CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

INVESTIGATIONS OF MINERAL RESOURCES AND THE MINING INDUSTRY, 1926

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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Annual reports on Mines Branch investigations are now issued in four parts, as follows:—

Investigations of Mineral Resources and the Mining Industry.

Investigations in Ore Dressing and Metallurgy (Testing and Research Laboratories).

Investigations of Fuels and Fuel Testing (Testing and Research Laboratories).

Investigations in Ceramics and Road Materials (Testing and Research Laboratories).

Other reports on Special Investigations are issued as completed.

MINES BRANCH INVESTIGATIONS OF

MINERAL RESOURCES AND THE MINING INDUSTRY, 1926

I

FLOTATION REAGENTS MANUFACTURED IN CANADA

C. S. Parsons

In order to encourage the use of Canadian manufactured products, the Mines Branch of the Department of Mines undertook the compilation of a list of flotation reagents which are manufactured in Canada. The accompanying table, compiled by Miss D. M. Stewart of the Mineral Resources Division, contains a list of the principal reagents used in flotation, together with the names of Canadian manufacturers.

In order to obtain the information a list of the manufacturers of chemicals and of any other class of manufacturers which it was thought might possibly produce reagents as a by-product was prepared. The companies then were circularized for detailed information as to what products were produced by them.

The market for chemicals used in mining is rapidly broadening in conjunction with the growth of the industry. It may be safely predicted that the consumption of chemicals used in the mining industry in Canada will double within the next two years.

FLOTATION REAGENTS

Flotation reagents can be divided into two principal classes, frothing and collecting reagents and addition reagents. Frothing and collecting reagents are, in most cases, oils or substances of an oily nature, such as distillation products of wood or coal. It has been recently found that certain organic compounds containing sulphur, such as potassium xanthate and thiocarbanilide, are very active collecting reagents; and that other organic substances, such as certain aldehyde derivatives, ketones, xylidine, orthotoluidine, and aniline are good frothers and possess, in some degree, collecting properties. Sulphurized oils, produced by boiling oils with sulphur, are used extensively. Addition reagents are as a rule chemical salts and are used to either modify the surface of the mineral particles so that one sulphide may be floated in preference to another, or to correct the deleterious effect of contaminated water and also the effect of certain soluble salts, principally sulphates, which are found in some ores. The sulphides and polysulphides of the alkaline earth metals are used to produce films of sulphide on oxidized minerals to make them more amenable to flotation. Sodium and calcium compounds are used in practice, the other alkaline earth metals being too expensive.

[1] See Mines Branch Memorandum Series, No. 11 and No. 29.

Coal-tar Products

The products of coal tar are the most universally used of all flotation reagents. Coal tar used alone is an excellent collector but it is generally mixed with some lighter solvent, such as creosote. The creosotes are good collectors and fair frothers. The acid creosotes are more commonly used on lead ores and gold and silver ores. The neutral creosotes have a more selective action on zinc and copper ores.

All kinds of tar products are used, such as blast-furnace oils, water-gas oils, and coke-oven oils.

The by-products of coal tar, such as thiocarbanilide, aniline, alpha-naphthylamine (X cake), xylidine, orthotoluidine, etc., are very important reagents. They possess remarkable selective properties and are used chiefly as collectors. Thiocarbanilide dissolved in orthotoluidine is the well known TT reagent, XY is X cake dissolved in xylidine, and TA is thiocarbanilide in aniline. These alphabetical reagents are patented by the General Engineering Company.

Petroleum Products

Both asphaltic- and paraffin-base fuel oils are extensively used. Kerosene is used in the flotation of graphite and molybdenite. They are good collectors but possess poor frothing property and must be used with some frother, such as pine oil.

Wood Products

There are two principal classes of wood oils, the distillation products of hardwood and the distillation products of the southern long-leaf pine dead wood.

Of the hardwood products the creosote oils are the most frequently used. They are good frothers and good collectors, and are used on copper, lead, gold, and silver ores. The ketones from the manufacture of acetone are good frothers but are expensive. Pine oils are obtained by steam distillation, and by the destructive distillation of the resinous dead pine wood of the southern United States. Steam-distilled pine oil is the most widely used frothing reagent. Turpentine destructively distilled is a good frother and has fine collecting properties. The creosotes, pine-tar oils, and resins are excellent frothers which strengthen the bubble films. They are also good collectors. The tar is also used. It is a heavy frother and a good collector. There are no softwood distillation plants in Canada.

Miscellaneous Flotation Reagents

A number of other products, such as xanthate, acetaldol, and fusel oil, are used in flotation. Potassium or sodium xanthate is one of the most important flotation reagents. It is of recent discovery but already has found its way into practically every flotation mill. Its collective and selective properties are very marked but, as it has no frothing power, pine oil or some other frothing reagent is always used in conjunction with it. The chief advantage of xanthate is that since it is less sensitive to variations in the ore and mill circuits than are oils less skill is required in operating.

ADDITION REAGENTS

These reagents can be divided into two classes, inhibiting and reactivating reagents, and reagents for sulphidizing oxidized ores.

Lime

Lime is an important reagent in flotation. It precipitates soluble sulphates which are present in some ores and which have a detrimental effect on flotation and neutralizes acid mine waters. Its principal use is as a depressant for sulphides of iron. For example, when lime is added to the flotation pulp chalcopyrite or zinc blende may be floated from pyrite and pyrrhotite. When added in excess the flotation of all sulphides is inhibited. The action is probably due to the formation of films of basic salts on the mineral particles. When the mill water is returned and used over again lime should be used with great caution, because, as stated previously, any excess will retard the flotation of all the sulphides, lead especially.

Sodium Carbonate and Bicarbonate

These are used for much the same purposes as lime, but their action is less severe. The carbonate is generally used when the ore contains sulphides of iron in large amounts, and the bicarbonate when the iron sulphide content of the ore is low. Their action as depressants on sulphides of iron is not great, but their great value in flotation arises from the property of increasing the difference between the relative flotation properties of two or more sulphides, such as zinc and iron sulphides, so that a sharper separation between the two minerals is obtained.

Sodium Cyanide

This reagent is one of the most valuable of all modifying reagents by reason of its effectiveness in preventing the flotation of zinc and iron sulphides. Galena and copper may be separated from zinc blende and pyrite by its action. In an alkaline circuit with lime or soda ash, the cyanide seems to produce films of hydroxides on the sulphide particles and complex cyanides in an acid circuit.

Sodium Sulphite and Thiosulphate

They are sometimes used for the same purpose as cyanide, that is, as depressants for zinc blende and pyrite.

Zinc Sulphate

Zinc sulphate is chiefly used to retard the flotation of zinc blende in the separation of galena and zinc blende, and chalcopyrite and zinc blende. It is sometimes used in the separation of galena from zinc blende in conjunction with cyanide and xanthate. A zinc xanthate is said to be precipitated on the galena, which is a better selective agent than the potassium xanthate.

Copper Sulphate

The use of copper sulphate is practically standard practice in the flotation of zinc blende. It has a strong promoting action on the blende. If cyanide or some other inhibiting agent has been used on the blende, copper sulphate reactivates it by cleaning up the surface of the particles.

PRINCIPAL REAGENTS USED IN FLOTATION

COAL TAR PRODUCTS

CANADIAN MANUFACTURERS	ANILINE	ANTHRACENE	BENZOL	CREOSOTE	CRESOLS (CRESYLIC ACID)	NAPHTHAS	NAPHTHA, CRUDE HEAVY SOLVENT	NAPHTHA, CRUDE LIGHT SOLVENT	NAPHTHA, SOLVENT	NAPHTHA, SPECIAL SOLVENT	NAPHTHALENE	NAPHTHYLAMINE, ALPHA-(X CAKE)	OILS, FLOTATION	PHENOL	PYRIDINE	TAR, COKE OVEN	TAR, GAS	TAR, WATER GAS	THIOCARBANILIDE (Z CAKE)	"THIO-FIZZAN"	TOLUIDINES	TOLUOL	XYLIDINE	XYLOL
ALGOMA STEEL CORPORATION, LTD. SAULT STE. MARIE, ONT.																O								
AMERICAN CYANAMID CO., NIAGARA FALLS, ONT.																								
THE BARRETT COMPANY, LTD. 2001-2021 ST HUBERT ST., MONTREAL, QUE.													O			O								
THE BISHOPRIC AND LENT CO., DUNKIRK, SASK.																								
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BROWN CORPORATION, LA TUQUE, QUE.																								
BRUNNER, MOND CANADA, LTD. ROOM 701, 137 MCGILL ST., MONTREAL, QUE.																								
CANADIAN ELECTRO PRODUCTS CO. LTD. POWER BLDG. MONTREAL, QUE.																								
CANADIAN GIANT LIMITED, VANCOUVER, B.C.																								
THE CANADIAN SALT CO., LTD. WINDSOR, ONT.																								
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COWAN, JOHN, CHEMICAL CO., LTD. 1-15 DALHOUSIE ST., MONTREAL, QUE.																								
THE DOMINION TAR AND CHEMICAL CO. LTD. CANADA CEMENT BLDG. MONTREAL, QUE.				O		O					O		O			O								
DYE AND CHEMICAL CO. OF CAN., LTD. KINGSTON, ONT.														O										
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THE STEEL COMPANY OF CANADA, LTD. HAMILTON, ONT.			O				O	O	O	O						O						O		O
THE TRIANGLE CHEMICAL CO. LTD. BOX 1011, NEW WESTMINSTER, B.C.																								
YOCUM FAUST, LTD. LONDON, ONT.																								

PETROLEUM PRODUCTS[1] (GASOLINE to PARAFFIN) and **WOOD PRODUCTS** (HARDWOOD CREOSOTES to TURPENTINE, CRUDE)

CANADIAN MANUFACTURERS	GASOLINE	GRAVITY FUEL OILS	KEROSENE	KEROSENE ACID SLUDGE	OILS, ASPHALT BASE, CRUDE	OILS, PARAFFIN BASE, CRUDE	PARAFFIN	HARDWOOD CREOSOTES	HARDWOOD KETONE OIL (FIZZOL)	HARDWOOD OILS	HARDWOOD TARS	PINE CREOSOTE	PINE OILS, DISTILLED	PINE TAR	PINE TAR OILS	ROSIN OILS	TURPENTINE, CRUDE
ALGOMA STEEL CORPORATION, LTD. SAULT STE. MARIE, ONT.																	
AMERICAN CYANAMID CO., NIAGARA FALLS, ONT.																	
THE BARRETT COMPANY, LTD. 2001-2021 ST HUBERT ST., MONTREAL, QUE.																	
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CANADIAN GIANT LIMITED, VANCOUVER, B.C.																	
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THE HAMILTON TAR PRODUCTS CO. LTD. HAMILTON, ONT.																	
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STANDARD CHEMICAL CO. LTD. 200 BAY ST. TORONTO 2, ONT.								O	O	O	O						
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THE TRIANGLE CHEMICAL CO. LTD. BOX 1011, NEW WESTMINSTER, B.C.																	
YOCUM FAUST, LTD. LONDON, ONT.																	

MINERAL PRODUCTS

CANADIAN MANUFACTURERS	ACID, HYDROCHLORIC	ACID, SULPHURIC	BARIUM POLYSULPHIDE	BLEACHING POWDER	CALCIUM CYANIDE	COPPER SULPHATE	FERRIC CHLORIDE	HYDROGEN SULPHIDE[1]	LIME[1]	POTASSIUM XANTHATE	SALT[1]	SODIUM BISULPHATE	SODIUM BISULPHITE	SODIUM CARBONATE (SODA ASH)	SODIUM CRESYLATE	SODIUM CYANIDE	SODIUM HYDROXIDE (CAUSTIC SODA)	SODIUM PERMANGANATE	SODIUM PHOSPHATE	SODIUM RESINATE	SODIUM SILICATE	SODIUM SULPHIDE	SODIUM SULPHATE (SALT CAKE)	SODIUM SULPHITE (SELECTO)	SODIUM THIOSULPHATE	SULPHUR	ZINC SULPHATE
ALGOMA STEEL CORPORATION, LTD. SAULT STE. MARIE, ONT.																											
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THE CONSOLIDATED MINING AND SMELTING CO. OF CAN., LTD. TRAIL, B.C.		O				O																					
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THE HAMILTON TAR PRODUCTS CO. LTD. HAMILTON, ONT.																											
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THE NICHOLS CHEMICAL CO. LTD. 285 BEAVER HALL HILL, MONTREAL, QUE.	O	O										O											O				
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THE TRIANGLE CHEMICAL CO. LTD. BOX 1011, NEW WESTMINSTER, B.C.	O	O																									
YOCUM FAUST, LTD. LONDON, ONT.													O														

MISCELLANEOUS

CANADIAN MANUFACTURERS	ACETALDOL (ALDOL)	"FUMOL"	FUSEL OIL[2]
ALGOMA STEEL CORPORATION, LTD. SAULT STE. MARIE, ONT.			
AMERICAN CYANAMID CO., NIAGARA FALLS, ONT.			
THE BARRETT COMPANY, LTD. 2001-2021 ST HUBERT ST., MONTREAL, QUE.			
THE BISHOPRIC AND LENT CO., DUNKIRK, SASK.			
BRITISH EMPIRE STEEL CORPORATION, LTD. CANADA CEMENT BLDG. MONTREAL, QUE.			
BROWN CORPORATION, LA TUQUE, QUE.			
BRUNNER, MOND CANADA, LTD. ROOM 701, 137 MCGILL ST., MONTREAL, QUE.			
CANADIAN ELECTRO PRODUCTS CO. LTD. POWER BLDG. MONTREAL, QUE.	O	O	
CANADIAN GIANT LIMITED, VANCOUVER, B.C.			
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DYE AND CHEMICAL CO. OF CAN., LTD. KINGSTON, ONT.			
THE GRANBY CONSOLIDATED MINING, SMELTING AND POWER CO. LTD. ANYOX, B.C.			
THE GRASSELLI CNEMICAL CO. LTD. HAMILTON, ONT.			
HAMILTON BY-PRODUCT COKE OVENS, LTD. HAMILTON, ONT.			
THE HAMILTON TAR PRODUCTS CO. LTD. HAMILTON, ONT.			
THE MOND NICKEL CO. LTD. CONISTON, ONT.			
THE NICHOLS CHEMICAL CO. LTD. 285 BEAVER HALL HILL, MONTREAL, QUE.			
SODIUM CORPORATION, LTD. 302 BAY ST., TORONTO, ONT.			
STANDARD CHEMICAL CO. LTD. 200 BAY ST. TORONTO 2, ONT.			
THE STEEL COMPANY OF CANADA, LTD. HAMILTON, ONT.			
THE TRIANGLE CHEMICAL CO. LTD. BOX 1011, NEW WESTMINSTER, B.C.			
YOCUM FAUST, LTD. LONDON, ONT.			

Prepared by D.M. Stewart.

1 Manufacturers of common commodities not listed.

2 Also manufactured by all firms making ethyl alcohol for industrial purposes.

Table I

II

ANTHRAXOLITE NEAR SUDBURY, ONTARIO

Hugh S. Spence

Deposits of a brittle, coal-like material, to which the name anthraxolite has been given, occur in the Chelmsford district, 15 miles west of Sudbury. Exception is sometimes taken to the term anthraxolite, as applied to the material of these deposits, it being held that analysis shows the pure, selected mineral to have the composition of a very pure anthracite coal. Occurrences of the material in this area have been known for over thirty years, and various attemps have been made to develop them as a source of fuel. It has even been claimed by promoters that the deposits contain enormous tonnages of material of high fuel value, and that they constitute the solution of Ontario's coal problem.

However, it would appear from investigations of the Federal and Provincial Mines Departments, that not only is the quantity of material in sight distinctly limited, but that its grade, considered as fuel, is low. While the fixed carbon content of selected samples has been found to be as high as 90 per cent, it is much lower in the run-of-mine material, the ash content of which runs as high as 35 per cent.

The origin of the anthraxolite has been the subject of much speculation. The theory most generally favoured is that it represents an alteration product of asphalt or bitumen, possibly distilled out of the enclosing black slates, under the influence of heat and pressure, and deposited on fractures in these slates. The slates, which have been assigned to the Animikie series of the Upper Huronian, were probably originally carbonaceous shales.

During 1926, the British Colonial Coal Mines of Canada had half a dozen men employed in mining operations on an anthraxolite occurrence on range I, lot 10, of Balfour township. The property lies 15 miles west of Sudbury, and 2 miles south of Larchwood station, on the Canadian Pacific railway. A side road of one mile connects it with the main highway from Sudbury.

The equipment comprised a portable, gasoline-driven compressor for operating the drills and hoist. An inclined skip-way serves the single pit, the latter being a shaft, 9 feet by 6 feet, put down to a depth of 150 feet on an incline of about 25 degrees, following two seams or veins of anthraxolite separated by a few feet of slate. The veins pinch and swell irregularly, from a few inches to as much as 9 feet, the average width probably being about 2 feet.

A small stock-pile of about 50 tons was stated by the mine foreman to represent the results of the year's mining to date (August 7th). Previous operations on this property, in 1921, produced 50 tons, which were shipped to Toronto to be sold for fuel.

III

ASBESTOS IN NORTHERN ONTARIO

Hugh S. Spence

During the past few years, interest has been shown in deposits of chrysotile asbestos in Deloro and Bannockburn townships, northern Ontario. The occurrences in Bannockburn township, near Mount Sinclair, are difficult of access and little development has been undertaken. In Deloro township, deposits have been found within a few miles of the town of Timmins, and the most important property can be reached by automobile from that point.

The latter property, that of the Porcupine Asbestos Corporation, lies seven miles south of Timmins and three miles south of the Ankerite gold mine. It was first actively worked in 1923 by Bowman Asbestos Mines, and in that year about 20 tons of crude fibre are reported to have been shipped. After lying idle for some time, the property was acquired in 1926 by the Porcupine Asbestos Corporation, which continued active development for six months. Mining was conducted by contract, forty men being employed, and a serious effort was made to prove up the deposit. Results, however, were not considered sufficiently encouraging to warrant further work, and operations were suspended in October.

The property is served by power line of the Northern Ontario Power Company. Mining equipment consisted of a 4-drill compressor and derrick-hoist. Waste was removed in 4-yard dump-cars on a trestle tram-line.

Operations have been confined to a single open pit, 80 by 60 by 50 feet deep, opened on an outcrop of dark green serpentine. The asbestos occurs mainly on several narrow, well-defined, almost vertical veinlets. Four such veins occur over a width of 25 feet on the east side of the pit. Outside of these veins, little asbestos can be seen in the rock, so that the output has been mostly crude fibre. The crude fibre was picked out in the pit and trammed to a cobbing-house for cobbing and grading, three grades being made, namely: No. 1 green (+ $\frac{3}{4}$ inch); No. 1 brown (+ $\frac{3}{4}$ inch); and No. 2 mixed (− $\frac{3}{4}$ inch). A small tonnage of mill-rock has been stock-piled, but none shipped.

The fresh asbestos from depth is light green in colour, but the weathered, surface fibre is brown. The quality of the asbestos is very high, being fully the equal of the best spinning grade, but has been mostly short fibre being less than $1\frac{1}{2}$ inches long. Comparative analyses of the asbestos from this property and from the Quebec field, made by the Milton Hersey Company of Montreal, showed:—

	Porcupine	Quebec
Silica	40·85	40·49
Alumina	0·60	1·27
Ferric oxide	1·02	2·53
Magnesia	41·40	41·41
Combined water	14·64	14·06
	98·51	99·76

IV

FELDSPAR IN THE SUDBURY REGION, ONTARIO

Hugh S. Spence

The interest in feldspar possibilities in the Sudbury region, noted in Mines Branch Report No. 616, published in 1924, has been maintained, and although certain of the first properties to be opened up have since been abandoned, a number of others have been taken up and worked more or less actively. Most of the mines lie adjacent either to the main line of the Canadian Pacific railway, between Sudbury and Mattawa, or to the Sudbury—Parry Sound sections of the Canadian Pacific and Canadian National railways. This region, in which are included portions of Sudbury, Nipissing, and Parry Sound districts, now furnishes a considerable proportion of the total feldspar mined in Canada.

The spar is predominantly buff to pale pink-coloured microcline. Although many of the deposits carry undesirable, accessory minerals, particularly muscovite and biotite mica, these as a rule occur segregated in zones in the dykes, enabling the feldspar to be won clean without an undue amount of cobbing. At certain mines, however, mica is scattered throughout the dyke mass and seriously interferes with the obtaining of a satisfactory product; at others, the dyke consists principally of graphic granite.

Dill Township, Concessions III and IV, Lots 1 and 2. This mine is owned and operated by Elizabeth Feldspar Mines, Ltd., of Toronto. It lies 12 miles southeast of Sudbury, and a few hundred feet from the track of the Sudbury-Toronto line of the Canadian Pacific railway, between Dill and Wanup stations. Cars are loaded from a pocket beside the company's siding at Mileage 115.

Mining was commenced early in 1925, and has been confined to a large inclined drift carried into a mass of pegmatite forming the side of a low knoll. The drift which is 150 feet long by 20 feet wide, and is open cut for the first 100 feet, terminates in a large chamber 50 by 50 feet and 25 feet high. The ore is drawn out on a skipway, carried on a trestle, and dumped into a cobbing-house equipped with crusher and picking-belt. This installation is unusual in Canadian spar-mining practice, and the property is believed to be the only one in Canada so equipped. The system was prompted by the character of the ore, which consists of a somewhat intimate mixture of feldspar and quartz, containing considerable amounts of both biotite and muscovite mica, and which, consequently, was not amenable to straight hand-cobbing methods.

The ore is dumped from the mine-skip onto a platform inside the cobbing-house, where a preliminary sorting takes place, as much quartz and mica as possible being culled out. The rock is then fed to a small jaw crusher and elevated to a picking-belt which has space for 12 pickers. The clean spar is picked off the belt and dropped into loading chutes discharging to tram-cars, which convey it to rail. The overs from the belt go to waste. The system followed is, in principle, somewhat similar to that used in Sweden, except that in Swedish practice, the picking operation is facilitated by washing and sizing of the ore before it passes to the belt.

V

GRAPHITE IN ONTARIO AND QUEBEC

Hugh S. Spence

The Canadian graphite industry continued dull in 1926, only two mines and mills being in operation. The operators were the Black Donald Graphite Company, near Calabogie, Ont., and the Canadian Graphite Corporation, near Guenette, Que. The last-named company has come into existence since the publication of Mines Branch Report No.511 dealing with the graphite industry. Both properties were visited late in the year, and the following notes made on the operations being conducted.

ONTARIO

Renfrew County

Brougham Township, Concession III, Lots 17, 18, and 19. Black Donald mine, owned by the Black Donald Graphite Company, Ltd., Calabogie, Ont. This mine has been in almost constant operation for the last thirty years, and has produced the larger part of the graphite mined in Canada during that period. The ore differs materially in character from that of other Canadian mines, the graphite of which occurs as disseminated flake in either gneiss or crystalline limestone. The Black Donald ore-body is a massive deposit consisting essentially of exceptionally pure, fine-grained, flake graphite, enclosed in white, crystalline, Grenville limestones. It dips at a steep angle, and attains a maximum width of 70 feet. The average graphite content of the ore is 65 per cent, with local enrichments up to 80 per cent.

Very little of the flake is coarse enough to grade as crucible rock. The gangue consists chiefly of chlorite and calcite. The flake occurs disseminated in a matrix of granular graphite which is classed as "amorphous" by the management. It is estimated that about 25 per cent of the total mill output consists of flake grades, the remainder being amorphous and dust products. There is no attempt made to produce crucible graphite, the output consisting of high-grade, lubricating and electrotyping flake, and foundry, grease, stove polish, and core wash graphites.

