. Minister of Mines' Report, 1927.

ANALYSES, COAST LIMESTONE DEPOSITS—*Continued.*

	(15)	(19)	(22)	(31)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	0.87	0.35	1.00	1.27
Fe and Al oxides	0.37	Trace	0.29	......
$CaCO_3$	98.90	99.21	98.66	55.86
$MgCO_3$	None	0.44	Trace	41.89

REFERENCES—*Continued.*

(15) Provincial Analyst—sample submitted by Mr. George Morrison.
(19) Analysis by Ocean Falls Pulp and Paper Co.
(22) Mines Branch No. 719—Beale limestone-quarry.
(31) Submitted by Mr. Angus McAllister, Claxton.

INTERIOR AREA.

The limestones of the interior of British Columbia are largely restricted to formations of Precambrian to Triassic age. As might be expected, the deposits of the interior exhibit greater diversity in character and occurrence than those of the coastal region. In general, however, crystalline limestone and marble predominate.

Limestones are widely distributed in the interior of the Province; only those, however, along major lines of transportation or readily accessible by water have potential value for the manufacture of rock wool. For this reason the following section is restricted to a description of deposits along railroads or close to centres of population.

CANADIAN PACIFIC RAILWAY.

VANCOUVER TO KICKING HORSE PASS.

35. AGASSIZ.

Massive greyish crystalline limestone outcrops on Bear Mountain overlying a series of black slates which appear on the low hills rising out of Agassiz Flat. High-calcium limestone, containing up to 50 per cent. insoluble material, is reported to occur near Agassiz.

36. RUBY CREEK.

A band of schists containing a few thin beds of limestone appears at the mouth of Ruby Creek.

37. HOPE.

A small exposure of conglomerate, dolomite, and greenstone occurs at Schkam Lake, about 1 mile north of Hope. A kiln was operated at one time in the vicinity of Hope, limestone being obtained from a deposit 1 mile above Hope and the same distance back from the railway.

38. YALE.

A small patch of conglomerate, a band of rusty-weathering dolomite, and a considerable mass of serpentine occur in the valley of Gordon Creek, 1 mile south of Yale. A deposit of siliceous limestone is reported to outcrop on the old wagon-road 6 miles above Yale.

39. SADDLE ROCK.

A small area of slates and quartzites, containing narrow bands of limestone and some serpentine, is found at Saddle Rock.

40. NORTH BEND TO KANAKA.

A series of slates and schists containing occasional beds of crystalline limestone extends from 3 miles south of North Bend to within 3 miles of Kanaka.

41. PUKAIST CREEK.

Two miles south of Pukaist Creek beds of high-calcium marble are exposed.

42. Spatsum to Ashcroft.

Large exposures of fine-grained, light-blue, high-calcium limestone occur between Spatsum and Ashcroft. These are associated with argillite and greenstone.

43. Savona to Cherry Creek.

Greenstone with interbeds of fossiliferous, often dolomitic, limestone are exposed from Savona to Cherry Creek.

44. Kamloops.

Cherty quartzites and altered argillites containing bands of medium- to fine-grained, high-calcium limestone appear for 4 miles east of Kamloops. A large deposit of rather impure dolomite is reported to occur in the vicinity of Kamloops as well.

45. Ducks.

A large exposure of grey crystalline limestone, 1 mile wide, appears on the north bank of the South Thompson River nearly opposite Ducks Station. The deposit, although predominantly high-calcium limestone, contains dolomitic lenses and siliceous layers.

46. Notch Hill to Sicamous.

Extensive limestone deposits extend north of Carlin to Shuswap Lake, and outcrop on the north shore of Salmon Arm opposite Canoe and on the west shore opposite Sicamous.

At and west of Sicamous for 2 miles similar limestone appears.

In general, the limestone is thin-platy, light bluish-grey to dark grey, and is commonly interrupted by closely spaced sericitic films. The rock, although effervescing with cold acid, is somewhat magnesian.

47. Albert Canyon.

A band of thin- to thick-bedded, white to bluish, magnesian marble, 170 feet thick, occurs at Albert Canyon, overlying and passing by interbedding into an underlying arkosic quartzite.

48. Illecillewaet Gorge.

Thin beds of blackish limestone and a 40-foot bed of light-grey limestone are intercalated in argillite, 2 miles east of Albert Canyon.

49. Cougar Creek.

A band of light-grey, rather sericitic, finely crystalline limestone about 600 feet thick occupies the bed of Cougar Creek. The limestone is interbedded with quartzite and argillite.

50. Bear Creek.

A band of grey limestone, interbedded with blackish limestone and rusty impure dolomite, occurs just west of Bear Creek.

51. Beavermouth.

Limestone-bands similar to the above occur 2½ and 4½ miles west of Beavermouth.

52. Glenogle.

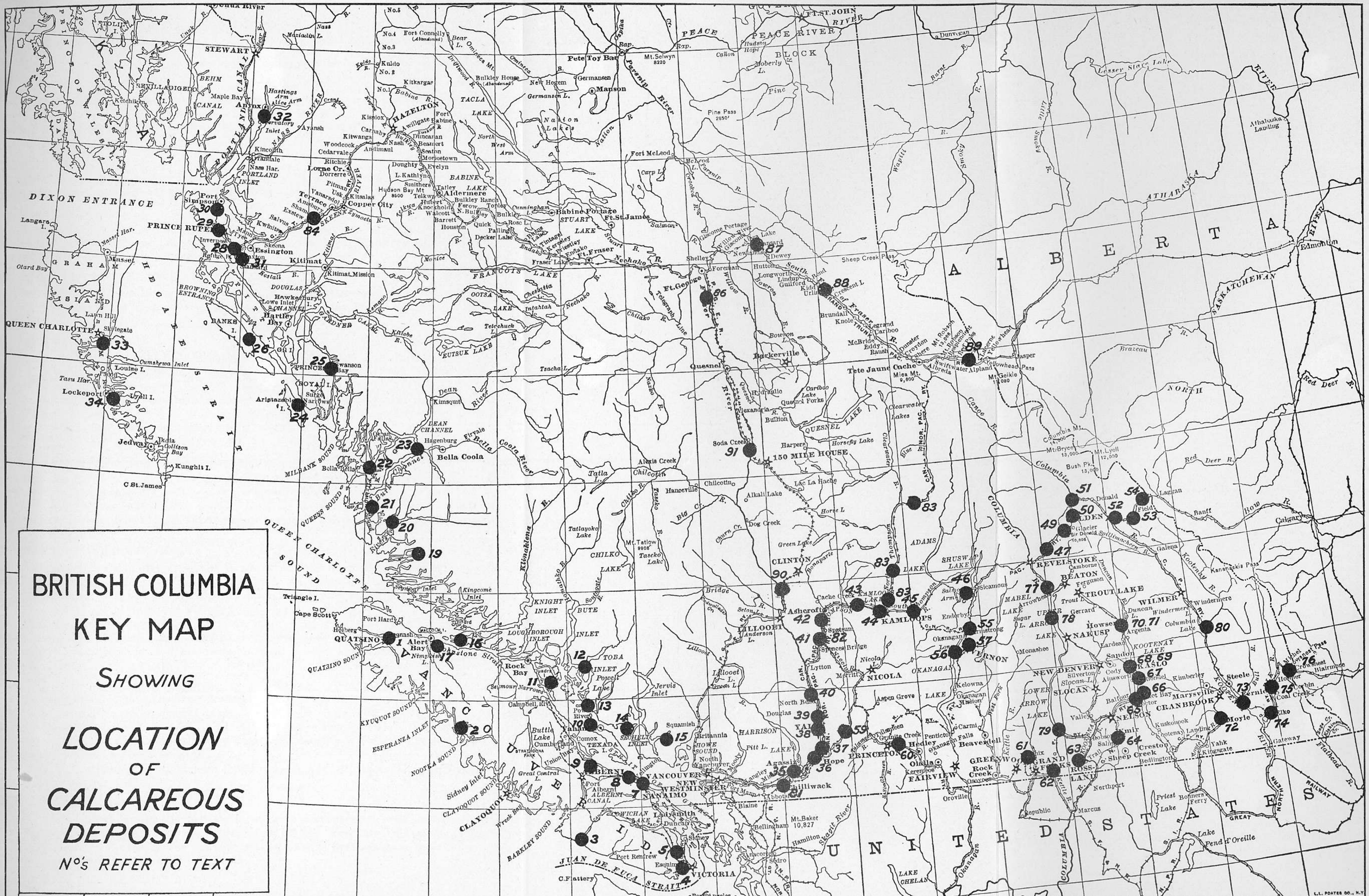
Massive beds of grey dolomitic limestone associated with white quartzite and interbedded shale are exposed for several miles west of Glenogle.

53. Ottertail.

Massive beds of blue to grey limestone and dolomitic limestone, interbedded with calcareous shale, outcrop 7 miles east of Ottertail.

54. Field to Kicking Horse Pass.

Extensive exposures of limestone and dolomite, pure and impure, are found at various places between Field and Kicking Horse Pass. In 1911 claims were staked for marble in Yoho Valley about 2 miles north of the railway. The deposits are of dolomitic marble, 400 feet thick, varying in colour from white to grey.


BRITISH COLUMBIA
KEY MAP
SHOWING
LOCATION
OF
CALCAREOUS
DEPOSITS
N°s REFER TO TEXT
DIXON ENTRANCE
PRINCE RUPERT
QUEEN CHARLOTTE
HECATE STRAIT
QUEEN CHARLOTTE SOUND
HAZELTON
STEWART
PEACE RIVER BLOCK
ALBERTA
SASKATCHEWAN
ATHABASKA
NORTH
KAMLOOPS
REVELSTOKE
NELSON
CRANBROOK
VANCOUVER
NEW WESTMINSTER
NANAIMO
VICTORIA
JUAN DE FUCA STRAIT
UNITED STATES
Bella Coola
Barkerville
Quesnel
Ashcroft
CLINTON
150 MILE HOUSE
Edmonton
Calgary
Banff
Jasper
L.L. POATES CO., N.Y.

