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DEPARTMENT OF MINES

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

MINES BRANCH

JOHN McLEISH, DIRECTOR

INVESTIGATIONS OF MINERAL RESOURCES AND THE MINING INDUSTRY, 1928

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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.

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MINES BRANCH INVESTIGATIONS OF

MINERAL RESOURCES AND THE MINING INDUSTRY, 1928

I

PRELIMINARY REPORT ON THE LIMESTONES OF NORTHERN AND WESTERN ONTARIO AND OF THE PRAIRIE PROVINCES

M. F. Goudge

Previous preliminary reports[1] have dealt with the limestone resources of Canada as far west as lake Timiskaming. In this report brief mention will be made of the limestone resources adjacent to transportation in northern and western Ontario and in the Prairie Provinces.

The writer wishes to express his thanks to the owners and operators of the various quarries examined for courtesies received; and also to Dr. Wallace, President of the University of Alberta; to Mr. H. B. Lumsden of the Development Branch of the Canadian Pacific Railway; and to Dr. J. A. Allan and Mr. R. L. Rutherford of the University of Alberta, for information furnished on the limestone resources of the Prairie Provinces. A. H. Robinson of Winnipeg rendered efficient assistance in the field.

NORTHERN AND WESTERN ONTARIO

A large area of Palæozoic limestone on the James Bay slope in northern Ontario is now being made accessible by the extension of the Timiskaming and Northern Ontario railway northward from Cochrane towards Moose Factory. This area has not yet been visited by the writer but the following information has been derived from the descriptions of the limestone by Williams[2], Kindle[3], Malcolm[4], and McLearn[5] of the Geological Survey of Canada.

[1]"Preliminary Report on the Limestones of Quebec and Ontario"; Mines Branch, Dept. of Mines, Canada, Rept. No. 682 (1927).
"Preliminary Report on the Limestones of Nova Scotia and New Brunswick"; "Preliminary Report on the Limestones of Gaspe Peninsula"; "Preliminary Report on the Limestones of Timiskaming District"; Mines Branch, Dept. of Mines, Canada, Report No. 687.

[2]Geol. Surv., Canada, Sum. Rept. 1919, pt. G, pp. 1-12.

[3]Geol. Surv., Canada, Sum. Rept. 1923, pt. C1, pp. 21-41.

[4]Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 96-98.

[5]Geol. Surv., Canada, Sum. Rept. 1926, pt. C, pp. 16-44.

The limestone is of the Devonian age and is exposed only at intervals along the valleys of the Abitibi, Mattagami, and Moose rivers, within 85 miles of Moose Factory. The strata lie nearly horizontally and the thickness of sections exposed varies from a few feet to 60 feet; the latter thickness being visible in a cliff at Long rapids on the Mattagami river.

The following analyses show the composition of three areas:—

—	I*	II*	III*	IV**
Insoluble	2·42	0·74	2·73	1·40
Alumina	1·85	2·48	1·10	0·04
Oxide of iron				0·36
Calcium carbonate	95·46	95·71	94·55	86·38
Magnesium carbonate	1·09	1·11	1·15	10·90
	100·82	100·04	99·53	99·08

I. Abitibi river on east side at head of Coral rapids.

II and III. Abitibi river at upper end of island near head of Long rapids.

IV. Mattagami river. All beds in 25-foot cliff on west bank at Grand rapids.

Palæozoic limestones are also found on the islands along the north shore of lake Huron. An examination at several places shows that dolomite and magnesian limestone are both available. Further field work is to be done in this area.

In the Precambrian area of western and northern Ontario considerable limestone occurs but apparently it is all impure—much too impure for chemical and metallurgical uses or to be burned to lime. An excellent exposure of the typical Precambrian limestone of this area is to be seen on the east bank of the Nipigon river about 2 miles below Nipigon village, where about 40 feet is visible above the water level. The limestone is almost flat-lying, very siliceous, and overlain by 175 feet or more of basalt. A small quarry was worked here at one time for building stone.

In the Thunder Bay region numerous calcite veins are associated with the Precambrian rocks. Some of these veins can be traced for several thousand feet and they vary in width from mere stringers up to 70 feet or more. The wide veins are, however, more in the nature of vein systems than simple veins and much foreign matter, such as country rock, quartz, barite, and various metallic minerals, is usually present. The calcite is in large crystals. The veins are usually nearly vertical. Calcite for stucco dash has been obtained from these veins at Silver Mountain, at the Neepatyre deposit 6 miles west of Fort William, and also from a vein 2 miles north of Wolfe station on the Canadian National railway.

MANITOBA

There are two large areas of limestone in Manitoba, one in the northeast corner of the province bordering on Hudson bay; the other extending northwesterly across the province from near Winnipeg to The Pas. Very little is as yet known of the possibilities of the first-mentioned area.

*Analyses published by Malcolm in Geol. Surv., Canada, Sum. Rept. 1924, pt. C, p. 96.

**Analysis published by McLearn in Geol. Surv., Canada, Sum. Rept. 1926, pt. C, p. 44.

From Winnipeg to north of The Pas limestones are exposed over a strip about 100 miles in width. This territory includes the basins of lakes Winnipegosis and Manitoba and the western half of lake Winnipeg. The limestones are of three geological periods, Ordovician, Silurian, and Devonian, and comprise both high-calcium limestones and dolomites. The prevailing dip is to the southwest at a very low angle.

Ordovician Limestones

These, the oldest of the Manitoba limestones, occupy the eastern edge of the limestone belt and are exposed south of lake Winnipeg, along the west shore and on certain islands in the lake, and also along the Hudson Bay railway from The Pas to Mile 87½. They differ widely in appearance and composition in different areas.

In the southern part of the province the succession of Ordovician rocks is:—

5. Stony Mountain shales and dolomite.
4. Upper Mottled limestone.
3. Cat Head limestone.
2. Lower Mottled limestone.
1. Winnipeg sandstone.

Exposures of the Lower Mottled limestone and of the Cat Head limestone occur on various headlands and islands in the southern half of lake Winnipeg. Neither formation is of interest from the standpoint of providing stone for chemical or metallurgical purposes or for lime, as both are quite impure; the Cat Head formation being studded with nodules of grey chert and the Lower Mottled limestone being usually sandy and argillaceous. A number of years ago a quarry was opened in a cliff of Lower Mottled limestone on the north end of Hecla island to supply crushed stone and rubble. Shipments were made by scow to Winnipeg.

The Upper Mottled limestone resembles the Lower Mottled in many respects but is less impure and is more pleasing in appearance. The groundmass is fine-grained, buff-grey and blue-grey in colour, and high-calcium in composition. The mottlings are coarser grained, buff-brown and blue-brown in colour, and are highly magnesian. It is from the top 30 feet of the Upper Mottled limestone that the well-known building and ornamental stone, Tyndall limestone, is obtained. This stone is in even beds 15 to 30 inches thick and when freshly quarried is quite soft and easily worked. The operating quarries are located at Garson, about 30 miles northeast of Winnipeg; three companies, Gillis Quarries, Limited, the Tyndall Quarry Company, and the Western Stone Company, were producing during 1928.

Lime is burned at Garson by the Gillis Quarries, Limited. The stone used for this purpose is the spalls and broken blocks from the building stone quarry.

In chemical composition the Upper Mottled limestone is magnesian, the magnesium content being largely derived from the material composing the mottlings; where the limestone is heavily mottled the magnesium content is greatest and *vice versa*. The content of silica, alumina, and ferric oxide rarely exceeds 2 per cent in the building stone beds, but below these comes a cherty, siliceous band the thickness of which was not ascertained. The following analyses[1] indicate the character of the Tyndall stone:—

—	I	II
Moisture	0·03	0·10
Insoluble	1·20	1·08
Oxide of iron and alumina	0·70	0·60
Calcium carbonate	89·67	82·12
Magnesium carbonate	8·40	16·25
	100·00	100·15

I. Average sample from Garson's quarry (now owned by the Wallace Sandstone Company but not operated).
II Average sample from Gunn's quarry (now operated by the Western Stone Company).

Succeeding the Upper Mottled limestone is a thick shale formation, the Stony Mountain shales, at the top of which are some beds of yellowish dolomite. This dolomite is well exposed at Stony Mountain and at Little Stony mountain to the north of Winnipeg where it has been extensively quarried for crushed stone and rubble. Only the top 15 feet or so is suitable for this purpose as lower down the stone becomes quite soft, shaly, and thin-bedded. At present crushed stone is produced by the city of Winnipeg and by the municipality of Rockwood from their quarries at Stony Mountain. At one time a lime plant was in operation at Stony Mountain and utilized the top few feet of the dolomite, which, as analysis No. I shows, is moderately pure:—

—	I	II
Silica	1·86	2·96
Oxide of iron and alumina	0·78	2·80
Calcium carbonate	53·79	52·63
Magnesium carbonate	44·37	40·99
	100·80	99·38

I. Top 7 feet of face in quarry operated by the municipality of Rockwood (formerly Gunn's quarry).
II. Next 5 feet of face in same quarry.

North and east of The Pas, Ordovician limestones are commonly exposed along the Flin Flon railway, along the Hudson Bay railway as far as Mile 87½, and along the shores of many of the lakes in the area between the railways. All of the stone observed was dolomite. No high-calcium limestone has been reported in this area. The dolomite is hard, fine-grained, varies in colour from yellow-brown to purplish red, and in many localities is quite pure. The beds are nearly horizontal and most of the exposures are in low escarpments, up to 20 feet in height, which can be traced for miles.

Southwest of Cormorant lake, at Mile 40 on the Hudson Bay railway, the Manitoba Marble Quarries, Ltd. has acquired a property along a 20-foot escarpment of pinkish and buff dolomite, and has done considerable development work preparatory to the commercial production of marble.

[1]Wells, J. W.: "Preliminary Report on the Limestones and the Lime Industry of Manitoba"; Mines Branch, Dept. of Mines, Canada, Rept. 7, p. 42 (1905).

Much of the dolomite of this area is sufficiently pure to yield a good quality lime. The following analysis[1] indicates the chemical composition:—

	I
Insoluble matter	1·16
Soluble silica	0·08
Alumina	0·14
Iron oxide	0·18
Calcium carbonate	53·21
Magnesium carbonate	43·26
	98·03

I. Grey dolomite mottled with pink and red, from rock cut at Mile 42, Hudson Bay railway.

Silurian Limestones

The rocks of the Silurian system outcrop over a broad belt of country east of lakes Winnipegosis and Manitoba extending from Stonewall to The Pas. They consist of two dolomite formations separated, in several localities, by a thick belt of shales in which deposits of gypsum are found. The prevailing dip of the dolomites is to the southeast at a very low angle.

The Lower Silurian formation where examined at Stonewall and Gunton, is composed largely of buff-coloured, fine-grained, porous and cavernous, faintly mottled dolomite in beds of variable thickness. At both places the base of the formation is apparently exposed and at both places the succession of beds is very similar.

At Stonewall the top 10 to 12 feet of the dolomite has for many years been used in the lime plants. It is very pure and yields a high-grade, white lime. Beneath this the dolomite becomes quite impure and finally passes into shale. The Winnipeg Supply and Fuel Company operates five lime-kilns and a stone crushing plant at Stonewall. It markets the quicklime in lump form only, but part of the output is taken by Canada Gypsum and Alabastine, Ltd., who hydrates it at its Winnipeg plant and puts it on the market in that form.

The following analysis is typical of the dolomite quarried at Stonewall by the Winnipeg Supply and Fuel Company:—

Silica	0·28
Oxide of iron and alumina	0·30
Calcium carbonate	54·82
Magnesium carbonate	44·84
	100·24

In the large quarries at Gunton, beds of the same horizon as at Stonewall are visible as well as 20 to 25 feet of the beds higher up. The upper beds are mostly soft and argillaceous. The Gunton quarries were operated chiefly for crushed stone, but at one quarry lime was burned in set kilns. The quarries have been idle for a number of years.

The upper dolomite formation of the Silurian system differs from the lower largely in being finer in grain and less porous. At the top of the formation is a considerable thickness of very impure red dolomite. Exposures of the pure, fine-grained dolomite are to be seen at Inwood, Broad Valley, Fairford, and at many points to the north. The impure, red dolo-

[1]Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 388, p. 110 (1916).

mite is exposed near Spearhill and Fairford. At none of these places is a really good section visible, the exposures at best consisting of but a few feet of beds.

The dolomite has been burned for lime at a number of places notably Spearhill, Inwood, and Broad Valley, but not during recent years. Small-scale operations to produce decorative stone from some of the mottled beds of this formation were once commenced at Broad Valley, but they did not get beyond the initial stages. That this dolomite is not being utilized is due to no inherent defects in the stone but rather to the fact that similar dolomites are available nearer the large consuming centres.

A single available analysis[1] from the small quarry at Broad Valley shows the dolomite to contain only a small proportion of impurities.

Insoluble	1·00
Iron oxide and alumina	0·26
Calcium carbonate	55·35
Magnesium carbonate	43·26
	99·87

Devonian Limestones

The Devonian system in Manitoba is represented by three formations which Kindle of the Geological Survey of Canada has named the Elm Point limestone, the Winnipegosan dolomite, and the Manitoban limestone. These formations are exposed in the basins of lakes Manitoba and Winnipegosis. To the west they are overlain by the sandstones and shales of the prairies.

The Elm Point formation is the present source of the limestone for cement and high-calcium lime in Manitoba. It is a thin formation, about 25 feet thick, composed of thin-bedded, mottled, grey, high-calcium stone. The mottling is due not to magnesian material as in the Ordovician limestones, but seemingly to a spotty distribution of iron oxide. This limestone is well exposed in the quarries at Oak Point, Steep Rock, and Spearhill, as well as at several points on the shores of lake Winnipegosis and also south of Ashern on the Gypsumville branch of the Canadian National railway.

At Steep Rock and Spearhill the stone is quite similar and contains on the average less than 1·5 per cent each of silica and of magnesium carbonate. At the former place a large quarry is worked by the Canada Cement Company, who ships the stone by rail to its plant at Winnipeg. At Steep Rock the Winnipeg Supply and Fuel Company operates a 4-kiln lime plant and also ships limestone for use in pulp mills and sugar factories. The Steep Rock deposit is an outlier about 150 acres in area and 20 feet in maximum thickness—evidently an erosion remnant.

At Oak Point a quarry was once operated in the Elm Point limestone to supply a lime plant and a crushed stone plant. The formation here is more impure than in the other localities where it has been worked and contains from 3 to 5 per cent silica and oxides of iron and alumina, and from 5 to 12 per cent magnesium carbonate. Along the shore of lake Winnipegosis, at Brabant point, where this formation is again exposed, it is also impure.

[1]Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 388, p. 92 (1916).

The following analyses serve to show the composition of the Elm Point limestone in the areas where it has been exploited:—

—	I	II	III
Silica	1·48	1·55	3·09
Oxide of iron and alumina	0·76	0·36	0·94
Calcium carbonate	95·44	97·26	89·14
Magnesium carbonate	2·78	0·84	7·82
	100·46	100·01	100·99

I. Steep Rock. Canada Cement Company quarry. Analysis furnished by the company.
II. Spearhill. Moosehorn Lime Company quarry. Analysis furnished by the Winnipeg Supply and Fuel Company.
III. Oak Point. Quarry formerly worked by Bowman Coal and Supply Company. Analysis furnished by Mr. Chas. Bowman.