The mill treats 12 tons of ore per 24 hours. The milling system has been considerably altered and improved in recent years, and is now quite different from that described in Mines Branch Report No. 511. The adoption of flotation has enabled the carbon content of the different grades to be brought up very materially, and the flake produced is of superfine quality. Figures taken from the mine assay office records show the following averages for the various products made:—

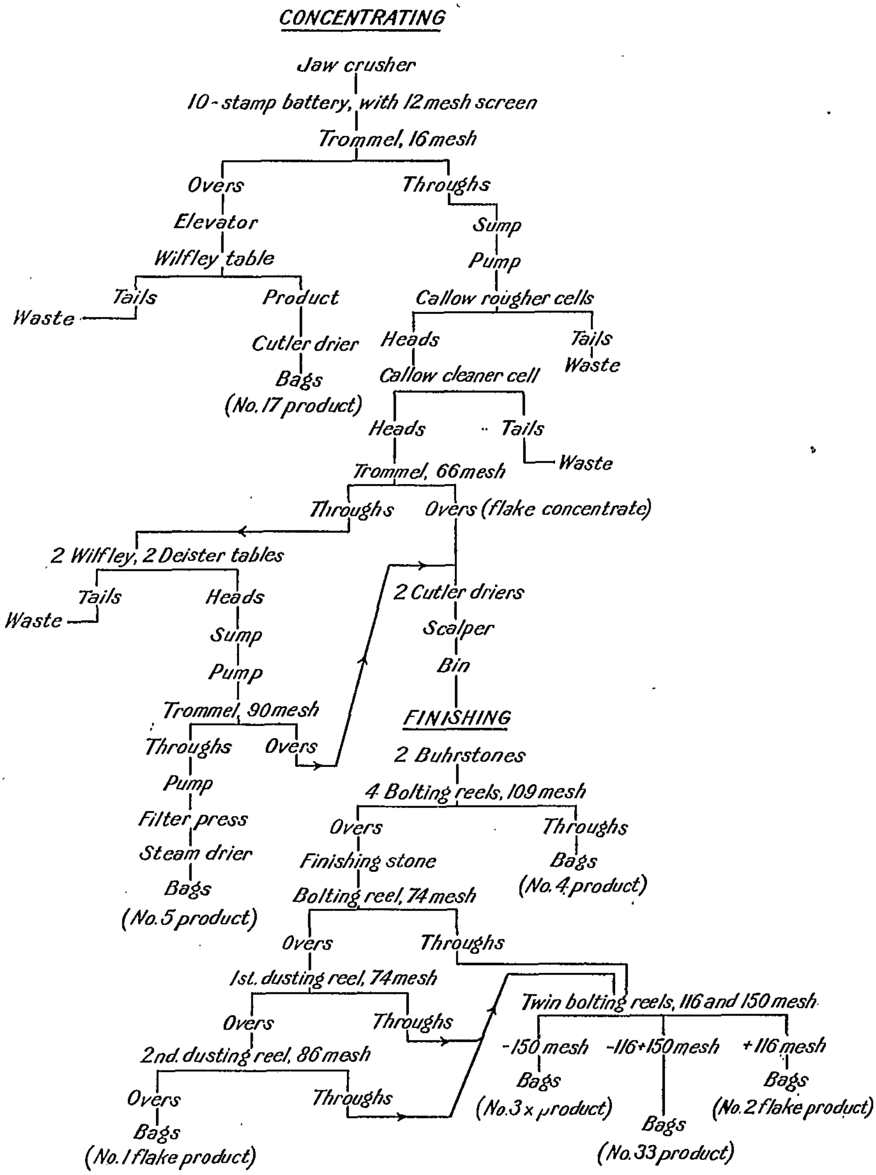

Figure 1. Flow-sheet of mill of Black Donald Graphite Company, Calabogie, Ont.

Product	Per cent carbon	Grades
No. 1	99·2	Lubricating.
No. 2	98·6	"
No. 33	96·2	"
No. 3x	89·5	Lubricating, and electrotyping.
No. 4	75·9	Foundry facings, high-grade greases, and stove polish.
No. 5	69·7	Foundry facings, low-grade greases, and stove polish.
No. 17	60·0	Core washes.

A flow-sheet of the mill is shown in Figure 1.

QUEBEC

Labelle County

Boyer Township, Range VI, Lots 29, 30, 31. This property lies 2½ miles from Guenette station, on the Montreal-Mont Laurier branch of the Canadian Pacific railway. It was opened up in 1922 by the Standard Graphite Company, which in 1924 was taken over by the Canadian Graphite Corporation, the present operators.

A short mine road connects the property with the Provincial highway over which shipments are made by motor truck to Guenette. A spur line from Guenette to the granite quarry of Brodie's, Ltd., on lot 37 of range VI, passes within a few feet of the mill building, and offers an alternative means of shipment.

The ore on these lots is of the disseminated type, and occurs as irregular bands or lenses in gneiss. In character and mode of occurrence it resembles that of the Buckingham district. The graphite content averages from 15 to 20 per cent. While scattered outcrops of graphite occur at a number of points on the property, no large ore-bodies have yet been encountered.

Mining has been confined to a number of shallow pits opened on top of a low ridge, distant a few hundred feet from the mill. Work is at present being conducted in the largest of these pits, which is about 25 by 30 feet and 60 feet deep. The ore-body here attains a width of 20 feet. Mining equipment comprises a small oil engine, which runs the compressor and hoist, and jackhammer drill. Ore is drawn to the mill by teams.

Large and well-equipped staff quarters and bunk-house were erected in 1926. Water for the mill is obtained from a small lake, one-quarter mile distant, from which a gravity flow is obtained. A 14-inch flume also leads from this lake to a turbine generator plant at the mill; this source of power is only available when the lake level is high.

The mill is a 3-storey building, with a capacity of 50 tons of ore per 24 hours. Power is supplied by a 120 h.p. Diesel engine.

The usual products are made, namely No. 1 and No. 2 flake, and dust. The management furnished the following particulars relating to these grades from the mine assay office records:—

Product	Carbon content	Proportion of output
No. 1 flake	93·0	65
No. 2 flake	86·0	15
Dust	82·0	20

A flow-sheet of the mill is shown in Figure 2.

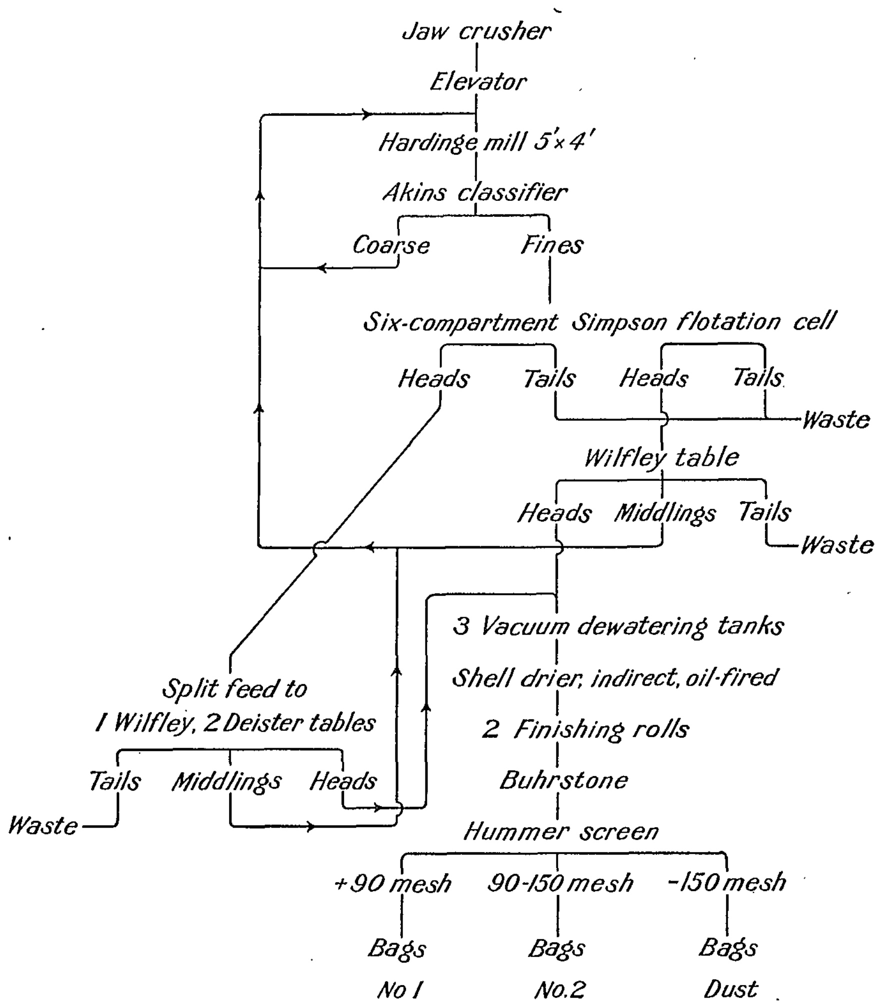

Figure 2. Flow-sheet of mill of Canadian Graphite Corporation, Guenette, Que.

VI

LITHIUM MINERALS IN SOUTHEASTERN MANITOBA

Hugh S. Spence

The discovery of an important deposit of lithium minerals in southeastern Manitoba was first reported in 1924. Since then, numerous references to this deposit and to other occurrences in the region have appeared in the press and in official reports. It is, therefore, not necessary to repeat here the information already available in the existing records, the chief of which are listed at the end of this section.

The discovery, in 1924, of lithium-bearing pegmatite on the property now under development by the Silver Leaf Mining Syndicate, was the first indication of the existence in Canada of deposits of lithium minerals

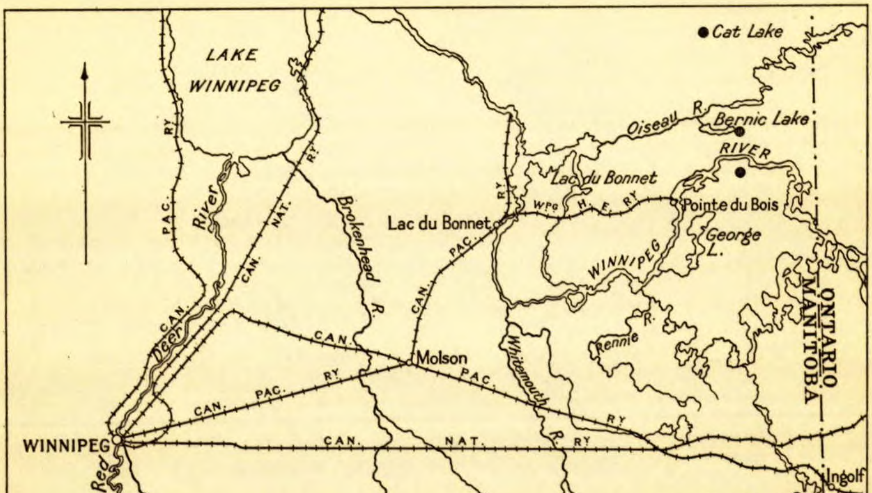

Figure 3. Occurrences of lithium minerals in southeastern Manitoba.

which might prove of economic importance. This discovery stimulated prospecting and, as a result, lithium minerals have been reported from a number of localities. These include Cat lake, 10 miles north of the Oiseau river, in township 19, range 15; Bernic lake, near the border of ranges 15 and 16, township 17; several claims near the original discovery point in township 16, range 16; and West Hawk lake, in township 9, range 17, all east of the Principal Meridian. Little other than prospecting work has yet been done on any of these properties, and the operations at the Silver Leaf mine constitute the only important development work carried out for lithia minerals.

In 1926, the Geological Survey placed an officer in the district to study and report on the geology of the lithium-bearing pegmatites.

In July 1926, the writer visited the property of the Silver Leaf Mining Syndicate, near Pointe du Bois, and the following notes were made on the operations of the company.

Silver Leaf Syndicate's Mine. Situated in township 16, range 16, 12 miles east of Pointe du Bois and about one mile south of the Winnipeg river. The property comprises two claims, each 1,500 by 1,500 feet, and is owned by the Silver Leaf Mining Syndicate, of Bradford, England, with Canadian office at 506 McIntyre Block, Winnipeg.

The company has erected two camps, one, on the Winnipeg river, 8 miles above Pointe du Bois, and the other at the mine, which lies 3½ miles farther to the east. A pole-line tramway, on which a gasoline locomotive

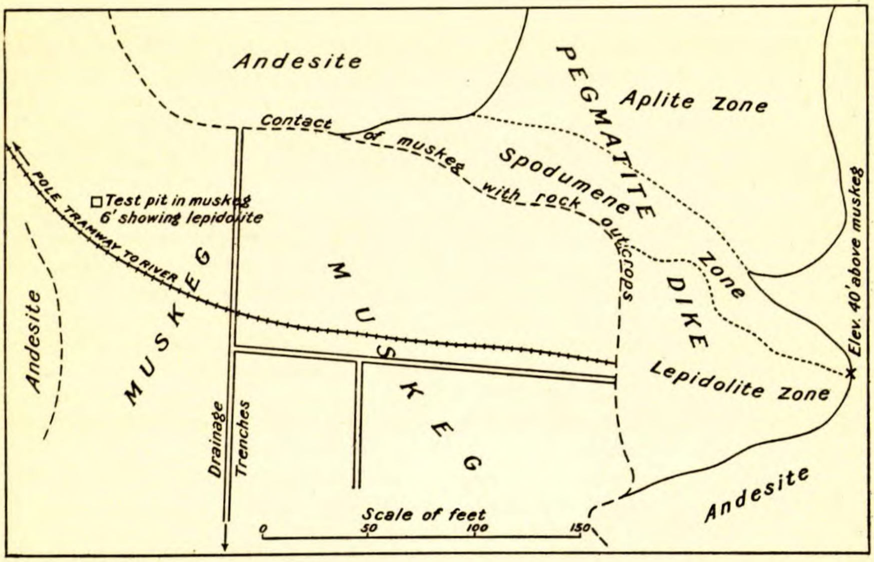

Figure 4. Sketch plan of property of Silver Leaf Mining Syndicate, Winnipeg river, Man.

is used, connects the mine with the lower camp, which is situated at the limit of river navigation, and from which point all shipments to and from the mine are made.

Beyond the initial development work conducted during the latter part of 1925, little further mining has been undertaken, and the work done in 1926 consisted mainly of drainage operations on the muskeg area that covers the extension of the ore-body to the west. Test holes through this muskeg cover have shown that the pegmatite mass persists for a distance of at least 300 feet from the present workings, and it was intended to drain this area and remove the overburden. Up to the time of the writer's visit, no mining equipment had been installed on the property. About 100 tons of lepidolite and the same amount of spodumene had been mined by hand-drilling, part of which was stock-piled at the mine and part at the river. Shipments up to this time had consisted only of sample lots for test purposes, but during the winter 1926-7, a carload of spodumene was consigned to Germany and a carload each of lepidolite and spodumene to an American glass-works.

The development work has indicated the existence at this point of a lithium-bearing pegmatite dyke of considerable size. The initial discovery was made on the west side of a low knoll, which slopes gently into muskeg. Stripping has disclosed a pegmatite mass, having a width at the base of the knoll of 75 feet and extending 125 feet up the slope. Test pits put down in the swamp on the strike of the ore-body have shown the pegmatite to extend at least 300 feet farther to the west, though no data have been secured regarding the width over this distance. Whether this portion of the deposit can be worked, depends on the results of the attempt being made to drain the swamp and enable the considerable peat cover to be stripped off.

All of the ore mined has been obtained by blasting out masses of clean lepidolite and spodumene that occur distributed irregularly throughout the dyke mass. Most of the work has been confined to the lower part of the hill, where the dyke is widest, and has proceeded bench-fashion up the slope. From a width of 75 feet at swamp level, the dyke gradually narrows up the hill, until at 125 feet, it pinches out completely into the andesite country rock.

The dyke mass consists principally of aplite, containing irregular masses of spodumene, lepidolite, quartz, and pink feldspar (albite). The two first-named occur as irregular zones or segregations of relatively clean mineral, the quartz and feldspar filling the interspaces between such zones. Most of the feldspar is in the form of slightly radiated, interlocking aggregates of short, thin plates or blades. This irregular intergrowth of small individuals tends to give the mineral a massively-fibrous appearance. Throughout the dyke occur stringers and small nodular masses of a dark mica (probably rabenglimmer, a variety of zinnwaldite). This mica is predominantly much coarser flaked than the lepidolite, the flakes being $\frac{1}{2}$ to $\frac{3}{4}$ inch across: like lepidolite, it contains lithia, but in rather less amount.

Spodumene is probably the most abundant lithium mineral in the deposit. It occurs as large masses of closely intergrown crystals, which are sometimes as much as 2 feet long by 1 foot through. The crystals seldom or never exhibit free faces or terminations. The mineral is grey to white in colour, and has a characteristic hackly or splintery fracture. Quartz is the principal mineral occurring closely associated with the spodumene, and cobbing of the latter is often necessary in order to obtain clean mineral.

The lepidolite occurs as a compact aggregate of small scales, averaging about $\frac{1}{10}$ inch across. In the mass, it possesses a reddish lilac colour. The ore contains very little in the way of admixed mineral, and the lepidolite zones yield practically clean material which requires no cobbing to make a shipping product. The lepidolite masses tend to occur distributed through the dyke mass adjacent to the south wall of the deposit, while the spodumene lies in the central portion and toward the north wall.

Amblygonite occurs in the deposit, but thus far has been found only in small amount, and only a few pounds have been obtained as specimen material. The amblygonite found here is reported to belong to the variety montebrasite.

Rare accessory minerals in the dyke are tourmaline, beryl, tantalite, topaz, and lithiophilite.[1]

Analyses

The lepidolite ore from the Silver Leaf deposit consists of a compact aggregate of small flakes of a maximum diameter of about $\frac{1}{8}$ inch. It was thought that possibly there might be some variation in the lithia content of the various-sized flakes, in which case it should prove practicable to effect some degree of beneficiation of the run-of-mine ore by crushing and screening. A representative sample of the ore was therefore taken from the stock-pile at the mine and analysed by the Chemical Division of the Mines Branch. Part of the same sample was crushed down, care being taken to effect as little breaking down of the flakes as possible. The crushed sample was then screened, so as to make the five fractions shown in the following table, and a lithia determination was run on each fraction. The results of the analyses, however, showed that there was little variation in the lithia content of the different-sized products.

Analyses Nos. 8 and 9 are of micas, other than the typical lepidolite ore, which occur distributed in minor amount throughout the pegmatite. No. 8 is a dark, greyish, fibrous-bladed mica, found in radiated aggregates, measuring up to 2 inches along the fibres. No. 9 is an exceedingly fine-grained, almost massive, mica, of a lilac-rose colour, found occasionally associated with the normal lepidolite: the low lithia and high potash content of this mica indicate that it is near muscovite in composition.

[1] Communication from C. H. Stockwell, Geological Survey, Canada.

Analyses of Lithia Micas from Manitoba[1]

	1	2	3	4	5	6	7	8	9
Lithia	2·9	3·5	4·1	4·1	4·0	4·0	3·7	2·0	0·5
Silica	52·4	52·1	....	....	....	....	....	46·2	47·6
Alumina	27·1	26·3	....	....	....	....	....	29·4	36·3
Ferric iron	0·3	0·4	....	....	....	....	....	1·4	0·1
Ferrous iron	....	nil	....	....	....	....	....	0·6	0·3
Magnesia	nil	0·3	....	....	....	....	....	2·1	nil
Lime	0·3	nil	....	....	....	....	....	nil	nil
Soda	2·6	3·2	....	....	....	....	....	0·5	trace
Potash	9·7	9·1	....	....	....	....	....	12·7	13·1
Fluorine	3·6	3·1	....	....	....	....	....	2·6	0·9
Manganese	0·3	0·9	....	....	....	....	....	2·1	trace
Water at −105° C.	....	0·3	....	....	....	....	....	....	....
Water at +105°C.	2·0	1·3	....	....	....	....	....	1·2	1·6
	101·2	100·5	....	....	....	....	....	100·8	100·4

1. Run-of-mine, lepidolite ore, Silver Leaf mine.
2. " " " "
3. " " −20 + 35 mesh fraction
4. " " −35 + 48 "
5. " " −48 + 65 "
6. " " −65 + 100 "
7. " " −100 + 200 "
8. Fibrous-bladed, dark mica (rabenglimmer), Silver Leaf mine.
9. Massive, rose-coloured muscovite (?) Silver Leaf mine.

[1] Analysis No. 1, furnished by Corning Glass Works, Corning, N.Y.; analyses Nos. 2 to 9, by E. A. Thompson and A. Sadler, Mines Branch.

With respect to the commercial grade of the spodumene and lepidolite from this deposit, a prominent American glass-works, to which representative samples of these minerals were furnished by the Mines Branch, wrote in April, 1927:—

> The samples of lepidolite were quite high in oxides of iron and manganese, which may make this material objectionable for use in glass because of the high colour which will be produced. The oxide of iron content was 0·25 per cent and the manganese 0·5 per cent. We found the sample of spodumene to contain 4·0 per cent of lithia, with practically no other alkali. This material was also very free from impurities of manganese and iron. If the run-of-mine is as good as the sample we tested, we believe it can be used to advantage in glass work in place of lepidolite.

Summary

The development work conducted thus far on this property indicates that there exists here a deposit of lithium-bearing minerals having interesting economic possibilities. It also suggests similar possibilities for the other deposits discovered in the region, that are as yet in the prospect stage.

While nothing can be said about that portion of the deposit (possibly the larger portion) at present concealed by muskeg, sufficient pegmatite is exposed above swamp level to permit of a large tonnage of rock being broken without interference by water. Whether the lepidolite and spodumene zones in this part of the deposit are large enough to permit of the simplest method of working, by quarrying back the breast of the dyke across its entire width, and discarding the intervening waste, remains to be demonstrated. Failing this, it will probably be necessary to run drifts into the face, following the lepidolite and spodumene zones and leaving the dead rock in place.

Before regular shipments can be undertaken, an improved system of transportation to the dock on the Winnipeg river will be required. The present pole tramway is only a temporary, makeshift device, incapable of handling any considerable tonnage. The swampy nature of the terrain to be traversed renders the maintenance of a more permanent tramway difficult and also makes impracticable the building of a wagon road that will be serviceable during the open season. For this reason, it may prove necessary to confine shipments to the winter months, using teams or tractor: this would enable ore to be transported the entire distance to rail at Pointe du Bois, by way of a winter road on the river, and doing away with the necessity of transhipment to and from scow, as at present.

Favourable freight rates are obtainable from rail-head at Pointe du Bois. According to advice from the Canadian Pacific Railway's Winnipeg office, the rates from the above point to Atlantic seaboard are $12.55 per ton to St. John, N.B., and $11.65 to Quebec. Allowing $2.50 for haulage from mine to rail, the total freight charges to the above ports would be $15.05 and $14.15 respectively.

Industrial Uses for Lithium Minerals

Following the discovery of lithium minerals in the Pointe du Bois region, research was undertaken by Winnipeg interests on a means of extraction of lithia from these minerals, the idea being to treat the ores near the point of production, and build up a local chemical industry. It is claimed that a satisfactory method of treatment has been worked out, and the process has been patented in Canadian patents Nos. 265,449, November 2nd, 1926, and 268,639, March 1st, 1927, issued to A. J. MacDougall.

Most of the world's production of lepidolite, the greater part of which is obtained in the United States, is employed in the glass industry. Manitoba lepidolite, for this purpose, will have to meet the competition of California and New Mexico mineral, in both of which States important deposits occur.

Spodumene and amblygonite are the raw materials for the manufacture of lithium carbonate, which is the basic lithium compound employed in the lithium salts and chemicals trade. The extraction of lithia from its ores is confined to a few important firms, with plants in the United States, France, England, and Germany. Most of the spodumene used by these firms is furnished by deposits in South Dakota, which State also produces a large proportion of the amblygonite used. The European supply of this latter mineral is derived principally from France and Spain.

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Fuchsite or Chrome Mica in Southeastern Manitoba

On sections 13 and 14, township 16, range 15, east of the Principal Meridian, the Silver Leaf Mining Syndicate has taken up three claims on which occurs a deposit of fuchsite, or chrome mica. Work was conducted for three months in 1926 on this deposit, and about 150 tons of ore were mined. Part of this was shipped to Winnipeg to be used as stucco dash, and part stock-piled at the company's dock on the Winnipeg river. The deposit lies only a few hundred yards distant from the dock.

The fuchsite ore consists of a compact aggregate of small flakes and has a distinctly schistose structure. In the mass, it exhibits a deep emerald-green colour. It occurs as a narrow band, having a width of about 6 feet, enclosed in granite gneiss, and is exposed in the face of a small knoll. Most of the exposed portion above ground level has been removed by quarrying back the rock face across the strike of the band, and further mining will have to be conducted by sinking on the ore-body.

Fuchsite is a relatively uncommon mineral, having no commercial uses outside of its possible employment, as in the present instance, for decorative purposes. This is believed to be the first recorded occasion that any mining of fuchsite has ever been undertaken.

An analysis of a representative sample of fuchsite ore from this deposit, made in the Mines Branch chemical laboratory, is given below, together with that of a hard, green compact material that occurs as a band bordering the fuchsite body. This band evidently consists mainly of quartz, through which is distributed fuchsite in varying amount: in place its colour becomes grey to almost white.

—	1	2
Chromium oxide	3·6	0·7
Silica	48·0	86·6
Alumina	30·5	7·8
Ferric iron	1·4	0·6
Ferrous iron	0·1	0·4
Magnesia	0·8	nil
Titanium oxide	1·7	nil
Soda	1·0	0·4
Potash	8·9	2·9
Water	3·9	0·4
Total	99·9	99·8

VII

THE CANADIAN SOAPSTONE INDUSTRY

Hugh S. Spence

Production of soapstone in 1926 took place at two localities: (1) Eagle lake, in the Lake of the Woods area, Ontario; and (2) Leeds township, in the Eastern Townships, Quebec.

Prior to 1922, little attention had been directed towards developing a domestic supply of soapstone, and the requirements of the sulphate pulp mills were met entirely by imported stone, most of which came from the United States. A small quantity was also obtained from Scandinavia. While Canada continues to import both American and Scandinavian soapstone, increasing amounts of domestic stone are being used, and there would seem to be no reason why the requirements of the kraft mills cannot be met entirely by Canadian stone.

Canadian pulp mills are estimated to use in the neighbourhood of 2,500 tons of soapstone per year. This stone is employed in the form of sawn blocks and bricks for lining the furnaces and driers used in the recovery of the alkali or black liquor from the digesters, and is the only natural product known that will satisfactorily resist the action of the molten alkali. Since the recovery of such alkali is of great import in kraft mill practice, it follows that soapstone is a very essential material to the pulp mill operators.

Production has grown from an initial output of 167 tons in 1922, to 1,411 tons in 1927, the bulk of the stone coming from the province of Quebec.