Sicamous–Armstrong–Okanagan Lake.

55. Armstrong.

Large deposits of good-quality, high-calcium limestone occur in the vicinity of Armstrong. A quarry was operated 3½ miles north-east of Armstrong in a 25-foot vertical band of fairly pure, high-calcium limestone, enclosed in slate. A large deposit is also reported to occur a few miles west of Armstrong.

56. Long Lake.

White to grey crystalline limestone occurs in large quantity between Long Lake and Okanagan Lake, and around the head of Long Lake.

57. Vernon.

A deposit of good-quality, high-calcium limestone is reported to occur on the shore of Okanagan Lake at Vernon. In addition, numerous prominent limestone exposures are found within a short distance of the town.

58. Other Deposits, Okanagan Lake.

A few beds of limestone outcrop on the west side of Okanagan Lake several miles above Mission. Deposits are also reported to occur in the vicinity of Peachland.

Hope to Crowsnest.

59. Coquihalla Area.

A few narrow limestone-beds are associated with slate and chert in this area. A 20-foot bed is exposed on the railway a short distance above 10-Mile Creek. Some of the slaty members are calcareous as well.

A belt whose most characteristic constituent is serpentine crosses the railway between Jessica and Verona. Although lime is practically absent, it is possible that some of this material might yield rock wool, either alone or with additions of other rocks.

60. Princeton.

A series of slates, schists, and limestones occur about 2 miles below Princeton along the Similkameen River. A quarry was operated on a bed of crystalline limestone 2½ miles south of Princeton, the rock being utilized for the manufacture of cement.

A similar series outcrops for 4 miles north of Hedley. Lime is burnt at Hedley from a band of massive, light-blue, medium-grained limestone, overlain and underlain by siliceous altered limestone.

61. Midway-Grand Forks Area.

Limestone occurs in many parts of this area, usually in small irregular masses and often included in volcanic rock. When little altered the limestone is dark and carbonaceous; usually, however, it is altered to a white marble. In places lime silicates are developed and at a few points the limestone is almost wholly replaced by silica.

Deposits occur along the railway at the following places: One-half mile north of Boundary Falls, at Eholt, near Hodges, at Niagara, and at two places near Smelter Lake. A lime-kiln was operated at one time on a small deposit about one-half mile north-east of Boundary Falls.

62. Fife.

A large body of blue, medium-grained, high-calcium but somewhat siliceous limestone occurs north of Fife. The deposit takes the form of a belt 400 to 800 feet wide and over 2 miles long, enclosed in volcanic rock, tongues of which penetrate the limestone in all directions. The Consolidated Mining and Smelting Company of Canada quarries this material for use as flux in the Trail Smelter.

Several small lenses of crystalline limestone occur as inclusions in igneous rock between Coryell and Farron.

63. Rossland.

A broad belt of highly silicified slates, in part carbonaceous, with arenaceous and calcareous varieties, is exposed on the western half of Red Mountain and on the lower eastern slopes of Mount Roberts. A few narrow beds of impure limestone are reported to occur on the Columbia River in the vicinity of Trail.

64. Ymir.

Limestones and calcareous argillite are well developed in the Pend d'Oreille series of the Ymir-Salmo area, especially along the Pend d'Oreille River and north to Ymir.

65. Procter, Kootenay Lake.

A limestone-quarry is operated by the Consolidated Mining and Smelting Company of Canada on Kootenay Lake, 1¼ miles east of Procter.

66. Crawford Bay, Kootenay Lake.

An outcrop of grey to white limestone, 100 to 250 feet wide, occurs on the east side of the head of Crawford Bay.

67. Bluebell Mine, opposite Ainsworth, Kootenay Lake.

Large deposits of mixed limestone and dolomite occur at the Bluebell Mine on Kootenay Lake.

68. Opposite Kaslo, Kootenay Lake.

A band of white to blue, coarse-grained marble, interbedded in schist, outcrops on the shore of Kootenay Lake opposite Kaslo. In places tremolite is an abundant constituent and interbands of dolomite are numerous. An old quarry is situated here.

69. Kaslo, Kootenay Lake.

A band of bluish-white, crystalline limestone marble, interbedded in schist, outcrops on the shore of Kootenay Lake, 1 mile south of Kaslo. Very pure crystalline limestone was formerly obtained from the shore of Kootenay Lake, 9 miles above Kaslo, for use by the Hall Smelter at Nelson.

70. Lardeau, Kootenay Lake.

Crystalline limestone, interbedded with schist, occurs a short distance north of Lardeau along the railway. A quarry was formerly operated for the recovery of flux-rock, used in the old Hall Smelter, from a siliceous limestone member one-half mile from Lardeau.

71. Marblehead.

Massive dark-grey, bluish-grey, and white marble outcrops along the railway in the vicinity of Marblehead. A quarry is operated by the Canadian Marble and Granite Works, Limited, for the recovery of marble.

72. Upper Moyie Lake.

A series (at least 4,500 feet thick) of calcareous and dolomitic argillites, limestones, and quartzites is exposed along the railway near the tunnel at Jerome.

73. Wardner.

Extensive exposures of blue-grey, crystalline, magnesian to high-calcium limestone are found on both sides of the Kootenay River at Wardner. In many outcrops interbedded shale and chert is abundant. The limestone is well exposed in railway-cuts near Wardner.

74. Elko.

A thick series of impure limestones and dolomites, calcareous and dolomitic shales, argillites, and quartzites is exposed along the railway for some distance east of Elko. Overlying this, grey to blue limestone outcrops along the track nearly to Morrissey.

75. Fernie.

In the vicinity of Fernie occurs a thick series of dark shales, commonly arenaceous, and passing towards the base into shaly limestone and calcareous shale. This series is exposed in occasional outcrops along the railway from Fernie north to the mouth of Michel Creek.

76. Crowsnest.

In the vicinity of Crowsnest and as far as McGillivray limestone predominates, with only two small inclusions of black shale.

Revelstoke–Arrow Lakes–West Robson.

77. Arrowhead.

A large deposit of white to blue, high-calcium marble occurs east of the railway 4 miles north of Arrowhead.

78. Upper Arrow Lake.

A band of white to pinkish marble outcrops on the west side of Upper Arrow Lake, 22 miles from Arrowhead and 2 miles below Pingston Creek.

79. Lower Arrow Lake.

Extensive deposits of high-calcium limestone occur on the east shore of Lower Arrow Lake, 5 miles north of Deer Park.

Cranbrook–Golden.

80. Windermere Lake.

Dolomite of a high degree of purity occurs in large quantities on the mountain-side east of Windermere Lake. An entire spur of the mountain, 1 mile south-east of Fairmont Springs, is composed of fine-grained, massive blue dolomite of uniform composition. The dolomite outcrops within 2 miles of Radium on the Kootenay Central Branch of the Canadian Pacific Railway. Abundant dolomite is also to be found on the west side of Windermere Lake.

CANADIAN NATIONAL RAILWAY.

Vancouver to Tete Jaune Cache.

In general, the formations traversed by the Canadian National Railway between Vancouver and Kamloops are the same as those exposed along the Canadian Pacific Railway between these points. For this reason no attempt is made to describe all the calcareous deposits along the railway; instead only a few outstanding localities are mentioned.

81. Fraser River Delta Area.

A large deposit of siliceous blue limestone occurs at Popcum, half a mile from the southern bank of the Fraser River. This deposit is quarried to supply agricultural limestone.

82. Spences Bridge.

Massive limestone outcrops along the railway for some distance north of Spences Bridge.

83. North Thompson River.

Extensive occurrences of limestone appear along the North Thompson River. The rock is in general high-calcium, but commonly siliceous and usually crystalline.

Deposits are found at points 6½ and 17 miles above Kamloops. In addition, an immense deposit of limestone was quarried for lime 20 miles from the city.

Thick beds of high-calcium, crystalline limestone occur on both sides of the river at Vavenby.

Prince Rupert to Yellowhead Pass.

84. Shames-Amsbury.

A large body of grey to white crystalline marble is exposed near Shames, north of the railway.

85. Other Deposits West of Prince George.

Limestone has been reported from the following places: Terrace, New Hazelton, Smithers, and Aldermere.

86. Prince George.

A large deposit of high-calcium limestone is reported to occur 15 miles south of Prince George and 2½ miles from the road.

87. Hansard.

A ridge of fine-grained, high-calcium limestone appears just west of Hansard and immediately south of the railway.

88. URLING.

A large deposit of crystalline magnesian limestone appears along Ptarmigan Creek. The deposit has been quarried by the railway company for ballast, a spur track connecting it with the railway.

89. GRANT BROOK.

A band of pink to blue crystalline dolomite, over 400 feet wide, interbedded with shale towards the edges, outcrops 1 mile east of Grant Brook. A marble-quarry was opened up on this deposit at one time.

PACIFIC GREAT EASTERN RAILWAY.

90. ASHCROFT-CLINTON.

Massive crystalline limestone, in places very pure, occupies a broad belt between Ashcroft and Clinton.

91. SODA CREEK.

Cliffs of limestone occur along the Fraser River below Soda Creek.

92. OTHER LOCALITIES.

Serpentine is exposed on the railway-track north of 17-mile Ranch and south of 4-Mile Creek above Clinton.

ANALYSES, INTERIOR LIMESTONE DEPOSITS.