The Winnipegosan dolomite formation conformably overlies the Elm Point limestone. It is well exposed in low domes along the shore and islands of the northern part of lake Winnipegosis, and on several islands and at Sifton narrows in lake Manitoba. The Lake Winnipegosis outcrops are composed of interbedded magnesian limestone and dolomite, much of which seems to be of indifferent quality. The stone is thin-bedded and fractured, and, although it is porous and filled with cavities, much of it is extremely hard. The colour ranges from grey to yellow, the latter tint being chiefly due to iron sulphide which is quite plentiful in some of the exposures.

The only exposure examined in the Lake Manitoba area was at Sifton narrows where a section of 9 feet of Winnipegosan dolomite is visible in a small quarry which, many years ago, was opened to supply dimension stone and lime to the prairie markets. The stone lies horizontally, is heavily bedded, light buff in colour, soft and porous, and according to the following analysis by Wells[1] it is very pure:—

Moisture	0·18
Insoluble	0·30
Oxide of iron and alumina	0·50
Calcium carbonate	53·80
Magnesium carbonate	45·55
Sulphur trioxide	0·08
	100·41

The Manitoban limestone, the youngest of the Palæozoic limestones in Manitoba, succeeds the Winnipegosan dolomite. It is exposed along the western shore and islands of lake Winnipegosis and also on Swan lake and Red Deer lake. To the west it is overlain by the Cretaceous sandstones and shales. The exposures seen in Dawson bay at the north end of lake Winnipegosis and again near Winnipegosis village and islands in the extreme south end of the lake are in the form of low domes. The stone is fine-grained, soft, thin-bedded, grey or light brown, high-calcium limestone; most of it seeming very pure. Occasional seams of soft shale and masses of earthy ferruginous stone occur in some of the exposures, and at Point Wilkins in Dawson bay there is, underlying 40 feet of pure limestone, a thickness of 30 feet of argillaceous limestone and an unknown thickness of shale.

[1]Wells, J. W.: "Preliminary Report on the Limestones and the Lime Industry of Manitoba"; Mines Branch, Dept. of Mines, Canada, Rept. 7, p. 55 (1905).

The Manitoban limestone is quarried on a small scale $1\frac{1}{2}$ miles west of Winnipegosis village and also has been quarried at Charlie point at the southwest end of lake Winnipegosis. The stone is shipped to the plant of the Canada Gypsum and Alabastine, Ltd. at Winnipeg where whiting substitute is prepared from it. The whiting substitute which is simply the finely ground limestone analyses[1] as follows:—

Moisture	0·52
Silica	0·42
Ferric oxide	0·09
Alumina	0·30
Calcium carbonate	98·67
Magnesium carbonate	trace
	100·00

The Niobrara shale formation of the Cretaceous system contains some limestone beds, but they are mostly thin and many are more in the nature of calcareous shale than true limestone. Exposures of these Cretaceous limestones are reported at several places along the Assiniboine and Pembina rivers in southern Manitoba and also at Babcock station on the Canadian National railway. At the latter place a bed 8 to 10 feet thick of calcareous shale was, a few years ago, mined and burned to natural cement by the Commercial Cement Company. The Cretaceous limestones are of little or no interest from the chemical and metallurgical standpoint.

SASKATCHEWAN

The belt of Palæozoic limestones which crosses the province of Manitoba continues on across northern Saskatchewan but this area is so remote from existing transportation lines that these limestones have no present economic value.

The only other source of limestone in Saskatchewan is from the limestone boulders which in some areas are quite plentifully bestrewn over the surface of the prairie. These boulders, however, were nowhere seen in quantity sufficient to afford a continuous supply of stone to a lime plant of any considerable size. Also, although practically all of the boulders are of dolomite, they are from different formations and are of varying degrees of purity; this would further complicate matters for a lime producer desiring to make a lime of uniform quality. At Young, which is served by both the Canadian National and Canadian Pacific railways and in which vicinity small dolomite boulders are numerous, a large lime-kiln was erected in 1913 but it operated for only a few weeks. The boulders have, however, been burned by settlers in many localities. At present, lime is being produced in a pot kiln at Nipawin, 100 miles east of Prince Albert.

For building material the boulders offer greater possibilities and they have been used for this purpose in several places, notably at Saskatoon.

[1]Analysis supplied by Canada Gypsum and Alabastine, Ltd. The raw material is from the Winnipegosis Village quarry.

ALBERTA

There are two limestone areas in Alberta, the one in the northeast corner of the province along the valleys of the Athabaska, Peace, and Slave rivers, the other in the Rocky mountains. The area in the northeast part of the province is of little present importance owing to its location and was not examined.

The eastern ranges of the Rocky mountains are largely limestone, the estimated thickness of limestone strata being about 9,000 feet. The geologic age is from Cambrian to Carboniferous. As may be expected, in such a great thickness of limestone deposited over such a long period of time there is a wide variation in quality and type. This variation, unfortunately, is not confined merely to major differences between the various formations, thus leaving great thicknesses of uniform stone, but persists in detail throughout the formations. The distinct banding of the Rocky Mountain limestone, apparent from a distance, gives a hint of this variation, and on close observation it is seen that rarely indeed is there a thickness of more than 40 feet of limestone strata free from interbeds of siliceous rock or of limestone of a different composition, and usually the interbeds of undesirable stone occur at much more frequent intervals than this. If the strata were either vertical or horizontal this variableness would not greatly interfere with quarrying operations, but, as the usual dip of the strata is between 20 and 70 degrees, the variableness of the limestones is an unfavourable factor of importance as far as quarrying is concerned but would not greatly interfere with mining.

To further appreciate the difficulties of locating quarry sites in the mountains it is necessary to have in mind a clear picture of the topography. The mountains have a general northwest-southeast trend. The eastern ranges consist principally of lines of huge fault blocks having precipitous faces to the east and more gradual slopes to the west, the gradient of the western slopes usually corresponding quite closely to the angle of dip of the strata. Quarrying is out of the question on the steep eastern faces, the only possible locations, as Parks[1] has pointed out, being on the backs of the ranges and on the spurs of limestone which jut out into the valleys that have been cut through the ranges. In many of the favourable sites, however, only impure limestone or another type of rock is to be found. The available areas are further limited to the immediate vicinity of railway transportation. Thus it may be seen that vast as is the quantity of limestone in the Rockies, only in comparatively few localities can a pure limestone be obtained by the usual quarry methods.

The following descriptions of the various limestone formations are very general in character, but generalities are particularly applicable to the Rocky Mountain limestones because different sections of strata only a few hundred feet apart and apparently at the same horizon may, and usually do, differ markedly in detail. Sometimes this difference is so pronounced that there is little, if any, lithologic resemblance between the sections. The main causes of this are, first, individual strata do not maintain a uniform thickness, but thicken and thin and often disappear entirely; secondly, it is not unusual to find in a stratum a change in composition in a lateral direction, this change may be gradual or very abrupt.

[1]Parks, W. A.: "Building and Ornamental Stones of Canada", vol. IV, Mines Branch, Dept. of Mines, Canada, Rept. 388, p. 112 (1916).

in the Devonian limestones particularly, are beds which are high-calcium in one place and dolomite in another. Also the limestone beds may become more and more siliceous or shaly along their strike until they become wholly quartzites or shales.

Cambrian Limestones

The Cambrian formation where seen on the southern end of the Sawback range is composed principally of dolomite with subordinate amounts of quartzite, shale, and high-calcium limestone. Most of the dolomite is either blue or brown in colour, fine-grained, much shattered and contains siliceous beds and nodules of chert. Near the top of the section is a thickness of several hundred feet of medium-coarse-grained, grey dolomite which is of much better quality than is the remainder, This pure dolomite is to be seen on the mountain side just east of the large gully midway between mount Edith and mount Hole in the Wall. Above this is a hard, black dolomite which becomes more and more shaly and siliceous until the shale and quartzite beds predominate. These siliceous beds are apparently the top beds of the Cambrian formation as exposed in the Sawback range. The maximum thickness of this section is about 4,000 feet. The Cambrian is exposed on Castle mountain where it is composed chiefly of dolomite very similar to that in the Sawback range. In the Lake Louise district and near Stephen, the Cambrian limestones are very impure. At Jasper the Cambrian rocks are principally schists, quartzites, and shales with little or no limestone. Farther south in the Crowsnest Pass area this formation is not known to occur.

No present use is being made of the Cambrian dolomites nor has the writer been able to learn of any use that has been made of them in the past. Some of the dolomite is sufficiently pure for chemical purposes and for lime-burning but the high-calcium beds appear to be of little value. No analyses are as yet available.

Devono-Carboniferous Limestones

Under this heading will be considered the limestones of Devonian and Carboniferous ages which together constitute the main part of the Rocky Mountain limestone. In the Banff area where the greater part of the detailed work has been done on the Devonian and Carboniferous rocks, they have been subdivided and mapped as follows:—

		Estimated thickness in feet
Carboniferous	Rocky Mountain quartzite	
	Upper Banff limestone	2,500–3,000
	Lower Banff shale	1,000–1,500
Devonian	Lower Banff limestone	1,000–1,500
	Intermediate limestone	1,500–2,200

These divisions are applicable in other areas where the Devonian and Carboniferous limestones were examined, namely in the vicinity of Blairmore and Crowsnest pass, from Brûlé to near Jasper, at Nordegg (or Brazeau) and at Cadomin, but owing to the strong lithologic resemblance between the various limestone formations it is very difficult to distinguish them by appearance alone, and as they have not yet been separately mapped, it is necessary to treat of them collectively elsewhere than in the Banff area.

Banff Area

Between Kananaskis and Castle stations on the main line of the Canadian Pacific railway an excellent cross section of the Devonian and Carboniferous formations is exposed. The formations strike northwest-southeast and on account of the faulted structure are each repeated several times. This is the type locality for the various formations of the Devonian and Carboniferous in the Rocky mountains. A brief description of each formation follows:—

Intermediate Limestone. This formation is composed chiefly of fine-grained, dark brown dolomite, some of which is quite pure but much of which is filled with chert and some is shaly. In general it is not very promising as a source of dolomite for chemical purposes. The best quality of stone is in the middle part of the formation, which is composed of massive-bedded dolomite usually exposed in steep cliffs well up on the mountain sides where it cannot be readily obtained. The lower part of the formation is thin-bedded and contains much quartzite and impure, high-calcium limestone. Sections of this formation are exposed on the mountain side north of the west end of Lac des Arcs, on the east side of Sulphur mountain, on the ridge between Johnson creek and the base of Castle mountain, and in a number of less accessible localities. A wide variation in the quality and type of stone was observed in the different localities.

The only place where any use has been made of the Intermediate dolomite is at Castle station where a small quarry was opened up a number of years ago to supply stone for lime-burning. Some of the dolomite here is very pure averaging only about 1 per cent total impurities, but it is interbedded with high-calcium limestone and siliceous magnesian limestone so that operations can be conducted only on a small scale. The Sulphur Mountain section contains the greatest amount of relatively pure dolomite free from interbeds of undesirable stone that was observed, but conditions are unfavourable for either quarrying or mining.

Lower Banff Limestone. This formation is an important one from the standpoint of yielding high-calcium limestone for cement and lime. It is composed principally of heavily bedded, grey and blue, fine-grained, high-calcium limestone in which, parallel to the bedding, are zones containing magnesian material. The magnesian matter is of sugary texture, brown in colour, and more resistant to weathering than is the limestone, and usually projects on the weathered surfaces as an irregular network. On a fresh fracture it shows as a faint brown mottling. Minor amounts of black chert are noticeable in some sections and thin siliceous beds were also observed, but rarely are these impurities sufficiently in evidence to constitute a serious drawback. The magnesian bands are the main undesirable feature. They vary from a few inches to many feet in thickness and rarely is there more than 40 feet of limestone altogether free from them. The above refers to the normal occurrence of the Lower Banff limestone as seen in the vicinity of Kananaskis and at Exshaw. Some sections are composed almost entirely of the magnesian mottled stone, and on Sulphur mountain the Lower Banff is largely dolomite. Overlying the Lower Banff is a shale formation and usually the limestone becomes increasingly shaly towards the top.

A representative analysis of the better grade of Lower Banff high-calcium limestone would be:—

Silica	1·30
Oxides of iron and alumina	0·30
Calcium carbonate	95·80
Magnesium carbonate	2·60
	100·00

The magnesian bands will run about the same in silica but may contain as much as 20 per cent magnesium carbonate. The siliceous bands are very high in silica and are sometimes magnesian as well.

At Kananaskis the Loder Lime Company operates a quarry in the Lower Banff limestone to supply three kilns. The strata dip at 75 degrees to the west. The quarry is opened along the strike and faces toward the mountain. All the limestone is fine-grained, moderately hard, and free from shale and chert. Four types of stone are seen in well-defined bands in the quarry face: a light grey limestone very low in impurities and magnesia; a nearly black limestone only slightly less pure; a dark grey limestone mottled with magnesium carbonate; and a steel-grey, siliceous, magnesian band which is discarded. The three varieties of stone are burned separately. All make white lime. The light grey stone is used in making "finishing" lime and the darker-coloured stone for masons' lime.

In connexion with its cement plant the Canada Cement Company operates a large quarry in the Lower Banff limestone at Exshaw. The quarry is located on the southwest face of a high hill and is opened along the strike of the limestone which is parallel to the hillside. The dip of the strata is 45 degrees to the southwest. Several magnesian bands are interbedded with the high-calcium limestone but the method of quarrying is such that they are not included in the material sent to the plant. The limestone is very fine-grained, heavily bedded, hard, and nearly black in colour. No chert nor shale was observed.

Lower Banff Shale. As the name implies this formation consists largely of shale. No limestone of economic importance is contained in it.

Upper Banff Limestone. The limestone of this formation differs from the Lower Banff limestone largely in the matter of impurities. The mottled magnesian bands are not in evidence but silica in the form of chert nodules is a characteristic feature. The lower part of the formation is composed chiefly of dark grey, fine-grained, high-calcium limestone in which chert nodules are so plentiful as to render the stone worthless for any chemical or metallurgical purpose. A few light grey, coarser grained, chert-free beds also occur in this lower part but it is only in the middle and upper parts of the formation that they become of sufficient thickness to be of economic importance. Interstratified with this bed and becoming more numerous towards the top of the formation are beds of siliceous limestone and dolomite. The overlying formation is the Rocky Mountain quartzite. A thickness of 100 feet of coarse-grained, grey, high-calcium limestone absolutely free from chert or siliceous beds was observed on Grotto mountain. A 75-foot thickness of the dark, fine-grained limestone free from these undesirable features was also observed. Usually the belts of pure stone occur between equally thick or thicker belts of impure stone. The siliceous beds are not always visible at first glance in examining an outcrop, for, by reason of the fact that they weather more rapidly than the pure limestone, they are found in shallow depressions generally covered by earth or leaves.

The Upper Banff limestone was examined on Rundle, Stoney Squaw, Tunnel, and Grotto mountains. The various sections differ in detail but all bear a general resemblance to one another. The difference in detail is due to the beds not being of constant thickness, they thicken and thin and sometimes pinch out altogether. In no two places, a few hundred feet apart, is the succession of beds exactly the same.

In chemical composition the chert-free stone is usually remarkably pure, containing as it does from 95 to 98 per cent calcium carbonate.

Rarely is the better grade of limestone of this formation found in places where it can be readily quarried. It is usually exposed high up on the mountains where, owing to its massive bedding and uniform composition, it forms steep cliffs. On the lower slopes it is usually overlain by the succeeding Rocky Mountain quartzite. In only one locality in the Banff area has the Upper Banff limestone been utilized and that is on the south slope of Grotto mountain at the Gap. The Alberta Portland Cement Company opened a quarry here a number of years ago but it has been idle since 1914. Nearby is a small quarry from which was obtained stone for two lime-kilns. The lime plant known locally as the Gap Lime Works has not operated since 1913.