The increase in production indicates that the Quebec deposits yield a grade of stone that meets the requirements of the mills, and it should not be a difficult matter to increase the output so as to supply the entire market in eastern Canada. The Ontario stone also appears to be proving satisfactory.

It will be necessary for producers, however, to study consumers' requirements closely, if the industry is to progress satisfactorily. While these requirements are not unduly strict, and while there is a general disposition evidenced by the pulp trade to take domestic in preference to imported stone, certain main specifications have to be met. The chief of these are: (1) that the stone be sufficiently hard and compact to stand handling without breakage; (2) that it be free from quartz veinlets, rusty streaks, or joint-planes, that induce spalling in handling or under furnace conditions; (3) that the blocks and bricks be cut true to the specified dimensions; (4) that the grain of the stone lie parallel, or approximately so, to the long dimension of the block or brick (this prevents spalling inward in the furnace). Reports from many of the pulp mills indicate that the Quebec stone is fully equal in its refractory and alkali-resistant properties to imported soapstone, and that if the above specifications were observed, the users would prefer it to either the Scandinavian or Alberene stone.

A point worth noting is the wide diversity in the sizes of the blocks and bricks of soapstone used. It might be expected that furnace practice would have become so standardized that the demand would be for blocks and bricks of a standard shape and size. This is far from the case, and the necessity of sawing to so many individual specifications tends to complicate matters for the producer. A survey of a number of Canadian mills showed that the following sizes in furnace blocks are used by them:—

6 by 6 by 12 inches
6 " 6 " 18 "
6 " 12 " 12 "
8 " 8 " 18 "
9 " 12 " 13½ "
9 " 12 " 18 "
12 " 12 " 12 "
12 " 12 " 18 "

There is a similar wide variation in the sizes and tapers of soapstone bricks used in the furnace arches and for lining the drier shells. The producer has, therefore, to exercise great care in sawing and in keeping separate the various sizes of bricks made. He is unable, also, to stock up ahead of his contract with each mill, since he cannot be sure that the dimensions may not be changed on the next order.

Inquiry at the mills elicited the information that there is little likelihood of the trade adopting a limited number of standard sizes of blocks and bricks, owing to individual preferences for furnaces of different types and sizes.

The following is a list of the sulphate pulp mills in Canada, all of these mills using soapstone blocks and bricks:—

Bathurst Lumber Company, Bathurst, N.B.
Brompton Pulp and Paper Co., East Angus, Que.
Brown Corporation, La Tuque, Que.
Canada Paper Company, Windsor Mills, Que.
Dominion Paper Company, Kingsey Falls, Que.
Dryden Paper Company, Dryden, Ont.
Fort Frances Pulp and Paper Company, Fort Frances, Ont.
Pacific Mills, Ltd., Ocean Falls, B.C.
St. Maurice Valley Corporation, Three Rivers, Que.
Wayagamack Pulp and Paper Company, Three Rivers, Que.

In 1926, the prevailing price of soapstone blocks and bricks was $4.00 per cubic foot, laid down at the mills.

ONTARIO

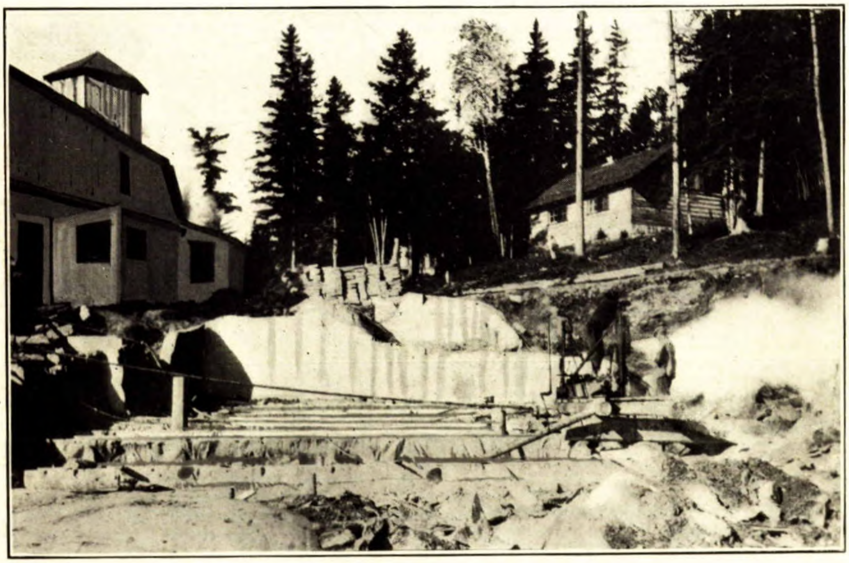
Soapstone has been reported from a number of scattered localities in Kenora and Rainy River districts, western Ontario. It is stated to occur, also, at various places around the north end of lake Winnipeg, in Manitoba.

In 1921, the writer examined a deposit of soapstone in Zealand township, near Dryden, and described the occurrence in two Mines Branch publications (Memorandum Series No. 4, and Report No. 588). The deposit was subsequently taken up by the Wabigoon Soapstone Company, which, however, has not proceeded with its development.

A. Outcrop of lithium-bearing pegmatite on property of Silver Leaf Mining Syndicate, Winnipeg river, Manitoba, looking east. Stock-piles of spodumene (left) and lepidolite (right) in foreground.

B. Looking west from top of knoll shown in Plate IA, showing muskeg area concealing extension of deposit. A test pit almost in line with the small knoll in the distance showed lepidolite.

A. General view of soapstone quarry of Grace Mining Company, on Eagle lake, Ontario. Sawing-shed is shown at left of pit.



B. Soapstone quarry of Grace Mining Company, Eagle lake, Ontario, showing bench method of working.

In 1923, another deposit about 15 miles southwest of the preceding occurrence, on an island in Trap lake, was taken up by Thermo-Stone Quarries, Ltd. This company produced no stone, and its interest was later acquired by the Wabigoon Soapstone Company.

The only locality at which active developments for soapstone have taken place is on Eagle lake.

Eagle Lake Deposit

This deposit is owned and operated by the Grace Mining Company. It is situated on the southwest shore of the lake, in unsurveyed territory, and lies 21 miles by water from Eagle River or Vermilion Bay stations on the main line of the Canadian Pacific railway. The company makes rail shipment of stone from either of the above points, to which the blocks are transported by scow.

Mining was commenced in 1924, and a sawing plant was installed.

A small quarry has been opened at the water's edge, upon what appears to be a belt of soapstone about 100 feet wide, having a trend of N. 30 degrees E. The wall-rock is a talc-chlorite schist, cut by granite stringers. The shore shelves gently up from the water, and the stone is cut out on 3-foot benches by a Sullivan channeler. Channeling proceeds at right angles to the apparent strike of the soapstone body.

The blocks are lifted from the pit by derrick and dropped onto small flat cars, which run directly into the sawing-shed. This shed is a large, substantial structure and contains three 15-foot gang-saws. Sand, obtained locally, is used to feed the saws.

The output of sawn stone consists entirely of blocks and bricks for furnace work. The blocks are cut to the dimensions specified by individual mills, chiefly 12 by 12 by 12 inches, and 12 by 12 by 18 inches. The bricks are mostly building-brick size. The long freight haul makes it difficult for the stone to compete with Quebec or imported soapstone in the eastern market, and the output thus far has been consigned chiefly to the nearby Dryden and Fort Frances mills.

The stone is light green in colour, of medium grain, and inclining to schistose in structure. It is very similar to Alberene stone in appearance, but is slightly harder. It is reported to give good service in kraft mill furnaces.

QUEBEC

The production of soapstone in Quebec commenced in 1922, when L. Cyr commenced development of a deposit on lot 4, range V, Thetford township, Megantic county. In the following year, Mr. Cyr formed the Robertson Soapstone Quarry Company, and this company has since conducted operations at several localities in the same district. In 1925, a deposit was opened up on lot 15, range XV, Leeds township, and the operations of the company are now confined to this property.

Much of the soapstone in the Thetford—East Broughton district of the Eastern Townships occurs as an an apparently persistent band which can be traced for some miles along the flanks of the hills on the north side of the valley, through which runs the Quebec Central railway. This band consists of a fairly coherent mass of finely foliated talc, rather than of material similar to the Ontario or Alberene soapstone. This talc mass exhibits a fissile structure, and blocks of the stone can be split readily into thin slabs having moderate structural strength. Such slabs, up to $1\frac{1}{2}$ inches in thickness, can be punched by the pick or hammer without breaking, and with only slight spalling around the holes.

In colour, the stone is a mottled, light greenish-grey. It is extremely uniform in grain, and is translucent in thin plates. It is quite soft and easily sawn.

Until recently, the stone has been broken out by drilling and blasting, with the result that an excessive amount of waste has been made, due to shattering in the quarry and the impossibility of securing blocks that would give a minimum of sawing waste. At the quarry at present being worked, the stone is cut out into roughly rectangular blocks by means of jackhammer drills.

The following notes on the various soapstone properties in the district were made in October, 1926. Except where noted, the whole of the operations have been conducted by the Robertsonville Soapstone Quarry Company.

Beauce County

Broughton Township, Range X, Lot 12; Range XI, Lot 12. A small pit was opened here in 1923, and yielded a few cars of cut stone. Work was discontinued in the following year and has not been resumed.

The quarry lies beside the road from Leeds station to St. Pierre de Broughton. The stone is very soft and consists essentially of translucent, fine-grained talc. It would grind to a first-class, off-colour grade of talc. Cobalt bloom was noticed in some quantity on joint-planes in the broken stone of the pit.

Megantic County

Thetford Township, Range II, Lot 12. This property is situated about one mile northwest of the village of St. Antoine de Pontbriand, and $4\frac{1}{2}$ miles from Robertson station, on the Quebec Central railway.

A band of soapstone has been opened up by a pit 25 feet deep, 40 feet wide and 175 feet long, following the strike of the band along the flank of a ridge. The stone exposed in the pit shows evidence of considerable crushing and is traversed by numerous thin seams of chlorite and small quartz stringers.

The property was worked in 1924, and 18 cars of stone are reported to have been shipped from it. It is now abandoned and all mining and sawing equipment has been removed.

Range III, Lot 12; Range IV, Lot 12. The same band of soapstone as worked on the preceding property extends across these lots, and was worked on a small scale in 1925 by Joseph Houlle, of St. Antoine de Pontbriand. Operations were discontinued after a couple of cars of cut stone had been shipped, and have not been resumed.

Range V, Lot 4. A small pit was opened on this lot in 1925, and several cars of cut stone were produced. The property is now idle and all equipment has been removed.

The stone is a clear, fine-grained, fissile talc, and forms a 20-foot band dipping into the hill-side. A large amount of stone on this and the adjoining property (see below) has been destroyed by the blasting methods of quarrying used. The stone is very similar on both lots, and consists essentially of light-coloured, greyish-green talc, that yields a fine grade of grey talc, when ground, and possesses high slip.

Range V, Lot 5. This property was described in Mines Branch Report No. 583, "Talc and Soapstone in Canada", and was worked a number of years ago in a small way for foundry talc. Since the above report was published, the property has been actively worked by the Robertson Soapstone Quarry Company, as one of its principal sources of stone in the district, until the company transferred its operations to its present quarry in Leeds township. In 1926, the company still had a few men engaged in sawing bricks with two portable, gasoline-driven saws, and several cars of cut stone were turned out. Most of this consisted of small-sized bricks, measuring 6 by 4½ by 2½ inches.

Several pits have been opened at this point, all on the same band of stone, that extends on to lot 4 and for several miles along the ridge on the north side of the valley through which runs the Quebec Central railway. All of the pits are shallow, open cuts, following the strike of the deposit.

Range V, Lot 9. In 1924, the Federal Asbestos Company opened a small pit here, a short distance to the north of its asbestos workings. The soapstone band is, apparently, the same as that worked on lots 4 and 5 in the same range, and the stone is similar in character.

Two cars of cut bricks were produced. There has been no further work conducted since 1924.

Leeds Township, Range XV, Lot 15. The operations of the Robertsonville Soapstone Quarry Company are at present centered upon this property. The distance to rail is 7 miles, shipment being made from Leeds station on the Quebec Central railway, to which point the stone is drawn by teams.

Development of this deposit commenced in 1925, and six pits have been opened. Five of these are small, shallow openings which have since been abandoned, work at present being confined to a single pit that has reached a depth of 30 feet and is 50 feet long by 20 feet wide. All of the workings are situated on a mass of soapstone that outcrops through a light overburden on more or less level, high ground.

The stone differs in character from that worked elsewhere in the district, being a fairly coarse-grained aggregate of foliated talc and lacking the fissile structure and even texture of the Thetford Township stone. It is harder than the latter, and stands handling better. In general appearance, it more nearly resembles the soapstone imported from Scandinavia. Near the surface, the rock exhibits rusty streaks, but these tend to disappear in depth and the quality of the stone improves. Thin quartz seams and small ankerite crystals are common in the stone, and occasional small pockets of coarsely-crystalline talc and calcite occur.

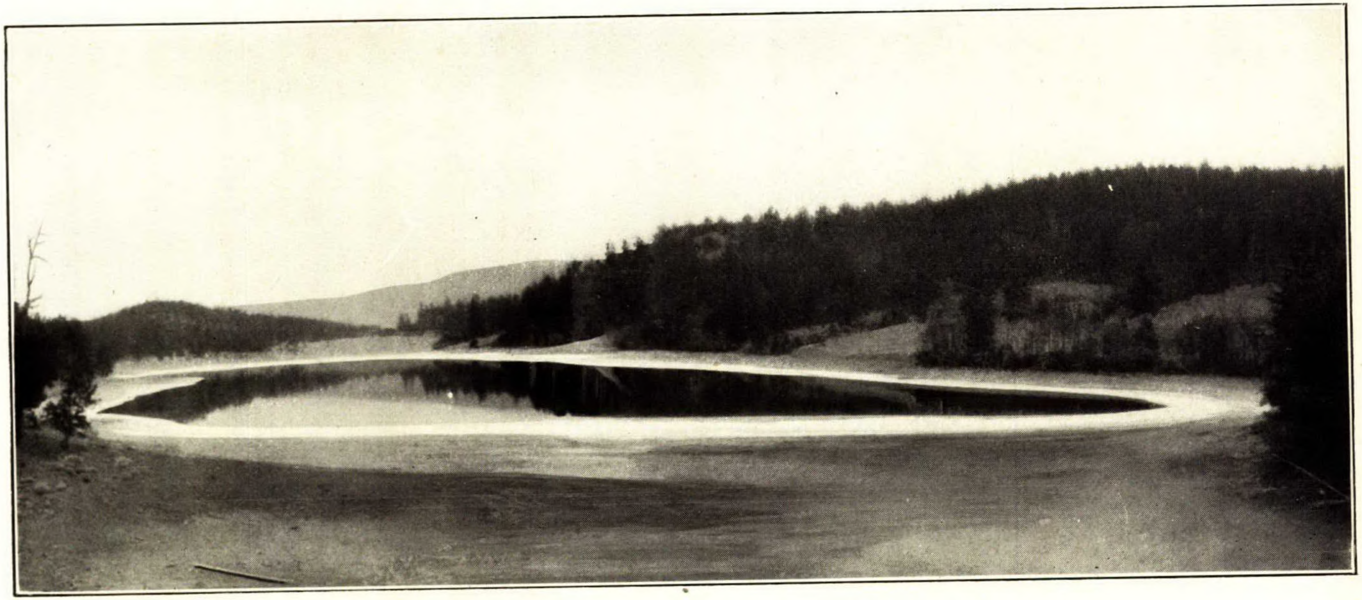
The present method of quarrying the stone is to cut out roughly rectangular blocks, up to a cubic yard in size, by means of jackhammer drills, but as soon as the pit has been opened up sufficiently to furnish a working-face, it is intended to install channeling equipment.

The stone is lifted out of the pit by derrick and swung directly into the sawing-sheds, of which there are five, arranged around one end of the pit. The sheds are small, temporary structures, each containing a single sawing unit, driven by individual gasoline engine. Each sawing bench is equipped with two circular saws and one straight, cross-cut saw; the latter is set below and in front of the bench, to cut the large blocks from the pit to a size small enough to be laid on the bench and sawn into blocks and bricks.

Twenty men are employed in quarrying and sawing. The total production of cut stone from the property, up to November 1926, is reported as about 37,000 cubic feet. The stone is sawn into blocks and bricks of the dimensions specified by the various kraft mills, and shipments have been made to most of the mills in eastern Canada. An attempt is also being made to market the fine dust produced in sawing, this dust being of a grade suitable for the roofing trade.

A. Quarry of Robertsonville Soapstone Company, range XV, lot 15, Leeds township, Que.

B. Type of portable, sawing equipment employed by Robertsonville Soapstone Company, Leeds and Thetford townships, Quebec.



Western end of Soap lake, B.C., looking northeast.

VIII

SODIUM CARBONATE AT SOAP LAKE, B.C.[1]

L. H. Cole

A small lake containing carbonate waters occurs in section 25, township 16, range 25 west of the 6th meridian, and approximately 7 miles by pack trail to the south of Spence's Bridge on the main line of the Canadian Pacific railway. The lake is on a plateau at an elevation of 2,000 feet (aneroid) above the level of the track at Spence's Bridge.

The lake which lies in a depression in rolling plateau country is completely surrounded by gently sloping hills and has no apparent outlet. The country is sparsely wooded with bullpine and fir and the slopes are well covered with grass during certain seasons of the year.

According to Drysdale[2] the rock formation of the surrounding hills belongs to the Kamloops Volcanic group of Lower Miocene age, and consists mainly of basaltic lavas and pyroclastics with younger mica andesites cutting them and forming coarse agglomerates in an andesitic matrix. The basalt in many places displays vesicular and amygdaloidal types. The amygdules are agates, well banded but pale in colour, and are generally oval-shaped. Zeolites, green chloritic material, rose quartz, and calcite (the latter intergrown with chalcedony) also fill the vesicles. The erosion of these rocks has strewn the shores of the lake with many agates and fragments of rose quartz.

The lake (*see* Figure 5) is over one mile long and 1,300 feet wide at its widest point, but in dry seasons it is rather a chain of lakes separated by alkali-covered mud flats, and when visited in August 1926, the eastern half of the lake was dry with a white incrustation of salts not more than an inch in thickness. Only the western end of the lake contained a greenish-coloured brine to a depth of 3 feet, underneath which a soft oozy mud occurred which could be penetrated by a pole to a depth of 10 feet.

The area of the western part of the lake in which the brine occurred was approximately 60 acres. The tonnage of the salts present in the brine will run 15,000 tons per foot in depth.

A spring of potable water flows out of the hill-side, 30 feet above the shore of the lake on the south side. As the season advances the shoreline recedes leaving an incrustation of salts surrounding the lake. No crystal bed was encountered in any part of the lake. Information as to whether the lake ever becomes completely dry was not available.

A sample of the brine from the centre of the western half of the lake was taken at a depth of 2 feet below the surface and analysed with the following results:—

[1] A comprehensive report on "Sodium Carbonate in British Columbia" by M. F. Goudge is given in "Investigations of Mineral Resources and the Mining Industry, 1924", Mines Branch, Dept. of Mines, Canada, Rept. No. 642, pp. 81-102 inc.

[2] Geol. Surv., Canada, Sum. Rept. 1912, pp. 142-143.

(Expressed in parts per million)

Potassium (K)	none
Sodium (Na)	60,018
Magnesium (Mg)	169
Chlorine (Cl)	2,439
Sulphuric acid (SO_4)	5,900
Bicarbonic acid (HCO_3)	10,697
Carbonic acid (CO_3)	67,700
	146,923

(Hypothetical combination—parts per million)

Magnesium chloride ($MgCl_2$)	672
Sodium chloride (NaCl)	3,195
Sodium sulphate (Na_2SO_4)	8,725
Sodium carbonate (Na_2CO_3)	119,603
Sodium bicarbonate ($NaHCO_3$)	14,728
	146,923

E. A. Thompson—Analyst.

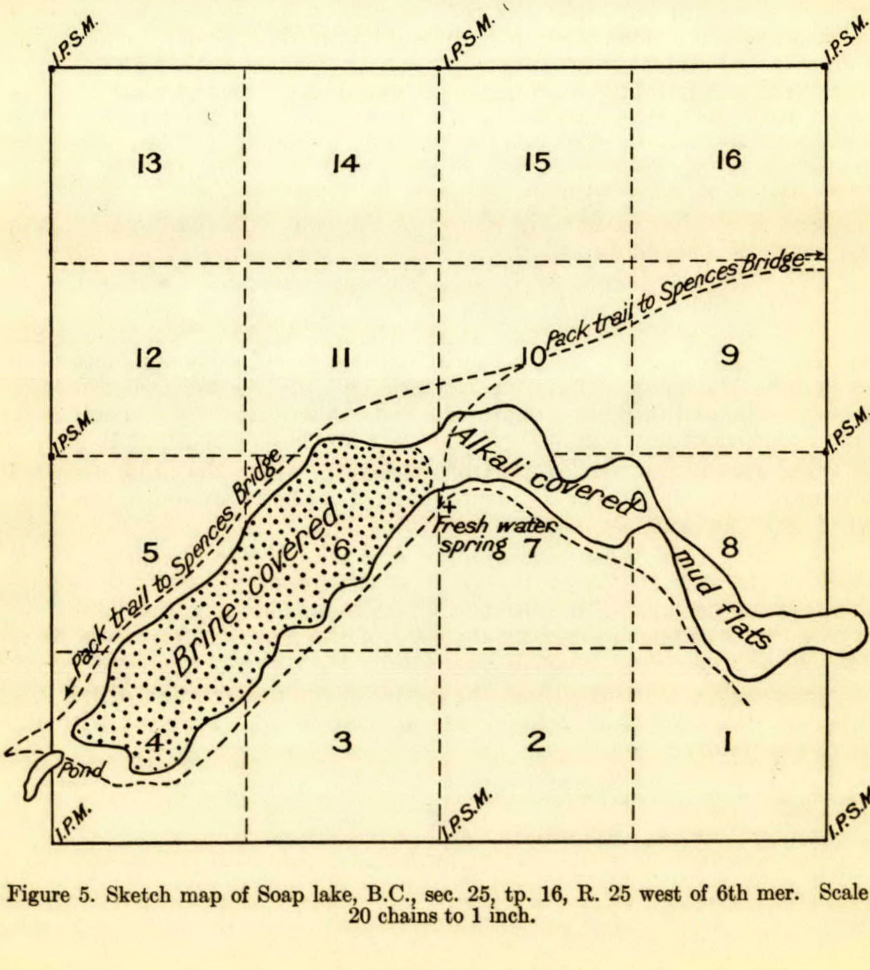


Figure 5. Sketch map of Soap lake, B.C., sec. 25, tp. 16, R. 25 west of 6th mer. Scale: 20 chains to 1 inch.

For purposes of comparison the following hypothetical compositions of a number of brines from other soda lakes in British Columbia and the brine from Soap lake, are given.[1]

(Expressed in per cent of total solids)

Constituents	1	2	3	4	5	6	7	8	9	10
Potassium chloride......	None	6·54	3·97	2·31	5·35	3·23	3·92	3·12	1·58	5·09
Potassium carbonate......	..None	....	....	....	....	....	....	....	....	2·66
Magnesium bicarbonate..	....	2·08	4·23	3·64	5·65	7·42	4·82	3·01	....	2·81
Magnesium chloride......	0·45	....	....	....	....	....	....	....	....	....
Magnesium carbonate.....	....	....	....	....	....	....	....	....	4·07	....
Sodium sulphate.........	5·93	6·87	0·39	26·05	5·52	2·33	2·23	0·17	0·98	....
Sodium chloride..........	2·17	3·19	3·96	6·58	6·52	16·23	6·97	4·57	4·38	....
Sodium bicarbonate......	10·03	14·16	4·94	3·78	4·78	6·83	11·51	11·85	....	3·75
Sodium carbonate........	81·42	67·16	82·51	57·64	72·18	63·96	70·55	77·28	88·99	85·69
Totals...............	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Specific gravity at 22° C..	1·161	1·108	1·091	1·146	1·104	1·104	1·115	1·108	1·121	1·059
Salinity per mille........	146·923	133·53	95·75	143·81	112·97	125·22	121·285	110·74	120·25	62·29

1. Soap lake. 2. Goodenough lake. 3. Safety lake. 4. Last Chance lake.
5. Rob and Nan lake. 6. Anita lake. 7. Lela lake. 8. Margaret lake.
9. Rose lake. 10. Porter-Hutchinson lake.

From these analyses it will be seen that the brine of Soap lake is very similar in composition to the soda lakes situated on the line of the Pacific Great Eastern railway to the north of Clinton.

Whether the salts from this lake are commercially recoverable at the present time is highly problematical mainly on account of the difficulty of transportation from the lake to the railway.

[1] Analyses Nos. 2 to 10 are taken from the report on "Sodium Carbonate in British Columbia" by M. F. Goudge, "Investigations of Mineral Resources and the Mining Industry, 1924" Mines Branch, Dept. of Mines, Canada, Rept. No. 642, pp. 81-102 inc.

IX

RECENT DEVELOPMENTS IN THE GYPSUM INDUSTRY IN BRITISH COLUMBIA

L. H. Cole

Deposits of gypsum have been known in British Columbia for many years and intermittent attempts have been made to operate several of them, but it is only within the past two years that any real progress has been made in the gypsum industry of the province.