	(60)	(62)	(68)	(71A)	(71B)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	2.90	2.72	2.44	0.36	0.24
Al and Fe oxides	0.58	0.34	0.14	0.46	0.16
$CaCO_3$	93.43	96.11	93.04	90.75	99.07
$MgCO_3$	2.86	0.53	4.37	8.42	0.71
	(73)	(80)	(81)	(82)	(83)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	0.14	0.70	10.48	1.44	0.63
Al and Fe oxides	0.16	0.63	0.36	0.44	0.80
$CaCO_3$	93.59	55.70	87.09	97.68	96.74
$MgCO_3$	5.82	43.58	2.10	0.42	1.82
	(84A)	(84B)	(87)	(89A)	(89B)
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	9.00	2.00	1.68	5.42	1.24
Al and Fe oxides	2.00	1.00	0.68	2.28	0.95
$CaCO_3$	88.90	97.00	95.41	52.62	55.09
$MgCO_3$	0.10	Trace	0.90	40.19	43.43

REFERENCES:

(60) Mines Branch No. 719—30-foot band of limestone, Hedley.
(62) Mines Branch No. 719.
(68) Mines Branch No. 452.
(71A) Mines Branch No. 452—25-foot band of blue limestone.
(71B) Mines Branch No. 452—5-foot band of white limestone.
(73) Mines Branch No. 719—purer material.
(80) Mines Branch No. 719—dolomite, typical sample from ridge near Fairmont.
(81) Mines Branch No. 719—typical material.
(82) Mines Branch No. 719—extensive deposit on C.N.R., 7 miles north of Spences Bridge.
(83) Submitted analysis.
(84A) Mines Branch No. 452—grey.
(84B) Mines Branch No. 452—white.
(87) Mines Branch No. 719.
(89A) Mines Branch No. 719—pink marble 25 feet.
(89B) Mines Branch No. 719—white and blue 100 feet.

SLAG-PILES.*

Smelters have been operated at various times and at different places in the Province during the past, although but one, that of the Consolidated Mining and Smelting Company of Canada at Trail, is now in operation. Several were barely erected before being abandoned; others treated large quantities of ore. In the latter class eight old smelter-sites are known which contain reasonably large slag piles.

COAST REGION.

1. CROFTON, VANCOUVER ISLAND.

The smelter at Crofton, on the east coast of Vancouver Island, was built by the North-western Smelting and Refining Company in 1901, originally to treat ores from the Lenora and other properties on Vancouver Island. The capacity of the plant was 400–500 tons of ore per day. Although completed in 1902, it lay idle through lack of ore until acquired by the Britannia Copper Syndicate in 1905, who used it to smelt ore from the Britannia mine and from the Mount Andrew mine on Prince of Wales Island. The plant was closed about 1908 and has since been dismantled.

The slag-dump is large, containing several hundred thousand tons, and is easily accessible, being situated on the shore-line of Osborne Bay. The slag is in a granulated form. A typical analysis of the slag being produced in 1907 is as follows:—

	Per Cent.
SiO_2	44
Fe	27
CaO	14

A representative sample taken by the writer had the following composition:—

	Per Cent.		Per Cent.
SiO_2	41.26	MgO	3.17
FeO	31.60	TiO	0.32
Al_2O_3	5.88	P_2O_5	0.15
CaO	16.44	S	0.40

2. LADYSMITH, VANCOUVER ISLAND.

The smelter was built on the west shore of Ladysmith Harbour by the Tyee Copper Company in 1902. It was enlarged in 1907–8 and practically rebuilt in 1909–10. Ores were largely drawn from the company's mine at Mount Sicker until 1907, after which custom-work was done until 1911, when the smelter was closed down. The plant in 1911 had a capacity of 20,000 tons per month.

Slag was granulated and flushed to the dump situated on the shore. Several hundred thousand tons are easily accessible. In view of the change to custom-work after 1907 the slag may be expected to vary considerably in composition from place to place. This is well illustrated by the following analyses:—

Typical Slag from Tyee Ore.			Composite Sample of Surface Slag.	
	Per Cent.	Per Cent.		Per Cent.
SiO_2	34.70	36.25	SiO_2	38.18
Al_2O_3	8.20	10.03	Al_2O_3	6.88
FeO	17.70	19.26	FeO	30.75
CaO	4.9	3.47	CaO	18.65
BaO	28.50	23.70	S	0.40
ZnO	6.10	7.40	P_2O_5	0.10
			TiO_2	0.32

3. TEXADA ISLAND.

A smelter, situated at Vananda, was put into operation in 1899 by the Vananda Copper and Gold Company, 5,000 tons of ore being treated in that year. In 1900 an additional furnace was erected. The plant operated intermittently for the next two years and finally closed down in 1903.

* Information taken largely from "The Copper Smelting Industries of Canada"—Mines Branch No. 209, Dept. of Mines, Canada, 1913.

A slag-dump containing at least 8,000 tons of ungranulated slag, the result of the above operations, is situated on the shore at Vananda. An average sample, taken by the writer, had the following composition:—

	Per Cent.		Per Cent.
SiO_2	39.08	TiO_2	0.24
FeO	22.13	CaO	22.41
Al_2O_3	6.66	MgO	9.55

4. ANYOX.

The Anyox Smelter was erected about 1912 by the Granby Consolidated Mining, Smelting, and Power Company to smelt ores from the Hidden Creek mines near Granby Bay, Observatory Inlet. The smelter was operated until 1935.

An enormous quantity of granulated slag is available on tide-water. A sample, obtained for the writer by Ross Oatman, Mining Recorder, Anyox, had the following composition:—

	Per Cent.		Per Cent.
SiO_2	36.7	Al_2O_3	8.5
FeO	43.9	CaO	6.9
TiO_2	0.2	MgO	2.4

INTERIOR REGION.

5. BOUNDARY FALLS.

The Standard Pyritic Smelting Company erected a smelter at Boundary Falls in 1901. It was taken over by the Montreal and Boston Copper Company soon afterwards and operated with occasional interruptions until 1905. In that year it was taken over by the Dominion Copper Company and operated intermittently until closed down in 1908.

Although no analyses are available, the slag is probably similar to that of the Granby and Greenwood Smelters, which treated similar ores. The slag was ungranulated.

6. GREENWOOD.

The British Columbia Copper Company's smelter was erected in 1900 and treated Motherlode and Boundary ores until 1918. The capacity in 1907 was 1,700 tons and in 1910 2,200 tons per day.

An effort was made to maintain a slag of the following analysis:—

	Per Cent.		Per Cent.
SiO_2	43–46	CaO	21–28
FeO	19–27	Al_2O_3	9

7. GRAND FORKS.

The smelter was erected by the Granby Consolidated Mining, Smelting, and Power Company primarily to treat ores from their own properties at Phoenix. The original plant was blown in during 1900 with a capacity of 700 tons per day. This was increased to 3,000 tons in 1906, and again to 4,000 tons in 1909. In all, some 8,000,000 tons of ore were treated up to 1912. The smelter was closed down in 1919.

Slag was in general maintained close to the following composition:—

	Per Cent.		Per Cent.
SiO_2	45.0	MgO	3.8
FeO	15.0	Al_2O_3	7.0
CaO	22.0		

An enormous quantity of slag, both granulated and ungranulated, is available.

8. NELSON.

The first important copper-smelting plant to be erected in British Columbia was that of the Hall Mines, Limited, which was built in 1896. In 1897 one furnace was converted for the custom-smelting of lead ores. After 1900 operations were confined to the treatment of lead ores. The plant was shut down in 1907.

A typical analysis of the slag obtained from copper-smelting operations is as follows:—

	Per Cent.		Per Cent.
SiO_2	41–44	MnO	8–10
Al_2O_3	15–25	CaO	11–14
Fe	7–10		

BRITISH COLUMBIA
KEY MAP
SHOWING
LOCATION
OF
OLD SLAG
PILES
No's REFER TO TEXT
ALBERTA
UNITED STATES
DIXON ENTRANCE
HECATE STRAIT
QUEEN CHARLOTTE SOUND
JUAN DE FUCA STRAIT
PEACE RIVER BLOCK
PRINCE RUPERT
HAZELTON
STEWART
VANCOUVER
NEW WESTMINSTER
NANAIMO
VICTORIA
KAMLOOPS
REVELSTOKE
NELSON
CRANBROOK
GRAND FORKS
GREENWOOD
ROSSLAND
PRINCETON
VERNON
NICOLA
CLINTON
ASHCROFT
LILLOOET
YALE
GOLDEN
NAKUSP
SLOCAN
KASLO
NEW DENVER
FAIRVIEW
Hope
Barkerville
Quesnel
150 MILE HOUSE
Bella Coola
ALBERNI
QUATSINO
Edmonton
Calgary
Jasper
L.L. POATES CO., N.Y.

When it is considered that this smelter during the height of its operations in 1905 drew ore from over 125 different mines it will be realized that fairly wide variations in the composition of the later slags is to be expected. Unfortunately no analyses of these are available.

CONSIDERATIONS AFFECTING THE ESTABLISHMENT OF A MINERAL WOOL INDUSTRY IN BRITISH COLUMBIA.

THE ADVANTAGES OF HOUSE-INSULATION.

When a difference in temperature exists between the inside and outside of a wall or ceiling, heat will flow from the surface of higher temperature to that of the lower. This flow of heat is usually measured in B.T.U.'s per hour, per square foot of surface, per degree temperature difference, and is spoken of as " conductance." The conductance of a homogeneous material 1 inch thick is equal to its conductivity, as used before to compare the insulating value of mineral wool with other substances; conductance decreases with increased thickness. Perhaps a more graphic term to use, however, in discussing the function of insulation is " resistance." Resistance (the reciprocal of conductance) is most simply considered as the numbers of hours required for 1 B.T.U. to pass through 1 square foot of the given material with a temperature difference of 1 degree Fahr. between the surfaces.

In general, the resistance to heat-flow offered by a 3⅝ inches of mineral wool is roughly equivalent to that offered by 15 inches of solid wood, 60 inches of brickwork, 67 inches of hollow tile, 100 inches of concrete, or 107 inches of stonework. The resistance offered by 3⅝ inches of mineral-wool filling is about 13 hours, whereas the resistance of a ½-inch layer of mineral wool or other equally efficient material, such as corkboard, is but 1.85 hours. It is obvious, therefore, that effective insulation is dependent not only upon low conductivity, but upon adequate thickness.

The resistance of several typical wall sections as given by the A.S.H.V.E. Guide for 1926–27 is as follows:—

(1.) Stucco on metal lath, 1" furring, paper, wood sheeting, 2" by 4" studs (3⅝" air-space), lath and plaster—4.132 hours.
(2.) Clapboard or shingles, paper, wood sheeting, 2" by 4" studs, lath and plaster—3.333 hours.
(3.) 4" brick, paper, wood sheeting, 2" by 4" studs, lath and plaster—4.746 hours.
(4.) 4" brick, 8" hollow tile, plaster—4.994 hours.