The main quarry of the Alberta Portland Cement Company is located in a belt of dark grey, heavily bedded, high-calcium limestone over 75 feet thick and dipping southerly at 41 degrees. The strike of the beds is here parallel to the face of the mountain, so there is no impure rock to remove. A very large tonnage of uniform limestone is available. Cherty and dolomitic limestones underlie the 75-foot belt.

Blairmore-Frank Area

Between Blairmore and Frank is a narrow mountain range trending north and south, composed almost entirely of Devono-Carboniferous limestone. The Crowsnest branch of the Canadian Pacific railway follows the valley of the Crowsnest river through this range. On both sides of the railway limestone is exposed. The greater part of the limestone is typical of the Upper Banff formation in which hard, grey, fine- to medium-grained, high-calcium limestone alternates with bands of very cherty limestone and siliceous magnesian stone. The bands of pure limestone vary in thickness from a few feet up to an observed maximum of 40 feet. The dip is westward at 65 degrees. Owing to the angle of inclination of the strata and to the fact that the relatively narrow belts of pure stone are separated by wide zones of impure stone there is in this area little possibility of extracting large quantities of uniformly pure stone by quarrying methods, but mining methods could be employed on some of the wider belts of pure stone. In chemical composition the pure limestone may run as high as 98 per cent calcium carbonate.

North of the railway, on the eastern outskirts of Blairmore, E. J. Pozzi operates a small mixed-feed lime-kiln to supply the local market. The stone is obtained from a small quarry located adjacent to the kiln in a 30-foot band of pure, medium-grained, high calcium limestone.

On the opposite side of the railway is the now abandoned quarry and plant of the Rocky Mountain Cement Company. Previously the quarry was worked to supply a lime plant. The opening is along the strike and faces into the north end of Turtle mountain. The beds dip at 65 degrees to the westward. A thickness of 150 feet of strata has been worked. The thickest belt of pure, high-calcium limestone showing in the working face is 40 feet; several narrower belts also occur separated by zones of cherty or otherwise impure stone. The impure stone constitutes nearly half of the working face. The high-grade stone is grey and medium-grained; the impure stone is finer in grain, darker in colour, and in some beds is magnesian. The quarry has been located in the best stone available in the district.

Southeast of Frank is a large area covered with broken blocks of limestone which fell from Turtle mountain in the great Frank rockslide of 1903. The stone is similar to that already described with only a minor amount of pure stone available. The Frank Lime Company erected three draw-kilns at Frank with the intention of utilizing the broken limestone from the slide but found the stone was too variable to make a satisfactory lime.

Crowsnest Pass Area

Along the Crowsnest branch of the Canadian Pacific railway limestone is exposed for a distance of 2½ miles from just east of the British Columbia boundary to a short distance east of the cave on the north shore of Crowsnest lake from which issues the headwaters of the Oldman river. Apparently the whole series of the Devono-Carboniferous limestones from the Intermediate formation to the Rocky Mountain quartzite is here represented. The dip is uniformly to the southwest at 35 to 45 degrees.

East of the cave is a thickness of several hundred feet of interbedded high-calcium limestone, dolomite, and shale, the shale becoming increasingly prominent to the eastward until all is shale and shaly limestone.

Westward from the cave is a thickness of over 1,000 feet of interbedded high-calcium limestone and mottled magnesian limestone. The mottled magnesian beds are most common in the lower middle part of this section. The stone appears quite pure except for the magnesian mottlings and an occasional siliceous layer. The bedding is massive.

Overlying the above is a 700-foot thickness of shale and cherty, shaly limestone which in turn is overlain by 600 feet of extremely cherty, grey, high-calcium limestone with an occasional band of pure limestone. Above this comes a thickness of 400 feet of mostly pure, medium-grained, high-calcium limestone in which are a few cherty beds and siliceous magnesian layers. At the top of this horizon are located the quarries of the Summit Lime Works.

The stone quarried by the lime company is medium-grained, brown-grey, heavily bedded high-calcium limestone with which is interbanded some few irregular beds of siliceous magnesian material which has to be discarded. The jointing is pronounced but very irregular and the stone breaks in large angular pieces. Owing to the jointing it is difficult to distinguish the bedding in the quarry, but apparently the strata dip to the southwest at 45 degrees. The quarry is of the side-hill type but does not follow exactly the strike of the beds. Five hundred feet east of the present quarry is an abandoned quarry in a coarse-grained, grey limestone seemingly of somewhat greater purity than the stone now being worked, but the lime from the coarse-grained stone crumbles in the kiln and also air-slakes rapidly, thus the finer grained stone is preferred. Between the two quarries is a thickness of over 200 feet of strata, similar to those now being quarried, with occasional siliceous, magnesian beds.

The Summit Lime Works has four draw-kilns in operation. The product is white lump lime which is shipped in barrels and in bulk. A rock-pulverizing plant crushes some of the spalls from the quarry, the rock dust being sold for dusting the coal mines of the district.

Westward from the lime company's quarry limestone is exposed for a distance of 1½ miles to the contact with the overlying quartzites. The dip is uniformly to the southwest at from 35 degrees to 45 degrees. The succession of beds is very similar throughout this distance, there being great thicknesses of cherty high-calcium limestones with lesser thicknesses of chert-free limestone and minor amounts of impure dolomite. Siliceous magnesian bands also occur at intervals. Of the bands of pure limestone two are especially worthy of note. The first of these forms the upper part of a prominent spur of rock which juts out from the mountain side just northeast of the small lake on the Alberta side of the interprovincial boundary. It is composed of pure, rather coarse-grained, light-grey, high-calcium stone free from chert and siliceous beds and is over 150 feet thick. The dip is 35 degrees to the southwest. It is in such a position that it can be readily quarried. East of this band and separated from it by a wide zone of mashed limestone is a band of similar light-grey stone of about the same thickness and appearance. It is possibly the same band repeated by folding or faulting, but quarrying opportunities are not so favourable in the second location.

Cadomin Area

Devono-Carboniferous limestones are exposed south of Cadomin along the Mountain Park branch of the Canadian National railway. The exposures begin about 1,000 feet north of Mile 25 and extend southerly to the bridge over the McLeod river at Mile 26·7.

The best limestone available in quantity is on the mountain east of the railway, just north of Mile 25. Here, exposed on the southern slope of the mountain from the base to the summit, is a band of high-calcium limestone over 100 feet thick. All is fine-grained, dark-grey in colour and much fractured. The dip follows the slope of the mountain and varies from 35 to 60 degrees to the south. No analyses are yet available but the stone in this band appears to be of good quality and is mostly free from chert and magnesian interbeds. Underlying this is a thicker belt of limestone much mottled with magnesian material.

Some smaller exposures of high-calcium limestone of fair quality are to be seen southerly from here but for the most part the stone is magnesian and impure. South of Cadomin creek is a heavy band of magnesian mottled stone containing some chert. South of this the limestone becomes increasingly siliceous and dolomitic and interbeds and bands of shale are common. For the most part the limestone in this area is thin-bedded and much fractured.

Jasper Area

For a distance of over 30 miles from Brûlé to just east of Jasper the limestones and shales of the Devono-Carboniferous formations are exposed along the main line of the Canadian National railway. The limestones have the same characteristics as those in the Banff area, but dolomite is not conspicuous as it is at Banff and what there is is mostly quite impure. Shaly phases in the stone are more common than in limestone of the same age elsewhere.

Even a brief description of all the sections exposed in this 30-mile stretch would be manifestly impossible in this preliminary report, so mention will be made only of the sections nearest to Edmonton and of the places where the limestone has been quarried.

West of Brûlé station the limestone is to be seen high up on the mountain side, but the first limestone available for quarrying is at Ogre canyon 2½ miles to the south. Here is a ridge 275 feet high, and increasing in height towards the north, composed of interbedded, high-calcium limestone and mottled magnesian limestone. Thin films of shale are to be observed throughout most of the stone. The bedding is very indistinct, there being thickness of 50 feet without a definite bedding-plane. The dip is southwest at 30 degrees. All is fine-grained.

Southwest of Ogre canyon for a distance of about one mile is a succession of high-calcium limestone, cherty beds, mottled magnesian limestone and siliceous dolomitic limestone, all interbedded. Blebs of shale are common throughout most of the mottled and high-calcium beds. There is little opportunity for the quarrying of a uniform grade of stone in this section.

The exposures over the next mile across the strike of the beds are mostly shaly limestone and siliceous magnesian beds, with minor amounts of better grade material. Chert is very conspicuous in the beds near the base of this section. The limestone gradually becomes more shaly until shale predominates. The next limestone visible is on the slopes of Roche Ronde, 4 miles to the southwest.

Across Athabaska river on the northwest slope of Roche Miette, at a place known as Disaster point, is an abandoned quarry and lime plant formerly operated by the Fitzhugh Lime and Stone Company of Edmonton. The beds dip nearly vertically. The limestone is mostly very fine-grained, almost black in colour, and is unevenly bedded. Interstratified with the high-calcium limestone are beds of fine-grained siliceous dolomite from a few inches to 11 feet in thickness. In no place is there a greater thickness than 12 feet of limestone without an interbed of the impure dolomite.

An analysis of the dark, high-calcium limestone as given by Parks[1] follows:—

Insoluble	0·16
Soluble silica	0·20
Ferric oxide	0·07
Ferrous oxide	0·19
Alumina	0·08
Calcium carbonate	96·38
Magnesium carbonate	1·67
	98·75

[1]Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 388, p. 120 (1916).

This area was formerly served by the Grand Trunk railway but the rails have now been removed.

Four miles north of Jasper is the quarry operated by the Marlboro Cement Company to provide limestone for its plant at Marlboro. The quarry is just west of the main line of the Canadian National railway. The stone quarried is very fine-grained, nearly black, heavily bedded, high-calcium limestone. The maximum height of the quarry face is 90 feet. The dip of the beds is at 25 degrees to the southeast and a thickness of 140 feet of strata is exposed in the excavation. Very thin films of black, carbonaceous shale occur irregularly throughout the stone. Two 3-foot beds of mottled magnesian stone were observed in the quarry but the proportion of this material to the total output of the quarry is so small as to be negligible in its effect on the magnesium content of the stone.

A typical analysis[1] of the stone obtained in the quarry follows:—

Silica	2·01
Ferric oxide	0·42
Alumina	0·51
Calcium carbonate	93·53
Magnesium carbonate	2·92
	99·39

Vast as is the quantity of limestone exposed in the Jasper area there are very few sites where quarries could be located to produce large quantities of a uniform grade of stone.

Nordegg Area

Along the branch line of the Canadian National railway extending to Nordegg, or Brazeau as the railway station is called, Devono-Carboniferous limestones are exposed in numerous cuttings and on the mountain sides, from the bridge over Mira creek at Mile 145·3 for 4 miles to the outskirts of Nordegg village. Both dolomites and high-calcium limestones are represented, with the dolomite predominating. Most of the dolomite seems impure but at a few places notably at Mile 146 and again just outside the limit of the Brazeau railway yard, the dolomite seems of a fair degree of purity, although in the absence of any chemical analysis no definite statement can be made.

At Mile 146 finely granular, brown dolomite is exposed in the railway cutting. The band seems about 400 feet thick. It dips at 60 degrees to the north. Some of the top beds are cherty, in the centre is a 20-foot band of mottled stone containing some high-calcium material and near the base of the dolomite band are some shaly beds, but notwithstanding these impure zones there is a vast quantity of dolomite, seemingly of good quality, available.

Just outside of the Brazeau railway yard limit is a cutting in fine-grained, porous, grey dolomite. Many of the cavities in the stone are filled with solidified petroleum but otherwise it seems quite pure.

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[1]Analysis furnished by the Edmonton representative of the Marlboro Cement Company.

The only exposure of high-calcium limestone worthy of note is that in the old quarry and railway cutting slightly more than a mile northeast of Nordegg. The quarry was once worked for ballast. In the cutting to the northeast of the quarry a 40-foot thickness of heavily bedded, coarse-grained, fossiliferous, grey limestone is visible. Beneath it come interbedded dolomite, impure limestone, and more coarse-grained, high-calcium limestone. The dip is to the southwest at 14 degrees. The quarry has been opened in these lower beds. The top 10 feet of the quarry face is in fine-grained, nearly black, high-calcium limestone in beds from 4 to 9 inches thick. Broken fossils are numerous and the stone smells strongly of sulphur when struck by a hammer. The remaining 10 feet of the quarry face shows interbedded, high-calcium stone and dolomite.

II

POTASH SALTS IN THE MARITIME PROVINCES OF CANADA

L. H. Cole

Although commercial deposits of potash salts have not yet been found in Canada, there are a number of localities in which indications have been encountered so promising as to be well worthy of detailed study. Prospecting of such localities is, however, a costly matter, as it usually involves core drilling by special methods in order to recover all the soluble salts in the strata drilled.

The world's requirements of potash in 1927 were valued at $100,000,000, of these Germany and Alsace produced 95 per cent. Canada in the same year imported 22,721 tons of various grades of potash salts valued at $1,234,355. Details of such imports for 1926-28 are given in the accompanying tables.

Potash salts are employed principally for fertilizing purposes. Canada does not at present use fertilizers on so extensive a scale as some of the European countries, but the time is not far distant when the demand for artificial fertilizers, including those containing potash, will greatly increase. If, therefore, a commercially workable deposit of potash salts can be proved to exist in Canada it would prove of great benefit to the whole country. In fact such a development would be of even wider interest because no extensive deposits of potash salts have been exploited within the British Empire.

There are a number of localities in eastern Canada where mineral springs, drill holes, or mining operations have shown the presence of potash salts in varying quantities. Several localities in the Maritime Provinces where these salts have been noted will be briefly described.

NOVA SCOTIA

At Malagash, in Cumberland county, a deposit of rock salt was discovered in 1917. An analysis of the brine which led to the discovery of the salt showed 0·55 gramme per litre of potassium. Since that time a number of analyses of the rock salt from this deposit showed from 0·14 to 0·20 per cent potassium (K). Figure 1 gives the location of the Malagash Salt Company's plant with respect to water and rail transportation.

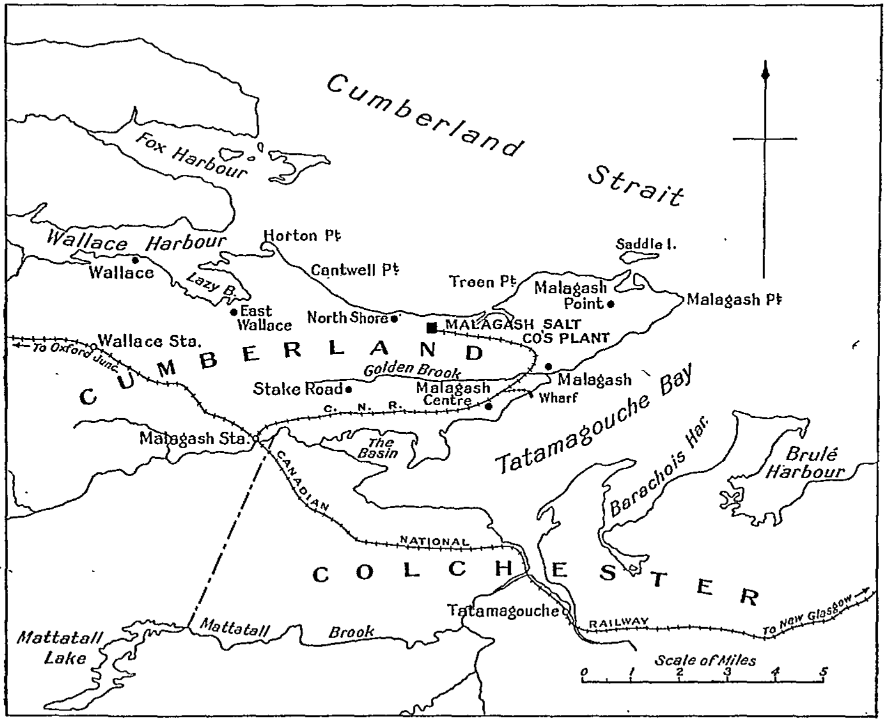

Figure 1. Sketch map showing transportation facilities at Malagash Salt Company's plant, Malagash, N.S

Potassium chloride occurs at this locality in small lenticular concentrations in the form of crystalline masses of pink and yellowish green sylvite in a matrix of halite. One of these zones has been penetrated at two points 30 feet apart and varying in thickness from a few inches to 5 feet. These potash-bearing lenses first attracted attention because their red colour resembled some of the German occurrences. Subsequent observations by H. V. Ellsworth[1] have shown that the red-coloured strata carry the most potash and that the sylvite lenses are associated only with the red-coloured salt.