The first claims were staked as early as 1894 when several areas were filed in the Salmon River district, about 40 miles southeast of Kamloops. These deposits are now known as the Falkland deposits. Two years later the first staking of the Spatsum deposits occurred, but the claims were allowed to lapse and were not re-staked until 1906. The Merritt deposits of gypsite were discovered around 1910 and similar deposits at Canford a few years later. The deposits in the vicinity of Mayook and Wardner were discovered only within the last few years.

Production of gypsum in British Columbia commenced in 1911, when 780 tons were shipped to Vancouver for use in the manufacture of cement. Since that time, production has been intermittent and the tonnages produced have been small until the year 1926 when they increased enormously, due to the extensive operations at Falkland and Mayook. The following table[1] shows the production in British Columbia since the first shipment in 1911.

Calendar year	Tons	Value	Calendar year	Tons	Value	Calendar year	Tons	Value
		$			$			$
1911	780	1,875	1916	.....	....	1921	40	100
1912	......	....	1917	10	20	1922	100	500
1913	200	1,300	1918	.....	....	1923	323	1,615
1914	......	....	1919	.....	....	1924	30	150
1915	......	....	1920	.....	....	1925	240	865
						1926	20,916	156,964

Within the past year (1926) extensive work has been done on both the property at Falkland and the Sunrise claim at Mayook, and the regular shipments from these two properties have given the gypsum industry in British Columbia the most promising outlook it has yet had.

OPERATING PROPERTIES

Falkland Deposits[2]

The Falkland deposits, formerly known as the Salmon River deposits, are located in township 18, range 12 west of the 6th meridian, and are owned and operated by the British Columbia Gypsum Company. The

[1] Dominion Records.

[2] A full description of these deposits, before they were taken over by the B.C. Gypsum Co., is given in Report No. 245 "Gypsum in Canada", Mines Branch, Dept. of Mines, Ottawa, Canada, pp. 91-95 inc. (1913).

distance from Kamloops is approximately 40 miles in a southeasterly direction and the Canadian National Railway branch line from Kamloops to Vernon affords transportation facilities to the property.

The gypsum occurs on the side of a hill facing south and the quarry has been opened up at an elevation approximately 500 feet above the level of the railway. The rock is a massive, opaque white to translucent gypsum with occasional lenses of grey gypsum and minute crystals of pyrite. Anhydrite is present in small amounts.

The following analyses of samples taken from this property serve to show the character of the rock:—

—	1	2	3
CaO	32·60	32·60	31·77
SO_3	46·87	46·67	46·14
H_2O	20·80	20·40	16·79
Insol	0·06	0·04	3·74

1. This sample was taken from the face of the tunnel driven 40 feet into the face of the hill to the east of the present quarry. Mines Branch, Dept. of Mines, Canada, Rept. No. 245, p. 104.
2. Taken from the sides of the same tunnel as sample No. 1. Mines Branch, Dept.of Mines, Canada, Rept. No. 245, p. 104.
3. Quartered sample of 500 pounds of run-of-quarry, January 1927.

Work was started on these deposits on June 10, 1925, and the first shipments of crude gypsum were made early in January 1926.

The rock is won by open quarrying as shown in Plate VA. A working-face of over 60 feet has already been obtained. Very little overburden has to be contended with, and consists chiefly of from 2 to 3 feet of surface soil and impure gypsite.

The broken rock is placed in 1-ton steel dump-cars and trammed to the top of the 50-ton bin at the upper end of the gravity aerial tramway. At the quarry there is a 20 h.p. gasoline driven compressor which supplies air to the necessary jackhammer drills needed in the quarry. The aerial tramway (Plate VB) is 3,500 feet in length, with 14 buckets, each of ½-ton capacity.

At the railway terminal of the tramway there is a 200-ton storage bin as shown in Plate VIA.

Shipments at the rate of 2 carloads per day have been maintained since the deposits were first opened. The ore goes to the company's mill at Port Mann, B.C., as well as to the British Columbia Cement Co., Victoria, B.C.

When received at the mill the rock is first crushed by jaw crushers, then ground to 100 mesh in a battery of burr mills, after which it is calcined in stationary, circular calcining kettles. From the calcining kettles it passes through screens to remove oversize material and is then prepared into the several grades of wall plaster, or else it is employed in the plaster board mill where standard grades of plaster wall-board are made.

The products from this mill find a ready market in the province, and an export market to New Zealand, Australia, Japan, etc., is rapidly developing.

Mayook Deposits

Within the past five years gypsum deposits of considerable extent have been discovered 10 to 15 miles southeast of Cranbrook, B.C., the more important claims being in the Mayook, Wardner (Chipka creek), and Bull River areas.[1] At the present time, production is confined to the Mayook area, where the Canada Cement Company has opened up the Sunrise claim, situated on the north side of the highway between Cranbrook and Mayook and about $\frac{3}{4}$ mile west of Mayook station on Crow's Nest Pass line of the Canadian Pacific railway.

The gypsum deposits on the Sunrise claim occur in steeply dipping beds between limestone of Carboniferous age and is, in all probability, formed from the limestone by sulphate waters coming up from below. The purity of the gypsum thus depends on the purity of the original limestone. The strike of the gypsum beds is approximately south to a few degrees to the west of south, and they dip steeply from 60 to 70 degrees to the east. A quarry has been opened up about 100 yards to the north of the highway above mentioned, and pits have been dug exposing gypsum 90 feet above the level of the quarry on the top of the ridge. The lateral extent of the gypsum has not yet been fully proved, but test pits have shown it to extend for 600 yards at least.

The gypsum rock varies in colour from a dark grey to a creamy white, some of it being quite soft and granular. Fragments of limestone, only slightly altered, are occasionally found in the gypsum.

A quarry, Plate VIB, has been opened up for a length of 100 feet with a face of 15 feet. Drilling is done by hand and the broken gypsum is loaded into wagons and hauled to the railway. When this property was visited in August 1926, shipments at the rate of from 2 to 3 carloads a week were being made to the plant of the Canada Cement Co., at Exshaw, Alberta, where it is employed as a retarder in the manufacture of cement.

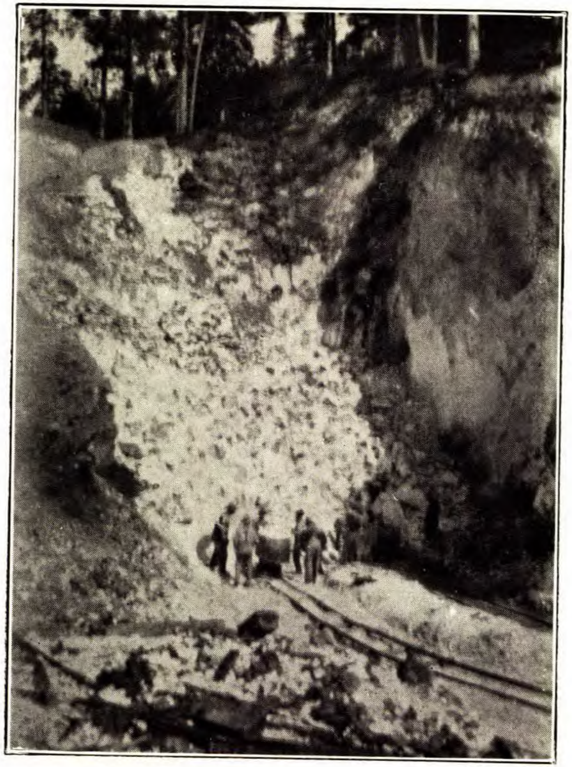
MARKETS

The gypsum industry in western Canada has been showing steady improvement during the past two years. This development was to be expected in view of the increasing activity in the building trades.

Heretofore, the demand for gypsum and gypsum products in British Columbia has been met by shipments from Manitoba together with a small local production of the crude rock for use in the cement industry. There was also a small import of various grades of calcined plasters.

With the advent of the British Columbia Gypsum Company as a producer of all grades of calcined plasters and plaster board, as well as the steady operation of the Mayook deposits, the gypsum industry in British Columbia has made great advances in the past year, and with the prospects of an increasing export trade to the Orient as well as New Zealand and Australia, British Columbia gypsum deposits should show a steady development in the years to come.

[1] A more detailed account of the gypsum deposits of these areas together with analyses will be given in a later report.



A. Quarry of the British Columbia Gypsum Company at Falkland, B.C.

B. Aerial tramway of the British Columbia Gypsum Company at Falkland, B.C., quarry on sidehill in distance.

A. Storage bins and shipping terminal of the British Columbia Gypsum Company at Falkland, British Columbia.

B. Gypsum quarry on Sunrise claim, Canada Cement Company's property near Mayook, British Columbia.

X

MANITOBA AS A MINING PROVINCE

A. H. A. Robinson

Up to the present, Manitoba, the most easterly of the Prairie Provinces, has been generally regarded as essentially an agricultural one, an assumption that, though perfectly true of its settled southern plains, is not applicable to its northern districts, in which forest products and minerals are the most important natural resources. Of the 251,832 square miles of land and water area included in the province, the 168,000 square miles added by the extention of the provincial boundaries in 1912, as well as that portion of the older part of the province lying between lake Winnipeg and the Ontario boundary, is largely a country of rock and forest, underlain by the same ancient crystalline rocks that have been so productive of metals in Ontario and Quebec. The southern plains area is underlain by younger sedimentary rocks that yield only non-metallic useful mineral products, but, since this is the area in which the population is massed, on the agricultural lands, it has so far been the chief seat of such mineral industries as the province could boast, i.e. the production of building materials and other non-metallic mineral commodities.

In the older settled part of the province probably the first mineral industry was the extraction of salt from brine springs on the west side of lakes Winnipeg and Winnipegosis to supply the early trading posts and settlements, an industry that is now extinct. As the communities grew the quarrying of building stone and the burning of lime became lucrative, and these are now among the most important mineral industries of the province. Tyndall limestone is one of the most attractive, and possibly the best limestone produced for building purposes in Canada, either for dimension stone or interior finish. It has been marketed as far east as Quebec city. The quarrying and burning of gypsum, now next to the manufacture of cement the most important mineral industry in Manitoba, was started at Gypsumville in the late eighteen-nineties. Brick-making and the manufacture of Portland and natural cements is largely a development of the present century.

In so far as metal mining is concerned, sustained active interest in the province's possibilities in this direction is a matter of little more than the last fifteen years. No doubt a certain amount of prospecting was done in the southeastern part, in the country contiguous to lake of the Woods, in the eighteen-nineties, at the time that mining excitement ran high, in the adjoining part of Ontario, but this produced no permanent results, and it was not until the impetus given to prospecting throughout the Canadian Shield by the development of wonderfully rich silver and gold mines in northern Ontario, during the first decade of the present century, had spread westward to Manitoba that the foundations for a metal mining industry were laid there.

Systematic search for minerals began in 1907 in the country north of The Pas, in what is now known as The Pas mineral belt, and these resulted in discoveries at Wekusko (Herb) lake in 1914, at Flin Flon and Mandy in 1915, followed by a number of others since. East of lake Winnipeg, gold was discovered at Rice lake in 1911; since that date prospecting has been more or less continuous and the boundaries of the known metal-bearing areas have been considerably extended. At the present time there are two chief centres of interest to mining men, i.e. the Flin Flon mine and the adjacent territory north of The Pas, and the country surrounding the Kitchener mine in the Long—Bulldog Lakes area east of lake Winnipeg.

Actual production of metals in Manitoba commenced in 1917, the official record up to date being as follows:—

Metal Production of Manitoba, 1917-1926

—	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926*
Copper....Lb.	1,116,000	2,339,751	3,348,000	3,062,567	......	......	......	......	......	......
Gold......Oz.	440	6,755	724	781	207	156	31	1,180	4,424	188
Silver......Oz.	7,201	13,316	20,760	15,510	33	20	5	140	582	27
Tungsten concentrates.Lb.	....	177	....	....	......	......	......	......	......	......

*Figures subject to revision.

The copper, as well as most of the silver and gold, from 1917 to 1920, was obtained from a rich ore-body on the Mandy mine in The Pas district, that high metal prices, during and immediately after the war, made it profitable to work in spite of the heavy cost of transportation and supplies due to the somewhat inaccessible situation of the deposits. Some 25,000 tons of ore having an average recoverable value of $91 were mined, hauled in winter 40 miles on sleighs, then in summer 130 miles farther by barge to the railway at The Pas, and thence by rail to Trail, B.C., to be smelted. Though the high-grade ore on the Mandy is now all worked out, the handsome profits made despite heavy handicaps during its short period of operation focussed the attention of mining men on the possibilities of the district and have no doubt served greatly to stimulate the efforts now being made to devise means for the profitable working of other ore-bodies of similar mineralogical composition, but lower grade, that occur in the vicinity.

The small annual gold and silver production since 1920 has all been derived from material obtained in the course of exploration on various properties. At one time or another small gold mills have been in operation on the Luleo property in the Wanipigow River area; on the Gold Pan property at Gold lake; the Penniac property at Star lake; the Webb property at Elbow lake; and the Rex and Bingo properties at Wekusko, or Herb, lake. At the present time, however, the greatest promise of continuous gold production in considerable amount is afforded by the Long—Bulldog Lakes area in eastern Manitoba, where arrangements are about completed for bringing into production the first commercial body of gold-bearing quartz to be developed in Manitoba. This is on the Kitchener property of Central Manitoba Mines, Ltd.

Central Manitoba Mines, Ltd. is an amalgamation of the interests of the "WAD" Syndicate, an exploration company backed by Winnipeg and Boston capital, and of Anglo-Canadian Explorers, Ltd., a British concern controlled by the well-known mining firm of John Taylor and Sons, London, England. The company's property lies about 125 miles northeast of Winnipeg near Long and Bulldog lakes, and consists of 52 claims and fractions covering almost 1,500 acres. The management of the property is in the hands of John Taylor and Sons. The main ore-body has been explored to a depth of over 500 feet by a shaft and winze sunk on the Kitchener claim, from which levels have been driven at depths of 125, 250, and 375 feet. A report made on the property by Mr. Thomas Pryor for John Taylor and Sons in the fall of 1926, gives the main ore shoot on the Kitchener a length, on the surface, of 906 feet, a width of 5·1 feet, and an average value of $11.45 in gold per ton. At the same time ore reserves indicated by surface and underground work were estimated by the company's engineers at 112,589 tons carrying $9.67 in gold, and by outside engineers at 73,324 tons carrying $14.86 in gold per ton, the total gross value in either case being approximately $1,100,000. In February 1927, it was reported that development work had shown that the main ore shoot was considerably longer underground than on the surface; drifting on the 375-foot level having proved it to be at least 1,500 feet long. Values are also said to have proved higher than expected, so that the indicated gross value is now considerably greater than that given above, though no formal estimate of reserves has been made since October 1926.

In view of the success attained in the development of ore reserves, the building of a mill was decided late in 1926, and the necessary materials and supplies for this purpose were taken into the mine during the winter of 1926-27 over the snow roads, a distance of 55 miles from the end of steel at Great Falls on the Winnipeg river. The ore will be treated by standard cyanide methods, and the mill, which will have an initial capacity for the crushing of 300 tons and the cyaniding of 150 tons of ore per day, will, it is expected, be in operation by October 1927. Provision is made to increase the capacity of the mill when and as warranted by increase in ore reserves. The company also has a sawmill on the mine for cutting their own lumber.

Hydro-electric power for mining and milling purposes is being supplied by the Manitoba Power Company over a transmission line about 55 miles in length from their generating station at High Falls on the Winnipeg river to a sub-station on the Kitchener mine. Power from this line will also be available to other properties in the district and thus one of the more serious of the handicaps under which it has laboured has been removed.

As for transportation, standard gauge railway connects Winnipeg with Great Falls, whence most of the supplies for the district are taken in during the winter months, by team, over excellent snow roads. In summer a much longer, combined water and wagon route via Riverton on the shore of lake Winnipeg is used. An automobile road that will give ready access to the district at all seasons of the year is being mooted. The building of a railway into the district, however, will probably have to wait until developments promise sufficient traffic for its profitable operation.

At Flin Flon mine, the second centre of mining activity in Manitoba, the position of affairs differs somewhat from that east of lake Winnipeg. At the Kitchener and neighbouring gold-quartz properties ore treatment offers no technical difficulties, and permanent success is dependent on the discovery and development of further commercial ore-bodies, to which end the efforts of the operators is consequently now chiefly directed. At Flin Flon, on the other hand, very large ore-bodies have already been proved by diamond-drilling. The ore, however, is a low-grade and complex mixture of zinc and copper minerals carrying small values in silver and gold, the successful exploitation of which awaits the development of a process for their separation and recovery that can be operated commercially under the conditions of comparative isolation under which they occur. Large-scale experiments with this end in view are now under way.

The ore reserves developed on the Flin Flon by diamond-drilling and shaft development amount to some sixteen million tons carrying, on the average, 1·68 per cent copper and 3·49 per cent zinc, together with 0·074 ounce gold and 1·04 ounces silver per ton. A pilot plant financed by the Henry P. Whitney interests of New York is now at work on the property trying out, on a large scale, processes developed in the laboratory by the Minerals Separation Company, for the treatment of this type of ore. Over $500,000 is said to have been spent on this preliminary plant and incidental work, the materials for which had to be transported 160 miles by summer route or 87 miles by winter road from the end of steel to the mine. It is expected that it will be possible to reach a decision as to the feasibility of commercial operation before the end of 1927, a decision that, if favourable, will mark the beginning of a new era in the history of mining in Manitoba.

Success at the Flin Flon pilot plant will be immediately followed by preparations for commercial operation, the financing for which has already been provided for, and since the working of low-grade complex ore of the Flin Flon type can only be carried on profitably on a very large scale the preliminary expenditure will be heavy. This will include in addition to the cost of the reduction and mining plant, and of the underground workings necessary to maintain a sufficient supply of ore for the works, the construction of a railway probably 85 miles in length to connect the mine with the present railway at The Pas. The bonds for this railway are being guaranteed by the provincial Government of Manitoba. The total initial expenditure necessary to bring the property into production is estimated at about $12,000,000.

The importance of a successful outcome to the Flin Flon experiments to the people of Manitoba, rests less on the immediate expenditure of a considerable portion of this large sum in their midst, than it does on the fact that there will be established in their province a large mining and metallurgical industry, for which long life is assured by known ore reserves. To the people of Canada it means a new and important addition to the older and already famous productive mineral districts.

Exploitation of the Flin Flon would also, without doubt, lead at once to the active development of a number of other known occurrences of a similar nature throughout The Pas mineral belt: to the working out of the remaining 180,000 tons of low-grade ore in the Mandy mine, 4 miles to the southeast; to the further development of the copper-zinc deposits at Kississing, or Cold lake, about 40 miles to the northeast; to the further exploration of similar deposits on the Baker-Patton properties, 11 miles to the east, as well as to renewed intensive prospecting throughout the province. Needless to say that under these circumstances the progress of the experiments being carried out at Flin Flon is being followed with interest, and a decision as to whether or not the deposits can be profitably worked under present-day economic conditions is eagerly awaited by mining men throughout Canada.

XI A

PRELIMINARY REPORT ON THE LIMESTONES OF NOVA SCOTIA AND NEW BRUNSWICK

M. F. Goudge

The general survey of the limestones of Canada, begun in 1925, was continued during the field season of 1926. The greater part of the summer was spent in gathering data on and samples from the limestones in Nova Scotia, New Brunswick, and Gaspe. Prince Edward Island has not yet been visited, but no limestone of commercial value is known to occur in that province.

Very few analyses of the samples obtained were completed at the time of writing this summary report, but they will be included in a final report on the subject which will be issued later.

Acknowledgment is gladly made of the assistance received from the reports and maps of Faribault and Fletcher, dealing with Nova Scotia; and to those of Ells, Bailey, and Matthew, dealing with New Brunswick and Gaspe.

The thanks of the Mines Branch are due to the officials of the British Empire Steel Corporation at Sydney who very kindly allowed the writer access to their records containing hundreds of analyses of Nova Scotia limestones.

H. K. Sandford was field assistant during the greater part of the season and fulfilled his various duties in a satisfactory manner.

THE LIMESTONES OF NOVA SCOTIA

Limestones of commercial importance in Nova Scotia are of Precambrian or Carboniferous age. Isolated occurrences of Ordovician, Silurian, and Devonian limestones are known, but, with the possible exception of one occurrence, noted later on, they are of little value. Precambrian limestones are found in large quantities on the island of Cape Breton, but are not known to occur on the mainland. Carboniferous limestones are common both in Cape Breton and the eastern part of the mainland. No limestone of commercial quality or quantity has been found in that part of the province west of a line from Windsor to Chester.

Precambrian Limestones

Limestones are not found throughout the entire Precambrian formation, but are confined mostly, if not entirely, to that division known as the George River series. This series consists chiefly of crystalline limestones, quartzites, and slates, all of which have been intruded by granite and gneiss and cut by diabase dykes. The limestones are commonly exposed over large areas, and they vary widely in appearance, quality, and composition, the colours ranging from white to blue, the texture from fine-to coarse-grained, and the composition from high-calcium to dolomite. An unfortunate feature is the variation in content of magnesium which commonly occurs to a marked degree without in any way affecting the outward appearance of the stone; this makes the quarrying of stone of uniform composition very difficult. The stone is much fractured and secondary jointing is common. The visible impurities, aside from bands of slaty rock, are chiefly mica, serpentine, tremolite, quartz, and occasionally pyrite and hematite. These impurities are, as a rule, most noticeable near the margins, the limestone in the remainder of the deposits being relatively pure.

The maps of the Geological Survey of Canada show outcrops of the George River limestones in the counties of Inverness, Cape Breton, and Victoria.

Victoria County. In this county are a number of scattered outcrops of limestone, most of them in inaccessible places. In the vicinity of St. Columba and New Campbellton there are, within 2 miles, and less, of tidewater, deposits of both high-calcium limestones and dolomites of good quality.

Inverness County. The George River limestones are extensively exposed on the Craignish hills and on North mountain. The Craignish Hills area, extending from near the strait of Canso to beyond Whycocomagh, is for the most part remote from both rail and water transportation and the limestones have not been exploited to any great extent. A small amount of white dolomite is quarried near Whycocomagh and shipped to Halifax where it is ground and used as whiting substitute. Along the slopes of North mountain, bordering on Bras d'Or lake, are some huge deposits of crystalline limestone which are principally high-calcium in composition. At the village of Marble Mountain on the shore of Bras d'Or lake, the Dominion Iron and Steel Company for many years operated the largest quarry in the Maritime Provinces. The product, high-calcium limestone, was shipped by steamer to Sydney where it was used for flux in the blast furnaces. The large-scale operations gradually exhausted the pure high-calcium stone and the plant was dismantled and new quarries opened up at Port-au-Port, Newfoundland. Much limestone of good quality is still available on North mountain but the most of it is in the more inaccessible parts. Some good stone is still available in the floor of the Marble Mountain quarry.

Cape Breton County. The best known deposit of crystalline limestone is on the mountain side at Scotch Lake where the large dolomite quarry known as the George River quarry has been worked for many years. The dolomite, which is much veined with serpentine, is hand-sorted before it is shipped to the plant of the British Empire Steel Corporation at Sydney where, after being calcined and crushed, it is used as a lining for the bottoms of the open-hearth furnaces. Southwesterly from Scotch Lake to Eskasoni occasional outcrops of both dolomite and high-calcium limestone are to be seen.

ANALYSES OF PRECAMBRIAN LIMESTONES

Owing to the variableness of the Precambrian limestones analyses are not of much value unless accompanied by an estimate of how much of that particular grade of material is available. The following analyses are from developed properties and will serve to give an idea of what grade of material can be actually obtained.

—	1	2	3
Silica	2·32	2·30	1·28
Oxides of iron and alumina	1·32	1·80	0·50
Calcium carbonate	54·46	85·68	54·55
Magnesium carbonate	42·55	9·03	43·89
	100·65	98·81	100·22

1. Typical shipment from George River quarry to Sydney. Analysis by the British Empire Steel Corporation.
2. Typical shipment from Marble Mountain quarry just previous to the cessation of operations. Analysis furnished by the British Empire Steel Corporation.
3. White dolomite 1½ miles north of New Campbellton. Analysis on record at the Mines Branch, Ottawa.

USES

The great drawback to the use of George River limestones is their variableness in chemical composition with respect to calcium and magnesium. They do not offer a promising field for large-scale operations when a product of a uniform composition is desired; but there are many places where a uniform quality of pure high-calcium limestone, or of dolomite, can be obtainable for smaller operations. For instance, many deposits are large enough to supply lime-kilns or pulp mills with high-grade material free from impurities, such as mica, graphite, pyrite, hornblende, or hematite, usually found in the crystalline limestones of Precambrian age.

As a rule the George River limestones are so fractured and sheared that large blocks free from flaws are not readily obtainable. This prevents the general utilization of some of the beautifully variegated stone for decorative purposes but there are possibilities of decorative and building material being produced in conjunction with the quarrying of stone for other uses.

In addition to the dolomites being quarried for manufacture into whiting substitute and refractory material a small amount of limestone is ground for agricultural purposes. These are the only uses being made of the crystalline limestones at present.

Ordovician, Silurian, and Devonian Limestones

Several outcrops of calcareous rocks shown within areas mapped as Ordovician and Silurian by the Geological Survey of Canada were visited, but they were found to be very impure and they are of no interest in this report.