The resistance of some typical roof sections is as follows:—

(1.) Shingles, paper, wood sheeting, rafters—1.939 hours.
(2.) Shingles, paper, wood sheeting, rafters, lath and plaster—3.567 hours.

The resistance of some typical ceiling sections is as follows:—

(1.) Unfloored attic—ceiling-joists, lath and plaster—1.628 hours.
(2.) Floored attic—wood floor, ceiling-joists, lath and plaster—3.768 hours.

The following table compares the theoretical resistance of the above sections with the addition of various thicknesses of mineral wool.

	No Insulation.	½".	1".	2".	3".	4".
Walls—						
(1)	4.132	5.98	7.8	11.5	15.2	18.9
(2)	3.333	5.18	7.0	10.7	14.1	18.1
(3)	4.746	6.59	8.4	12.1	15.8	19.5
(4)	4.994	6.84	8.6	12.4	16.1	19.8
Roof—						
(1)	1.939	3.79	5.6	9.3	13.0	16.7
(2)	3.567	5.41	7.2	10.9	14.6	18.3
Ceiling—						
(1)	1.628	3.47	5.3	9.0	12.7	16.4
(2)	3.768	5.63	7.5	11.2	14.9	18.6

In general, a resistance of five hours is a safe assumption for the average wall and three hours for the combined effect of ceiling and roof with unfinished attic.

To effect a 50-per-cent. reduction in the heat transmitted through an average wall requires that its resistance be raised to ten hours, while a 75-per-cent. reductions requires a resistance of at least seventeen hours. Similarly, the roof resistance must be raised to six and ten hours to effect the same savings.

As illustrated in the above table, a theoretical saving of over 50 per cent. would result from the addition of 2 inches of mineral wool to wall and roof, while the standard 3⅝-inch filling would effect a saving of approximately 75 per cent. The same result would follow if the walls and roof were surrounded by 15 inches of solid wood, 100 inches of concrete, or eight layers of one of the better grades of ½-inch insulating-board.

When a building is surrounded by outside air at a lower temperature than that maintained within, there will be a continuous loss of heat which must be compensated for by the heating system. Heat escapes from the building in two ways—by infiltration of cold air through cracks to replace air which has already been heated, and by transmission through the materials forming the outside walls, roof, and floor.

The loss through infiltration may be checked by caulking cracks and by the use of weather-stripping and tightly-fitting storm-windows. The conduction-loss may be reduced through increasing thickness or by the use of insulation in conjunction with existing wall design. In general, the latter is the only practical alternative from the viewpoint of expense.

In the average house* 43 per cent. of the total heat-loss is through the walls and roof, 30 per cent. through doors and windows, and 27 per cent. by air-leakage. In this case, if a 75-per-cent. saving through walls and roof has been effected by insulation as discussed above, the net result will be 75 by 43 or a 32-per-cent. saving on the total heat-loss. Since heat-loss must be compensated for by the heating system, this 32-per-cent. saving will be directly reflected in reduced fuel-consumption.

The largest single heat-loss, that due to conduction and radiation through windows and doors, may be nearly cut in half by the use of double windows and doors, yielding a further net gain of from 10 to 25 per cent.

In general, strict attention must be paid to correct construction and to the reduction of leakages if insulation is to be really effective.

The following example illustrates the theoretical value of house-insulation under local conditions, a relatively small house being chosen purposely to show the benefits under least advantageous conditions:—

EXAMPLE.

Building—5-room cottage, 35′ by 25′ by 12′ to eaves, attic unfinished.

Location—Vancouver, B.C.

Heating Period—Middle of October to middle of April, 6 months.

Mean Temperature Inside—70 deg. F.

Mean Temperature Outside—39 deg. F.

Area of Walls—1,440 sq. ft.

Area of Windows and Doors—274 sq. ft.

Net Area—1,166 sq. ft.

Area of Ceiling—925 sq. ft.

Area of Floor—925 sq. ft.

Walls—Stucco, metal lath, 1″ furring, paper, wood sheeting, studs, lath and plaster: Res. 4.1 hours; Con., 0.24. As above with 3⅝-inch filling of mineral wool: Res., 17.5; Con., 0.057.

Heat-loss through Walls—

Uninsulated: $1{,}166 \times 0.24 \times 31$—8,675 B.T.U. per hour.

Insulated: $1{,}166 \times 0.057 \times 31$—2,160 B.T.U. per hour.

Roof—

Roof-shingles, paper, wood sheeting, rafters	Res., 1.94
Ceiling—joists, lath and plaster	Res., 1.63
Effective Resistance	3.57
Conductance	0.28

As above with 3⅝-inch mineral wool filling in ceiling: Res., 16.99; Con., 0.059.

* Importance of Good Construction—Kratz; paper presented before the 2nd Annual Mineral Industries Conference, Urbana, Ill. 1934.

Heat-loss through Roof—
Uninsulated: 925×0.28×31—8,029 B.T.U. per hour.
Insulated: 925×0.059×31—1,692 B.T.U. per hour.

Floor—
Temp. diff. of 15 deg. F. assumed.
Flooring, sheeting, joists: Res., 2.66; Con., 0.37.

Heat-loss through Floor—
Uninsulated: 925×0.37×15—5,133 B.T.U. per hour.

Loss through Doors and Windows—
Res., combined doors and windows taken as 0.88; Con., 1.13.
Area: 274 sq. ft.
Loss: 274×1.13×31—9,598 B.T.U. per hour.

Loss due to Infiltration—
Allow 1.5 complete changes of air per hour. This figure gives more than adequate ventilation.
Heat-loss: 35×25×10×1.5×0.075×0.24×31—7,323 B.T.U. per hour.

Total Heat-loss per Hour—

Losses not affected by Insulation—

Doors and windows	9,598
Floor	5,133
Air infiltration	7,323
	22,054 B.T.U. per hour.

Losses affected by Insulation—

Walls—uninsulated	8,675	
insulated		2,160
Roof—uninsulated	8,029	
insulated		1,692
	16,704	3,852

Total Losses—

Uninsulated	38,758
Insulated	25,906
Difference	12,852 B.T.U. per hour.

Saving due to Insulation—12.852 B.T.U. per hour.

Per cent. saving—33 per cent.

Fuel-saving—Allow 50 per cent. efficiency for heating system and 14,000 B.T.U.'s per pound coal. Then effective heating value of 1 lb. coal equals 7,000 B.T.U.'s.

Assuming 6 months' operation of heating system, 16 hours per day, or a total of 2,880 hours.

Coal consumed in uninsulated house $\frac{38758}{7000}\times\frac{2880}{2000}=8$ tons.

Coal consumed in insulated house $\frac{25906}{7000}\times\frac{2880}{2000}=5.3$ tons.

By insulating the floor the total saving could be increased to 3.3 tons of coal.

In a general way, this example is typical of all Coast points; the value of insulation, however, is emphasized by a more rigorous climate. The above house transferred to Kamloops, for instance, where the temperature for seven months averages 33 degrees, would show a saving of over 4 tons partly insulated, and 5 tons completely insulated, on the basis of 12 tons of coal consumed. Under Coast conditions, it is probable that in many cases the actual fuel reduction following upon insulation will not be marked, the householder preferring to maintain more comfortable and uniform living conditions with the same amount of fuel as burned previously.

Allowing a density in place of 12 lb. per cubic foot, 1 ton of mineral wool would have a coverage of 570 square feet, when applied $3\frac{5}{8}$ inches thick. On this basis the above house would require $2091/570 = 3.6$ tons partly insulated or $3016/570 = 5.2$ tons completely.

Actually, experience has shown* the cost of insulation to range from 3 to 7 per cent. of the value of a new house. The cost of completely insulating an old house may range from $300 to $700.

In most cases it will be found that the saving in heating cost will pay for the initial cost of insulation within a few years' time. Apart from this, the insulation of a new house will allow of the installation of a smaller, less expensive heating system, the saving thus effected often serving to defray a large part of the cost of insulation.

The following graph illustrates, roughly, the relation between thickness of insulation and overall efficiency:—

The resistance of the roof, including roof and floor of unfinished attic, is assumed to have a factor of 3. The resistance of the walls is assumed to have a factor of 5. Forty-three per cent. of the total heat-loss is assumed to be affected by insulation.

It is apparent that the efficiency of insulation is not a linear function of its thickness, but decreases rapidly as thickness passes a certain figure. For the greatest economy, therefore, a balance must be struck between initial cost and increased saving.

If partial insulation is contemplated, the cost of insulating a roof or attic gives better returns than the cost of insulating any other part of the house. In an uninsulated house a large part of the avoidable heat-loss takes place through or around the roof, due to the greater temperature difference between its surfaces and in general to its lower heat resistance.

In addition to reducing conductance, insulation is also of value in reducing a leakage of cold air through thin or poorly constructed walls, especially when they are subjected to heavy wind.

Although the most tangible proof of the value of house-insulation, fuel-saving is not the only advantage to be gained, probably the most important consideration of all being increased comfort.

The use of efficient insulation makes it possible to maintain all parts of a house at a uniform temperature, thus adding not only to the comfort and health of the inhabitants, but in many cases to the effective size of the house itself under winter conditions. Again, the increase in temperature of the inside surfaces of outside walls will often lessen the heat lost by the human body through radiation to an extent allowing air temperature of outside rooms to be reduced several degrees without discomfort. Not the least value of insulation is the protection it affords against summer heat, it being possible to maintain an interior temperature 7 to 15 degrees lower than exterior, even in attics and upstairs rooms.

* The Insulation of New and Old Houses—Dom. Fuel Board, No. 15, 1932.

Forty to 50 per cent. relative humidity at temperatures of 64 to 68 degrees is commonly recommended for most comfortable and healthful conditions. Poorly insulated walls may have inside temperatures so low that condensation will occur with a relative humidity of even 40 per cent. Insulation not only prevents this, but aids in the maintenance of suitable humidities through helping to reduce excessive air-leakage.