Most of the lenses known to carry potash minerals have been sampled and analysed, the most systematic examination being that by Ellsworth of the Department of Mines, Ottawa. The following analyses show some of his results[2].

[1]Ellsworth, Dr. H. V.: Sum. Rept., Geol. Surv., Canada, pt. C. 1924, p. 183.
[2]Op. cit., p. 185C.

Analyses of Samples Representing Channel Sampling, Foot by Foot, Normal to Dip of Strata[1]

(Analyst, H. V. Ellsworth)

Series	KCl	K_2O equivalent	H_2O insoluble after ignition	Total H_2O	KCl on soluble salt basis	K_2O on soluble salt basis
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
A 1	2·67	1·69	2·94	0·49	2·76	1·75
2	6·31	3·99	2·04	0·31	6·46	4·08
3	2·41	1·52	0·95	0·17	2·44	1·54
4	6·32	4·00	2·10	0·34	6·48	4·10
5	0·85	0·53	10·98	1·20	0·97	0·60
6	1·16	0·73	13·69	1·27	1·36	0·86
Average	3·29	2·08	5·45	0·63	3·41	2·15
D 1	1·01	0·64	15·79	1·94	1·23	0·78
2	0·89	0·56	11·03	1·79	1·02	0·64
3	0·74	0·47	7·53	1·13	0·81	0·51
4	1·22	0·77	10·47	1·98	1·38	0·84
5	0·92	0·58	6·25	1·15	0·98	0·62
6	0·63	0·40	4·65	1·03	0·67	0·42
Average	0·90	0·57	9·29	1·50	1·01	0·63
E 1	0·66	0·42	3·06	0·51	0·68	0·43
2	0·81	0·51	3·71	0·57	0·84	0·53
3	4·32	2·73	2·55	0·27	4·44	2·81
4	3·53	2·23	1·32	0·24	3·58	2·27
5	2·66	1·68	1·29	0·34	2·70	1·71
6	1·21	0·76	11·36	1·74	1·39	0·87
7	11·52	7·28	1·04	0·29	11·67	7·37
Average of 1 to 6	2·19	1·39	3·88	0·61	2·27	1·44

NOTE.—H_2O insoluble weighed after ignition, hence results are appreciably lower than the true values, due to loss of water and combustion of considerable organic matter.

The extent of these potash-bearing lenses and the possibility of encountering larger ones as the deposit is further developed are at present unknown. It is not economical to recover the potash by the present method of operating the deposit, which aims at the recovery of the sodium chloride only. Unless larger bodies of high-grade potash salts are encountered, which will lend themselves to mining, the potash will not be commercially recoverable.

[1]Dr. Ellsworth's sampling was done in 1919 just after the drift north from the shaft had been opened and the surfaces were still fresh and clean. Series A, B, C, and E were 2-inch channel samples cut normal to the dip, each successive number representing 1 foot of the channel from the top downwards. Sample A1 represents the uppermost foot of the red zone and C 6 represents the lowest part of the horizon accessible to sampling at the time. Series D consists of samples obtained by boring with an auger through the same strata as Series B; Series E samples are supposedly the same strata as Series A, but taken on the opposite side of the drift about 12 feet along the strike from Series A.

With the installation of an evaporating plant on this property it is possible there will be sufficient concentration of the potash salts in the mother liquor after the sodium chloride has been extracted to make it commercially feasible to recover potash salts as a by-product from the evaporating pan.

Brine springs at other localities in this province show small percentages of potash, but further geological exploration in the vicinity of such springs should be undertaken to determine the possibility of commercial deposits being found.

NEW BRUNSWICK

Near Gautreau village, Westmorland county, about 8 miles to the southeast of Moncton, a well was drilled by the D'Arcy Exploration Company, for the New Brunswick Gas and Oilfields, Ltd., in a search for gas and oil. Figure 2 gives the location of this drill hole with respect

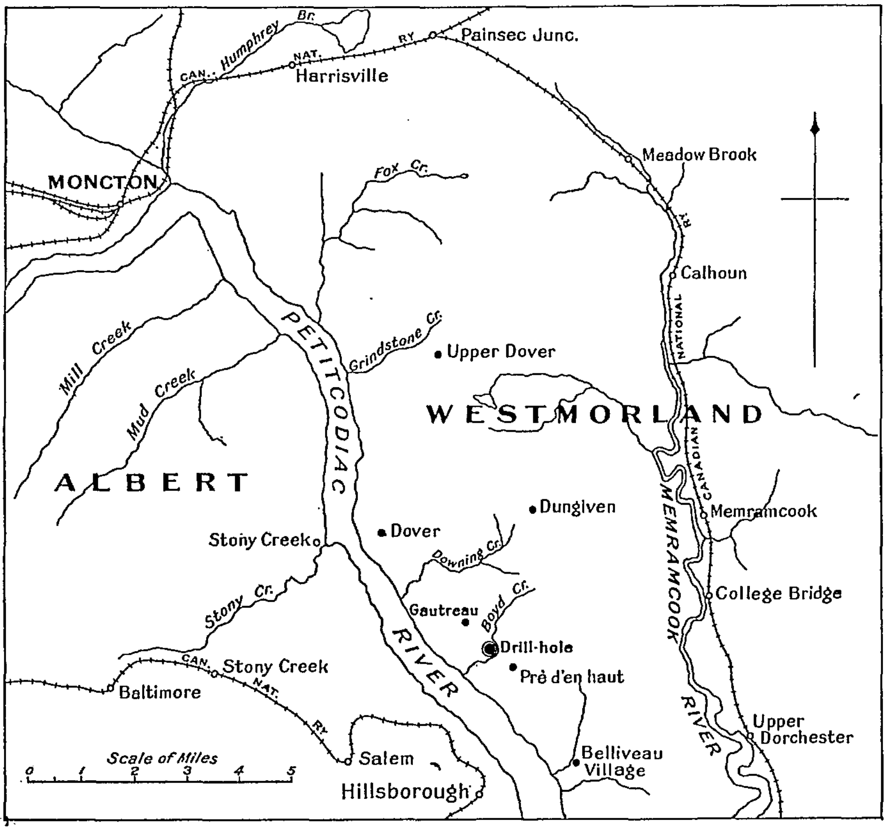

Figure 2. Sketch map showing location of drill hole at Gautreau, N.B., with respect to rail and water transportation.

D'ARCY EXPLORATION CO.

TEST WELL GAUTREAU Nº 1

Location: On land of Cassimier Gautreau, Village of Gautreau
Westmorland Co., N.B. on the north bank of Boyd Creek
about 300' east of main highway from Moncton N.B. to Gautreau

Elevation of collar of hole 70·7 feet above sea level

Scale: 100 feet to 1 inch

Depth	Geologic Column	Strata Thickness	Explanation of Geologic Column
20'		20'	No sample
70		50'	Surface Gravel - red to green
85		15'	Conglomerate - sandy red
97		12'	Sandstone and grit, quartz and pink feldspar
113		16'	Grit - reddish brown
191		78'	Sandstone and grit - red to brown
221		30'	Grit and sandstone - brown red quartz and feldspar
243		22'	Conglomerate - grey
249		6'	Sandstone and grit - brown
[illegible]		8'	Conglomerate - grey to brown
264		9'	Sandstone and grit - brown
285		21	Conglomerate - red and grey sandstone - fine grained, cem^d hard
317		32'	Sandstone and grit - reddish brown with dark red sandstone - fine-grained, cemented hard, calcareous
363		46'	Sandstone - dark red, fine-grained, cemented hard, calcareous and conglomerate brown red bands and thin red marl
385		22'	Conglomerate - grey with dark fine-grained red sandstone
405		20'	Conglomerate - grey and grit
435		30'	Sandstone - red marly, fine-grained, cemented hard, calcareous and brown grey limestone and conglomerate bands
447		12'	Sandstone and grit - red
470		23'	Conglomerate and grit - red to grey
490		20'	Sandstone - dark red marly, fine-grained, cemented, calcareous
520		30'	Conglomerate and grit - brown red and thin dark red sandstone bands
570		50'	Conglomerate and grit and dark red, fine-grained, cemented marly sandstone
605		35'	Sandstone and grit - brown red with sandy marl or marly sandstone - dark red
625		20'	Limestone - grey to brown, sandy hard micaceous
678		53'	Marl - brown red, sandy BASE OF RED BEDS?
744		66'	Shale - blue grey non-bituminous, calcareous and thin bands of light grey sandy limestone
774		30'	Shale - blue grey to light grey, calcareous, non-bituminous
825		51'	Limestone - brown to grey, sandy hard with little shale
900		75'	Shale - blue grey to light grey, non-bituminous, calcareous with thin bands grey limestone
987		87'	Limestone - brown sandy and thin shale blue grey, non-bituminous, calcareous
1027		40'	Shale - blue grey to light grey, non-bituminous calcareous and gypsum
1106		79'	Limestone - light grey sandy with thin bands blue grey to light grey shale - non-bituminous, calcareous
1126		20'	Limestone - brown hard sandy and thin shale - blue grey, non-bit. calc. and light grey sandstone - fine-grained, micaceous, calc.
1236		110'	Shale - blue grey to light grey, generally non-bituminous calcareous with some light grey limestone bands and light grey cemented fine-grained, calcareous, micaceous sandstone and calcite veins
1295		59'	Shale - blue grey generally non-bituminous, calcareous, sligtly carbonaceous some gypsum 1236-46. Traces of Na Cl 1236-56 Flame of Na 1280-89 Mixture of shale and white soluble salt (largely Na Cl traces K)
1784		489'	Rock Salt - generally large crystals and fine-grained cemented calcareous sandstone 1300-14, some efflorescence 1319-25, 1540-44 and 1771-84 and large crystals of Na Cl 1410-20
1863		79'	Shale - blue grey to light grey generally non-bituminous, calcareous, cherty, slightly carbonaceous and bands very slightly bituminous to bituminous 1806-11, slightly bituminous 1811-16, very slightly bituminous to non-bituminous 1816-20, slightly bituminous to non-bituminous 1820-25, slightly bituminous to very slightly bituminous 1825-35, non-bituminous to bituminous 1835-45, light brown to grey green. Some sandy limestone 1860-63 Na 1789-1806. Na colour in flame 1857-60
1878		15'	Shale - blue grey, non-bituminous and thin light grey fine-grained cemented sandstone

Bottom of hole

Figure 3.

to water and rail transportation. At 1,295 feet the hole entered beds of rock salt which had a total thickness at this point of 485 feet. The drilling was done by a standard churn drill so that no cores were recovered, but chip samples were taken for every 5 feet in depth. As far as known no special precautions were taken to prevent the soluble salts being washed out from these cuttings. A log of this well is given in Figure 3.

A study of these chip samples in the laboratories of the Department of Mines revealed some interesting data, since all those obtained from that section of the hole embracing the salt showed the presence of small quantities of potassium. A number of the 5-foot chip samples showed quite a persistent potash coloration by the flame test, indicating that there is a possibility of concentration of potash salts in certain definite horizons in the salt strata, but further drilling and sampling with a core drill will alone determine whether potash salts are present in commercial quantities.

The chip samples from the complete section of this well were examined by F. J. Fraser of the Borings Division, Geological Survey, and his summary of results is as follows:—

Summary of Gautreau Well. The position of the well on the map does not suggest the possibility of any great thickness of drift, and the occurrence of pebbles for the first 100 feet may indicate a conglomerate. Below this depth to 600 feet the samples are coarse, reddish arkosic sandstones and fine-grained grits. The quartz content is low, and the feldspars are, in general, fresh. Optical examination of occasional feldspar grains shows absence of broad plagioclase twinning, and sodic rather than calcic composition. With the exception of 15 feet at 91 to 105 feet and 35 feet at 435 to 470 feet, the beds are calcareous. An intensive search for purple volcanic ash was made but only a few fragments were noted at 530 to 550 feet.

At 580 feet, the reddish colour commences to give way to grey. At 600 feet the reddish sandstone commences to change to a grey shale, the transition being quite complete at 625 feet. The colour change lags behind that of the lithology, the change to grey being complete at 670 feet.

The grey shale, with minor colour variations, continues down to 1,295 feet. The shale is compact and uniform in character throughout, and has a persistent content of anhydrite, usually pink, and gypsum, fibrous, granular and clear needles. The fragments of these sulphate minerals are sufficiently dissociated from the shale to suggest that they occur in numerous thin veinlets invariably associated with calcite. No fossils were seen in the shale. Sometimes gypsum needles up to 0·2 mm. are scattered throughout the shale in sufficient size and profusion to be plainly visible under low magnification. The greatest gypsum content is at 660 to 720 feet. From 1,295 feet to 1,325 feet rock salt is associated with the shale.

At 1,325 feet there is a very sharp change from shale to a massive rock salt, colour impure white. The salt is very uniform in character, is persistently calcareous and contains soluble sulphates; the salt solution does not contain any soluble carbonates. The total depth of salt is 485 feet including the mixed salt and shale strata from 1,295 feet to 1,325 feet.

At 1,780 feet the salt reverts suddenly to a dark shale. A thin limestone probably rests on the top of the shale.

A second drill hole, put down about 1 mile northwest of the first hole failed to encounter the salt strata, but furnished valuable geological data that will be of the greatest assistance in any drilling contemplated.

There are in the Maritime Provinces a number of saline springs but the analyses of the brines from these are not yet completed, so that it is not known whether potash is present in appreciable amounts.

The results so far obtained in the Maritime Provinces indicate that certain areas are well worthy of careful examination by drilling methods especially designed to recover complete sections of the possible potash-bearing beds.

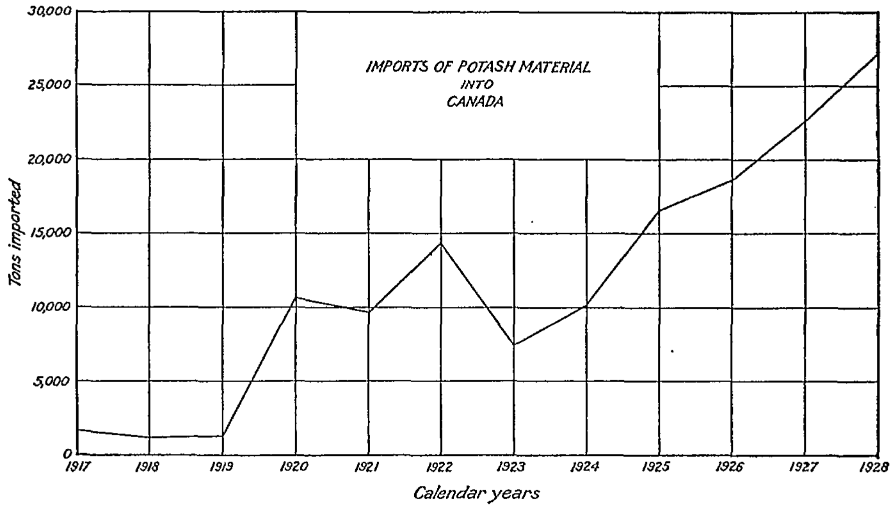

Figure 4.