Limestones mapped within the Devonian areas were visited on the west side of the strait of Canso, about 3 miles south of Mulgrave, and on the south slope of Cobequid mountains just north of Lornevale, Colchester county. The limestone on the strait of Canso appeared worthless. The deposit north of Lornevale consists of a fairly pure, yellowish white, fine-grained, high-calcium crystalline limestone. Owing to the heavy covering of drift, the amount available could not be ascertained.

Carboniferous Limestones

Pure Carboniferous limestones are peculiar to that division of the formation known as the Lower Carboniferous. Below this division is the Carboniferous conglomerate and above it are the Coal Measures and other divisions, none of which contain commercial limestones.

The Carboniferous limestones are widely distributed over the lowlands of the eastern part of the province. There are two distinct types—

1. A pure limestone composed of shells and broken corals which shows little or no semblance of bedding. This type is commonly termed "shell" limestone.

2. A distinctly bedded limestone of all degrees of purity.

The shell limestones are, as a class, the purest of the Carboniferous limestones. They are composed largely of shells and broken corals cemented together by fine-grained limestone. In some cases the shells so predominate that there is not sufficient binder to hold them together and the deposit is one of loosely coherent shells. At the other extreme are deposits of shell limestone in which the fine-grained material predominates, even the cavities within the shells being filled with calcite, giving a dense stone. Intermediate varieties are more common than either extreme. The colour varies from buff through grey and brown to dark blue. Shell limestones are usually very low in magnesium carbonate content and contain only a very small percentage of impurities such as silica, iron, and alumina. The deposits of shell limestone are irregular in size and shape but they are usually found as mounds and ridges suggestive of reef structures. In places they form a cap or blanket over a core of Precambrian igneous rock. They are sometimes associated with gypsum and anhydrite and that portion of the limestone immediately adjoining the sulphate deposits always contains much sulphur.

The bedded limestones comprise all types, pure and impure dolomites and high-calcium stones. The colour range is practically the same as in the shell limestone. They are all fine-grained and bituminous. Some are soft and earthy, others hard and brittle. The dolomites are nearly always porous and light brown in colour. During Carboniferous times conditions must have been such that local beds of limestone were formed instead of one continuous bed over a large area, for it is common to find the limestones thinning out and becoming more and more sandy or shaly along the strike and it is seldom that one bed of limestone can be traced for any great distance. Limestones apparently occur at several horizons in the Lower Carboniferous, but rarely do the deposits exceed 50 feet in thickness without shale or sandstone beds intervening. Many of the limestones show evidence of their mode of origin or of conditions that obtained during their deposition. Some beds are apparently due to the consolidation of limestone sands. Some are seemingly cemented breccias and conglomerates. Others are apparently chemical precipitates. Still others are composed of oolites. Some limestones rest on the Precambrian granite, some on conglomerate, some on sandstone, some on shale. Some limestones bear ripple-marked surfaces, others show mud-cracked surfaces. Some are sandy, others very pure. Some contain many fossils, others are practically devoid of fossils, and so on. Wherever the bedded limestones are associated with gypsum they are almost invariably shaly or sandy. The limestone beds are rarely horizontal but dip at various angles, a few being in a vertical position.

The chemical composition of individual Carboniferous deposits is usually quite constant throughout, the chief variable being silica which is naturally present in greatest quantity in the top and bottom beds of the deposit when such beds are in contact with sandstone or shale. The majority of the deposits are of high-calcium limestone, some are of dolomite, and a few are composed of alternate beds of dolomite and high-calcium stone. In one or two localities high-calcium limestone mottled with dolomite was observed. In some places, as in the vicinity of Guysborough, the limestone contains considerable hematite. In other places, particularly in Hants county near Walton and Tennecape, manganese oxide occurs in veins and pockets throughout the stone.

There are literally thousands of outcrops of the Carboniferous limestones throughout the eastern part of the province.

Lunenburg County. The most promising occurrence of limestone is at Indian point just south of East River station. A quarry was formerly operated here.

Hants County. Hundreds of exposures of Carboniferous limestone occur in this county, particularly along the line of the Midland division of the Dominion Atlantic railway, and also near the shore of Minas basin and along the rivers which flow into the basin. The majority of the outcrops seen were of high-calcium limestone. Along the railway, shell limestone occurs near Riverside Corner on the property owned by H. C. Burchell of Windsor, and at Rhines Siding on the land of Wm. Nolan, as well as at many other places farther removed from transportation. At South Maitland on the land of J. H. Waddell is a deposit of bedded limestone of fair quality.

At Windsor the only lime plant in Nova Scotia, the Eastern Lime Company, is operating on a deposit of shell limestone.

Halifax County. Limestones of commercial importance are found only in the Musquodoboit valley. A branch line of the Canadian National railway serves this area. Exposures of both high-calcium limestone and dolomite occur; but the dolomite, most of which is sandy and otherwise impure, is most common. The purest dolomite observed was that near Elderbank.

Colchester County. Many outcrops of high-calcium limestone occur in this county, particularly in the southwestern part where both the shell and bedded varieties are to be found. Transportation is provided in this area by both the Dominion Atlantic and Canadian National railways. A large exposure of easily quarried limestone occurs west of Brookfield. About 7 miles northeast of Truro, near Manganese Mines P.O., a small plant for the production of agricultural limestone is operated by J. B. Thompson. In the western part of the county the only outcrops of limestone seen were those north of Upper Economy.

Cumberland County. There is but little limestone of value in this county. Some impure stone is found near Parrsboro and some variable stone at Upper Nappan where it was formerly quarried for agricultural purposes. The best limestone deposit seen was that at the old quarry on Dewars Hill near Pugwash.

Pictou County. High-calcium limestone outcrops in many places along the valley of the East river. Several deposits in this valley were formerly worked for flux by the Nova Scotia Steel and Coal Company. Near Lorne on the property of John A. Dunbar is an exceptionally large outcrop of easily quarriable limestone, apparently of good quality. Agricultural limestone is produced near Sunnybrae in a plant erected by the Nova Scotia Government, and operated by Messrs. Porter and Kennedy of Stellarton.

Antigonish County. Outcrops of both high-calcium limestone and dolomite are abundant, the majority being either near the sea coast or within a few miles of the Canadian National railway. There is a large deposit of porous dolomite on the land of John Boudreau near Pomquet village. On the east side of Antigonish harbour, about 2½ miles from the entrance, is an extensive outcrop of pure, high-calcium, shell limestone.

Guysborough County. In the vicinity of Guysborough harbour are some outcrops of ferruginous, brecciated limestones, apparently of little commercial value.

Richmond County. Practically all of the limestones in the county are high-calcium in composition. The most promising outcrops are along the southeast shore of St. Peters inlet and along the shore of Bras d'Or lake. In the first-mentioned locality there are extensive exposures of bedded limestones of fair quality. At Robinson cove a small quarry is worked, the product of which is shipped to Prince Edward Island. Along the shore of Bras d'Or lake at Red Islands and at Irish Cove are very large deposits of pure, high-calcium, shell limestone resting on the Precambrian granite. Outcrops of lesser importance occur at widely separated points over the county.

Cape Breton County. Scattered occurrences of both dolomite and high-calcium limestone are common throughout the county. The best deposits of high-calcium limestone are found about 3 miles south of East Bay at Glen Morrison and at Point Edward in Sydney harbour. The British Empire Steel Corporation operates a quarry at Point Edward, the product being used for flux in the open-hearth furnaces at Sydney. The dolomite deposits are of little value.

Victoria County. Both shell and bedded limestones are to be found in the southern part of the county. Along the east coast deposits of dolomite and high-calcium limestone occur at intervals from St. Ann bay to cape North. The best dolomite deposit seen is the one at Ingonish, owned by the British Empire Steel Corporation.

Inverness County. Although limestone outcrops are numerous in this county, pure and easily accessible limestone is not common. In the vicinity of Orangedale a dolomite deposit was formerly worked by the Dominion Iron and Steel Company.

ANALYSES OF CARBONIFEROUS LIMESTONES

The following analyses will serve to illustrate the composition of typical Carboniferous limestones of the purest types.

—	1	2	3	4	5
Silica	2·08	0·88	0·84	1·60	0·48
Ferric oxide	1·20	1·76	0·46	0·40	0·31
Alumina					0·37
Calcium carbonate	95·29	53·82	97·82	95·35	97·18
Magnesium carbonate	1·79	42·53	0·57	2·25	0·76
	100·36	98·99	99·69	99·60	99·10

1. Shipment from Point Edward quarry to the blast furnaces at Sydney. Analysis furnished by the British Empire Steel Corporation.
2. Shipment from quarry at Orangedale, Inverness county, October 1921. Analysis furnished by the British Empire Steel Corporation.
3. Shell limestone at Red Islands, Richmond county.
4. Lunenburg county.—Blue limestone from the Lordly quarry at Indian point. Analysis on record at the Mines Branch, Ottawa.
5. Shell limestone from the south quarry on the property of the Eastern Lime Co., Windsor. Sample analysed at the Mines Branch, Ottawa.

USES

Very little use is being made of the Carboniferous limestones in Nova Scotia. The quarry at Point Edward near Sydney is worked for blast furnace flux. The Eastern Lime Company at Windsor produces lump lime, hydrated lime, and ground limestone for agricultural purposes. Limestone is being quarried and ground for agricultural purposes at a number of points but, according to the Nova Scotia Department of Agriculture, the amount of such material marketed during 1926 did not exceed 4,000 tons. In the past many quarries were operated in conjunction with small limekilns, and along the sea coast much stone was quarried for shipment to Prince Edward Island where it was burned to lime. The St. John lime plants now supply nearly all the lime used in Prince Edward Island and in Nova Scotia too. This does not imply that the Nova Scotia limestones are not suitable for lime manufacture, many of them are, but as the great majority of the bedded limestone deposits do not exceed 40 feet in thickness and they are inclined at various angles to the horizontal, extensive quarrying in many cases has been rendered impossible and much pure limestone has been regarded as unworkable and dismissed from further consideration. To-day, however, in the United States, the practice of mining limestone is becoming increasingly common in areas where the overburden is heavy and where perfectly clean stone is desired for chemical purposes. This method of working opens up new possibilities for the utilization of Nova Scotia limestones.

THE LIMESTONES OF NEW BRUNSWICK

A difference of opinion exists as to the age of certain of the New Brunswick limestones and although knowledge of the age of a limestone is not of great importance from the economic standpoint, it provides a very suitable basis for classification. The geological maps, prepared by

Drs. Ells, Bailey, and Matthew, cover all the province and, except for a few restricted areas, are the only ones that are available. These maps were used during the present investigation and in this summary report the limestones will be classified according to the geological periods to which they were finally assigned by these geologists. Under this classification the limestones of commercial value in New Brunswick belong to three geological periods: (1) Precambrian; (2) Silurian; and (3) Carboniferous.

Precambrian Limestones

Limestones are not found throughout the entire Precambrian formation but are characteristic of one particular series or group of rocks. This group, for which several names have been proposed, consists largely of crystalline limestone, quartzite and slate which have been intruded by masses of granite and gneiss, and dykes and sills of diabase.

The crystalline limestones comprise both dolomites and high-calcium limestones. The high-calcium stone varies in texture from fine- to coarse-grained and in colour from white to a very dark blue. A blue-and-white striped variety is also common. The dolomite is usually fine- to medium-grained and the colours are yellowish and pinkish whites and various shades of blue, the blue being predominant.

The dolomites and high-calcium limestones occur alternately in roughly parallel belts. The dip is at a very high angle, being frequently vertical. Usually the two types of stone are quite distinct one from the other and either can be quarried without danger of contamination. The width of the limestone belts varies greatly, some being only a few feet and others many hundreds and even thousands of feet wide. Apparently interbedded with the limestones are quartzite bands of varying thicknesses. The width of any particular belt of limestone is not constant but varies greatly throughout its length and the belt may pinch out entirely or be abruptly terminated by a fault. The best grade of stone is found in relatively narrow bands and lenses within the major belts, usually near the centres. The greatest width of pure high-calcium stone being worked at present is about 200 feet, and the widest belt of dolomite worked is about 80 feet. The impurities in the best stone consist chiefly of silica with minor amounts of pyrite. A noteworthy feature is the almost complete absence of mica, large flakes of graphite and grains of silicate minerals such as characterize the limestones of similar age in Ontario and Quebec. The impurities in the stone, outside of the purest bands, include stringers of quartz (especially characteristic of the dolomites), pyrite in varying amounts usually greatest in the vicinity of diabase intrusions, blebs and interbeds of slate, and also siliceous strata. The diabase dykes and sills intrude pure and impure stone alike but, aside from the expense involved in removing it, the diabase does not constitute a serious impurity as it can be easily sorted out. The limestones have been subjected to great stresses and consequently numerous fracture lines have been developed causing the stone to break readily into small angular fragments. This is particularly true of the dolomites, and numerous spalls are obtained in quarrying. The faulting has also, in many places, interrupted the continuity of the beds, abruptly terminating the belts of pure stone.

The Precambrian limestones are exposed only in the southern part of the province where they occur at intervals, from the shore of Mace bay northeasterly past St. John city to near the village of Salt Springs, Kings county. Areas of Precambrian rocks containing no limestones intervene and, in the northeastern part, between the limestone outcrops are large areas covered by younger sedimentary rocks. The limestones are commonly exposed in ridges throughout this area and could be easily quarried.

The most extensive area of Precambrian limestones is in the vicinity of St. John city and northeastward therefrom. The outcrops commence some 4 miles west of South Bay station, cross Green Head, and continue to about 2 miles northeast of Torryburn, in all a distance of about 15 miles. This strip of country is quite hilly, elevations of 250 feet above sea-level being common. The exposures have a maximum width of $1\frac{1}{2}$ miles. The general strike of the beds corresponds roughly to trend of the main belt. Within this area are the most important quarries and lime plants in New Brunswick. The other Precambrian limestone areas, notably the ones to the northeast, contain much good stone and are in some cases within 1 to 2 miles of the railway, but they have not been developed.

ANALYSES OF PRECAMBRIAN LIMESTONES

The following analyses are typical of the pure stone available in many of the quarries:—

—	1	2	3	4	5	6
Insoluble	0·62	2·30	....	1·09	1·29	1·10
Silica	....	....	2·04	....	....	....
Oxides of iron and alumina	0·50	0·20	0·82	0·78	0·78	0·16
Calcium carbonate	57·59	94·64	95·79	55·88	95·08	95·72
Magnesium carbonate	40·96	2·20	0·76	41·18	3·84	1·98
	99·67	99·34	99·41	98·93	100·99	98·96

1. White dolomite from Randolph and Baker quarry, St. John. Analysis furnished by Mr. Randolph.
2. Blue limestone, Green Head quarry, St. John. Analysis on record at the Mines Branch, Ottawa.
3. Blue stone burned for lime, Provincial Lime Co. quarry, Brookville. Sample analysed at the Mines Branch, Ottawa.
4. White dolomite from Stetson, Cutler quarry, St. John. Analysis furnished by the company.
5. Blue stone burned for lime by C. H. Peters, Sons, Ltd., Torryburn. Average of two analyses by the Atlantic Sugar Refinery, St. John, furnished by Gordon Peters.
6. Purdy and Green quarry, St. John. Average of a number of analyses on record at the Mines Branch, Ottawa.

USES

Since the time the country was first settled the Precambrian limestones in the vicinity of St. John have been burned for lime, and lime is still the principal product. Both dolomitic and high-calcium white limes are produced. Five companies are at present engaged in lime-burning. The product is lump lime which is usually marketed in wooden casks and barrels.

In addition to their main product some of the lime companies ship limestone for use in pulp mills.

Pulverized limestone for agricultural purposes is produced by C. H. Peters, Sons, Ltd.; The Provincial Lime Co., Ltd.; and by the Brookville Manufacturing Co., Ltd. The last-named company operates the grinding plant at Brookville that was established by the New Brunswick Government.

A few buildings of rather striking appearance have been built of crystalline limestone, but the shattered nature of the stone would not permit of profitable operations being conducted for building material alone as there would be a great amount of waste. However, there are interesting possibilities of building stone being produced as a side line by some of the lime companies.

Silurian Limestones

The maps issued by the Geological Survey show large areas of Silurian rocks in the northwestern part of the province. They underlie the greater part of Restigouche and Madawaska counties and extend southerly down the valley of the St. John river to below Woodstock. Isolated outcrops are found lower down the river in Kings and Queens counties and in the vicinity of Passamaquoddy bay.

The greater part of the Silurian rocks are calcareous shales and impure limestones. Occasional bands of pure limestone are found among the impure strata and it is these bands which are of interest in this report. Large Silurian areas in Restigouche and Madawaska counties have never been carefully investigated and their limestone resources are unknown.

A most promising outcrop of limestone is at L'Etang, at the mouth of Passamaquoddy bay. The age of this limestone has been disputed, but according to Ells[1] it is Silurian. The band of limestone is about one-third of a mile wide and dips almost vertically. It crosses the L'Etang peninsula and is again seen on Frye's island where, however, it is much narrower. Not all of the band is composed of pure limestone, but strata over widths of from 20 to 200 feet are quite pure. (*See* analyses below.) The pure zones are separated by wide diabase dykes and by zones of slaty limestone. The pure limestone is highly crystalline, fine-grained, and ranges from yellowish white to blue in colour. It is predominantly high-calcium in composition, though a few magnesian streaks were observed in places. Diabase dykes are very numerous and the stone is much sheared.

In the basin of the St. John river the only known Silurian limestone of importance is in the vicinity of Windsor, Carleton county, about 9 miles from the railroad. The exposures here indicate a large deposit of fine-grained, semi-crystalline, grey, high-calcium limestone. Analyses show the stone to be quite pure.

Along the south shore of Chaleur bay limestone occurs at intervals from Petite Rocher to Charlo. Most of the limestones contain much shale, either interbedded or disseminated through them. Near the Elmtree river, three-quarters of a mile west of the railway, is an irregular band of pure, fine-grained, semi-crystalline, pinkish limestone. The limestone could not be traced far and it appeared to be more or less of a lens. The remainder of the stone seen in this area is dark blue, fine-grained, and slaty with much interbedded shale.

[1] Ells, R. W.: Geol. Surv., Canada, vol. XV, pt. A, p. 154 (1903).

ANALYSES OF SILURIAN LIMESTONES

—	1	2	3
Silica	1·82	2·38	0·90
Iron oxide	0·32	0·45	0·22
Alumina	0·56	0·55	0·64
Calcium carbonate	96·73	94·31	97·50
Magnesium carbonate	0·53	2·56	0·46
	99·96	100·25	99·72

1. L'Etang, Charlotte county. Blue-and-white striped limestone across a width of 73 feet along the shore.
2. L'Etang, Charlotte county. Yellowish white limestone across a width of 29 feet along the shore.
3. Windsor, Carleton county. General sample across 100-foot outcrop of grey limestone, ½ mile east of the village.

USES

Other than for a small amount being ground for agricultural purposes no use is being made of any of the Silurian limestones. At one time lime-burning was extensively carried on at several places, notably L'Etang and Windsor, but the kilns have been abandoned for many years. These limestones would provide lime for chemical purposes and, provided all the stone is as low in magnesium carbonate content as the foregoing analyses indicate, would also be suitable for Portland cement manufacture. In general, the Silurian limestones are too thin-bedded and too much sheared to yield building or ornamental stone and they are too soft and friable for road metal.

Carboniferous Limestones

Limestones are characteristic of the lower division of the Carboniferous formation, in which they occur at several horizons. The limestones vary greatly in appearance and purity in different localities. Some deposits are shaly and flaggy, others are heavily bedded or massive. All the stone is more or less fine-grained and bituminous and all appears to be high-calcium in composition, no dolomites being observed. The colours are usually reddish, greenish, or grey. The chief impurities are sand grains and shale streaks in most localities, and nodules of chert in a few localities. Fossils are numerous in some deposits and practically absent in others. No typical shell limestones were seen. The thickness of the deposits usually varies from 20 to 50 feet. In some few cases it is apparently more than 50 feet. The beds dip at various angles.

These limestones are commonly exposed in the counties of Kings and Albert and to a lesser extent in Westmorland. They are also exposed along the valley of the Tobique river in Victoria county.

In Kings county exposures of limestone, much of which is of good quality, are numerous along the line of contact between the Carboniferous and Precambrian rocks, from Hanford Brook through Hillsdale and Markhamville to Waterford. These exposures are in all cases about 8 to 10 miles from the railway. The best exposures adjacent to rail transportation are at Norton, Havelock, and near Petitcodiac. The limestone is grey and reddish grey in colour, fine-grained, semi-crystalline, and heavily bedded. Dips are variable. The exposures at Havelock are very extensive. The stone is of good quality, is flat-lying, has very little overburden on it and could be easily quarried. Geo. Downey operates a small crusher at Havelock for the production of agricultural limestone.

In Albert county limestone exposures are frequent along the line of contact between the Carboniferous and Precambrian formations from Elgin through Pleasant Vale and Prosser Brook to Albert Mines. Most of these outcrops are remote from transportation. On McHenry brook and Demoiselle creek are exposures of limestone. At the former place the overburden is very heavy and there is considerable chert in the limestone. At the latter place there is about 15 to 20 feet of limestone resting on the Precambrian rock. Much of it is shaly but some is of excellent quality.

There are a few other exposures of Carboniferous limestone in southern New Brunswick, the most promising being about 2½ miles north of Dorchester, Westmorland county, and at Queenstown, Queens county. At the latter place the limestone is red in colour and has been altered to a marble.

In Victoria county, in the valley of the Tobique river, in the vicinity of Plaster Rock and Oxbow, exposures of red and green, impure Carboniferous limestones are quite numerous. There is usually much red shale associated with the limestone and none of the outcrops seen gave much promise of yielding limestone or lime fit for chemical uses. At Oxbow, Charles Hayden operates a small crusher for the production of agricultural limestone.

ANALYSES OF CARBONIFEROUS LIMESTONES

The following analyses may be considered as representative of the better grade of limestone exposed in the areas mentioned.

—	1	2	3
Silica	3·46	2·56	4·80
Iron oxide	0·67	0·33	0·60
Alumina	0·91	0·79	1·96
Calcium carbonate	93·70	95·61	90·88
Magnesium carbonate	0·90	0·61	1·13
	99·64	99·90	99·37

1. Demoiselle P.O., Albert county. Ten-foot thickness of reddish grey limestone near head of Wilson brook.
2. Havelock, Kings county. Nine-foot face in quarry worked by Geo. Downey.
3. Wapske, Victoria county. Outcrop of red limestone on land of John Day.

USES

A small amount of pulverized stone for agricultural purposes is being produced from the Carboniferous limestones, but aside from this no use is being made of them. In many localities a good lime could be, and formerly was, produced, but the established lime plants near St. John are well situated as regards shipping facilities and supply an excellent grade of lime to all areas which would be accessible to lime plants established at the Carboniferous deposits.

Judging from a surface examination the deposit at Havelock contains a large tonnage of limestone suitable for the manufacture of Portland cement.

The pure grey stone free from shale streaks is suitable for use in pulp mills, but the red stone is usually too high in iron for this purpose.

XI B

PRELIMINARY REPORT ON THE LIMESTONES OF THE GASPE PENINSULA

The peninsula of Gaspe has, along its southern part, great areas underlain by Silurian rocks, as well as lesser areas underlain by rocks of Devonian, Carboniferous, and other ages. The Carboniferous rocks include no limestone of importance. The Devonian areas contain considerable limestone, particularly in the neighbourhood of Percé and along the northeast shore of Gaspe bay,[1] but this Devonian limestone will never be quarried as it constitutes such striking scenic features as Percé Rock, Les Murailles, and Gaspe cape.

The Silurian limestones are associated with shales and sandstones. They were found at frequent intervals along the peninsula from White Cape, near Percé, eastward to Escuminac and beyond. There are two general types:—

1. A crystalline or semi-crystalline, heavily bedded, pinkish limestone.
2. A dark-coloured, fine-grained, thinly bedded limestone.

The first type is seen in the cliffs along the seashore from Gascons to Port Daniel West and it apparently represents the uppermost member of the Silurian limestone series. The cliffs which vary from 100 to 300 feet or more in height are entirely composed of limestone which dips steeply seaward at from 30 to 70 degrees. The overburden is comparatively light and many excellent quarry sites are available. Some strata in this crystalline series are dense and show few or no fossils, but others are largely composed of broken corals and angular bits of limestone cemented together by calcite. Angular pieces of red sandstone, shale, and vari-coloured limestone are numerous in spots and give the stone the appearance of being a breccia. In other places the limestone is heavily bedded and shows no brecciated structure. The pure limestone occurs in large areas separated by areas of impure stone in which seams of sandy limestone and shale are common. Some of the deposits of pure stone have a thickness across the strata of 200 feet or more, and a length of half a mile or more. Other deposits are much smaller. The whole thickness of the light-coloured crystalline limestone series is apparently in excess of 500 feet, but this thickness includes sandy and shaly layers. All of the stone is high-calcium in composition. The worst impurities are the seams and pieces of red sandstone and shale. Two quarries are operated, that of the Bathurst Company at Port Daniel and that of the Bonaventure Pulp and Paper Company at Gascons. Both quarries produce stone for use in the manufacture of pulp.