In a well-insulated house heat is retained to such an extent that it is often possible to maintain comfortable temperatures by means of such auxiliary heaters as fireplaces and kitchen stoves even in chilly weather. When the furnace must be used the laborious tasks of stoking and removing ashes are greatly reduced.

Mineral wool, in common with many other heat-insulating media, is an effective sound-insulator as well. When applied as heat-insulation it not only reduces heat-losses, but eliminates outside noises to a large measure.

In addition to other benefits, mineral-wool insulation tends to reduce fire-hazard, not only by doing away with the necessity of forcing the heating system in cold weather, but by interposing a layer of inert, fire-proof material between the walls. Such a layer forms an excellent protection against vermin as well.

MARKETS.

In the previous section a review of the benefits of house-insulation was presented for two reasons: First, because the largest proportion of the output of mineral wool is employed in house-insulation elsewhere and it is probable that an even larger proportion would be so used in British Columbia; and, secondly, because it is questionable whether the value of house-insulation is fully appreciated in this Province as yet. The latter is probably due mainly to the fact that most of the population is to be found in or near Coast centres, where relatively mild climatic conditions prevail. However, the value of insulation is by no means restricted to severe climates, and when the various benefits such as fuel-saving, lessened furnace operation, and increased comfort and health are fully realized, there is little question but that a considerable demand for insulation will be established. Although mineral wool is by no means the only efficient insulating material available, it is doubtful if another can be found which combines its desirable features with equally low cost. The popularity of mineral wool is well illustrated by the remarkable increase within the past five years in the number of plants in the United States manufacturing the product. In 1930 there were but eight plants with an output valued at $2,000,000; this had increased to thirty plants in 1935 reporting sales amounting to $5,571,469, while by 1936 forty-five to fifty plants were in operation* with an estimated production of $15,000,000. Four plants have been established in Eastern Canada since 1934.

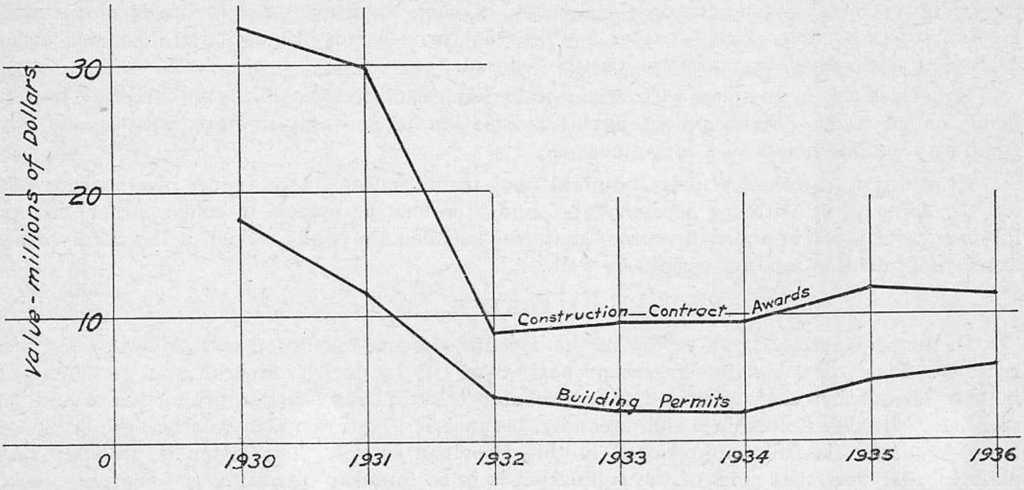
The potential demand for mineral wool in the housing-field is somewhat difficult to estimate quantitatively in view of the complex nature of the problem. Primarily the establishment of a market is dependent upon making the public conscious of the value of house-insulation. If this is accepted, the market afforded by new houses is dependent upon construction activity. A study† of population trends, vital statistics, and other available data indicates that there was created in Canada during the period 1931 to 1936 a potential demand for at least 200,000 houses and apartments. By subtracting from this figure the estimates of dwelling-houses constructed, there remains a deficiency of about 120,000. Under normal conditions the demand for additional accommodations may be expected to exceed 40,000 dwelling units per year in addition to a reasonable proportion of the present deficiency.

Of the above construction activity, British Columbia may be safely assumed to contribute her share in proportion to population, although actually it will probably be somewhat higher than the Canadian average. In ratio to population, however, there would appear to be a demand for at least 3,000 dwellings per year under normal circumstances. On this basis, and allowing only 2 tons per dwelling, a possible market of at least 6,000 tons may be assumed for new houses.

That the building industry has made a substantial recovery since depression times is well illustrated by recent building permits and construction contract awards.

* Mineral Wool—A Growing Industry—Pit and Quarry, April, 1937.
† The Construction Industry—Nesbitt, Thomson & Co., 1937.

Construction contract awards may be subdivided into Residential, Business, Industrial, and Engineering. In Canada the proportion attributed to Residential construction has remained between 20 and 26 per cent. for the last seven years, and by Business construction between 22 and 33 per cent., with an average of 30 per cent. Applying the Canadian proportions to British Columbia, the value of contracts awarded for Business and Residence construction for 1936 would be, roughly, $5,800,000.



This graph shows the value of building permits and construction contract awards in British Columbia. The building permits are for seven cities only. Figures from Canada Year Book, 1936.

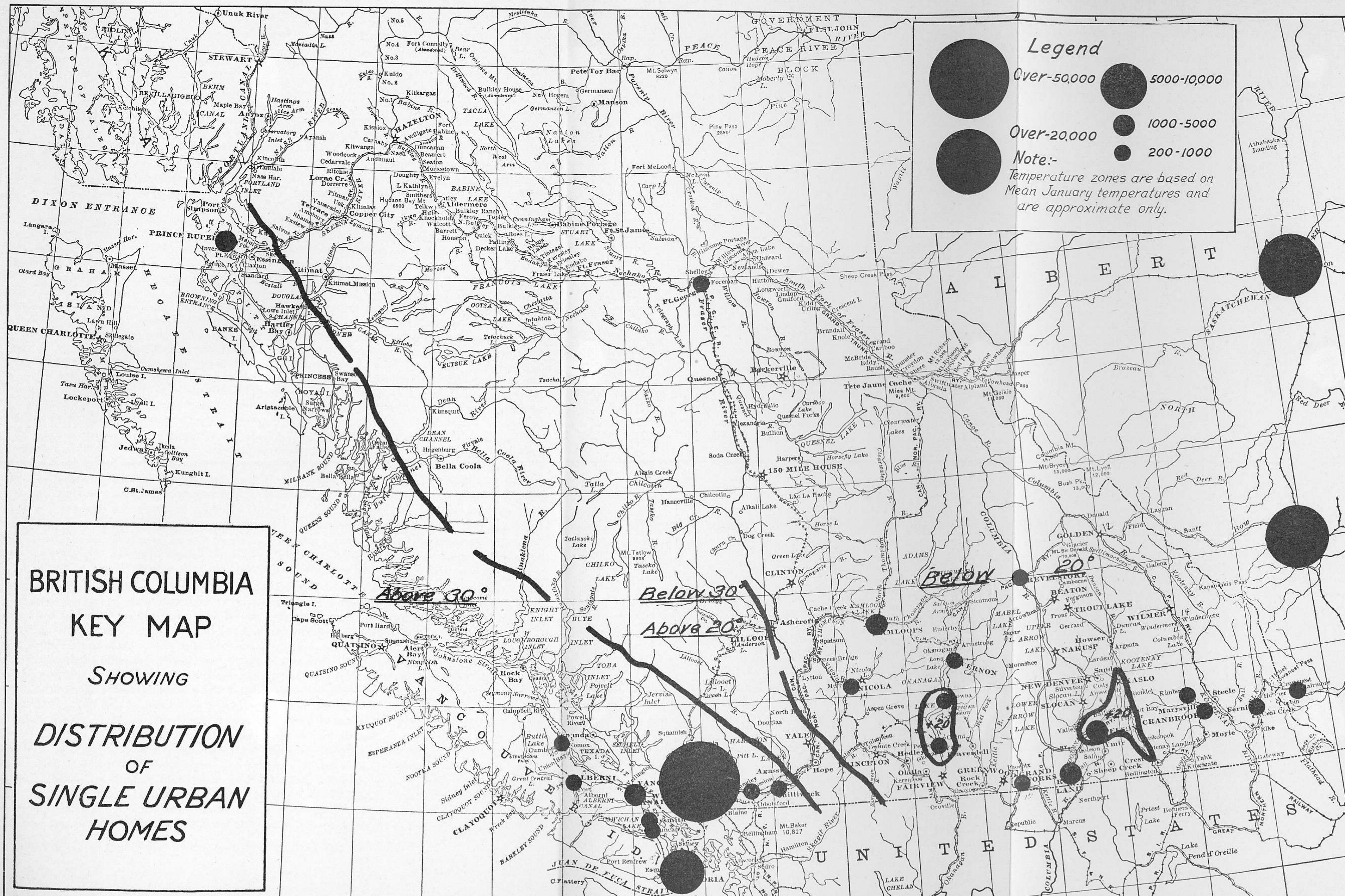
From a consideration of building permits and contract awards there would appear to be at least $6,000,000 spent annually on building construction at present. The proportion actually entering into the construction of new buildings is not available, but on the basis of statistics on the construction trade, about two-thirds would seem a fair estimate. On this basis, $4,000,000 appears a safe minimum for the value of new building construction within the next few years. It is impossible to estimate what proportion of this total the mineral-wool industry would reach, but allowing even 3 per cent. of this figure for insulation, a potential market of $120,000 a year, or at $50 a ton of 2,400 tons per year, may be assumed to exist.

As mentioned above, it is impossible to attempt to estimate quantitatively the potential market for mineral wool; the above figures can be accepted as little more than an indication of the fact that a reasonably large market might be created in connection with new building construction. Actually the first estimate is probably closer to the maximum possible market, since building permits and construction contract awards are far from complete for the Province as a whole.