TABLE I

Potash Materials Imported Into Canada[1]

Material	Approx. K_2O content %	1926				1927				1928			
		Pounds	Content of K_2O		Value $	Pounds	Content of K_2O		Value $	Pounds	Content of K_2O		Value $
			Pounds	Per cent of total			Pounds	Per cent of total			Pounds	Per cent of total	
Used Chiefly in Fertilizer—													
Kainite and other crude German potash salts for fertilizers........	14·0	12,200	1,708	0·01	83	863,100	120,834	0·55	11,283	403,400	56,476	0·21	5,694
Potash, muriate of, crude...............	50·0	29,665,000	14,832,500	82·20	432,537	37,346,900	18,673,450	85·16	627,997	47,710,100	23,855,050	89·03	842,988
Potash, sulphate of, crude...............	48·6	1,716,700	834,316	4·60	36,395	1,548,300	752,474	3·44	36,018	1,993,300	968,744	3·62	50,167
		31,393,900	15,668,524	86·81	469,015	39,758,300	19,546,758	89·15	675,298	50,106,800	24,880,270	92·86	898,849
Used Chiefly in Chemical Industries—													
Potash—													
Cream of tartar in crystals or argols.........	20·0	927,350	185,470	1·03	140,957	831,547	166,309	0·76	144,765	757,536	151,507	0·57	144,529
Pearl ash, in packages not less than 25 lb....	50·0	220,961	110,480	0·61	12,566	102,783	51,391	0·23	6,436	106,636	53,318	0·20	6,744
Pearl ash, in packages less than 25 lb........	50·0	51	25	....	21	170	85	....	54	83	42	....	30
Bicarbonate of.........	46·0	10,628	4,889	0·03	981	2,100	966	0·01	307	2,854	1,313	0·01	435
Bichromate of..........	40·0	145,379	58,158	0·32	10,764	191,798	76,719	0·35	15,127	193,940	77,576	0·29	17,155
Caustic, in packages not less than 25 lb........	80·0	387,776	310,221	1·72	39,147	558,362	446,690	2·04	40,695	624,438	499,550	1·86	42,032
Caustic, in packages less than 25 lb............	80·0	21,940	17,552	0·10	4,031	3,691	2,953	0·01	1,072	3,756	3,005	0·01	926
Chlorate of, not further prepared than ground	38·0	1,309,240	497,511	2·75	79,172	1,950,874	741,332	3·38	123,904	1,306,829	496,595	1·85	86,306
Red and yellow prussiate of..............	42·0	27,677	11,624	0·06	5,433	19,758	8,298	0·04	3,500	16,462	6,914	0·03	3,734
Saltpetre, or nitrate of potash...............	40·0	1,646,546	658,618	3·65	79,813	1,253,430	501,372	2·28	58,785	1,002,435	400,974	1·49	45,641
All other potash compounds n.o.p.[2]........	50·0	1,055,060	527,530	2·92	146,787	769,480	384,740	1·75	164,412	444,141	222,070	0·83	117,821
		5,752,608	2,382,072	13·19	519,672	5,683,993	2,380,855	10·85	559,057	4,459,110	1,912,864	7·14	465,353
Grand total[3], [4]......lb.	....	37,146,508	18,050,596	100·00	988,687	45,442,293	21,927,613	100·00	1,234,355	54,565,910	26,793,134	100·00	1,364,202
short tons	....	18,573	9,025	....	....	22,721	10,964	....	....	27,283	13,396	....	....

[1] Compiled from *Trade of Canada*, Calendar Years 1927 and 1928.

[2] KCN import figures not included as they are grouped in above reports with cyanogen bromide.

[3] According to a report of the U.S. Bureau of Mines entitled "Potash in 1926" by A. T. Coons, the following amounts were imported into the United States:—

	Short tons
Potash, muriate of..	3,242
Potash, sulphate of..	8
Manure salts..	289
Potash, bitartrate of..	1
	3,540

[4] *Trade of Canada* 1928 gives the following exports:—

	1927		1928	
To United Kingdom........	21,600 lb.	$ 2,430	34,100 lb.	$4,086
United States...........	753,400 lb.	$13,524	132,800 lb.	$2,986
Totals..............	775,000 lb.	$15,954	166,900 lb.	$7,072

TABLE II

Origin of Potash Materials Imported into Canada

—		United Kingdom			United States			Germany			Belgium		
		1926	1927	1928	1926	1927	1928	1926	1927	1928	1926	1927	1928
Kainite and other crude German potash salts for fertilizers.	lb.	12,200	11,200	...	...	421,900	...	...	...	...	...	...	...
	$	83	79	...	...	3,691	...	...	...	...	...	...	...
Potash, muriate of, crude	lb.	...	...	...	6,402,700	15,060,300	14,333,700	22,580,000	20,728,000	27,401,800	...	...	...
	$	...	...	...	110,100	242,395	284,140	308,983	342,262	451,107	...	...	...
Potash, sulphate of, crude	lb.	20,000	100	200	596,900	460,800	758,800	1,026,400	1,067,400	1,067,300	...	...	...
	$	360	11	31	13,248	10,600	17,975	21,109	24,932	28,381	...	...	...
Cream of tartar in crystals or argols	lb.	40,404	90,173	160,707	37,062	67,116	31,629	...	...	...	...	...	...
	$	5,605	18,039	31,710	6,767	13,475	6,332	...	...	...	...	...	...
Pearl ash, in packages not less than 25 lb.	lb.	2,150	3,120	2,000	51,108	36,408	27,533	...	...	...	...	...	...
	$	195	291	172	3,663	2,727	2,507	...	...	...	...	...	...
Pearl ash, in packages less than 25 lb.	lb.	...	...	...	51	170	83	...	...	...	...	...	...
	$	...	...	...	21	54	30	...	...	...	...	...	...
Potash, bicarbonate of	lb.	1,456	514	224	1,726	1,586	2,630	...	...	...	...	...	...
	$	156	62	24	230	245	411	...	...	...	...	...	...
Potash, bichromate of	lb.	53,764	37,926	44,129	84,860	109,950	117,463	...	...	...	...	...	...
	$	4,329	3,286	3,709	5,834	9,515	10,899	...	...	...	...	...	...
Potash, caustic, in packages of not less than 25 lb.	lb.	40,929	32,559	18,878	107,990	138,656	163,602	232,619	305,447	436,208	...	...	...
	$	2,421	2,036	1,344	8,794	11,554	13,509	26,671	19,607	26,117	...	...	...
Potash, caustic, in packages less than 25 lb.	lb.	12	...	...	10,849	3,691	3,606	...	...	...	...	...	...
	$	6	...	...	2,135	1,072	885	...	...	...	...	...	...
Potash, chlorate of, not further prepared than ground.	lb.	7,200	218,899	101,570	865,200	680,292	581,782	...	...	...	...	...	...
	$	812	19,157	9,875	54,368	44,150	36,730	...	...	...	...	...	...
Potash, red and yellow prussiate of	lb.	4,792	4,509	15	10,639	2,459	852	...	...	...	...	...	...
	$	1,152	577	6	2,449	575	359	...	...	...	...	...	...
Saltpetre, or nitrate of potash	lb.	104,006	113,033	100,145	230,397	300,666	73,427	605,914	535,322	699,042	639,185	304,409	129,821
	$	5,235	5,729	3,945	12,648	15,510	4,434	29,635	24,199	30,272	28,935	13,347	6,990
Potash compounds n.o.p.	lb.	35,747	39,759	38,609	966,842	639,362	234,433	...	...	...	...	...	...
	$	17,873	18,925	13,621	120,916	135,373	88,373	...	...	...	...	...	...
Totals	lb.	322,660	551,792	466,477	9,366,324	17,923,356	16,330,640	24,444,933	22,636,169	29,604,350	639,185	304,409	129,821
	$	38,227	68,192	64,437	341,173	490,936	466,584	386,398	411,000	535,877	28,935	13,347	6,990
Percentage of total imports	tonnage	0·87	1·21	0·85	25·22	39·44	29·93	65·81	49·82	54·25	1·72	0·67	0·24
	value	3·87	5·55	4·72	34·51	39·77	34·20	39·08	33·29	39·28	2·92	1·08	0·51

[1]Compiled from *Trade of Canada*, Calendar Years 1927 and 1928.

TABLE II—Concluded

Origin of Potash Materials Imported into Canada—Concluded

—		France and Italy			Other Sources			Totals		
		1926	1927	1928	1926	1927	1928	1926	1927	1928
Kainite and other crude German potash salts for fertilizers.	lb.	...	...	...	...	430,000	403,400	12,200	863,100	403,400
	$	...	...	...	...	7,513	5,694	83	11,283	5,694
Potash, muriate of, crude	lb.	...	...	...	682,300	1,558,600	5,974,600	29,665,000	37,346,900	47,710,100
	$	...	...	...	13,454	43,340	107,741	432,537	627,997	842,988
Potash, sulphate of, crude	lb.	...	...	...	73,400	20,000	166,000	1,716,700	1,548,300	1,993,300
	$	...	...	...	1,678	475	3,780	36,395	36,018	50,167
Cream of tartar in crystals or argols	lb.	600,568	509,362	455,147	64,452	3,058	...	927,350	831,547	757,536
	$	90,418	84,720	86,105	10,027	434	...	140,957	144,765	144,529
		184,864	161,838	110,053	...	...	...	...	...	...
		28,140	28,097	20,382	...	...	...	...	...	...
Pearl ash, in packages not less than 25 lb.	lb.	...	...	...	167,703	63,255	77,103	220,961	102,783	106,636
	$	...	...	...	8,708	3,418	4,065	12,566	6,436	6,744
Pearl ash, in packages less than 25 lb.	lb.	...	...	...	...	...	...	51	170	83
	$	...	...	...	...	...	...	21	54	30
Potash, bicarbonate of	lb.	...	...	...	7,446	...	...	10,628	2,100	2,854
	$	...	...	...	595	...	...	981	307	435
Potash, bichromate of	lb.	...	...	...	6,755	43,922	32,248	145,379	191,798	193,940
	$	...	...	...	601	2,326	2,547	10,764	15,127	17,155
Potash, caustic, in packages of not less than 25 lb.	lb.	...	...	...	6,238	81,700	5,750	387,776	558,362	624,438
	$	...	...	...	1,261	7,498	1,062	39,147	40,695	42,032
Potash, caustic, in packages of less than 25 lb.	lb.	...	...	...	11,079	...	150	21,940	3,691	3,756
	$	...	...	...	1,890	...	41	4,031	1,072	926
Potash, chlorate of, not further prepared than ground	lb.	...	...	...	436,840	1,051,683	623,477	1,309,240	1,950,874	1,306,829
	$	...	...	...	23,992	60,597	39,701	79,172	123,904	86,306
Potash, red and yellow prussiate of	lb.	...	...	...	12,246	12,790	15,595	27,677	19,758	16,462
	$	...	...	...	1,832	2,348	3,369	5,433	3,500	3,734
Saltpetre, or nitrate of potash	lb.	...	...	...	67,044	...	...	1,646,546	1,253,430	1,002,435
	$	...	...	...	3,360	...	...	79,813	58,785	45,641
Potash compounds n.o.p.	lb.	...	...	...	52,471	90,359	171,099	1,055,060	769,480	444,141
	$	...	...	...	7,998	10,114	15,827	146,787	164,412	117,821
Totals	lb.	785,432	671,200	565,200	1,587,974	3,355,367	7,469,422	37,146,508	45,442,293	54,565,910
	$	118,558	112,817	106,487	75,396	138,063	183,827	988,687	1,234,355	1,364,202
Percentage of total imports	tonnage	2·11	1·48	1·04	4·27	7·38	13·69	...	...	...
	value	11·99	9·13	7·81	7·62	11·18	13·48			

III

CORE DRILLING BITUMINOUS SANDS OF NORTHERN ALBERTA

S. C. Ells.

During the field season of 1928, core drilling of the bituminous sands of the McMurray area was continued. Actual drilling was commenced on June 6 and discontinued on August 14. On the completion of this work, sampling was continued by means of hand augers in townships 89 and 94. Footage of drilling completed during the season was equivalent to 642 feet. This included 454½ feet of bituminous sand, which was represented by 274 samples, and 169½ feet of overburden. Results of analyses[1] of the samples are included in this report, and together with analyses of previous logs[2] indicate the class of bituminous sand which may be expected in many parts of the McMurray area. In considering the possible value of the bituminous sand for paving purposes, variation in grading of sand aggregate indicated by analyses of samples from Clearwater river (sec. 14, tp. 89, R. 9) is of especial interest.

As in 1927, Paul Schmidt was in immediate charge of drilling operations and M. S. Hutchison acted as assistant. Both discharged their duties in an efficient and satisfactory manner.

Six wells,[3] the positions of which are indicated on the outline map (Figure 5 on page 29), which accompanies this report, have now been drilled at representative points[4] in the McMurray area, and results clearly indicate that exposures of bituminous sand cannot be regarded as an accurate indication of conditions that may be met with in adjacent areas.[5] Thus, for a number of years, the writer has regarded the Beaver River area as one of unusual promise. At certain points within this area, topographic conditions[6] are ideal for large-scale development, while extensive exposures along Beaver river (Plates IA and IIA) appear to represent a very large tonnage of bituminous sand of good quality under light sand-gravel overburden. Results of the past season's drilling have, however, indicated conditions quite different from those which had been anticipated.

In a recent report[7] by the writer, on drilling operations during 1927, reference was made to procedure adopted, to conditions encountered in the bituminous sand itself, and to factors which would govern rate of progress. Operations during 1928 involved only minor additions to drilling equipment, although the possible value of two new types of drilling bits was investigated. Consequently the present report should be regarded as a supplement to that dealing with work of the previous year.

As in wells drilled prior to 1928,[8] separation of bitumen from unoxidized bituminous sand was readily effected in situ by the action of cold water.

[1] All analyses are by Fuel Research Laboratories.
[2] Mines Branch, Dept. of Mines, Canada, Rept. 694.
[3] For logs of Wells Nos. 1-4 (incl.) see Mines Branch Report 694.
[4] In McMurray settlement, on Clearwater river (sec. 14, tp. 89, R. 9). On Athabaska river (secs. 17 and 32; tp. 89, R. 9; in secs. 20 and 29, tp. 91, R. 9; sec. 19, tp. 93, R. 10; sec. 25, tp. 93, R. 11; and in sec. 19, tp. 94, R. 10*).
* Mines Branch, Dept. of Mines, Canada, Rept. 632, p. 37.
[5] Mines Branch, Dept. of Mines, Canada, Rept. 632, pp. 53-57.
[6] Mines Branch, Dept. of Mines, Canada, Map 636.
[7] Mines Branch, Dept. of Mines, Canada, Rept. 694.
[8] Mines Branch, Dept. of Mines, Canada, Rept. 694, p. 7.