The second type of limestone, the thinly bedded, fine-grained, dark-coloured stone is exposed at intervals all the way from White cape to Escuminac. At White cape, Gascons, and at Black Cape this limestone

[1] Geol. Surv., Canada, Guide Book No. 1, pt. I. "Excursion in Eastern Quebec and the Maritime Provinces," p. 95, et seq. (1913).

is exposed along the sea front but usually it is only to be found at a distance of several miles back from the shore, the intervening ground being occupied by Carboniferous rocks which overlie the Silurian limestones of both types. The fine-grained limestone underlies the crystalline limestone and is in turn underlain by shale. The greatest thickness of the limestone was not determined but it is in excess of 200 feet. The stone occurs in steeply dipping beds which are from 2 inches to 1 foot thick. Towards the base of the series interbedded shale is common. The limestone is, on the whole, quite pure, though in some localities it contains quantities of sand grains and silicified fossils. All of the better grade of this stone is high-calcium in composition. Two promising-looking deposits adjacent to transportation are north of the railway station at Gascons and near the head of Port Daniel bay.

Westward from Escuminac to Matapedia great hills of igneous rock fringe the shore and no limestones were observed. Along the valley of the Matapedia river for a distance of 6 miles from the mouth are impure slaty limestones interbedded with shale.

ANALYSES OF SILURIAN LIMESTONES

—	1	2	3
Insoluble	1·10	....	....
Silica	....	1·58	4·30
Oxides of iron and alumina	2·00	0·54	1·62
Calcium carbonate	94·54	96·95	92·46
Magnesium carbonate	0·84	0·42	0·71
	98·48	99·49	99·09

1. Port Daniel quarry. Pinkish crystalline stone as shipped to Bathurst, N.B. Analysis furnished by the Bathurst Company.
2. Fine-grained, blue limestone on property of John Imhoff, 4 miles north of New Carlisle.
3. Fine-grained, purplish brown limestone from cliff on west side of Middle river, ¾ mile above Port Daniel.

USES

In addition to the stone quarried for use in the pulp mills a small amount is ground for agricultural purposes. These are the only uses made of the limestone along the coast. Sufficient data on the chemical composition are not yet available to warrant any pronouncement on the possible uses.

XII

THE LIMESTONES OF TIMISKAMING DISTRICT: PRELIMINARY REPORT ON

M. F. Goudge

At the northern end of lake Timiskaming, limestones occur in an outlier of sedimentary rocks about 33 miles long and 8 miles wide, extending from North Cobalt to Englehart. The Temiskaming and Northern Ontario railway traverses the length of this outlier. The country is mostly flat and deeply covered with clay. The limestones are of special interest as they constitute the nearest source of supply of stone for lime and other purposes for the rapidly developing towns and industrial plants of northern Ontario and northern Quebec.

Hume[1] has shown that the limestones are of two geological ages, Ordovician and Silurian.

Ordovician Limestones

The Ordovician limestones occupy a horizontal position. The upper beds having a maximum observed thickness of 30 feet, consist of heavily bedded, fine-grained, fossiliferous, mottled limestone, in some respects similar to the Tyndall limestone of Manitoba. The freshly broken stone is grey in colour with numerous mottlings of dull-lustred, yellowish blue, granular, magnesian material which weathers to a rusty-brown, crumbly mass. From exposed surfaces the crumbly material is eventually washed away leaving a deep pit in the stone. The deeply pitted surface is quite characteristic of this type of limestone. Where a protective layer of overburden is lacking, the stone disintegrates to a loose rubble.

Below the mottled stone is a band of heavily bedded, coarse-grained, light grey limestone free from mottlings. In the new quarry of the Abitibi Power and Paper Company, on lot 10, concession V, Bucke township, this band is 10 feet thick. Showings of similar stone were seen near North Cobalt and presumably it will be found elsewhere beneath the mottled limestone in this area. Below the coarse-grained band are a few feet of impure, fine-grained limestone, then very shaly worthless stone, and finally shale. Very little information is available regarding the lower coarse-grained stone, but, as shown by the analysis on page 51, it is quite pure. The mottled stone is only of fair quality containing on the average about 5 per cent impurities such as silica, iron, and alumina. The magnesium carbonate content, which is largely due to the material composing the mottlings, varies from 5 to 10 per cent.

These Ordovician limestones are well exposed on two elevated plateaux: one, 4½ square miles in area, is just west of Haileybury; the other, slightly less in area, is immediately west and south of New Liskeard. The overburden is light on these plateaux and quarries could be opened at many places.

[1] Hume, G. S.: Geol. Surv., Canada, Mem. 145 (1925).

ANALYSES OF ORDOVICIAN LIMESTONES

—	1	2	3	4
Silica	2·68	3·30	1·32	5·43
Iron oxide	0·34	0·84	0·85	1·50
Alumina	1·42	1·00	0·45	1·90
Calcium carbonate	87·45	83·95	92·04	82·11
Magnesium carbonate	6·68	9·51	4·31	7·79
	98·57	98·60	98·97	98·73

1. Farr quarry, lot 11, con. III, Bucke tp. Sample from 5 feet of mottled stone being quarried for use in pulp mills.
2. Farr quarry, lot 11, con. III, Bucke tp. Bottom 3-foot bed just below the 5-foot section previously sampled.
3. Abitibi quarry, lot 10, con. V, Bucke tp. 10 feet of coarse-grained limestone.
4. Average of a number of analyses of limestone of the district. Analyses obtained from various sources.

USES

One mile west of Haileybury a quarry known as the Farr quarry has been worked for many years and by several operators. The present owners are Noranda Mines, Limited, who may utilize the limestone for flux in their smelter at Noranda, Quebec. Previously this quarry was operated for stone for use in pulp manufacture. At Moore cove, 1½ miles north of Haileybury, the Abitibi Power and Paper Company have recently opened a quarry to supply their pulp mills at Iroquois Falls.

Small quantities of lime and of building stone have been produced from the Ordovician limestones. No lime-kilns are operated at present. For a building material the mottled stone is in sufficiently thick beds to provide dimension-stone, but it is not highly desirable for building construction on account of the drab colour it assumes upon exposure and also on account of its poor weather-resisting qualities. The coarse-grained stone on the other hand would seem to be well suited to this purpose. It would also, to judge from the single available analysis, provide a lime of fair quality.

Silurian Limestones

The Silurian limestones, exposed in this district, vary in composition from high-calcium limestone to dolomite. The best dolomite occurs at the top of the series. Beneath it, as may be seen on the east side of Dawson point at the north end of lake Timiskaming, is a zone over 20 feet thick of cherty dolomite containing numerous silicified fossils. Below this, in the next 50 to 60 feet, come high-calcium limestones, magnesian limestones and dolomites, some of which are pure but many of which are impure. Below this again all the stone is impure and shaly. Except at the southern tip of Dawson point the stone below the cherty dolomite can be obtained only by mining, but at the tip of the point are about 25 feet of high-calcium limestone which could be quarried after removing from 10 to 20 feet of impure dolomite and dirt. An analysis of this limestone follows:—

Silica	5·64
Iron oxide	0·48
Alumina	1·40
Calcium carbonate	85·73
Magnesium carbonate	6·01
	99·26

On Mann island to the southeast of Haileybury, the uppermost exposures show fairly pure limestone. It was formerly utilized for lime-burning. Below it, come sandy, magnesian limestone and dolomite. The dolomite at the water's edge is fine-grained, dense, and in beds from 6 to 14 inches in thickness. A small quarry has been opened for building stone along the beach on the east side of the island. Only a limited quantity is available as the overburden of earth and other rock increases rapidly inland from the beach.

Other exposures of Silurian limestones were seen along a ridge that extends from Dawson point to Thornloe, and again along low ridges and in river valleys between Earlton Junction and Englehart. One-half mile west of the railway, in concessions II and III of Dymond township, steeply dipping beds of pure, bluish and buff dolomite are exposed in a good position for quarrying on the east face of a high escarpment. In some places they are overlain by cherty dolomite. The thickness of the pure dolomite could not be determined.

Along the ridge between Dawson point and Thornloe the pure dolomite is well exposed particularly near Thornloe and to a lesser extent near Hanbury and near Dawson point. The stone varies from pale blue to buff in colour. It is fine-grained, porous, and occurs in heavy beds up to 6 feet in thickness. There is no shale between the beds, but it is underlain by cherty dolomite. The best exposure of the dolomite is on lot 3, concession V, Harley township, about 2½ miles southeast of Thornloe station, where about 35 feet of the pure dolomite forms the top of a low escarpment. The overburden is practically nil and the stone can be traced for ¼ mile back from the face. The stone dips at an angle of 4 degrees. The analysis of a sample representative of 25 feet of strata exposed on the land of David Boyce is as follows:—

Silica	0·36
Iron oxide	0·64
Alumina	0·12
Calcium carbonate	55·77
Magnesium carbonate	42·57
Calcium phosphate	0·02
	99·48

All of the stone seen between Earlton Junction and Englehart was very impure.

USES

As mentioned above, small quantities of the Silurian limestones of the Timiskaming district have been used for building material, and lime has been produced at several localities, but at present the limestones are not being utilized. There is apparently an excellent grade of dolomite available in quantity adjacent to rail transportation and it should, sooner or later, serve as a source of lime and stone for chemical and building purposes.

XIII

NOTES ON THE QUICKSILVER OCCURRENCES IN CANADA

V. L. Eardley-Wilmot

The increase in the price of quicksilver during 1926 led to some activity in the mining of Canadian mercury ores. An investigation was, therefore, undertaken by the Mines Branch in order to ascertain the possible sources of supply and the latest processes for the recovery of the metal.

BRITISH COLUMBIA

Kamloops Lake Deposits

Several quicksilver deposits are known in Canada, but the only ones which have been operated in the past occur on the north shore of Kamloops lake, British Columbia. This series of deposits occurs at intervals along a belt of some 25 miles in length, striking approximately north and south across the westerly end of the lake. The principal deposits are at Copper Creek station on the Canadian National railway, about 5 miles east of Savona. At this point the ore zone is about 3 miles in width.

The deposits occur in irregular fissures traversing volcanic rocks and are closely associated with porphyry or rhyolite dykes. The region is much folded and faulted. The cinnabar (sulphide of mercury) mainly occurs in numerous, scattered, narrow dolomite veins carrying also quartz and calcite. In places these veins carry up to one inch of solid cinnabar, but in others they are barren. The average content would be in the neighbourhood of 1 per cent. Some of the cinnabar is associated with stibnite. Isolated occurrences of cinnabar also occur 8 miles east and west of the main belt.

The cinnabar occurs to a slight extent throughout the rhyolite which on the surface is weathered to a yellow-brown crumbly rock. Panning tests of the rocks, taken at numerous places, showed small quantities of metallic quicksilver as well as traces of cinnabar. In view of this, several samples of the rock were taken from the tunnels, open-cuts, and dumps, in order to ascertain the approximate percentage of the metal in the low-grade deposit. The tests were carried out at the Mines Branch Ore Dressing Laboratories, Ottawa, the results of which will be found below.

Between 1895-97 considerable mining was done on the hill-side about 500 feet above the mouth of Copper creek, when about 140 flasks (10,700 pounds) of quicksilver were produced by the Cinnabar Mining Company, Ltd., the cinnabar being retorted in a furnace erected on the property. The price then was about $35 per flask of 76½ pounds against the 1926 price of $100 to $105 for a 75-pound flask.

During 1926 and 1927 some of the old Copper Creek workings were reopened by Mr. J. Fleetwood-Wells of the British Quicksilver Mining Company. Some of the small cinnabar-bearing dolomite veins were opened up and a few tons of hand-sorted cinnabar were taken out. The ore was retorted in a small retort, about 6 flasks of quicksilver being recovered. The old retorts and furnace have been dismantled, or partly destroyed.

TESTS AND ANALYSES

Various parts of the old mine workings and dumps at Copper creek were panned during November, 1926, and in many instances a film of flower quicksilver was obtained, hence it was thought advisable to take samples and have them tested at Ottawa. The samples consisted of yellowish brown, decomposed rock of altered greenstone and rhyolite, obtained from the tunnel walls, open-cuts, and dumps. High-grade ore was purposely omitted.

The testing was done in iron retorts. The large retort, having a capacity of about 3,000 grammes, was heated with the contained sample in an oil-burning furnace to about 800° C. The retort was well sealed by a cover having a pipe which was connected with a long water-cooled chamber. The outlet of the pipe dipped into a basin of water which caught the distilled quicksilver. The small laboratory retort of 50-gramme capacity was operated in a similar manner, but heated to about 600° C by two Bunsen burners.

The following is a detail of the results of the tests:—

(1) Sample of 5 bags (450 pounds) from the lower tunnel, sent to the Mines Branch, Ottawa, by Mr. Fleetwood-Wells, during October, 1926.

(A) This was crushed and carefully sampled and two lots of 1,000 grammes each were separately retorted in the big retort. In each case only a faint trace of quicksilver was recovered, the quantity being too small to collect and weigh.

(B) A portion (4 pounds 8 ounces) was crushed to 3 sizes: −20+40; −40+100; and −100 meshes. Each was tabled separately, but no concentration was obtained in any instance. The tails, middlings, and concentrates products were then each carefully panned two or three times. A very fine streak of cinnabar and a few minute globules of native quicksilver were seen under the magnifying glass, but the residue largely consisted of iron minerals, mainly pyrrhotite. A similar quantity of mercury appeared in each of the tails, middlings, and concentrates, the highest percentage being from the −100 products. All the residues thus obtained from the 3 sizes were collected and retorted as one sample in the small retort.

By this method only 0·002 per cent by weight of quicksilver was recovered.

(2) Sample of big rock sent by Mr. Wells with the 5 bags.

The rock was crushed and carefully sampled and 3 lots of 2,000 grammes each were separately retorted in the large retort. In each case only the faintest trace was recovered.

(3) A number of samples along the open-cut, taken by Mr. Wells during November and [illegible] to Ottawa, were mixed together and crushed. A sample of 3 pounds 6 ou[illegible] w[illegible] taken and sized to the 3 sizes and each tabled. The results were s[illegible] to [illegible]e 5-bag sample (1, B). These products were panned as before and [illegible] the small retort from which 0·003 per cent quicksilver by weight [illegible]co[illegible]ered.

(4) [illegible]mber of samples along the lower tunnel taken by Mr. Wells were mixed [illegible]her, crushed, and sampled, and 2 pounds 7 ounces were treated exactly [illegible] the above, and the final pannings added together showed 0·007 per cent [illegible]ksilver recovered from the original sample.

(5) [illegible]ples taken by the writer in November, 1926, along 60 feet of the lower tunnel [illegible]d similarly treated showed 0·002 per cent quicksilver.

(6) [illegible] number of samples along the upper tunnel, taken by Mr. Wells, were mixed [illegible]gether, crushed, and sampled.

(A) The −100-mesh was treated by flotation in a small Minerals Separation machine using pine oil and creosote as the flotation mediums. The ore was too low-grade and the barren material that was floated entirely masked any cinnabar that might have been present.

(B) A sample weighing 2 pounds 2 ounces was crushed to 80 mesh. This was divided into 6 equal parts and each portion carefully panned several times until no more mercury or cinnabar was obtained. The pannings from all these were collected together and dried and the magnetics which were mainly pyrrhotite were carefully removed and the remainder retorted in the small retort giving 0·02 per cent quicksilver.

(7) A sample taken by the writer across 8 feet of gouge material in the upper workings was tabled, panned, and retorted in the small retort and showed 0·009 per cent quicksilver.

(8) A sample taken by the writer from 6 feet down the fines dump, tabled, panned, and treated as before in the small retort, gave 0·0024 per cent quicksilver.

(9) A sample taken by the writer from the coarse layer in the fines dump and treated as above gave 0·003 per cent quicksilver.

(10) A test sample of selected cinnabar was crushed fine and as much of the impurities as possible was panned out. Five grammes were then retorted in small retort with the following result: Hg 2·612 grammes recovered; sulphur (given off as gas) 0·37 grammes; residue (iron, quartz, and dolomite) 1·813 grammes; loss 0·20 grammes or 4 per cent, which shows that the quicksilver loss in the small retort would not affect the above series of assays.

Summary of Results of Tests

	Per cent quicksilver
1. 5-bag sample (A) 1,000 grammes; large retort	Faint trace
(B) 4 pounds 8 ounces, tabled, panned; small retort	0·002
2. Big Rock—2,000 grammes; large retort	Faint trace
3. Open-cut—3 pounds 6 ounces, tabled, panned; small retort	0·003
4. Lower Tunnel—2 pounds 7 ounces, tabled, panned; small retort	0·007
5. Lower Tunnel—along 60-foot, tabled, panned; small retort	0·002
6. Upper Tunnel (A) —100 mesh —Flotation	Nil
(B) 2 pounds 2 ounces, carefully panned; small retort	0·020
7. Across 8-foot gouge, tabled, panned; small retort	0·009
8. Fines dump, 6 feet down, tabled, panned; small retort	0·0024
9. Fines dump, coarse layer, tabled, panned; small retort	0·003
10. Selected high-grade cinnabar; small retort	52·00

Conclusions

From the above results it appears that it would not pay to carry out mining on the rocks and vein matter in which no cinnabar is visible. This is loosely termed "low-grade ore" and constitutes almost the entire hill above Copper Creek station. The high-grade veins are small, scattered, and often difficult to follow with the result that in the past a large tonnage of barren rock had to be removed for every ton of hand-picked ore. The variability of the quicksilver content of these veins also makes it a hazardous undertaking. It is understood that during operations 30 years ago the greater part of the metal recovered was obtained from one "pocket" and there is, therefore, always a possibility of discovering another similar pocket, but it is very unlikely that the exploratory work would pay for itself.

Only that part near the mouth of Copper creek was examined by the writer, but outcroppings of cinnabar have been discovered 4 miles north, up Copper creek, where at one time the Hardie Mountain Cinnabar Mines, Ltd., exposed an ore-body over a length of about 1,000 feet at Criss creek. Other discoveries were made on the south side of the lake along Durand creek and at Tunkwa lake, 12 miles south of Kamloops lake, in all of which the prospecting work was done.

In the quicksilver mines of California, the minimum payable recovery is considered to be 0·5 per cent quicksilver.

Sechart Channel, Barclay Sound, Vancouver Island

A deposit of quicksilver ore occurs on an island near Sechart on the west coast of Vancouver island, 100 miles northwest of Victoria.

The formation consists of pale green felsitic rocks with inclusions of limestone interbedded with highly altered andesite, tuff, and breccia. The whole formation is cut by stringers of calcite and iron pyrites. The cinnabar occurs in a shear zone some 25 feet wide, and is associated both with the calcite stringers and with the breccia, the latter mainly consisting of quartz and limestone fragments. Minute globules of native mercury generally occur sparsely scattered throughout the cinnabar zone.

During 1891 a Victoria company did some prospecting work and opened up the deposit by means of trenches and a 30-foot shaft. Although good ore is said to have been found, most of it is very much disseminated and scattered throughout the rock so that the ore as mined would be low grade. A sample taken from the ore dump assayed 0·38 per cent mercury. No work appears to have been done on the property for over 25 years.

Other Quicksilver Occurrences in British Columbia

Quicksilver has been reported as occurring in the silver ore of Silver peak near Hope; in the gravels of Kicking Horse valley near Field; at Boston Bar on the Fraser river; on the Homathko river, head of Bute inlet; and in the vicinity of Lillooet. Nearly all the above discoveries were in the form of native mercury and the original sources have not been found.

ONTARIO

Quicksilver is said to occur at Groundhog lake, northwest of Sudbury, north Ontario, but no development work has been recorded. The metal also occurs in the Cobalt silver ores chiefly in the Nipissing mine. Thirty-seven samples analysed by G. H. Clevenger[1], showed a trace to 4·74 per cent mercury with an average of a little over 1 per cent of the metallic silver. The mercury appears to occur in the form of an amalgam irregularly distributed in the metallics of some of the Cobalt ores, but there is a tendency for dyscrasite (Ag_6Sb) to carry higher mercury values than the native silver. In the Nipissing high-grade ores or concentrates of about 3,500 ounces of silver per ton, the average mercury content is about 0·25 per cent.

A little mercury was recovered by the Nipissing Mining Company previous to the abandoning, in 1918, of the process of amalgamation for the recovery of the silver in the Cobalt ores. About 3 flasks were obtained between 1916-18 by the Mining Corporation from the Buffalo ores and in one instance 175 pounds were collected from a 5-ton lot of very high-grade ore which was, however, mainly metallic silver. Some flasks were obtained from the Kerr Lake ores. Although there are no official records, it would appear that not more than a dozen flasks were produced

[1] Clevenger, G. H.: "Note on the Occurrence of Mercury in Cobalt Ores." Econ. Geol., Vol. 10 H 770-3 (1915)

from all the Cobalt ores. The South Lorrain and Gowganda metallic silver also contain traces of mercury but none appears to have been extracted.

The quicksilver is said to have been exceptionally pure and on this account was particularly suitable for recording instruments in which contacts are made with a mercury bath, the danger of an interfering film of arsenic being eliminated.

PRODUCTION AND IMPORTS

The following tables give the Canadian production and imports of quicksilver:—

Production of Quicksilver in Canada

(All from Kamloops, B.C.)

—	Flasks (a)	Value	Price per flask
		$	$ cts.
1895	71	2,343	33 00
1896	58	1,940	33 44
1897	9	324	36 00
1898-1924	(None recorded)		
Totals	138	4,607	....
1926-1927	6	Not sold	....

(a) Seventy-six and one-half (76½) pounds each; since 1904, 75 pounds each.

NOTE.—Besides the above, about 12 flasks were produced from the Cobalt ores between 1910-18.

Imports of Quicksilver into Canada

Calendar year	Pounds	Value	Calendar year	Pounds	Value
		$			$
1907	189,841	82,873	1917	71,608	76,322
1908	87,620	44,020	1918	56,936	68,903
1909	285,958	147,625	1919	26,465	31,573
1910	107,888	63,450	1920	209,020	272,152
1911	118,336	67,416	1921	30,894	20,570
1912	137,474	72,171	1922	59,296	47,742
1913	219,442	109,493	1923	135,953	95,922
1914	204,229	97,449	1924	85,459	60,675
1915	184,432	159,184	1925	146,435	118,697
1916	79,204	74,461	1926	100,492	84,910

Average prices for 75-pound flask: 1921, $45.46; 1922, $58.95; 1923, $66.50; 1924, $69.76; 1925, $83.128; 1926, $100 to $105; and in 1927, $100 to $128 for 76-pound flask.

XIV

NOTES ON THE OCCURRENCES, METALLURGY, AND USES OF QUICKSILVER

V. L. Eardley-Wilmot

SOURCES OF SUPPLY

Until comparatively recently, Spain has been the leading producer of quicksilver, but is now superseded by Italy. These two countries together now produce almost 90 per cent of the world's total. The United States is the third largest producer. In the former countries activity in quicksilver mining was greater in 1926 than in any previous year.

The world's production by countries for the last five years is given below:—

World's Production of Mercury, 1922-1926, by Countries[1]

(Compiled by L. M. Jones of the United States Bureau of Mines)

(1 metric ton = 29·395 flasks)

Country *(a)*	1922		1923		1924	
	Flasks	Metric tons	Flasks	Metric tons	Flasks	Metric tons
Algeria	....	....	....	....	79	2·7
Austria	....	....	....	....	132	4·5
China *(c)*	503	17·1	47	1·6	85	2·9
Czechoslovakia	185	6·3	1,514	51·5	2,287	77·8
Italy	45,298	1,541·0	48,666	1,655·6	48,237	1,641·0
Japan	35	1·2	*(d)*	*(d)*	....	....
Mexico	1,231	41·9	1,316	44·8	1,078	36·7
New Zealand	21	0·7	....	....	....	....
Rumania	....	....	*(e)*	*(e)*	8	0·3
Russia	647	22·0	1,499	51·0	*(f)* 1,945	*(f)* 66·2
Spain	38,748	1,318·2	33,646	1,144·6	26,417	898·7
United States	6,375	216·9	7,937	270·0	10,085	343·1
	930,43	3,165·3	94,625	3,219·1	90,353	3,073·9

(a) In addition to the countries shown in the table, Turkey is a producer of mercury. Information furnished on May 21, 1923, by the United States High Commissioner of Turkey places this country's average annual production at approximately 67 tons (1,969 flasks). These figures are not included in the above totals.

(b) Data not available.

(c) Exports. Statistics of production are not available, official estimates of the output in 1925 range from 128 to 470 metric tons.

(d) 4 kilograms reported.

(e) Production of 200 tons of ore reported; metallic content not stated.

(f) Figures represent output for year ended Sept. 30.

(g) Estimate.

[1] "Mercury in 1925 and 1926", Min. Res. U.S.

World's Production of Mercury, 1922-1926, by Countries—Concluded

Country (a)	1925		1926	
	Flasks	Metric tons	Flasks	Metric tons
Algeria	58	2·0	76	2·6
Austria	179	6·1	(b)	(b)
China (c)	97	3·3	(b)	(b)
Czechoslovakia	(b)	(b)	(b)	(b)
Italy	53,898	1,833·6	54,998	1,871·0
Japan	....	....	(b)	(b)
Mexico	1,138	38·7	1,335	45·4
New Zealand	....	....	(b)	(b)
Rumania	97	3·3	(b)	(b)
Russia	(f) 291	(f) 9·9	(b)	(b)
Spain	37,546	1,277·3	46,861	1,594·2
United States	9,174	312·1	7,642	260·0
	(g)104,000	(g) 3,500	(b)	(b)

Italy

The well-known mercury deposit at Idria, in Carniola, Italy, was discovered in 1470 and was worked for centuries by the Austrian Government, and since 1920 by the Italian Government. The ore zone has been worked over a length of almost 5,000 feet, but the ore apparently does not extend to a depth of more than 1,000 feet. At present the average content of the ore treated is 0·7 per cent mercury. The Idria district is said to be rapidly reaching exhaustion. The greatest production is now maintained from the Monte Amiata district, Tuscany. There are a considerable number of mines in this district, six of which are important producers, the Abbadia San Salvador mine being the largest. It has been estimated that the Monte Amiata district can maintain its present rate of production for about 20 years more.