The application of insulation is by no means restricted to new construction. Probably the largest and most immediate outlet for mineral wool is afforded by old houses. Again the extent of this market cannot be estimated directly from the number of houses, but depends upon value, age, whether owned or tenanted, whether rural or urban, and other factors.

According to census figures, there were in 1931 some 181,218 households and 166,216 dwellings in British Columbia. Of 177,823 households, 79,541 were rural and 98,382 were urban. The following table presents information on the classification of dwellings in the Province:—

Description.	No.	Per Cent.
Brick	2,076	1.25
Stone	786	0.47
Wood	151,627	91.22
Cement	240	0.14
Stucco	9,970	6.00


BRITISH COLUMBIA
KEY MAP
SHOWING
DISTRIBUTION
OF
SINGLE URBAN
HOMES
Legend
Over-50,000
5000-10,000
Over-20,000
1000-5000
200-1000
Note:-
Temperature zones are based on
Mean January temperatures and
are approximate only.
Above 30°
Below 30°
Above 20°
Below 20°
+20
UNITED STATES
ALBERTA
L.L. POATES CO., N.Y.

Kind.		Per Cent. of Population.
Apartments	14,022	5.00
Single houses	158,596	87.00
Others	8,630	------

In attempting to estimate maximum markets the following assumptions were made:—

(1.) Urban homes present the most immediately accessible market.

(2.) Owned homes form a more likely market for mineral wool than rented ones.

No figures could be found relating to the "value-distribution" of houses in British Columbia. It is probably true that houses valued at less than $2,500 are poor prospects for insulation; the low value does not warrant substantial improvements. On the rather questionable basis of a comparison with United States figures,* 85 per cent. were assumed to exceed this valuation and hence to form a potential market for insulation.

To allow a percentage of safety only the 158,596 single dwellings in the Province were considered. The others, apartment and semi-detachable buildings, would benefit equally by insulation, but the considerations involved are rather more complex.

Of the 98,382 urban households, 52 per cent. own their own homes. The 51,158 owned urban homes represent the most immediately accessible outlet for mineral wool. On the assumption that 85 per cent. of these have a value of $2,500 or more, the potential market would be afforded by some 43,500 houses. According to census figures, the average size of the typical British Columbia urban home is 4.89 rooms; eliminating the assumed 15 per cent. of low-priced dwellings, a five-roomed house may be safely assumed as typical. In summation, then, there are some 43,500 urban houses, valued at more than $2,500, containing typically five rooms and owned by their inhabitants. Taking the average amount of mineral wool necessary to insulate completely a five-roomed house as 4 tons, these represent a potential outlet for 174,000 tons. Even on the basis of roof-insulation, only a possible market of 50,000 tons exists.

Another aspect of the question of markets is afforded by a comparative study of Eastern and Western conditions. The major difference is climatic; the East suffering in general from much severer winters and warmer summers. On the other hand, however, it must be remembered that fuel-saving through insulation is proportionally independent of weather conditions; in other words, that a 30-per-cent. decrease in heat-loss from a house applies whether 6 or 12 tons of coal are burnt. Actual savings, and consequently returns on investment, are greater, however, where fuel-consumption is large. On this basis it must be admitted that the returns in fuel saved per dollar invested in insulation are in general greater in Eastern Canada. In passing, it should be noted that the present discussion is restricted to coastal climate; interior conditions being not dissimilar to Eastern.

Apart from monetary considerations, however, the benefits of insulation are even more marked in some ways under coastal conditions than under Eastern. There is little question but that some form of heating is essential for at least eight months of the year in Vancouver or Victoria. It is also notorious that in general lower house temperatures are maintained than in more severe climates. This is largely attributable to flimsier construction and to the fact that for a considerable period each year temperatures are such that furnace operation appears hardly justified, while at the same time auxiliary heaters such as fireplace and kitchen stove are insufficient to maintain comfortable temperatures throughout the house. Efficient insulation would allow the maintenance of an entire house at a uniform and comfortable temperature by auxiliary heaters alone for a considerable part of each year, with an enormous increase in general comfort, healthfulness of living conditions, and reduction in labour. Again, it is a fact that when precautions are taken to minimize undue heat-loss through air-infiltration and window-transmission, the comparative benefits of insulating a cheaply-constructed house are greater than for a well-built one. There is probably but little question that the proportion of cheaply-built houses is larger at the Coast than in Eastern Canada, where provision for cold winters is made. As a generalization, then, the proportional benefits of house-insulation in Western British Columbia might be expected to be even greater than

* Rock Wool from Illinois Mineral Resources—Bull. 61, Ill., Geol. Sur., 1934, p. 218.

for Eastern Canada. In order for this to be true, however, the value of weather-stripping, double-windows, and careful construction should be more completely appreciated than at present.

The increasing interest in air-conditioning of dwellings within the last few years attests not only to the fact that individuals are becoming more conscious of the improvements possible over the present residential conditions of comfort and health, but that they are more willing and able to make investments in improved living conditions without other direct returns. Fundamentally air-conditioning seeks to provide an indoor atmosphere of the correct temperature and humidity for maximum comfort and health; this is accomplished by controlling the intake of air and subjecting it to a combination of heating or cooling, humidification, or dehumidification, and where necessary filtration. The whole process to be efficient implies that the air entering a house must be under control and not free to enter indiscriminately through innumerable cracks and crevices. Although the major leaks in the average house take the form of cracks about doors and windows, tests* have shown that the infiltration of air through an ordinary 13-inch plastered brick wall may be as much as 6½ cubic feet of air per square foot of wall, with a wind-velocity of 15 miles per hour. By carefully applied insulation, most of this "wall-leakage" may be eliminated. It is therefore obvious that insulation may prove not only an adjunct to air-conditioning, but under some conditions be almost essential. Again, it may be seen that insulation, if not a form of air-conditioning itself, at least allows some of the benefits—maintenance of comfortable temperature and humidity—to be more easily attained in the ordinary home, and does so not only without operating expense, but with an actual return on investment represented by a substantial fuel-saving. It is not intended to minimize the value of air-conditioning, but to point out that ideally air-conditioning should be accompanied by insulation for maximum results, and that insulation in itself is a valuable means of promoting greater comfort and health in dwellings.

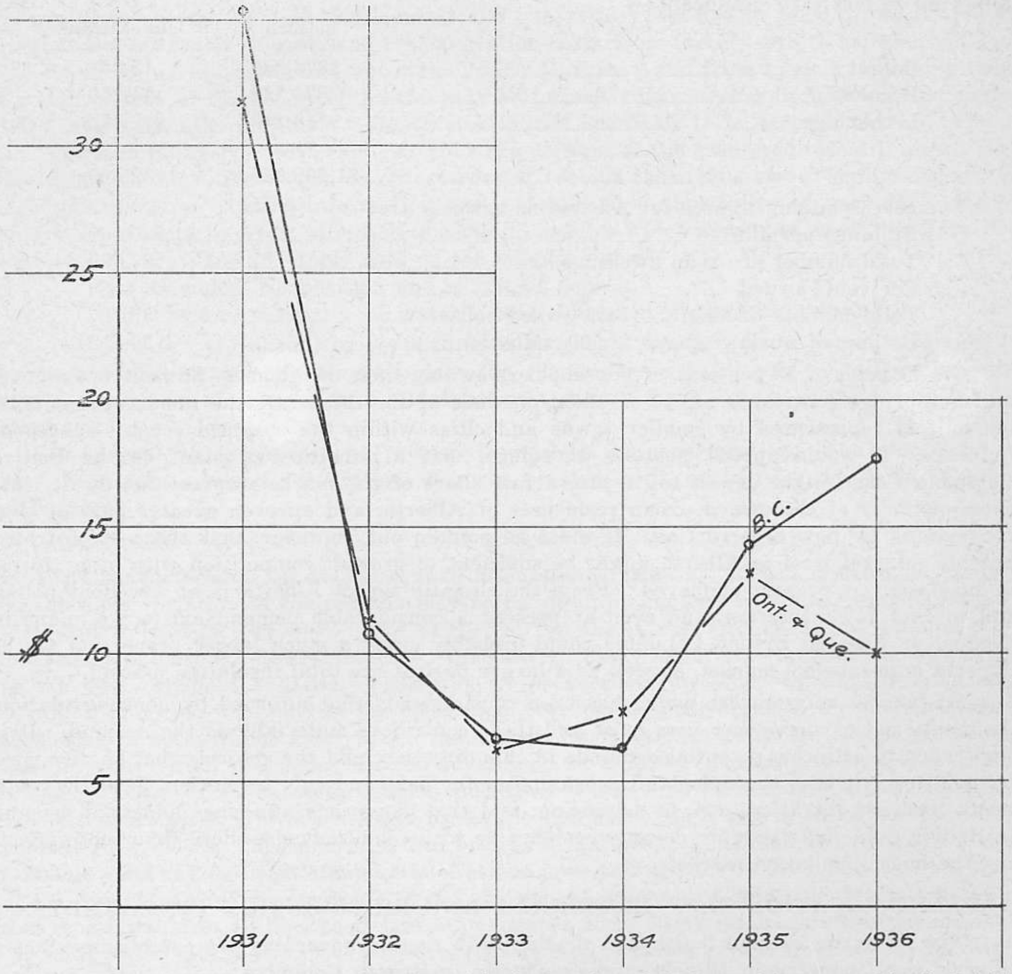
Keeping the above factors in mind, an actual comparison of some Eastern and Western figures might be suggestive. There are at present at least four plants manufacturing mineral wool in Canada: Spun Rock Wools, Ltd., Thorold, Ont.; Canadian Johns-Manville, Ltd., Asbestos, Que.; Rockwool Corporation (Canada), Ltd., Brantford, Ont.; and Gypsum Lime and Alabastine, Ltd., Caledonia, Ont. The principal market for these is afforded by house-insulation in Ontario and Quebec, with the demand decreasing rapidly with distance in the Maritime Provinces and Manitoba. In addition to the output of the Canadian plants, there were in 1936 some 950 tons, worth $62 per ton, and 20 tons, valued at $23 per ton, imported from the United States and Great Britain respectively. Although estimates of the potential British Columbian market for mineral wool have been presented earlier in this section, they cannot do more than merely indicate the extent of the possible market which might be established. Actually the market will depend primarily upon the creation of a demand through education and, secondarily, upon the activity of the construction trade. The graph on page 31 gives comparisons of building permits on a *per capita* basis for British Columbia as compared with Ontario and Quebec combined.