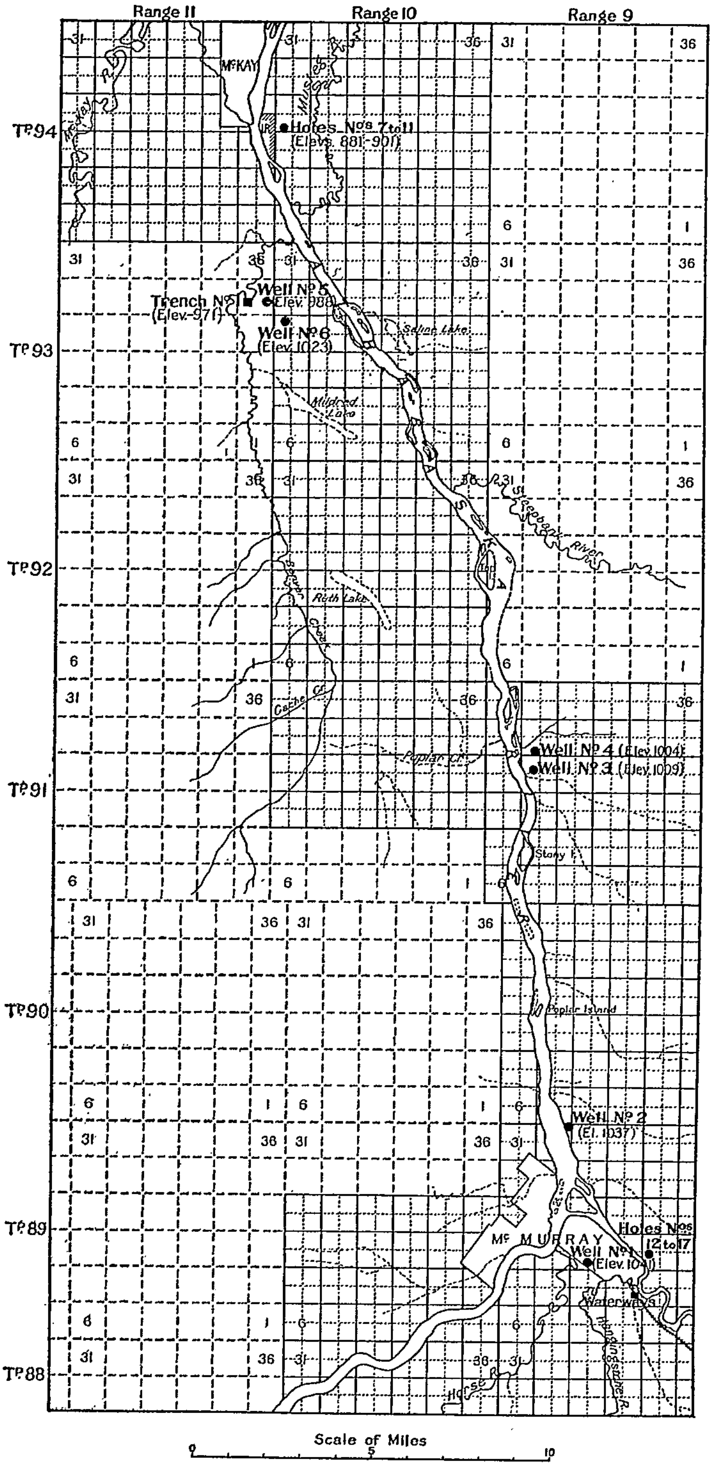

Figure 5. Index map showing location of wells drilled by Mines Branch, 1925-1928

Analyses of three samples scraped from cable tools showed 75·8, 85·5, and 96·2 per cent bitumen. This feature should prove of practical interest to any who may be interested in a study of separation methods, but who have depended for results on the use of bituminous sand which has been exposed to atmospheric action for considerable periods of time. On the other hand, in certain cases oxidation has already affected bituminous sand in place to some extent. This has been due to infiltration of water along a great number of slip planes which have subsequently become largely sealed up. This feature is referred to on pages 54 and 55, Mines Branch Report No. 632. The writer has opened up three small quarries at various times in secs. 8 and 14, tp. 89, R. 9, and in sec. 24, tp. 95, R. 11, and in each case the evidence of slipping has been clearly seen.

Having in view possible future requirements of bituminous sand in connexion with further demonstration work, two of the most promising areas near present rail transportation were examined in some detail. This work completed the season's operations.

As noted above, Paul Schmidt was in immediate charge of drilling operations during the field season of 1928, and the following report has been submitted by him:—

"A somewhat extended reference to previous core drilling undertaken by the Mines Branch has already been made in the Mines Branch report, No. 694. It is, therefore, unnecessary to make any detailed statement regarding equipment employed, or concerning those factors which will govern the efficient conduct of this form of exploration. Results obtained clearly indicate, however, wide variation in the character of the bituminous sand, and conclusively demonstrate the necessity of careful prospecting as a preliminary step in the selection of bituminous sand areas.

New Equipment

"During the field season of 1928, apart from the purchase of two new coring tools, drilling equipment employed was essentially the same as that used during the previous year. The new tools comprised an earth auger, and a core barrel spirally threaded on the outer face. Both proved useful for drying and cleaning out the well, but when passing through average bituminous sand, were not nearly so efficient as the standard augers usually employed. An attempt was made to use the earth auger socket[1] secured in the fall of 1927 since it was hoped that this might obviate the necessity of using rotary tools. This tool proved satisfactory in fairly soft bituminous sand, but the presence of even a small quantity of water rendered it ineffective. Hard partings or other obstruction in the well also tended to bend the lower edge of the pipe, and it was therefore discarded as unsatisfactory. As in 1927, wells were cased with 6-inch (outside diameter) I.J. casing when passing through overburden. In bituminous sand, $3\frac{3}{4}$-inch (outside diameter) I.J. casing was used. At times $4\frac{5}{8}$-inch casing was inserted prior to using the smallest size. Transportation equipment was augmented by the purchase of a full crawler tractor equipped with a winch. This type of tractor was of material assistance in moving equipment (more especially in muskeg, on steep grades and on loose sandy soil) and also for extricating the wheeled tractors and wagons. (Plate IIB). The winch was of great value for handling drill rods and casing.

[1] Mines Branch, Dept. of Mines, Canada, Rept. 694, p. 5, Fig. 1G.

Drilling[1] and prospecting operations during 1928 comprised:

(a) *Beaver River Area.* Drilling of Well No. 5 and excavation of Trench No. 1 in sec. 25, tp. 93, R. 11, and drilling of Well No. 6 in sec. 19, tp. 93, R. 10.

(b) *Muskeg River Area.* Five shallow test borings were made near the south boundary of the S.W. ¼ sec. 19, tp. 94, R. 10.

(c) *McMurray Settlement.* Two small areas in and adjacent to McMurray settlement were prospected by means of hand augers.

Beaver River Area

"Topographical conditions within this area are clearly indicated on Mines Branch Map No. 636, and require little comment.[2] Along the lower reaches of Beaver river, Devonian limestones attain an exposed thickness of more than 100 feet. With a marked dip toward the SW., these limestones disappear at a point some 2¾ miles from the mouth of the river, and are replaced in the valley walls by cliffs of bituminous sand approximately 100 feet high and apparently of good quality. Overburden seen along the cutbanks varies in thickness from 8 to 10 feet, and consists of sand and gravel. With townsite, disposal and plant sites, and water supply available, the area thus appeared to have marked advantages from the standpoint of possible commercial development.

Well No. 5. "The site (Plate IB) selected for the first well (No. 5) lies some 1,200 feet to the east of one of the principal exposures on Beaver river, and is adjacent to a shallow depression draining a nearby muskeg area. As a result, ground water was but 4 feet below the surface, and resulting caving necessitated the use of casing from the beginning. Overburden at the well site consists of 5 feet of reddish sand, 3 feet of fine white silt, 6 feet of coarse sand and gravel, and 7 feet of coarse gravel and boulders, with fragments of bituminous sand float. At 21 feet, a bed of white medium-grained sand, 2 feet in thickness, was encountered, and apparently represents water-leached bituminous sand.

"The upper horizon of the bituminous sand formation showed approximately 17 feet of fairly homogeneous material; but even here in spite of the use of three strings of casing, numerous water seeps along bedding planes caused great inconvenience and rendered accurate coring very difficult. Below 40 feet from the surface, banded material—bituminous sand, silt, and clay—was encountered, and at 114½ feet limestone was reached.

"At various times the use of cable tools was resorted to for reaming and for passing through hard strata. When withdrawn from the well, stem and bit were covered with bitumen which had separated out in the presence of cold water. The bitumen was rather soft and dripped slowly from the tools. Separated bitumen was also frequently brought up in the bailer. A summary[3] of the log of Well No. 5 is given in Table I.

"As noted above, owing to water seeps it was difficult to secure accurate samples between 35 and 46 feet. In the hope that No. 5 well would act as a drainage sump, 25 feet of outer (6-inch) casing was left in place in No. 5 well, and a second offset well (Well 5A) commenced at a distance

[1] Prior to 1928, Wells Nos. 1-4 (incl.) were drilled. The two wells drilled in 1928 are therefore numbered 5 and 6.
[2] Mines Branch, Dept. of Mines, Canada, Rept. 632, p. 36.
[3] Detailed notes on each individual sample, and on changes in character of material passed through are available at the Mines Branch, Ottawa.

of 4 feet. After passing through the overburden, however, it was apparent that the stability of the bituminous sand had been disturbed in drilling the original well, and that it would not form a shoulder on which to set the new casing. Water in both bores apparently stood at approximately the same level. Consequently it was only by using unusual pressure on the augers and thereby compacting the cuttings very tightly, that accurate samples of bituminous sand could be secured. Caving was frequent, and gravel overburden followed down, becoming mixed with the bituminuous sand. Apparently the radius of action of water in No. 5 had been greater than anticipated, with the result that separation of bitumen, even at a distance of 4 feet, had been partially effective. This would explain the lack of cohesion in bituminous sand encountered in the offset well, and also the unusual quantities of separated bitumen recovered from the original bore. Such a condition emphasizes and confirms the previous contention by S. C. Ells that efficient separation can only be effected when bituminous sand is fresh and unaffected by atmospheric action.

Trench No. 1. "In order to extend the area represented by the core from Well No. 5, a trench (here referred to as Trench No. 1) was excavated down the face of an exposure on Beaver river, approximately ¼ mile NW. by W. from Well No. 5. As excavation progressed, sampling was carried on, no samples being taken at a depth of less than 6 feet from the exposed face. Water seeps along bedding planes were frequent. Summarized results of analyses of samples are shown in Table II.

Well No. 6. "This well is drilled at a point approximately two-thirds of a mile SE. of Well No. 5. The bituminous sand lies under 77 feet of overburden, consisting of sand, gravel, boulders, and clay together with some bituminous sand float. Between 58 and 61 feet, a greenish sand mixed with black clay, and having a distinctly asphaltic odour, was encountered. Hard black shale was found at 63 and 76 feet, and again at 106 feet.

"As in Well No. 5, the bituminous sand was seriously affected by water seeps, and it was not until banded material was reached at 101 feet, that the bore could be dried out properly. At 110 feet the bailer became stuck and as it could not be recovered the well was abandoned. Table No. III furnishes a summary of the log.

Conclusions. "As a result of drilling in the Beaver River area, it is clear that:

(a) Overburden is comparatively light, varying from 8 feet at the site of Trench No. 1, to 77 feet at the site of Well No. 6. Its character is such that removal will present no serious difficulty.

(b) The bituminous sand formation comprises fairly rich beds of varying thickness but also includes much banded material and silt. Sand aggregate is fine, and this would probably militate against its use as a paving material. The total thickness of the formation is approximately 90 feet.

(c) The elevation of the top of the bituminous sand varies but 5 feet at Wells Nos. 5 and 6.

(d) In a general way, when drilling through bituminous sand with cable tools in the presence of water, the richness of the sand is at times roughly indicated by the quantity of separated bitumen adhering to the bits and stems. On the other hand, a higher gravity bitumen permits

greater radius of action by the water, and a correspondingly greater amount of separated bitumen may be recovered. When drilling tools were withdrawn from Wells Nos. 5 and 6, separated bitumen dripped freely or could be scraped off readily. On the other hand, in drilling previous wells the use of heated scrapers had frequently been necessary. In the Beaver River area, the bitumen brought up on the cable tools thus appears to have a somewhat higher gravity than that encountered during previous drilling elsewhere. During the progress of churn drilling, marked quantities of bitumen separated out readily and the radius of action of the water was greater than had been anticipated.

(e) Ground water lies near the surface and saturates the upper beds of bituminous sand. Apparently this has not resulted in serious leaching out of the bitumen since circulation of the water is negligible. Local drainage of a quarry would present no serious difficulty.

(f) The hard strata encountered in Well No. 6 might constitute a favourable condition were separation in situ attempted by the use of steam or heated water.

(g) An examination of outcrops[1] farther south along Beaver river does not indicate, except locally, any general improvement in quality of bituminous sand.

(h) The area drilled is easily accessible from the Athabaska river. With the exception of some 400 yards of muskeg, dry ground can be found for highway or railway construction.

(i) During summer months sufficient water for hydraulicking and other purposes can be secured from Beaver river. The supply of ground water is large.

"A study of records in Tables I, II, and III indicates that close correlation is possible between material passed through in Well No. 5 and Trench No. 1. Material passed through in Well No. 6 is, however, quite different, the only point of correspondence being that the top of the first consolidated strata is but slightly higher.

Muskeg River Area[2]

In the area lying between Muskeg river and Athabaska river, in tp. 94, R. 10, occur a number of low sand ridges the general trend of which is in a north-south direction. About one-quarter mile to the east of the eastern boundary of Fort MacKay Indian Reserve, two of the ridges cross the south boundary of sec. 19, tp. 94, R. 10. Seepages of bitumen, although of no commercial importance in themselves,[3] appeared to indicate the presence of rich bituminous sand, while light sandy overburden and topographical considerations are favourable to commercial development. It was anticipated that water seeps would not be encountered within rich bituminous sand, and adjacent exposures indicated that underlying limestone would be encountered at shallow depth.

"Accordingly five shallow borings (Nos. 7-11) were made by means of hand augers along the south boundary of the SW. $\frac{1}{4}$ sec. 19, tp. 94, R. 10. Contrary to expectations, water was encountered in each boring, and prevented completion of holes down to the limestone. In part this

[1] Mines Branch, Dept. of Mines, Canada, Rept. 632, p. 36. *See also* Map 636.
[2] Mines Branch, Dept. of Mines, Canada, Rept. 632, pp. 36-37.
[3] Mines Branch, Dept. of Mines, Canada, Rept. 632, p. 45.

was obviously surface water from adjacent muskegs, and in part, seepages along clay partings in the bituminous sand itself. Since, however, wells were commenced at different elevations[1] it is safe to assume that the lower and the higher elevations may be considered as supplementing each other, and that samples secured represent accurately a considerable aggregate thickness of bituminous sand.

"As anticipated, the bituminous sand is of good quality and with the exception of minor clay partings in the upper part of the bed, is apparently fairly uniform in character. Overburden proper consists of from 6 to 8 inches of loose sand, but the leaching out of from 3 to 4 feet of bituminous sand near the surface would increase actual overburden to be removed by that additional amount. A test pit some 197 feet to the north of the drilling site indicates the continuation of the bituminous sand under shallow overburden. A summary of analyses of samples will be found in Table IV.

"The above area undoubtedly offers unusual possibilities as a source of a large tonnage of bituminous sand. If quarrying operations were undertaken, drainage of adjacent muskeg areas would present no serious difficulty.

Possible Quarry Sites near McMurray

"On completion of the season's original drilling program, and in anticipation of probable future requirements of bituminous sand, the two most promising areas in the neighbourhood of McMurray were prospected in some detail.