Spain

The Almaden mercury mine, on the northern slope of the Sierra Morena, central Spain, is the largest and richest in the world and like the Idria mine, has been worked for centuries. The mine is over 2,000 feet deep and is remarkable for the fact that the ore-bodies increase both in width and in richness with depth. The content varies considerably up to 85 per cent, but the average mined and treated is said to be 8 per cent. The average Spanish ore treated is about 6 per cent mercury and the total output since 1564 is approximately 190,000 tons of quicksilver, but mining and reduction methods are crude and wasteful. The available reserve at Almaden has been estimated to be 40,000 metric tons of metal. The mines have been owned and worked by the Spanish Government since 1645, and during 1925 the Government made an exclusive selling agency with the Sociedad General Mercurio de Almaden, of Caballero di Gracia, Madrid, which now handles the Almaden output and quotes prices. Their 1926 output was the highest for over a decade. Deposits of minor importance are found in several other provinces.

United States

Almost the entire United States output (about 95 per cent) has come from California. The New Almaden mine in Santa Clara county, was first worked in 1824 and except for the last year or two has been in continuous operation since 1846. At present the New Idria quicksilver mine in San Beneto county is now the main source of supply. This mine has been operated since 1858. The Chisos mine in Texas is now believed to be the second largest producer. The production of 1926 was made by 7 mines in California; 9 mines located in Arizona, Idaho, Nevada, Oregon, Texas, Washington; and 1 in the Iditarod district of Alaska. The principal Californian quicksilver ores are associated with and close to contacts of serpentine, with shales and sandstone, the New Almaden being in the former and the New Idria mainly in the latter. The average grade of the ore treated has been gradually declining and is now under 0·5 per cent. The total United States mercury production since 1850 is about 80,000 short tons.

MARKETS

Germany is the leading importer of quicksilver and the quantity is increasing annually. The United States imported about 1,000 tons in 1926 valued at almost two million dollars, which constitutes a record. The annual imports into Great Britain amount to between 500 and 600 tons. The markets are indicated in the list of uses given at the end of this report.

The prices in New York during 1926 rose from $86 to $100 per flask (75 pounds) at the close of the year. This price kept on increasing during 1927 and in July reached $128, the war high level of 1918.

METALLURGY

Quicksilver ores are treated by a comparatively simple roasting process, as a result of which the mercury in the form of vapour is expelled from the previously dried ore and is collected in specially constructed condensers. In the direct furnace treatment, an excess of air is usually present; but, in retorting, the oxygen is almost entirely absent.

Although the extraction of part of the mercury in the ore is simple to obtain, a high recovery, particularly from low-grade ores, is a difficult problem. In the past little attention was paid to improvements in methods of treatment, but in the last few years much research has been done in the United States, resulting in a considerable change in the system and types of furnaces.

The temperatures at which the ores are to be roasted or retorted are important and depend on the nature of the ore and the impurities present. Impurities such as iron pyrites, antimony, arsenic, etc., interfere with the complete vaporization so that charges of lime or scrap iron have to be added in order to flux the mercury, as well as to protect the linings of the furnace or retorts. The boiling point of mercury is 357° C. and if ore containing free mercury is heated above this temperature, the vapour will tend to force its way through the fractures in the ore. The subliming point of the sulphide, cinnabar, is about 530° C., above which temperature the ore should be retorted. Oxygen combines very rapidly with the sulphur at 450° C. with the liberation of mercury vapour so that the roasting temperature need not be so high as for retorting.

Furnaces

There are several types of brick furnaces, the commonest of which is the Scott type. This consists essentially of one or more pairs of narrow vertical shafts, containing 26 to 30 fireclay inclined shelves, down which the ore falls by gravity. The hot gases from the fire-box passing up the shaft, dry the ore as it falls down the top shelves and the ore is thoroughly roasted by the time it reaches the bottom where it is then drawn out and is discarded. The gases, dust, and mercury vapour pass through perforated ports ("pigeon holes") in the furnace wall into dust chambers and thence through the condenser system. Another form, but of more complicated design, is the Cermak-Spirek furnace. Brick furnaces have been in use throughout the world for centuries and are still used in Europe. Some of these furnaces are said to have been in continuous operation for 200 years.

Recently, in California, the old type of brick furnaces was abandoned and all the present operators have installed rotary, cylindrical roasting kilns. This type of kiln is a decided improvement over the old brick furnaces. It is simpler to operate, easier to control, gives higher recovery, has a greater unit capacity, and a preliminary drying of the average mine run ore is not necessary. At New Idria the rotaries are 5 feet diameter by 60 feet long, but it has been found that the smaller kilns are more efficient and they are now made either 3 feet by 26 feet or 4 feet by 30 feet with an enlargement at the discharge end so as to give the ore a thorough final roast. The kiln now largely used is the "Gould Improved Rotary" (San Francisco), which will treat material ranging from dust or mud up to 3-inch ore. They are usually oil fired, the oil being preheated by a steam coil and blown in under pressure, but in some cases the oil is atomized by steam. Dust problems have been largely overcome by carefully regulating the speed of the kiln and by special manipulation of the feed as well as the discharge of the roasted ore by means of screw conveyers.

Dust Chambers and Condensing System

The gases pass direct from the kiln to the dust chamber, which is usually made of concrete with inside baffles. When in operation the chamber is kept above the vaporizing temperature of mercury so that, theoretically, only the solid impurities settle out in the form of dust and are periodically removed and returned to the kiln to recover any mercury present.

The condensing system differs according to the peculiarities of the ore and to climatic conditions. At New Idria, the hot mercury vapour passes out from the top of the dust chamber through cast-iron pipes covered with concrete into which are inserted small pipes discharging fine sprays of water. These concrete-covered pipes lead to the bottom of the first condenser, also made of concrete, in which over 80 per cent of the quicksilver is condensed and collected in special traps. The remaining vapours pass through long, inclined parallel rows of glazed vitrified tile pipes, of 18 to 24 inches diameter, to the second concrete condenser and thence up to a set of 4 large, circular, water-sprayed redwood tanks, through another long, inclined row of tile pipes to the last concrete condenser and finally up into a 70-foot tower. All the condensers along the system have sloping bottoms and mercury traps, but in the latest designs the mercury from all the condensers and pipes in the system runs to a central collecting chamber; also, smaller tile pipes of 12-inch diameter are found to give better results. The mercury "soot," which usually collects in the first condenser is agitated on an inclined iron hot-plate with quicklime, when the minute mercury globules coalesce and run down to the bottom leaving the dust and dirt behind. The mercury from the condensers is skimmed clean and ladled into specially shaped iron "flasks" which hold 75 pounds of the metal.

Remarkably high recoveries can be made on low-grade mercury ores, provided they are not too dusty, at low cost with these rotary kilns and modern condenser systems.

For treating very high-grade or picked ores a good recovery can be obtained with a simple retorting plant which is much cheaper to install. Retorts are more suitable for the small operator.

Multiple hearth roasting furnaces of the McDougall type have been used in some of the new Almaden mines. The main difficulties were precipitation of mercury in the upper part of the furnace and excessive dust. The former was largely overcome by installing two external fire-boxes on opposite sides of the hearth next to the bottom and a third smaller fire-box which communicates with the top hearths. The dust problem was overcome by means of a Cottrell precipitator. The dust collected by electrostatic precipitation amounted to about 1,500 pounds per 24 hours and contained only a trace of quicksilver. Such an installation would be costly and it is doubtful whether it would be as efficient as the rotary kiln system described above. For very dusty ores, a Cottrell precipitator in connexion with the kiln might be advantageously employed.

Concentration

Prior to the world war little attention had been given to concentration, but in later years a number of mills have been erected in California on which gravity methods and flotation were used, but these have all been abandoned. In most low-grade ores, for which concentration might be profitable, the cinnabar is highly disseminated, necessitating fine grinding. Cinnabar slimes very readily causing considerable loss in the tailings so that concentration for the usual type of mercury ores has not been proved to be economical. The simplicity of furnace treatment at its comparatively low cost, when a finished marketable product can be obtained in a single operation, must also be considered.

USES

Quicksilver is unique in being the only metal that is liquid at ordinary temperatures. For this reason and for its other physical and chemical properties, it is essential for many phases of industry and for which no substitute is available. It is largely used in the form of the fulminate as a detonator for explosives and is only equalled by the highly expensive silver fulminate. In medicines and the manufacture of drugs, in the manufacture of electrical and scientific instruments, as well as in the general field of experimental science, quicksilver is indispensable. Another highly important application is as amalgam for the recovery of gold from its ores and is largely used by gold, silver, and placer mining companies;

it is also used as an amalgam in dentistry. An appreciable quantity is employed in the manufacture of pigments, and in anti-fouling paints for ship bottoms. It has a considerable application in the form of electric vapour lamps. It is sometimes used as a sealer for rotary compressors, and is also used by hatters and furriers in preparing raw materials. Other recent uses are as follows: in the making of caustic soda for use in the manufacture of artificial silk; in certain processes connected with petroleum refining; in the manufacture of automatic switches for iceless refrigerators and other electrical devices; radio tubes; storage batteries; in a fertilizer compound to cultivate grass for golf courses, etc. Another new field of application is the mercury vapour boiler invented by Dr. Emmett, and manufactured by the General Electric Company. Mercury is generated in a fuel-heated boiler to drive a turbine. The exhaust from the turbine heats a second boiler that serves as both a condenser for the mercury and a source of steam for a steam turbine.[1] If this proves a commercial success, it may lead to a further increase in demand for the metal. Mercury was at one time largely used for mirror backing, but silver is now substituted.

PRESENT SITUATION

The demand for quicksilver is steadily increasing due in part to the large consumption attributed to the increased manufacture of radio tubes, electrical appliances, storage batteries, corrosive sublimate, and to the numerous other uses of the metal. The price of the metal has steadily risen and is now 50 per cent more than it was two years ago in July 1925. This increased demand naturally tends to greater activity by the principal quicksilver producers so that the resultant larger output may cause a decline in the price of the metal. On the other hand, the great Idria deposits in Italy are rapidly approaching exhaustion and the present rate of production for Monte Amiata is limited. The United States is now only a minor contributor, their ore being low-grade and in spite of their highly efficient methods of mining and reduction the costs per flask are about $70 against $35 for Italy, and $25 for Spain. It has been stated that in the United States "economic exhaustion undoubtedly will take place within a few years as there are no known undeveloped extensive deposits even of low-grade ore." On account, however, of the present high price many old mines have been reopened, new prospects found and developed, and new plants installed, which should result in an increased production in the United States during the next two or three years. Owing, however, to the growing increase in demand and gradual exhaustion of the world's supplies there is not likely to be any marked falling-off in price of quicksilver, unless some large, high-grade economic deposits are discovered.

[1] Cotton, J. W.: "Mercury Vapor Turbine" Aera, Vol. 12, pp. 916-920 (Jan. 1924).

XV

GRANITE PAVING BLOCKS

C. H. Freeman

Granite paving blocks, or setts as they are sometimes called, were among the first materials to be used for paving purposes; they have proved to be one of the most durable. First used in many European cities, they rapidly found favour in several American cities, superseding the old cobblestone pavement because of its extreme roughness and increasing cost. In Canada granite blocks or setts have been used to a varying extent in such places as Halifax, St. John, Montreal, Quebec, Sherbrooke, St. Hyacinthe, Toronto, Hamilton, Niagara Falls, Windsor, Winnipeg, St. Boniface, and Vancouver.

Granite block pavement has some features which make it particularly serviceable where traffic is very heavy. For instance the greatest underway boulevard in the world, the Holland Tunnel, now under construction, connecting New York and New Jersey, with an estimated capacity of 46,000 vehicles per day, is to be paved with granite blocks. On steep grades such as exist on hills and approaches to subways it provides excellent traction for horse-drawn vehicles. However, in Canada it finds its main use for paving the space between street-car tracks and a strip generally 18 inches in width on the outside of the rails on those streets which are subject to severe traffic conditions. Such is the case in Toronto. On the other streets in the city, chiefly residential ones, used by street-car lines and where there are average traffic conditions, other paving material, chiefly asphalt, is used instead of granite blocks. Generally the blocks are used on all curves and switch points. One chief advantage of blocks is, that part of the pavement can be torn up and replaced without heavy repair cost. The faces of worn granite blocks can be redressed with a loss of not more than 5 per cent, whereas in asphalt and concrete pavements the part removed in repairing is generally discarded. As rails at switch points and on curves must be more frequently replaced than those on tangents, this feature of easy repair is the main reason why blocks or setts are used. In some localities blocks are used as headers against the rails, the blocks being flanged to fit the groove inside the rail. The space between these two rows of headers is filled with some other paving material.

Granite block pavement has its disadvantages. The first is its heavy initial cost. In Montreal it is over three times the cost of sheet asphalt. It is also a very noisy pavement and this is the reason why Montreal is mainly replacing it with asphalt. However, on some of the streets where there are steep grades, a strip in the centre of the street will be paved with granite blocks of 4-inch cubes—asphalt being used for the strips on either side. This strip of granite of a width to permit two vehicles to pass will be of most service during the winter and spring months when the streets are covered with snow and ice, as only the centres of the streets are ploughed. Sherbrooke has some streets paved in the centre with granite blocks. In Montreal the old regulation block will not be dispensed with, as they will continue to be used between street-car track on steep grades, subways, curves, and switch points. Another trouble that some cities have experienced with block pavements that have not been well constructed, is the heaving of some of the blocks in alternate thawing and freezing weather.

In the laying of paving blocks great care must be given to the foundation as the success of the pavement depends on this. A foundation of concrete of approximately nine inches depth has taken the place of the sand base formerly used. On this a sand cushion is added. In Montreal this has an average thickness of one-half inch and is composed of one part Portland cement and three parts sand thoroughly mixed and laid dry. After the blocks are laid this is dampened. In Toronto the cushion averages one and one-half inches and is composed of one part Portland cement and four parts sand. This is made into a firm mortar stiff enough to hold the setts in place as they are laid, and moist enough to harden and properly set after the pavement is laid. Immediate ramming of the blocks takes place before the cushion sets so that all uneven or sunken places may be replaced and the whole surface made even. The blocks are laid in parallel rows with the long side of the blocks at right angles to the direction of the street or car tracks, as in this position they wear better than any other. The space between the blocks varies in different localities. In Toronto this must not exceed one-quarter inch, while in Montreal it may vary from one-quarter to three-quarters inch with one-half inch as an average. This space is filled with a grout of either cement or asphalt. A cement grout is the usual one used and is composed of one part Portland cement and one part sand. This must be well brushed into all crevices. In some cases a surplus quantity is allowed to flow over the surface to smooth out all remaining unevenness. The grout must be constantly maintained if a waterproof pavement is to be the result. If it is permitted to crumble away, water is bound to penetrate to the seat of the blocks. This is very detrimental during alternate freezing and thawing weather as frost will cause heaving. A few paving-block cutters are of the opinion that if a shorter block were used, there would be less liability of the block to lever or rock on an uneven foundation or too thin a sand cushion. A finished pavement must not be opened to traffic until the eighth or tenth day.

In Canada, granite blocks or setts are produced in New Brunswick, Quebec, and Ontario. In New Brunswick a small quantity comes from Hampstead,[1] Hampstead parish, Queens county. In Quebec there are three localities: (a) Graniteville[2] and House Hill (range IV, lot 2; range V, lots 1, 2, 3, 5; and range VI, lots 3, 4), Stanstead township, Stanstead county; (b) Guenette,[3] range V, lot 37, Boyer township, Labelle county; (c) Brownsburg,[4] range VII, lots 764, 765, Chatham township, Argenteuil county. By far the greater part of the production comes from the Stanstead area.

In Ontario there are also three areas: (a) The most important lies in Leeds and Escott townships, Leeds county, and Pittsburgh township, Frontenac county. In Leeds[5] township the operations are carried on in

[1] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 203, vol. II, p. 127.
[2] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 279, vol. III, p. 163.
[3, 4] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 279, vol. III, p. 147.
[5] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, No. 100, vol. I, pp. 299-300.

concession II, lots 5, 6, 7, being close to Gananoque and Cheeseborough. In Escott[1] township, the works are in concession II, lots 10 and 15, near the village of Escott; and in Pittsburgh[2] township the location is concession IV, north half lot 32, and is very near to the station of Findley. (b) At Sundridge in Strong township, Parry Sound district; blocks were shipped from here to Toronto, but the quarry has been idle for years. (c) The third locality is at Butler in Kenora district. Flanged paving blocks wêre shipped from here to Winnipeg in 1925.

In New Brunswick and Quebec paving blocks are not the entire product. The production of building, monumental, and curbstones exceed them in amount. In Quebec in 1925 there were four quarries and eight motions working and these were all located in Stanstead county. In Ontario, around Leeds and Frontenac counties, in 1925 there were two quarries and seven motions working. Here, paving blocks are the main product.

Below are two tables showing the production of paving blocks of all kinds in Canada for a period of five years. The first table shows the value by provinces, and the second the value of materials. These were compiled from reports of the Dominion Bureau of Statistics.

TABLE I

Year		New Brunswick	Quebec	Ontario	Total
1921	tons	1,351	6,317	7,677	15,345
	$	15,321	181,698	51,682	248,701
1922	tons	140	16,512	20,215	36,867
	$	3,036	177,699	222,385	403,120
1923	tons	215	14,717	11,351	26,283
	$	24,565	124,625	115,816	265,006
1924	tons	292	6,858	7,642	14,792
	$	4,171	96,957	61,184	162,312
*1925	tons	136	16,385	9,191	25,712
	$	3,153	137,974	72,849	213,967

TABLE II

Year		Granite	Limestone	Sandstone	Total
1921	tons	13,770	1,280	295	15,345
	$	214,770	31,603	2,328	248,701
1922	tons	36,404	....	463	36,867
	$	398,952	....	4,168	403,120
1923	tons	24,226	1,117	940	26,283
	$	255,568	671	8,767	265,006
1924	tons	14,602	....	190	14,792
	$	160,612	....	1,700	162,312
*1925	tons	25,712	....	....	25,712
	$	213,976	....	....	213,976

*Figures subject to revision.

[1] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, No. 100, vol. I, p. 301.
Wright, J. F.: Geol. Surv., Canada, Mem. No. 134, p. 54.
[2] Baker, M. B.: Ont. Dept. Mines, vol. XXV, pt. 3, page 34.

Paving blocks or setts are made at large quarries and by small operators working on claims known as motions.[1] Generally, all contracts for blocks are received by the operators of the large quarries, who fill orders from their own production plus that purchased from the motion workers. At the large quarries steam or air power is used for operating the drills, but at the motions the work is entirely done by hand. Only sound rock is used in making the blocks. No attempt is made to use outcrop rock. Fine-grained granite showing an even distribution of constituent materials of uniform quality, texture, and colour, without laminations, scales or brittleness and free from an excess of mica or feldspar is preferred. All blocks must have rectangular faces. This is not a difficult thing to attain as granite has three planes along which cleavage takes place fairly easily, known as the rift, grain, and the hardway. All corners and edges must be protected and not allowed to spall by rough handling. Blocks are of various sizes, each city having its own specifications. In Toronto they are 7 to 10 inches long, 4 to 4½ inches wide, and 4½ to 5 inches deep. In Montreal a heavier block has been used viz.: 7 to 12 inches long, 3½ to 4½ inches wide, and 4¾ to 5½ inches deep. A new type is being adopted in this city, this being a 4-inch cube.

In Canada a paving block has been made from sandstone. In Ontario, Ottawa and Kingston have used them chiefly in street-car track allowances. They make a fine pavement and are considered by some authorities to have some advantages over granite. They are less likely to cobble as they wear down more uniformly. As they are compacted sand grains the surface never wears smooth. Sandstone blocks have been made in two localities: one is Ste. Scholastique in Two Mountains county, Quebec; and the other at Bells Corners,[2] Nepean township, Carleton county, Ontario. No production has been recorded since 1924 and for four years prior to this the production was less than 2 per cent of Canada's total paving-stone production. The price of sandstone and granite is very much the same.

Vitrified brick and an iron slag block known as scoria are the chief competitors of granite blocks. Both are cheaper. Bricks are about half the price of granite blocks and make a neater and smoother pavement which is quite serviceable. But the pavement has not the life of a granite block pavement under severe traffic conditions. They are generally imported from the United States, Olean in New York supplying Ontario. A big objection to scoria blocks is that they wear smooth and make a very slippery pavement. Asphalt and concrete is also a large competitor. Concrete has also taken its place on grades where granite was believed to have had exceptional advantages. For instance on a steep street in Quebec, that was paved with granite blocks, it was the desire to keep horse-drawn vehicles from using it. Concrete was substituted in the hope that such vehicles would abandon it and seek other nearby streets that were paved with granite blocks. It was found out that there was no diminution of traffic as expected.

During the year 1926 most of the quarries and motions producing these blocks were working half time or not at all. One main reason for the falling-off was that Montreal, a large consumer, has largely dispensed

[1] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 100, vol. I, p. 302.
[2] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 100, vol. I, p. 134.

with this type of pavement. The Toronto Transportation Commission also bought less after a large paving program. During the years 1921-1925 inclusive this commission purchased enough paving blocks to pave approximately 300,000 square yards. This would pave over 28 miles of double-tracked streets on the 18-foot street-car track allowance. As there will be new extensions and repairs a fairly constant demand for blocks will continue. The city of Windsor will need annually, for sometime, 40,000 to 60,000 blocks. The price has dropped considerably during the years under review, the average price of all granite blocks in 1921 was $15.60 a ton, whereas in 1925 it has been reduced to the low amount of $8.30. Naturally very little profit is made at this latter figure. No doubt it should be a factor in stimulating the further use of them.

Much valuable information was given the writer by Mr. H. W. Tate of the Toronto Transportation Commission and Mr. J. E. Blanchard of the Department of Public Works, Montreal. Plate VII shows the method of laying paving blocks in subways in Toronto by the Toronto Transportation Commission. It will be noticed the entire width of the street is paved with the blocks and not just the street-car allowance.

Bloor St. E., Toronto, from C.N.R. subway, showing method of laying granite paving blocks, and conditions under which the blocks have their greatest use.

XVI

THE ASBESTOS INDUSTRY IN CANADA

C. H. Freeman

In 1925 Canada produced 80·6 per cent of the world's supply of raw asbestos; Rhodesia, our chief competitor, produced 11·3 per cent. The other asbestos-producing countries with their percentages are as follows, viz: Russia, 3·2; South Africa, 3·0; Cyprus, 1·5; and United States, 0·4. The value of asbestos for the same year amounted to 4 per cent of the mineral production of Canada. All the asbestos mined in Canada comes from Quebec, although in 1924 a small production was reported from McKay lake near Timmins, Deloro township, Ontario. In 1925 asbestos represented 28 per cent of the total mineral production of Quebec and 34 per cent of the wages paid in the mineral industry. The industry started in 1878 when the late Mr. Andrew S. Johnson began mining asbestos at what is now Thetford Mines. The total production to December 31, 1925, is 2,908,456 tons valued at $123,644,496.

The asbestos occurs in what is known as the serpentine belt. This belt extends in an irregular northeast direction from Brome county to L'Islet county. The most productive part lies in the townships of Thetford, Coleraine, and Ireland, all in Megantic county. Thetford Mines is the main centre and here most of the large mines or quarries are situated. The Black Lake district, 4 miles southwest of Thetford Mines, is really a continuation of the Thetford Mines area. Sixteen miles northeast of Thetford Mines, near East Broughton in Broughton township, Beauce county, is another district known as the Broughton field. Asbestos has been mined at two localities between East Broughton and Thetford Mines, but at present no mines are operating. Of the remaining area, one, known as Vimy Ridge, is located about 4 miles southwest of Black Lake; and the other, the Danville area, near the town of Asbestos in Shipton township, Richmond county, is 38 miles southwest of Thetford Mines.

The asbestos is of the chrysotile variety and is usually greenish yellow in colour. It is easily separated into threads, has a silky feel, and possesses excellent flexibility and high infusibility. It is found disseminated throughout the serpentine or as well-defined veins which may be either parallel, banded, forked or intersecting; or a combination of these features. The veins vary in width from $\frac{1}{8}$ inch to 5 or 6 inches, but by far the greater number are less than $\frac{3}{4}$ inch. The fibre is at right angles to the veins, and the width of the veins, therefore, represents the length of the fibre. The asbestos from these veins is known as "crude" and is marketed in two grades, No. 1 and No. 2. No. 1 grade is in excess of $\frac{3}{4}$ inch, and No. 2 is below $\frac{1}{2}$ inch, but authorities differ as to the grading between these two lengths. F. Cirkel designates crudes over $\frac{3}{4}$ inch as No. 1, and crudes $\frac{5}{16}$ inch to $\frac{3}{4}$ inch as No. 2. Around Thetford Mines, Black Lake, Vimy Ridge, Coleraine, and Asbestos, the asbestos occurs as described above, but in the Broughton field the fibre, instead of being at right angles to the veins or fault-planes, is drawn out and almost parallel with them,

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and is known as "slip fibre"; consequently, in this field no "crude" is recovered, it being necessary to mill all the ore. The fibre recovered is slightly shorter, of less tensile strength, and is less valuable than that produced in the other areas.