It is apparent that the recovery in the construction trade has been more rapid in British Columbia than elsewhere in Canada; again, the *per capita* wealth of British Columbia is $3,414, as against $2,496 for Ontario, $2,269 for Quebec, $1,600 for the Maritime Provinces, and $2,164 for Manitoba. British Columbia would therefore appear, from the financial point of view, to be an even more favourable potential market *per capita* for mineral wool at the present time than Eastern Canada.

There appears little question but that an appreciable demand for house-insulation, and hence for mineral wool, could be created in British Columbia through an intelligent educational programme. The insulation market is highly competitive, however, and a careful study of all the factors involved would be necessary before a new enterprise was initiated. At the present time there seems little danger of serious competition from existing producers. Mineral wool is extremely bulky, a maximum car-load being approximately 15 tons, with the result that freight rates are high. The quoted rate on mineral wool from producing centres in Ontario to British Columbia Coast points is $1.67 per 100 lb. or $33.40 per ton on the basis of a

* Quoted from "Why You Should Insulate Your Home"—National Resources Intelligence Service, Dept. of Int., Canada, 1929.

minimum car-load of 30,000 lb. When it is remembered that the average price of bulk mineral wool is $50 per ton, it is apparent that not only would Eastern manufacturers be unable to compete with a local industry, but that until such an industry is created it will be difficult to arouse much interest in the use of mineral wool at the present excessive prices. In a general way the same is true of competition from the United States, except that in this case an additional barrier exists in the form of a 25-per-cent. duty on imports of mineral wool entering Canada.



This graph is based on figures for thirty-three cities in Ontario and Quebec and for seven cities in British Columbia. The figures for 1936 are estimated. The information is obtained from the Financial Post Year Book, 1936.

The Illinois Geological Survey has* estimated that a two-cupola plant capable of producing 1,000 lb. of wool per hour can be built for about $38,000, indicating that a new enterprise should not require an investment of more than $50,000 or $60,000. With coke at $4 to $5 per ton, it is said to be possible to produce mineral wool, figuring all costs, at somewhat less than $20 per ton.

Goudge† estimates the cost of making a ton of mineral wool at $25 to $30, exclusive of selling-costs. This figure presumably applies to average Canadian conditions.

As mentioned above, the average selling-price of mineral wool in the United States is $50 per ton in bulk, while in the granulated form it sells for about $70 per ton.

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* Quoted from Pit and Quarry, Ap., 1937—Mineral Wool—A Growing Industry—Anon.
† Personal communication.

Before dismissing the present survey of market potentialities it might be pointed out that the possibility exists of developing markets in Alberta in addition to British Columbia. This possibility is dependent largely upon relative freight rates from east and west, which in turn is dependent in no small measure upon the location of British Columbia producers. A plant situated at the Coast could probably meet Eastern competition successfully as far as Medicine Hat. Neglecting this city, the urban market would be represented by Calgary, Edmonton, and Lethbridge, in addition to a number of smaller towns and cities. In this connection the following figures* are significant:—

	Building Permits.	No. of Urban Dwellings.
Calgary	$874,286	15,061
Edmonton	676,535	14,950
Lethbridge	118,442	2,478
Totals	$1,669,263	32,489

The corresponding figures for Alberta as a whole are:—

Building permits	$1,947,000
Total number of urban dwellings	67,730
Per cent. owned	53
Total number of single, urban, owned houses	35,897
Estimated number above $2,500 valuation	30,512

On the basis of 53 per cent. of householders owning their own homes, Edmonton, Calgary, and Lethbridge contribute 14,637 or about one-half of the total. Of the remainder, at least one-half is represented by smaller towns and cities within the assumed coastal sphere of influence. It would appear possible, therefore, that a mineral-wool plant on the British Columbia Coast might expect to capture a fair share of the market represented by at least three-quarters of the owned urban residences of Alberta, and an even greater part of that represented by new construction. It must be pointed out, however, that the cost of transporting mineral wool to Alberta might be sufficient to prevent competition with other forms of insulation at present employed. From the climatic aspect Alberta is an excellent potential market for insulation, and even at present a considerable demand exists. A plant in Central or Eastern British Columbia could probably enjoy a much larger proportion of the Alberta mineral-wool market, as well as a larger part of the total insulation market.

So far the only market which has been considered is that afforded by house-insulation. As mentioned earlier, other uses exist and these contribute materially to the demand. It is impossible to estimate potential demands in this direction, and the subject must be dismissed by pointing out that the industrial consumption for heat and cold insulation, acoustic treatment, packing, filtration, etc., is increasing, and that conditions affecting industrial demand in British Columbia are more directly comparable with conditions elsewhere than those affecting the house-insulation market.

PLANT LOCATION, RAW MATERIALS, AND DISTRIBUTION OF MARKETS.

The following excerpt,† although dealing with factors governing the establishment of a mineral-wool industry in Illinois, applies equally to British Columbia:—

" The insulating-materials market is a highly competitive one, and a plant location must be selected which will result in the lowest cost of assembling raw materials and fuel and delivering the finished product to the markets. The elements that comprise the factor of total cost may be enumerated as follows:—

(1.) Size, location, and probable growth of market.
(2.) Cost of site.
(3.) Cost of obtaining suitable fuel (or power) at the factory-site.
(4.) Cost of quarrying and delivering raw materials to the factory-site.
(5.) Cost of manufacturing.
(6.) Transportation costs on finished products from proposed point of production to markets.

* Financial Post Year Book, 1936.

† Rock Wool from Illinois Mineral Resources—Bull. 61, Illinois State Geological Survey, Urbana, Ill., 1934.

" It should be noted that the determining factor in selecting the plant-site is the aggregate annual cost of the items enumerated above rather than the cost of one item.

" Obviously, a woolrock deposit of suitable extent and low quarrying costs located near a large market centre would be most favourable for commercial exploitation or development. The market demand for rock wool, in terms of tonnage, is not large enough to warrant the building of railroad spurs or other special transportation lines to a deposit which in itself is of suitable composition and extent, solely for this traffic. However, the geological and site characteristics of deposits near market centres and the transportation facilities may be of a nature as to necessitate high development and quarrying costs due to price of site, depth of overburden, character of rock, and transportation costs from factory-site to railroad siding."

From the earlier discussion under the head " Markets " and from the accompanying map, a rough picture of market potentialities may be formed, remembering in addition that under more severe climatic conditions market potentialities are likely to be accentuated.

The factors involved with raw materials are perhaps of the greatest present interest. As has been mentioned, the section on occurrences of various calcareous and dolomitic deposits is a compilation from existing information, and, although as authoritative as possible, is offered only in an attempt to direct attention to certain localities which appear to merit more detailed exploration. This should supply data on the following points:—

(1.) Chemical composition and extent of deposit.

(2.) Physical character of material and character of resulting product.

The data for (1) should be supplied by a thorough sampling programme, involving in most cases drilling and analyses; the data for (2) can be supplied only by test-work in the actual production of mineral wool, obtained most satisfactorily by the operation of a pilot plant.

In general, three possibilities present themselves for consideration: The production of wool from true woolrock, a mixture of rocks or slag, with or without additions of other materials.

(1.) WOOLROCK.

The characteristics of woolrock were discussed on page 8. It was pointed out that a considerable variation in composition may be balanced by changes in operating conditions to yield equally satisfactory wool. The " CO_2 test " of the Illinois Geological Survey is a rapid means of eliminating unlikely material; the value of likely material depends upon the quality of the wool produced and the economy of its production. In other words, assuming that equally high-grade wool may be produced from two hypothetical deposits, the manufacturing costs may be such, in one case, due to the extreme temperatures necessary, or other factors, that they more than offset such natural advantages as location, proximity to fuel, etc. These considerations must be balanced against each other before a new enterprise is contemplated.

A true woolrock in which the acid-base ratio approaches 1 : 1, and in which the four components SiO_2, Al_2O_3, CaO, and MgO are present in the proportions delimited on page 9, will probable yield the most satisfactory wool at the lowest cost.

Although careful investigation of the various calcareous and dolomitic deposits listed in this report would in all likelihood disclose a number from which woolrock might be obtained, the most immediate possibilities for its discovery are probably represented by the following localities: Upper Moyie Lake (72), Elko (74), Fernie (75), and Crowsnest (76), on the Crowsnest Branch of the Canadian Pacific Railway; Glenogle (52), Ottertail (53), and Field (54), on the main line of the Canadian Pacific Railway. In addition, the calcareous shales in the vicinity of Trail (63) and Ymir (64) might bear investigation.

Of these, the deposits of southern East Kootenay, should they prove to contain rock of suitable composition, have many factors in their favour. They are, it is true, remote from major markets. On the other hand, they are centrally located in respect to the combined markets of British Columbia and Alberta, are easily accessible, and, above all, are close to a source of coke. Coke could probably be obtained more cheaply in this locality than at any other in the Province, the estimated cost being from $5 to $7 per ton. Manufacturing costs would be low, but against these would be rather high freight rates to Coast centres. The present quoted freight rate on mineral wool from Nelson to Vancouver is 81 cents per 100 lb. on the basis of a 20,000-lb. minimum car-load. At this rate the cost of delivery to the Coast would be slightly in excess of $16 per ton. It is understood, however, that the rate might be materially reduced in event of actual production. Whether cheap manufacturing cost would offset transportation to the major markets would need to be investigated carefully.

(2.) ROCK-MIXTURES.

Very little information has been published on the use of rock-mixtures for the manufacture of wool. Thoenen* states that the United States Mineral Wool Company at Netcong, N.J., produced wool from a mixture of silica rock and crystalline calcite. Thorndyke† mentions the fact that the Coast Insulating Company, of Torrance, Cal., utilized a mixture of limestone and silica refuse together with a fluorspar as a fluxing agent, but that the variability in raw materials caused difficulty, the wool being off-colour, short-fibred, and containing a large proportion of shot.