(*a*) *Outcrop on East Bank of Athabaska River in River Lots 2 and 6.*—"Although transportation from this site to present terminus of the A. & G.W. railway at Waterways[2] presents certain difficulties, the apparent extent and quality of the bituminous sand exposed were encouraging features. For the most part overburden is heavy, but at two points conditions appeared to warrant detailed examination. Two cores were therefore secured by means of hand augers.

"Number 1 core was taken at a point approximately midway along the main exposure and slightly to the south of the 50-foot escarpment indicated on Mines Branch Map No. 634. Here the section exposed may be roughly divided into two parts. The upper of these consists of a series of seams of banded material some 20 feet in thickness, while the lower comprises upwards of 30 feet of fairly homogeneous bituminous sand resting directly on the limestone. Although the greater part of this bituminous sand is of good quality, nevertheless in places it is badly spotted with clay pockets and interrupted by minor clay partings.

"From the floor of an excavated pit 5 feet deep, a hole was drilled at a point approximately 5 feet from the edge of the cliff. Overburden here is $5\frac{1}{2}$ feet in thickness, but this increases to 40 feet within a distance of 30 feet to the east. Classing banded material as overburden, total waste material to be removed would, in places, be not less than 60 feet in thickness. The floor of the drilling pit consisted of a bed of gravel agglomerate, varying in thickness, cemented together with bitumen, and difficult to remove.[3] A summary of analyses of samples secured in this well is indicated in Table V.

[1] *See* Table IV.
[2] This distance is approximately $4\frac{1}{2}$ miles by water.
[3] A similar condition was encountered by S. C. Ells during the course of extensive excavations on Horse river 1920.

"The main body of homogeneous bituminous sand was penetrated to a depth of approximately 10 feet, and it may be assumed that equally good material may be expected for an additional 20 feet farther. The clay pockets and partings, while a detriment from a paving standpoint, could probably be largely eliminated by rough sorting. On the other hand, even at the most favourable points, overburden is heavy and of a character somewhat difficult to remove cheaply.

"A second well was drilled at a point on the southern extremity of the hogsback[1] near the southerly boundary of McMurray settlement. The outcrop immediately adjacent shows a bed of bituminous sand approximately 30 feet in thickness, resting on Devonian limestone. The quality of the bituminous sand proved very disappointing, however, being highly banded with low-grade bituminous sand and clay partings. Superficial examination of the outcrop would indicate bituminous sand of fair quality, but close inspection shows that throughout its entire thickness the bed is full of impurities. Samples secured by coring were obviously not of sufficient importance to send to the laboratory for analysis, and the hole was abandoned. Overburden consists of uncompacted sand, clay, gravel, and many large boulders. At the drill site, 5 feet from the edge of the cliff, it was but 6 feet in thickness, but this increases to 38 feet within a distance of 40 feet.

"In view of conditions indicated by the above results, and considering that distance to present rail transportation, swift current, and seasonal low water would handicap the handling of shipments, this location as a possible quarry site was abandoned.

(*b*) *Outcrop on East Bank of Clearwater River (L. S. 4, Sec. 14, Tp. 89, R. 9).*—During 1924, two shafts were sunk, and in 1926 and 1927 a quarry opened up within the above area. Results of this work[2] indicated the presence of a considerable tonnage of bituminous sand of commercial grade, while the distance to the present terminus of the A. & G. W. railway at Waterways is but one mile. Consequently a series of 6 test holes (Nos. 12-17) was drilled by the use of hand augers, and 71 core samples secured. Results of analyses of these samples are shown in Table VI. The deposit represented by these samples shows marked variation in character at different elevations. The bituminous sand is, however, as uniform as that shipped during 1926 and 1927, and which gave excellent results as a paving material. The total thickness of the bed as exposed above river water level is approximately 25 feet. Overburden consists of clay and sand with minor partings of bituminous sand and one parting of quartzite or hard sandstone, 10 to 12 inches thick. Overburden at the outcrop is approximately 6 feet in thickness, and this increases to 15 feet within a distance of 80 feet inland. The total area represented by the test holes is estimated at 1,330 square yards, and this should yield from 10,000 to 12,000 tons of bituminous sand. A light, temporary trestle wharf would furnish the necessary connexion between a quarry and scows lying in deep water."

[1] Mines Branch, Dept. of Mines, Canada, Map 634.
[2] Mines Branch, Dept. of Mines, Canada, Rept. 684; Rept. 632, pp. 53-57; Rept. 694.

TABLE I

Log of Well No. 5

Surface elevation 988 feet. Location—L.S. 8, Sec. 25, Tp. 93, R. 11

Sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand							
					Held on 10 mesh	Passing mesh						
						10	20	30	40	80	100	200
	' " ' "	%	%	%	%	%	%	%	%	%	%	%
1	8 0 — 14 0	10·6			5·8	13·0	8·2	10·2	38·8	8·4	10·5	5·1
2	14 0 — 21 0	9·6			6·8	30·5	15·0	10·6	27·4	3·7	3·7	2·3
3	21 0 — 24 0	14·2			0·2	2·9	7·8	13·1	61·0	7·5	5·8	1·7
4	25 10 — 28 5	7·9	10·3		0·0	0·2	0·2	0·2	26·2	32·2	29·6	11·4
5	28 5 — 30 0	12·2	10·9		0·2	0·2	0·2	0·2	27·5	32·7	29·9	9·1
6	30 0 — 31 8	8·7	12·4	4·4	0·1	0·1	0·5	0·5	28·6	35·4	26·7	8·1
7	31 8 — 33 5	11·5	9·5		0·1	0·2	0·6	0·7	30·4	33·1	24·8	10·1
8	33 5 — 34 5	12·3	10·9		0·0	0·1	0·4	0·3	20·2	34·4	34·6	10·0
9	38 1 — 38 8	3·8	9·0		0·0	0·2	1·1	0·5	19·0	22·2	46·1	10·9
10	46 0 — 47 5	6·7	10·7		0·0	0·1	0·5	0·2	7·7	9·8	53·7	28·0
11	47 5 — 48 4	6·6	11·5		0·0	0·1	0·5	0·3	1·5	5·7	57·0	34·9
12	49 0 — 50 5	8·6	7·2		0·0	0·1	1·4	0·4	4·4	9·5	62·2	22·0
13	50 5 — 53 0	13·8	8·6	5·1	0·1	0·1	0·5	0·2	2·5	7·8	73·6	15·2
14	53 0 — 55 0	5·4	8·5		0·0	0·1	1·1	0·6	2·3	2·3	35·7	57·9
15	55 0 — 56 6	3·9	10·9		0·0	0·2	0·6	0·3	8·9	21·5	38·4	30·1
16	56 6 — 57 7	3·2	14·0		0·1	0·4	2·2	1·8	9·7	22·4	48·4	15·0
17	57 7 — 58 8	7·9	4·5		0·0	1·0	3·1	1·3	3·6	3·1	36·0	51·9
18	58 8 — 60 0	12·3	1·3		0·0	0·1	0·9	0·4	1·4	2·5	31·8	62·9
19	64 6 — 68 9	11·4	6·4		0·0	0·1	0·8	0·2	3·2	5·5	57·3	32·9
20	68 9 — 70 3	6·0	11·7	4·0	0·0	0·1	0·9	0·7	4·4	5·4	45·4	43·1
21	70 3 — 71 11	7·9	12·4		0·0	0·1	0·4	0·2	1·5	3·2	52·9	41·7
22	71 11 — 72 6	5·7	11·8		0·0	0·1	0·4	0·1	0·7	0·9	46·2	51·6
23	72 6 — 72 11	10·0	11·5		0·0	0·2	0·9	0·2	1·1	1·3	33·1	63·2
24	72 11 — 73 9	9·5	0·0		0·0	0·1	1·5	1·6	5·5	1·4	10·7	79·2
25	73 9 — 75 0	10·3	3·2		0·0	0·1	0·4	0·3	2·1	1·3	8·2	87·6
26	75 0 — 76 6	9·7	6·2		0·0	0·4	1·0	0·4	1·1	0·8	22·7	73·6
27	76 6 — 77 9	5·1	9·9		0·0	0·2	0·5	0·3	0·6	0·4	19·9	78·1
28	77 9 — 79 0	6·7	8·6		0·0	0·1	0·4	0·3	1·1	0·4	40·5	57·2
29	79 0 — 79 8	5·9	12·5	4·8	0·0	0·1	0·4	0·1	0·8	0·5	50·8	47·3
30	79 8 — 81 1	6·1	9·3		0·0	0·5	1·6	0·8	5·1	2·7	26·9	62·4

31	81 1 — 82 1	7·0	7·6		0·1	2·3	4·3	2·3	15·2	3·1	14·7	58·0
32	82 1 — 86 4	9·3	6·4		0·0	0·1	0·1	0·2	0·8	1·0	31·4	66·0
33	86 4 — 87 4	4·9	7·3		0·1	0·4	1·5	0·5	4·8	8·8	35·5	48·4
34	87 4 — 88 7	5·0	8·5		0·0	0·4	1·2	0·5	4·2	3·6	28·2	61·9
35	88 7 — 89 7	7·9	8·0		0·0	0·2	0·7	0·4	1·6	1·8	26·4	68·9
36	89 7 — 90 10	5·5	6·1		0·0	0·1	0·7	0·2	1·4	1·2	39·6	56·8
37	90 10 — 91 8	6·2	4·5	4·4	0·0	0·1	0·6	0·3	1·8	0·4	32·5	64·3
38	91 8 — 93 2	6·5	4·3		0·1	0·1	0·5	0·3	1·5	1·7	33·7	62·1
39	93 2 — 94 3	8·9	5·9		0·0	0·0	0·1	0·1	0·6	0·7	9·5	89·0
40	94 3 — 95 8	7·4	6·8		0·0	0·0	0·2	0·1	0·5	0·7	9·5	89·0
41	95 8 — 97 0	4·3	7·5		0·0	0·1	0·1	0·1	0·4	0·4	33·3	65·6
42	97 0 — 97 11	4·8	9·9		0·0	0·0	0·2	0·1	0·7	0·5	24·5	74·0
43	97 11 — 99 0	3·7	12·9		0·0	0·0	0·1	0·1	0·4	0·4	3·8	95·2
44	99 0 — 99 11	7·2	12·0		0·0	0·0	0·2	0·2	0·5	0·5	3·5	95·1
45	99 11 —100 10	4·1	10·4		0·0	0·2	0·5	0·4	0·9	0·6	12·6	84·8
46	100 10 —102 0	4·6	8·6		0·0	0·1	0·3	0·2	0·8	0·4	37·9	60·3
47	102 0 —103 2	5·8	6·8		0·0	0·0	0·1	0·1	0·4	0·2	32·6	66·6
48	103 2 —104 7	6·7	6·4	4·9	0·0	0·1	0·6	0·2	0·3	0·3	37·5	61·0
49	104 7 —106 0	7·7	6·1		0·0	0·0	0·2	0·1	0·1	0·1	34·0	65·5
50	106 0 —107 3	8·1	7·5		0·0	0·3	0·7	0·4	0·7	0·3	55·2	42·4
51	107 3 —108 8	6·9	11·6		0·0	0·0	0·2	0·2	0·7	1·1	61·6	36·2
52	108 8 —110 2	8·8	8·2		0·0	0·0	0·2	0·2	0·4	1·0	49·9	48·3
53	110 2 —111 7	9·9	5·9		0·0	0·0	0·2	0·1	0·2	0·8	30·8	67·9
54	111 7 —112 11	14·0	2·8		0·0	0·2	1·3	0·6	0·8	0·5	27·2	69·4
55	112 11 —113 6	11·6	1·1		0·0	0·0	0·6	0·2	0·8	0·4	15·8	88·2
56	114 0 —114 6	......	......	......	......	......	......	......	......	......	......	......

NOTE:—Between 34 ft. 5 in. and 38 ft. 1 in. no sample secured. Material apparently same as Sample No. 5.
Between 38 ft. 8 in. and 46 ft. no sample secured. Material apparently same as Sample No. 6.
Between 48 ft. 4 in. and 49 ft. no sample secured. Material apparently same as Sample No. 8.
Between 60 ft. and 64 ft. 6 in. no sample secured, owing to presence of water.
Between 113 ft. 6 in. and 114 ft. 0 in. hard strata which could not be penetrated by auger, Sample No. 56 apparently consists of unimpregnated limestone.

TABLE I—Concluded

Log of Well No. 5A

Surface elevation 988 feet. Location—L.S. 8, Sec. 25, Tp. 93, R. 11

Sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand							
					Held on 10 mesh	Passing mesh						
						10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
1	23 0 — 25 0	17·8	11·3		0·0	trace	0·2	0·2	32·7	35·1	24·1	7·7
2	25 0 — 35 7	10·2	10·8		0·0	0·1	0·4	0·3	20·2	34·4	34·6	10·0
3	35 7 — 37 0	8·0	8·8		0·0	0·4	1·0	0·3	12·6	35·4	36·2	14·1
4	37 0 — 38 11	11·6	10·1		0·0	0·1	0·3	0·3	14·5	30·7	41·7	12·4
5	38 11 — 40 8	11·2	8·2	4·7	0·0	0·2	0·5	0·3	20·7	34·5	28·6	15·2
6	40 8 — 42 10	12·6	7·4		0·0	0·1	0·4	0·2	2·3	6·5	56·5	34·0
7	42 10 — 44 8	12·3	7·4		0·0	0·0	0·3	0·2	0·9	1·8	50·2	46·6
8	44 8 — 46 4	11·6	9·5		0·0	0·1	0·1	0·0	1·0	3·1	57·5	38·2
9	46 4 — 47 2	10·4	9·4		0·0	1·1	0·2	0·1	1·2	3·5	54·9	40·0

NOTE:—Overburden from 0—23 feet similar to that encountered in Well No. 5.

TABLE II

Log of Trench No. 1

Surface elevation 971·5 feet. Location—L.S. 6, Sec. 25, Tp. 93, R. 11

Sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand							
					Held on 10 mesh	Passing mesh						
						10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
1	8 3 — 15 3	6·9	10·1		0·2	0·6	0·6	0·2	25·4	30·0	31·8	11·2
2	15 3 — 20 3	5·1	9·8	4·6	0·3	0·8	0·7	0·3	13·4	24·4	47·9	12·2
3	20 3 — 21 9	3·8	11·3		0·0	0·4	0·3	0·2	1·7	10·9	73·1	13·4
4	21 9 — 23 3	11·0	3·5		0·0	0·0	0·2	0·1	1·1	2·1	52·9	43·6
5	23 3 — 28 3	15·5	0·9		0·0	0·1	0·3	0·3	0·3	0·8	32·4	65·8
6	28 3 — 32 9	14·5	6·5	4·0	0·0	0·1	0·2	0·2	0·2	0·2	18·4	80·7
7	32 9 — 33 3	2·6	4·1		0·0	0·0	0·2	0·2	0·2	0·7	73·4	25·3
8	33 3 — 37 3	8·0	7·1		0·0	0·0	0·1	0·1	0·1	0·8	60·9	37·0
9	37 3 — 38 3	3·7	12·7		0·0	0·0	0·1	0·1	1·8	7·4	73·4	17·2
10	38 3 — 41 3	9·8	4·1		0·0	0·0	0·3	0·1	0·2	0·2	21·0	78·2
	41 3 — 42 9	clay ironstone	....		....	....	....	....	....	....	....	....
11	42 9 — 44 3	9·9	4·7		0·0	0·0	0·0	0·0	0·0	0·1	34·4	65·5
12	44 3 — 44 9	7·1	7·2		0·0	0·0	0·0	0·0	0·1	0·1	69·8	30·0
13	44 9 — 47 3	3·2	14·5	3·9	0·0	0·0	0·0	0·0	0·2	0·1	77·0	22·7
14	47 3 — 49 3	5·6	5·4		0·0	0·0	0·0	0·0	0·1	0·2	85·5	14·2
15	49 3 — 52 3	2·7	13·8		0·0	0·2	0·2	0·2	1·0	0·7	78·6	19·1
16	52 3 — 59 3	10·1	10·3		0·0	0·0	0·0	0·1	0·1	0·1	33·9	65·8
17	59 3 — 62 3	8·9	3·6		0·0	0·0	0·0	0·0	0·1	0·3	18·4	81·2

NOTE:—Overburden from 0′ 0″ to 8′ 3″.
At 41′ 3″ and at 42′ 9″ narrow bands of clay ironstone.