The asbestos industry of Canada has generally faced a situation of over-production. More mines were operated than were really needed to supply the market and many of these were forced to close down temporarily or reduce their output. Some concerns went bankrupt and their product sold for less than it cost to produce. This had a demoralizing effect on the solvent companies, who in consequence sold their fibre at too low a price. Some companies kept operating merely to protect their investments and to give employment to miners and mill hands. However, during 1919 and 1920, due to the war, the demand exceeded the supply and large profits were secured. For years there was talk of controlling the output by merging the different companies, but nothing was achieved until December, 1925, when a merger was completed which came into effect January 1st, 1926. The new company is known as Asbestos Corporation, Limited, and at present (October 1926) the following companies are members:—

(1) Asbestos Corporation of Canada, Limited,
(King, Beaver, British-Canadian, and *Fraser mines).
(2) Consolidated Asbestos, Limited,
(Thetford, *Kitchener, and *Belmina mines).
(3) Thetford-Vimy, Limited. (Formerly Bennett-Martin Asbestos and Chrome Mines, Limited).
(*Ward, Vimy Ridge, and *Edith mines).
(4) *Black Lake Asbestos and Chrome Co., Ltd.,
(Union, Imperial, and Southwark mines).
(5) *Federal Asbestos Company,
(B. A. mine).
(6) Maple Leaf Asbestos Corporation, Limited,
(Maple Leaf mine).
(7) Asbestos Mines, Limited,
(Boston mine).
(8) *Pennington Asbestos Company,
(Pennington mine).
(9) Asbestos Fibre Co. Inc.,
(Ward-Ross mine).

NOTE.—Properties marked (*) were idle in 1926.

It is the intention of the merger to regulate production and to stabilize prices. If these objects be attained the asbestos now exported in a raw state, at prices only slightly above the cost of production, can be sold to give a reasonably fair return.

Although the merger has been in effect for several months, the desired results have not been realized. The table below[1] shows that the increases in the quantity of ore mined and fibre produced are above normal, and only a slightly better price was secured. The first of the periods mentioned was in the year before the merger, and the last one just after the merger.

The table does not include that by-product now known as "sand and gravel" which, as it contains no asbestos, is kept separate. It was not possible to secure the exact amount of this for the half year 1925, but a close approximation was obtained by taking half of that year's quantity which was available.

[1] Dominion Bureau of Statistics.

—	Ore mined	Asbestos produced	Sold or shipped		Average value per ton of asbestos
			Quantity	Value	
	tons	tons	tons	$	$
Jan. 1-June 30, 1925..............	1,786,812	102,593	112,367	3,956,904	35·22
Jan. 1-June 30, 1926..............	2,212,678	147,042	126,287	4,508,143	35·68
Per cent increase 1926 over 1925..	23·8	44·2	12·4	13·9	1·3

During 1926 fifteen mines or open-cast quarries were in full or part time operation. Eleven of these were in the Thetford Mines and Black Lake areas; three in the Broughton area; and one in the Danville area. This is one more than during the previous year.

Naturally those mines which entered the merger would not speed up their plants to any great extent. It appears that the other five companies with seven working mines considerably increased their output. During these periods the same mines were working, Johnson's mine at Black Lake, which had been closed since March 1921, did not reopen until July 1926. This same company is at present enlarging its Thetford Mines plant to about double its original capacity.

MINING

Mining is carried on by different methods or a combination of methods, as enumerated as follows:—

(1) Open-cast quarrying with cable derrick hoisting.
(2) Open-cast quarrying with steam or electric shovels and cranes loading into trains or cars.
(3) Glory-hole mining.
(4) Underground and glory-hole mining.

No attempt will be made to describe the mining methods at every mine, but those employed at the more important active ones will be discussed, though not necessarily in detail.

Mines Operated by the First Method

The King mine of the Asbestos Corporation, Limited, on ranges V and VI, lot 26, Thetford township, at Thetford Mines, is the largest and deepest of this type. It was one of the earliest worked. It has a surface dimension of about 800 feet by 700 feet making an area of about 13 acres and has a depth of 375 feet. The quarry has been worked in a series of benches. Rocks that are too large to be easily handled are block-holed. Separations are made into crude ore, milling ore, and dry rock. Previous to 1926 all the hoisting was done in 5-ton boxes on 6 pairs of cable derricks each having a span of 938 feet. In 1926 two pairs of larger cable derricks were installed. These are of steel construction, electrically operated, and have a span of 1,400 feet. The cables are 3 inches in diameter and will handle boxes of 10-ton capacity. The mine has reached such a depth that the walls are closing in at the bottom and particular care must be taken in scaling the walls to prevent accidents. In order to go deeper and secure safer mining, the area of the quarry had to be increased. Accordingly, in 1920, stripping was begun on an area 900 feet by 600 feet on the northeast side of the quarry. The contract for this work was given to Fraser-Brace, Limited. Hydraulicking was first tried, but this was unsuccessful and steam shovels were used. The thickness of overburden was not uniform, being in some places as much as 80 feet. This work has increased the area of the quarry to about 25 acres. On the southeast side of the quarry the new tail derricks are set back a distance of 500 feet from the brink to allow extension of the quarry in that direction. A prospect tunnel, about 270 feet below the surface or 100 feet above the floor of the quarry, had been run under this piece of ground for a distance of 500 feet from the face of the pit. Paying ore was found throughout the entire length although there were inclusions of aplite rock locally known as "granite." Diamond-drilling also has been carried on in the floor of the quarry to an approximate depth of 425 feet or 800 feet from the surface. Ore was found here similar to that being mined.

At present the miners enter the workings by a ladderway, but in the fall of 1926 a 400-foot tunnel was started from the present deepest level. It is the intention to put an incline through to the surface from the inner end of this tunnel for a man-handling skip. Two shifts are worked.

The Beaver mine in range C, lots 31 and 32, Coleraine township, at Thetford Mines, belongs to the Asbestos Corporation, Limited. The open pit is about 1,100 feet by 500 feet by 245 feet deep and is worked in a series of benches. Two-ton boxes and nine wooden cable derricks are used for hoisting. A prospect tunnel about 160 feet from the surface runs southwesterly from the face of the quarry approximately 1,800 feet. Good ore was found along its length. Diamond-drilling was done in the bottom of the pit to about 500 feet from the surface and good ore was found to that depth. Since the merger has taken place the drainage of this mine is diverted into the drainage channels of an adjoining mine which formerly belonged to a rival company. This was accomplished by running a 310-foot tunnel from the underground levels of the Thetford mine of the former Consolidated Asbestos, Limited, to beneath the floor of the Beaver pit, a vertical distance of 90 feet. From the end of this tunnel a raise was put to the floor of the pit. Access to the Beaver mine is by means of a ladderway back from the face. These enclosed ladderways are much safer than those on the face of the quarries, particularly in winter.

Johnson's mine at Thetford Mines in range VI, lot 27, Thetford township, is immediately south of the Bell mine of Keasbey and Mattison, Co., only a wall of milling ore separate these two properties. Four cableways of the Johnson hoisting system are anchored in this wall. Eventually 6 or 8 cable derricks will supply the mill which is now undergoing additions, to bring it up to nearly double its present capacity. In the quarry, the rock is separated into four grades, viz.: crude fibre, coarse mill rock, fine mill rock, and dry rock. The Johnson mine at Black Lake on range B, lot 27, Coleraine township is quite similar to their Thetford mine. Four cable derricks are employed.

The Paré mine (formerly Lambly mine) is located in blocks A and B, Coleraine township and is the property of the Canada Asbestos and Chrome Co. Two cable derricks are used. Although crude fibre occurs no attempt is made to recover it, all of the ore being milled. This mine has considerably increased its output in the last year.

Mines Operated by the Second Method

The Jeffrey mine in range III, lots 8 and 9, Shipton township, Richmond county, at Asbestos, is owned by the Canadian Johns-Manville Co., Ltd. This quarry is nearly circular in shape and at present about 100 acres in a 500-acre tract is under active development. Recently a section of the highway between Danville, on the Canadian National railway, and the village of Asbestos, was shifted to allow an extension of the present quarry. The quarry is worked in a series of benches, much like the iron ore mines of the Lake Superior region; five benches in all being worked. The ore is hauled by steam trains to three mills. The equipment consists of 18 locomotives, 300 twenty-ton cars, and 28 miles of standard gauge track. As many as 12 steam shovels are used for loading overburden or ore. Less block-holing of large pieces of ore is done here than at any other asbestos mine, as the largest jaw crusher in the field is located at this plant. After each blast the miners collect all the crude possible.

The Bell mine in range V, NE. ½ lot 27, Thetford township, at Thetford Mines, is the property of Keasbey and Mattison, Co. (Bell Asbestos Mines Department). This is one of the oldest mines and adjoins the King mine on the northeast and the Johnson mine on the south. The open pit is 900 by 500 feet and comprises an area over 10 acres. It has an average depth of 160 feet. The floor of this pit is exceptionally level and is well suited for the series of tracks for the small switching trains. The broken ore is loaded onto these trains by 2 steam shovels and 3 steam cranes. Considerable ore has to be block-holed. The ore is conveyed to the mill over a 1,330-foot incline on a 10 per cent grade, 940 feet of which is through a tunnel. A string of four cars, each of 8-ton capacity, is hauled up this incline to the mill by a steel cable. In the pit the rock is separated into crude mill rock and dry rock. At the north side of the mine, near the Quebec Central railway, extensive stripping of overburden has been in progress for over two years.

The Maple Leaf mine in range A, lot 29, Coleraine township, lies between Thetford Mines and Black Lake. Formerly owned by the Maple Leaf Asbestos Corporation, Limited, it is now the property of the Asbestos Corporation, Limited. The pit is 600 by 500 feet and about 160 feet deep. A steam shovel on caterpillars loads the ore into a gravity skip which discharges into a jaw crusher. The crushed rock is hoisted by a conveyer belt to the storage bin at the mill. Almost all of the ore is milled as only 6 tons of crude fibre were recovered in 1925. The quality of the product from the first milling is excellent and is known as "fiberized crude". This mine was in operation throughout 1925, but was closed down part time in 1926. It is expected to reopen this fall.

The Boston mine is in range IV, lot 13e, Broughton township, Beauce county. It is about 1½ miles from East Broughton. It was formerly operated by the Asbestos Mines, Limited, but is now a part of the Asbestos Corporation, Limited. The ore is loaded by a steam shovel into a 6-ton car which is elevated by an air-hoist to a crushing and drying plant. The dried crushed rock goes to a storage bin which feeds into buckets of a 4000-foot aerial tramway to a dry rock storage at the mill. As this mine and the two next following are in the "slip-fibre" belt no crude is recovered, everything being milled. Steam or electric shovels are used to advantage here as no hand-sorting in the pits is necessary. The mine is now temporarily closed down.

The two mines, the Ling or No. 1, and Eastern Townships or No. 2 of the Quebec Asbestos Corporation, Limited, are situated at East Broughton in range VI, lots 12c, 43b, 13c, Broughton township, Beauce county. The Ling or No. 1 mine is about 950 by 350 feet and is about 125 feet deep. An electric shovel mounted on caterpillars loads the ore into cars which are hauled to an underground hopper by means of a cable. The ore is elevated to the mill by a conveyer belt up an incline, 975 feet long, 450 feet of which is through a tunnel.

The Eastern Townships or No. 2 mine is about 500 by 210 feet and 75 feet deep, and is separated from the Ling mine by only a narrow wall, which will be eventually broken down. An electric shovel is used for loading the ore into 10-ton cars, as in the Ling mine, but instead of an underground hopper a glory-hole is used and elevating is done by a conveyer belt. Each mine has a mill of its own. In 1926 both of these mines were being worked.

The Vimy Ridge mine is in range III, lots 23, 24, 27, Ireland township, Megantic county. This was formerly owned by Thetford-Vimy, Limited, but is now a property of the Asbestos Corporation, Limited. Steam cranes are used for loading the ore into cars which are hauled by steam locomotives. This property has not been worked much since its former owners, Bennett-Martin Asbestos and Chrome Mines, Limited, went into liquidation January 1924. During 1925 a little crude fibre was recovered from development work. There is a possibility that it will be reopened in the spring or summer of 1927.

Mines Operated by the Third Method

The British-Canadian mine is the only mine which is entirely using the third system mentioned before as glory-hole mining. This mine is an amalgamation of three old properties known as British-Canadian, Standard, and Dominion mines, and is located in block A, Coleraine township, Megantic county, near Black Lake. All the ore gravitates from the glory-holes into pockets located along a series of connected tunnels which have a total length of nearly a mile. Electric locomotives are used for haulage from these pockets. The main outlet is just above the crushing unit of the mill. The ore reserves of this mine are still very large as all the tunnel system is in and on good milling rock.

Mines Operated by the Fourth Method

Underground mining assisted by glory-hole mining is adopted only in the Thetford mine formerly owned by the Consolidated Asbestos, Limited, but now a property of the Asbestos Corporation, Limited. It was first known as the Jacobs mine and is in range VI, lot 28, Thetford township, Megantic county, at Thetford Mines. Around 1918 cable derrick mining was partly abandoned and a glory-hole system adopted. A three-compartment shaft, 515 feet deep, was sunk and a level run beneath the old pit to get ore from it by a glory-hole. By 1923 underground mining had been almost entirely adopted owing to limitations of the boundaries of the property, but the glory-hole system still was part maintained. Another level was run and a system of shrinkage stoping started between this and the first one. Stopes 35 feet wide and over 260 feet long were developed. By this method with a 30 to 40 per cent withdrawal of broken rock, the miners were kept up to the roof of the stopes. Crude asbestos is cobbed in the stopes. The shaft was abandoned for hoisting ore and a 1,700-foot incline substituted, on which cars are hoisted by means of a cable. The shaft is now only used for hoisting men and supplies in and out of the mine. The ore is hauled from pockets at the bottom of the stopes in trains of four 5-ton cars drawn by storage battery locomotives. For the last three years removal of the waste dumps from good mining land just east of the pit has been going on by the use of carts.

MILLING

The milling of asbestos ore was not attempted until about 11 to 15 years after the mines were first worked, as the production of crude was sufficient to supply the small demand. With a growing market, attempts were made to recover the fibre disseminated throughout the serpentine, which was being discarded. However, it was not until 1895 or 1896 that milling became general throughout the area. The milling practice adopted was developed by the operators and to-day no two mills have exactly the same flow-sheet, and constant attempts to recover more fibre by improvements in machines are being made. The milling consists essentially of coarse crushing, drying, fine crushing, and fiberizing, followed by extraction and grading.

Jaw crushers and gyratories are used for coarse crushing. The product from these going to either rotary or vertical driers, usually fired with anthracite screenings. The dried rock goes to dry rock storage bins holding from three to ten days' supply for the mills. A few of these bins have a capacity of 25,000 tons. The dry rock is further crushed by either gyratories, hammer crushers, disk crushers, or rolls. From these the product goes to fiberizing machines such as cyclones or jumbos. After any crushing, other than the primary and fiberizing, any freed fibre is sucked from the shaking screens and transferred to graders by means of fans. Every attempt is made to get the fibre away as soon as liberated to prevent its being ground up into smaller and cheaper grades. All grades of fibre are tested by a grading machine which was developed entirely in the industry.

A wet method of treating asbestos ores has been worked out by Selective Treatment Company, Limited, in a test plant at Thetford Mines. This invention relates to a process of treating asbestos ore in water to economically extract the fibre from the rock under such conditions of control that the character of the fibre, its length, texture, colour, cleanliness, and other qualities may be determined as required. Furthermore, it is claimed that the fibre so produced is free from rock dust which oftentimes constitutes a substantial percentage of the product obtained by the dry process, and that the amount of fibre recovered is in excess of that recovered by the dry process.

The process involves the following:—

(1) Ball milling under conditions to free fibre from attached rocky matter without completely fiberizing the asbestos.

(2) Maintaining high dilution in the ball mill to permit the fibre to be floated out of contact with the balls.

(3) Effecting a separation of coarse rock and fibre while wet.
(4) Collecting long fibre separately from short fibre.
(5) Compacting the fibre.
(6) Drying the compacted fibre.
(7) Fiberizing the dried fibre.

The foregoing claims and summary of the process are from patent specifications. Selective Treatment Company, Limited, erected a pilot experimental plant at Thetford Mines in 1923 after three years of laboratory research on the process. The plant operated during 1924 on shipments of asbestos rock from the principal mines such as the King pit of the Asbestos Corporation, The Bennet-Martin pit, the large pit and Imperial mine of the Black Lake Asbestos and Chrome Company, Vimy Ridge pit, and the Asbestos Mines pit at East Broughton. According to the reports of the company and of independent engineers the results were very encouraging and satisfactory, indicating that the process possessed a great deal of merit, warranting its consideration by the producing companies. The pilot plant operations of the Selective Treatment Company, Limited, were discontinued after the company's engineers had, in their opinion, done sufficient work on this scale to demonstrate that the process was an improvement over the dry methods, and to warrant the erection of a commercial plant. In 1924, negotiations were in progress by the company for the erection of a 720-ton mill on the property of the Imperial Asbestos Company, three-quarters of a mile southwest of Black Lake on the Quebec Central railway. This does not seem to have materialized.

In 1922, a small-scale test[1] was made by the Ore Dressing and Metallurgical Division of the Mines Branch on wet methods of recovering asbestos fibre from the rock. This test gave encouraging results, but was not conclusive as the sample tested was very small. The results showed that over double the amount of asbestos was recovered compared to a dry test on the same ore. On account of the pressure of other work, the test was not followed up and owing to the very preliminary nature of the test, and the difficulty of obtaining similar grades of samples even from the same ore shipment, a small-scale test of this nature may be misleading. No great weight was placed on the results.

Electrical power for driving the machinery in all the mines and mills, with the exception of one company, is secured from Shawinigan Falls by a transmission line, 110 miles long, carrying 50,000 volts. During 1925, 60,506,285 kilowatt hours of electricity were used.

PRODUCTION AND MARKETS

Below will be found a table compiled from annual reports of the Mining Operations in the province of Quebec, showing the growth of the industry covering a period of 11 years; during which period over 61 per cent of the total asbestos produced was mined. Production means "shipments and sales."

[1] Summary Report of Mines Branch Investigations, 1922, p. 124.

Year	Tons of rock mined	Pounds of fibre per ton of rock mined	Production				I and II Crudes	
			Value of fibre per ton of rock mined	Tons fibre	Value	Average price per ton of fibre	Per cent of total quantity	Per cent of total value
			$		$	$		
1915	2,134,073	93·2	1·46	113,115	3,544,362	31·33	4·75	30·3
1916	2,291,087	109·6	2·13	133,339	5,182,905	38·87	4·46	37·3
1917	2,634,410	108·7	3·08	137,242	7,198,558	52·45	3·91	38·1
1918	2,445,745	117·3	4·08	142,375	9,019,899	63·35	2·60	27·7
1919	3,061,690	100·8	3·88	135,862	10,932,289	80·47	3·01	30·5
1920	3,123,370	109·1	4·53	179,891	14,747,048	81·99	2·14	25·8
1921	2,224,138	107·2	4·28	87,475	5,199,789	59·44	1·08	11·0
1922	2,920,280	102·0	1·70	160,339	6,053,068	37·75	1·48	13·5
1923	3,747,576	117·0	2·12	216,804	7,364,260	33·97	1·45	11·4
1924	3,324,727	124·0	1·83	208,762	6,561,659	31·37	2·12	15·9
1925	4,121,258	129·7	1·95	273,522	8,976,645	32·82	1·76	12·9

It is interesting to note that during the 11 years, 1915-1925 inclusive, that that portion of the asbestos known as "crudes" does not occupy such an important position as it formerly did. The total quantity percentage of crude to all fibre recovered has decreased from 4·75 in 1915, to 1·76 in 1925. This is due in part to the fact that there is a better recovery of all grades. The total quantity of all fibres (including the crudes) has risen from 93·2 pounds in 1915, to 129·7 pounds in 1925 per ton of rock mined. This is not due to increasing richness of the ore apart from the vein asbestos, but to improvements in the extraction methods. The abnormal increase from 1923 to 1925 can be partly credited to that production known as "floats." Since May 1922, when a by-law was passed in Thetford Mines to eliminate dust discharge from asbestos mills, several mills have added dust-settling chambers. Besides nearly freeing the atmosphere from objectionable dust, the product mentioned above, termed "floats", was secured. Some mills recover 80 per cent of this material, previously lost. Also, it will be noticed that the average price per ton of fibre for these last three years is about the same as it was in 1915 before the war caused a general advance in prices, although nearly all commodities have retained their increases. It is to be expected, now that the merger is in effect, that much of the ruinous competition will be eliminated and that the industry will not have such a struggle as it has had in the past.

One thing which should not be lost sight of is the fact that although Canada in 1925 produced 80·6 per cent of the world's asbestos, this was due to the production of large quantities of the cheaper grades of asbestos, chiefly used in the manufacture of shingles, mill boards, papers, and cements. These cheaper grades made up 67·5 per cent of our entire asbestos production for 1925. The average price of these grades was $24 per ton; they were marketed largely in the United States. It is our proximity to this country which gives us the present monopoly in that field for these grades. The other principal producing countries, being distant from this large market, cannot successfully compete there with Canada.

When spinning fibres alone are considered, Canada does not lead the world in production. Its production of these grades in 1925 was 19,239 short tons valued at $2,919,329, whereas the production of Rhodesia was 38,471 short tons valued at $3,722,400. This total for Rhodesia includes a small amount which is of non-spinning fibre. Since 1918, Rhodesia has quadrupled its output. This product, which is a fine quality of chrysotile, is shipped mainly to the United States and provides brisk competition with our own spinning fibres. The three other principal producing countries, Russia, South Africa, and Cyprus, are also increasing their output annually. The production from the latter country is chiefly non-spinning fibre and very little of it reaches the United States market at present. In Russia and South Africa good mine rock is sent to the dumps; this could very easily be treated for non-spinning fibres if a market developed. Canada is faced with increasing competition in its production of asbestos and it is becoming more and more essential that the operators should take full advantage of every opportunity that presents itself for improving the quality and increasing the recovery of the fibre. The present outlook is that Canada will remain largely dependent upon the United States market to keep its asbestos mines in profitable operation.

No attempt will be made to describe the various uses to which asbestos is put. It is sufficient to say that it enters into the manufacture of many industries and new uses for it are continually being found. Some of the most important uses are in the making of brake linings and clutch facings of the automotive industry. It is also used in insulation materials for steam pipes, furnace packings, fire-proofing substances, wall boards, roofing shingles, cements, papers, cloths of various sorts, clothing yarns, ropes, and insulation for electrical goods.

In Canada in 1925 there were six firms manufacturing asbestos products. The largest plant is that belonging to Canadian Johns-Manville Company, Limited, located at Asbestos, within sight of their large mine, the Jeffrey. This plant first started to operate in 1924 and manufactured goods for consumption in Canada and other British possessions. Another firm is Asbestonos Company at East Broughton which makes brake linings exclusively. The second largest firm is Asbestos Manufacturing Company, Limited, at Lachine, Quebec.

During 1925 manufactured products to the value of $55,572 were exported to several countries. Following are the countries to which these goods were shipped and percentages of the total exports received by each, viz.: United States, 58·4; Newfoundland, 16·3; British South Africa, 10·6; China (Hong Kong), 4·8; Sweden, 1·9; and 15 others with the remaining 8 per cent.

During 1925 the exports of raw asbestos reached the large amount of 258,017 tons valued at $9,682,392. Following are the countries to which these were shipped and the percentages of the total value that each received.

United States	66·0	Japan	3·8	Denmark	0·1
Germany	8·0	Italy	2·7	Mexico	
Great Britain	6·6	Netherlands	2·4	Cuba	
France	4·6	Australia	1·0	Newfoundland	
Belgium	3·9	Spain	0·1	New Zealand	

In the above statistics no allowance is made for a product known as "sands and gravels" which was shipped to the United States and was included in the export figures. Whether the United States got all this by-product that was produced in 1925, it would not affect its import total by 0·1 per cent. In 1925 the production of this by-product was 16,865 tons valued at $10,814, giving it a value of 64 cents per ton. It is composed of the refuse crushed serpentine and is used in the building industry much as ordinary sand and gravel. Some of the lowest grades of asbestos are sometimes designated as "sands". Consequently there is sometimes a confusion between these grades and the by-product mentioned above. The average price of each clearly shows the difference between them, as the price of the cheapest grades of asbestos is generally over $12 per ton. There is a possibility that a further use for the crushed serpentine in the large waste dumps may be found. Experiments are being carried on to see if it could not be used as a fertilizer for some of our eastern soils.

MINES BRANCH
DEPARTMENT OF MINES

The following is a list of the more important publications on mineral resources issued by the Mines Branch. Copies of any of these publications may be obtained on application to the Director, Mines Branch, Ottawa, Canada. Publications are sent to any *bona fide* resident in Canada; a small charge is made for publications mailed to residents outside Canada; a complete catalogue of all Mines Branch publications will be sent free on request.

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