Goudge states‡: ". . . with the recent great expansion in the rock-wool industry in that country (United States), a number of plants have been established in localities far removed from deposits of natural woolrock and these depend on the blending of rocks of diverse composition in order to obtain a furnace charge of the correct composition. Rocks that are thus blended are shales, dolomites, sandstones, clays, and calcium limestones. Where possible, however, it is preferable to use a single rock of uniform composition and definite melting-point, rather than to use mixtures of rocks having diverse melting-points, because, with the latter, trouble is often encountered in cupola-furnace operations, owing to a gradual accumulation of the more infusible rock in the bottom of the cupola."

It is apparent that, despite possible difficulties or disadvantages, rock-mixtures have and are being used successfully for the manufacture of mineral wool elsewhere. Should such practice be contemplated in British Columbia, a great diversity of plant locations is thereby made possible.

At the present time it seems likely that a rock-wool plant at the Coast would have to rely upon the mixture of limestone or dolomite with shale, sandstone, or igneous rock. Future investigation may prove that true woolrock exists, but this would appear somewhat unlikely in view of the purity of most of the accessible calcareous or dolomitic deposits.

The only means by which the various factors contributing to a successful operation could be adequately judged is through actual test-work, preferably in a pilot plant, every attempt being made to duplicate actual operating conditions. In this way some estimate of the various difficulties to be met and costs involved can be obtained. There appears to be a wide field for investigation in the successful production of high-quality wool from rock-mixtures, and it is suggested that electrical melting not be overlooked. Should standard cupola practice be contemplated, coke could be obtained locally, but probably at a fairly high cost. Unfortunately, no direct electrical-power cost comparisons are available between Coast centres and Thorold, Ontario, in which the very successful operation of Spun Rock Wools, Limited, employs electric furnaces for melting. Thorold is situated on the Welland Canal and is within a few miles of Niagara Falls; for this reason power costs are low. No actual figures are available for Thorold itself, but it may be safely assumed that they will not differ materially from those of Welland or Niagara Falls. The following figures§ make comparison between power costs in Vancouver and Victoria with those of Welland and Niagara Falls:—

Town.	By H.P. and 100 Hours of Use. 25 H.P.	100 H.P.
Welland	$30	$109
Niagara Falls	30	120
Vancouver	37	149
Victoria	46	149

Although electric melting would be obviously cheaper in the Niagara Peninsula than on the Pacific Coast, the difference is not so large as to preclude the possibility of its use in Vancouver and Victoria.

There appears every reason to believe that, in view of experience elsewhere, a successful enterprise could be established on the Pacific Coast, depending upon the blending of rocks of

* Mineral Wool—Inf. Circ. 6142, U.S. Bureau of Mines, 1929.

† Mineral Wool from Wollastonite—Min. and Met., March, 1936.

‡ Rock Wool—C.I.M.M., Sept., 1936.

§ Financial Post Year Book, 1936.

diverse composition. Extensive experimental work in the production of wool from blends of the different materials within economic range of the proposed plant-site should be carried out, foundation-work of this nature being of even greater importance here than if true woolrock was to be employed.

The section on calcareous and dolomitic deposits (pages 10 to 20), with accompanying map, should afford a guide to the various deposits accessible to any particular location. It is to be emphasized that situation on or near tide-water will extend enormously the area from which raw materials may be economically obtained, water transportation being notedly cheaper than rail.

(3.) SLAGS.

The third possibility, and one that in British Columbia will merit the most careful consideration, is the manufacture of slag wool.. Slag of suitable composition has long been used for the manufacture of mineral wool. Thoenen* refers to four plants producing slag wool in 1929; more recent figures are not available, but the total has probably increased considerably since that time. Three of the four plants made additions of limestone, granite, or silica rock to the slag to control the composition of the melt, all four utilizing iron blast-furnace slag. Typical slags used in making mineral wool has the following compositions:—

SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	S.
38.0	1.0	11.0	28.0	19.0	0.5–0.8
38.4	0.7	10.5	31.5	15.3	1.6

Lang† describes the operation of a slag-wool plant and points out that the best slags are those produced by copper or pyrite smelting, since iron interferes with the production of satisfactory fibres during blowing. Many such slags, however, contain a much higher iron content in actuality than do iron blast-furnace slags. The plant described by Lang used air at 75 lb. per square inch, 1½ tons of compressed air being necessary to blow 1 ton of wool. A brick furnace, without water-cooling, was employed and oil and lampblack briquettes were used in the amount of 8 per cent. oil and 11 per cent. briquettes.

Mineral wool, whether made from rock or slag, is essentially the same for all market purposes, although the highest grade of wool is usually made from woolrock. Slag wool commonly contains appreciable amounts of sulphur and other objectionable impurities, and generally the fibres are not so long or tough; on the other hand, for ordinary insulation purposes there is little to choose between the two.

Thoenen's figures for fuel-consumption are essentially the same for both slag- and rockwool manufacture, four plants of each type being considered. Theoretically, the melting of slag requires less fuel, since the dissociation of $CaCO_3$ or $MgCO_3$ in woolrock or mixtures in itself requires considerable heat. Actually it is probable that in carefully controlled operations melting costs could be reduced below those for rock wool for this reason.

Through the absence of carbon dioxide slag enjoys another advantage which is reflected in lower manufacturing costs. Whereas through the elimination of carbon dioxide during melting only 1,400 to 1,600 lb. of wool may be expected from every ton of rock melted, no such loss occurs for slag.

Some slags were poured directly and are now represented by more or less solid masses; others were granulated and flushed to the dump by means of water. Handling the former would in some cases require blasting and crushing, in which event the operation would be roughly comparable in cost to quarrying of woolrock, except that overburden problems would not arise. The latter, however, being fine-grained and loose, could be handled directly and at a low cost. On the other hand, there is some question as to whether granulated slag could be used directly in the standard coke-fired cupola in view of the danger of "choking" the furnace. Melting by electrical or reverberatory furnace would eliminate this difficulty,

* Mineral Wool—Inf. Circ. No. 6142, U.S. Dept. Comm. Bureau of Mines, 1929.

† Some problems Encountered in Designing and Operating a Slag Wool Plant—Chem. and Met. Eng., Aug. 27, 1923.

while it is possible that the contemplated trouble might not be serious, or might be circumvented by some form of briquetting.

An outline of the old slag-dumps of British Columbia was presented on pages 21 to 23.

From the point of view of accessibility to Coast markets, the slag-dumps at Crofton (1) and Ladysmith (2) are most favourably situated, each containing several hundred thousand tons of granulated slag on tide-water. As judged by analysis, the composition of the slags is essentially similar.

A sample of Ladysmith slag, submitted to M. F. Goudge by the owner, Herbert Carmichael, was tested in the laboratory of the Mines Branch at Ottawa. It yielded a certain proportion of wool but largely shot in the first test. Further tests with additions of alumina and magnesia failed to yield a uniform product, the trouble, as suggested* by Goudge, lying in the high iron content and the uncertainty as to whether the iron would be reduced or form a silicate. Another test with additions of calcium and silica and under closely controlled furnace conditions yielded a brown, rather brittle, wool which, except for colour and a high proportion of shot, would probably be of commercial grade.

Preliminary tests would therefore indicate a strong possibility that with suitable additions of other materials and carefully controlled melting conditions a brown wool could be produced from these slags that would be suitable for house-insulation, and for most purposes in which colour was not important.

It must be emphasized, however, that much experimental work remains to be done to prove definitely that these slags may be made to yield commercial wool in a large-scale operation, and also to establish the economic feasibility of producing slag wool from this source.

The most important slag-dump so far studied as a source of mineral wool in the Province is that at Grand Forks (7). An enormous quantity of both granulated and ungranulated slag is available, and the fact that smelting was confined largely to ores from the same sources throughout operation would suggest that a fair degree of uniformity in composition is to be expected. A typical sample of granulated slag was submitted to M. F. Goudge by P. B. Freeland.† As a result of laboratory scale tests a very fine grade of snow-white wool was obtained without the necessity of resorting to admixture with other materials.

Grand Forks has several commendable features as a location for a possible mineral-wool industry. Although situated at some distance from Coast centres, it is centrally located with respect to the total Western market, difficulty is not anticipated in obtaining satisfactory plant-sites, and electric power is available. At the present rate transportation costs to the Coast would be roughly $15 per ton of wool, although this would be somewhat reduced in all likelihood with the advent of a producing plant.

Coke would probably be brought in from the Crowsnest District and on this basis would cost approximately $9 per ton laid down in Grand Forks. Electric-power costs are at present unknown.

Should use of the water-cooled, coke-fired cupola be contemplated, it is probable that a judicious mixture of massive and granulated slag could be employed, preventing " choking " and at the same time reducing over-all handling expenses.

Further experimental work is required before final conclusions as to the suitability of this slag for the production of slag wool is reached. In view of tests so far, however, it appears highly probable that a good grade of mineral wool could be economically made.

GENERAL CONCLUSIONS.

1. There appears every reason to believe that a demand for mineral wool could be established in British Columbia sufficient to justify the operation of at least one producing plant in the Province.

2. A producer of mineral wool in the Province would be effectively protected from existing competition by high freight rates from Eastern Canada, and by a combination of freight rates and tariff from the United States.

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* Letter to Mr. Carmichael.

† Chief Mining Engineer, British Columbia Department of Mines.

3. It is to be suggested that a prospective producer carefully explore the possibilities of producing mineral wool from the various available sources in light of markets and economics of operation. The erection of a pilot plant to test available raw materials is strongly recommended.

4. Although exploration would probably disclose other sources of suitable material, the following localities at present are suggested as meriting careful investigation for:—

(*a.*) Possible woolrock in southern East Kootenay and the Salmo-Rossland area.

(*b.*) The practicability of utilizing rock-mixtures for the manufacture of mineral wool on the Pacific Coast.

(*c.*) The amenability of the slags of Crofton and Ladysmith on Vancouver Island, and of Grand Forks, in Central British Columbia, to the economic production of slag wool.

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