TABLE III

Log of Well No. 6

Surface elevation 1,023 feet. Location—L.S. 14, Sec. 19, Tp. 93, R. 10

Sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand: Held on 10 mesh	Passing mesh: 10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
	0 0	overburden										
1................	55 0 — 58 0	13·0	0·2	....	1·4	7·5	3·7	1·2	11·3	4·3	25·7	44·9
	58 0 — 77 0	clay and sand with occasional hard black shales										
2................	77 0 — 87 0	10·8	2·5		0·0	0·1	0·4	0·3	2·6	1·9	62·9	31·8
3................	87 0 — 90 0	12·9	2·7	....	0·0	0·4	3·0	0·9	8·5	6·2	53·7	27·3
4................	90 0 —101 0	13·9	7·7	5·1	0·3	0·5	0·9	0·4	35·9	26·6	25·2	10·2
5................	101 0 —106 0	10·4	5·4		0·2	0·9	2·6	0·5	2·6	5·4	27·0	60·8
	band of hard shale 6 inches thick											
6................	106 6 —110 0	12·7	3·8	....	0·0	0·2	0·9	0·6	1·9	2·8	13·4	80·2

NOTE:—Overburden from 0—55 feet.
From 58—61 feet and from 61—77 feet material too low in bitumen to warrant analyses.

TABLE IV

Logs of Five Test Holes near South Boundary of SW ¼ Sec. 19, Tp. 94, R. 10

Hole, elevation, and sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand							
					Held on 10 mesh	Passing mesh						
						10	20	30	40	80	100	200
Hole No. 7 Elev. 900·7	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
	0 0 — 0 8	overburden										
Sample 1..........	0 8 — 3 0	5·4	3·1		0·1	0·1	0·1	0·1	9·1	41·0	44·5	5·0
2..........	3 0 — 4 10	6·1	5·9		0·0	0·0	0·1	0·1	9·3	42·3	42·4	5·8
3..........	4 10 — 6 7	3·1	9·9		0·0	0·0	0·0	0·1	7·5	40·6	44·7	7·1
4..........	6 7 — 8 0	2·7	10·7		0·0	0·0	0·1	0·1	8·4	45·7	39·2	6·5
5..........	8 0 — 9 0	3·7	9·8	4·9	0·0	0·1	0·2	0·2	9·1	46·6	37·3	6·5
6..........	9 0 — 9 10	4·8	9·3		0·0	0·0	0·2	0·1	7·6	52·0	34·4	5·7
7..........	9 10 — 11 0	6·1	14·3		0·0	0·1	0·1	0·1	7·4	38·7	46·0	7·7
8..........	11 0 — 12 4	4·3	16·0		0·0	0·0	0·2	0·0	10·8	45·1	35·7	8·2
9..........	12 4 — 13 7	8·5	14·1		0·0	0·1	0·1	0·1	8·0	38·5	45·3	7·9
Hole No. 8 Elev. 884·4												
	0 0 — 0 8	overburden										
Sample 1..........	0 8 — 4 0	16·5	3·0		0·0	0·3	1·0	0·6	11·9	30·7	47·1	8·4
2..........	4 0 — 5 6	2·4	17·6	5·5	0·2	0·9	2·0	1·0	12·6	46·8	30·5	6·0
3..........	5 6 — 6 10	6·9	16·6		0·2	1·2	1·7	0·8	15·1	46·4	28·9	5·7
Hole No. 9 Elev. 901·4												
	0 0 — 0 6	overburden										
Sample 1..........	0 6 — 4 10	7·0	3·1		0·0	0·1	0·2	0·1	4·3	38·7	48·6	8·0
2..........	4 10 — 6 10	11·1	3·6		0·0	0·2	0·2	0·1	5·6	39·7	46·9	7·3
3..........	6 10 — 7 8	10·6	7·1		0·0	0·0	0·1	0·1	6·8	39·0	47·1	6·9
4..........	7 8 — 8 6	7·2	8·8		0·0	0·0	0·2	0·1	5·1	36·5	48·3	9·8
5..........	8 6 — 10 2	3·5	8·1	5·1	0·0	0·1	0·1	0·1	13·4	39·0	40·3	7·0
6..........	10 2 — 11 6	8·1	9·6		0·1	0·2	0·2	0·2	38·8	34·7	21·6	4·2
7..........	11 6 — 13 0	9·5	13·9		0·0	0·1	0·1	0·1	44·8	33·8	16·9	4·2
8..........	13 0 — 14 1	10·3	14·5		0·0	0·1	0·1	0·1	47·5	32·1	16·2	3·9
9..........	14 1 — 15 6	12·4	15·1		0·0	0·0	0·1	0·2	46·1	32·7	16·7	4·2
10..........	15 6 — 17 4	16·6	14·0		0·0	0·0	0·2	0·4	44·3	30·7	20·1	4·3

TABLE IV—Concluded

Logs of Five Test Holes near South Boundary of SW ¼ Sec. 19, Tp. 94, R. 10—Concluded

Hole, elevation, and sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand: Held on 10 mesh	Passing mesh 10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
Hole No. 10 Elev. 893·2												
	0 0 — 2 1	overburden										
Sample 1..........	2 1 — 4 4	8·1	8·9		0·0	0·0	0·1	0·1	1·4	18·3	68·7	11·4
2..........	4 4 — 5 6	3·1	12·0		0·0	0·0	0·0	0·1	1·1	24·0	67·4	7·4
3..........	5 6 — 7 0	3·7	14·7		0·0	0·0	0·1	0·1	5·1	36·7	46·8	11·2
4..........	7 0 — 7 5	9·7	2·9	4·6	0·0	0·1	0·2	0·2	1·5	4·8	20·2	73·0
5..........	7 5 — 9 3	7·0	9·2		0·0	0·1	0·1	0·1	10·4	48·4	33·1	7·8
6..........	9 3 — 11 0	12·9	12·7		0·0	0·0	0·1	0·1	10·4	47·4	36·0	6·0
7..........	11 0 — 12 1	16·4	15·9		0·0	0·0	0·1	0·1	17·4	46·1	30·2	6·1
Hole No. 11 Elev. 881·4												
	0 0 — 2 0	overburden										
Sample 1..........	2 0 — 4 10	8·4	3·4		0·0	0·0	0·1	0·3	46·2	31·1	17·4	4·9
2..........	4 10 — 6 3	2·5	14·0		0·0	0·0	0·2	0·4	62·0	21·3	11·4	4·7
3..........	6 3 — 8 2	4·3	15·6		0·0	0·0	0·2	0·7	66·7	16·8	11·0	4·6
4..........	8 2 — 9 2	3·6	15·9		0·0	0·0	0·1	0·5	54·7	22·9	16·6	5·2
5..........	9 2 — 10 4	2·9	17·2	4·7	0·0	0·0	0·2	0·4	58·2	23·6	12·9	4·7
6..........	10 4 — 11 8	2·3	16·2		0·0	0·1	0·1	0·3	67·6	16·3	11·6	4·0
7..........	11 8 — 13 2	3·4	16·7		0·0	0·1	0·1	0·6	63·7	15·0	15·2	5·3
8..........	13 2 — 15 0	7·3	16·0		0·0	0·1	0·3	0·6	53·8	18·8	20·6	5·8
9..........	15 0 — 16 2	10·6	17·0		0·0	0·0	0·1	0·1	42·3	27·3	24·3	5·9
10..........	16 2 — 17 8	10·2	16·0		0·0	0·0	0·1	0·1	48·1	22·1	24·4	5·2

TABLE V

Log of Test Hole in River Lot 1, McMurray Settlement

Surface elevation 866 feet

Sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand: Held on 10 mesh	Passing mesh 10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
1	0 6 — 2 0	3·1	15·6	4·5	0·2	0·1	0·4	0·1	29·2	36·1	21·0	12·9
	2 0 — 3 2	grey clay	....									
2	3 2 — 6 1	11·3	0·6		0·0	0·0	0·3	0·2	1·9	1·4	6·2	90·0
3	6 1 — 9 0	10·3	1·1		0·8	2·1	5·2	4·1	16·2	14·5	31·0	26·1
4	9 0 — 11 8	9·3	3·9		0·1	1·3	1·9	0·9	10·4	34·3	38·2	12·9
5	11 8 — 13 4	14·1	8·5		0·1	0·5	0·5	0·2	4·8	33·0	45·5	15·4
6	13 4 — 15 2	8·2	9·9		0·2	6·3	8·1	2·2	9·0	25·4	30·8	18·0
7	15 2 — 17 2	12·2	11·6		0·0	0·5	1·3	0·5	8·2	32·2	43·6	13·7
8	17 2 — 18 10	8·7	13·4		0·0	0·2	0·3	0·2	5·0	34·4	43·3	16·6
9	18 10 — 20 1	3·4	13·9		0·0	0·3	0·4	0·3	10·9	44·2	32·8	1·1
10	20 1 — 21 5	2·0	16·4		0·0	0·0	0·5	0·6	2·6	28·6	52·6	15·1
11	21 5 — 23 2	2·1	15·9		0·0	0·1	1·5	2·5	13·1	34·9	35·2	12·7
12	23 2 — 24 9	1·5	16·5		0·0	0·1	0·5	0·2	19·4	36·0	35·1	8·8
13	24 9 — 26 5	1·7	16·5		0·3	0·4	0·7	0·6	22·7	25·8	38·5	11·0
14	26 5 — 28 1	1·6	16·2		0·1	0·1	0·2	0·1	2·5	27·7	56·3	13·0
15	28 1 — 30 2	2·1	14·2		0·1	0·2	0·2	0·2	2·0	27·9	58·6	10·8

Note: the sulphur value 4·5 is bracketed to apply to all samples.

TABLE VI

Logs of Six Test Holes in Sec. 14, Tp. 89, R. 9

Hole, elevation, and sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand							
					Held on 10 mesh	Passing mesh						
						10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
Hole No. 12 Elevation 824·3												
	0 0 — 8 1	overburden										
Sample 1..........	8 1 — 12 1	6·2	10·2		0·0	0·0	0·7	1·4	47·2	20·8	23·7	6·2
2..........	12 1 — 13 1	5·6	9·6		0·0	0·3	3·3	2·6	42·6	24·0	21·5	5·7
3..........	13 1 — 14 7	3·5	11·6		0·0	0·4	4·4	3·9	44·0	20·4	22·4	4·5
4..........	14 7 — 15 7	3·1	12·2		0·0	0·8	7·3	5·1	43·3	21·9	17·3	4·3
5..........	15 7 — 18 1	2·7	14·4		0·0	0·1	9·3	4·6	36·1	23·0	21·7	5·2
6..........	18 1 — 18 7	6·6	9·6	5·2	0·1	1·4	3·0	3·3	41·0	10·8	21·6	18·8
7..........	18 7 — 20 10	2·4	9·4		0·0	0·1	0·7	0·8	64·4	16·0	12·3	5·7
8..........	20 10 — 21 7	3·3	10·8		0·4	0·7	2·1	1·9	64·4	16·8	9·9	3·8
9..........	21 7 — 23 4	3·5	16·5		0·1	0·7	2·3	2·0	66·1	14·6	10·1	4·1
10..........	23 4 — 25 6	2·8	16·2		0·5	0·8	2·4	1·8	63·6	15·7	10·7	4·5
11..........	25 6 — 27 0	2·2	16·1		0·1	1·1	2·7	1·8	65·7	15·9	9·2	3·5
Hole No. 13 Elevation 824·9												
	0 0 — 7 6	overburden										
Sample 1..........	7 6 — 8 6	6·1	9·9		0·0	0·3	2·3	2·2	30·0	23·3	34·7	7·2
2..........	8 6 — 11 2	4·9	10·9		0·0	0·3	2·7	2·9	46·5	21·5	18·5	7·6
3..........	11 2 — 12 5	4·1	13·5		0·0	0·4	2·0	1·3	26·1	23·0	38·6	8·3
4..........	12 5 — 13 11	2·9	13·4		0·0	0·1	0·8	0·9	62·7	12·4	14·3	8·8
5..........	13 11 — 15 9	5·8	11·6		0·4	0·8	1·4	1·4	55·5	18·9	13·5	8·1
6..........	15 9 — 17 11	6·2	11·6		0·0	0·3	1·2	1·4	65·8	13·6	11·6	6·1
7..........	17 11 — 19 11	5·4	14·3		0·1	0·7	1·9	2·2	68·6	9·0	10·8	6·7
8..........	20 0 — 21 8	4·4	15·5	5·1	0·3	0·3	1·1	1·7	73·1	9·2	7·6	6·7
9..........	21 8 — 23 3	7·5	17·1		0·0	0·1	0·2	0·4	71·3	14·5	9·3	4·2
10..........	23 3 — 24 8	4·1	17·8		0·0	0·1	0·2	0·2	71·4	15·2	9·8	3·1
11..........	24 8 — 26 2	3·6	16·4		0·0	0·2	2·5	2·0	70·2	12·6	7·6	4·9
12..........	26 2 — 27 4	5·8	15·5		0·0	0·1	1·1	1·1	64·6	14·5	12·3	6·3
13..........	27 4 — 28 10	4·1	14·3		0·1	2·1	11·1	6·9	50·5	17·5	8·8	3·0
14..........	28 10 — 30 4	2·7	14·1		0·0	1·2	15·8	14·0	46·3	9·8	8·3	4·6
15..........	30 4 — 31 10	4·4	13·8		0·0	1·9	16·0	8·9	47·8	16·1	6·2	3·1

Hole, elevation, and sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand: Held on 10 mesh	Passing mesh 10	20	30	40	80	100	200
	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
Hole No. 14 Elev. 823·4												
	0 0 — 7 0	overburden										
Sample 1..........	7 0 — 9 2	7·7	8·0		0·0	0·7	4·5	3·2	28·1	27·4	29·3	6·8
2..........	9 2 — 10 8	3·9	9·5		0·0	0·8	6·0	3·9	29·2	26·4	28·2	5·5
3..........	10 8 — 12 2	3·7	10·6		0·0	0·7	3·7	3·2	33·6	24·2	28·1	6·5
4..........	12 2 — 13 11	2·6	11·2		0·0	0·2	3·2	4·7	46·4	19·2	20·7	5·6
5..........	13 11 — 15 2	2·2	14·5		0·1	1·1	7·8	4·9	27·4	13·1	37·2	8·4
6..........	15 2 — 16 4	2·4	12·8	5·0	1·2	5·3	9·2	4·2	33·5	10·8	22·6	13·2
7..........	16 4 — 19 0	5·1	11·8		0·0	1·1	3·7	2·4	56·0	17·7	11·8	7·3
8..........	19 0 — 20 6	4·7	14·3		0·0	0·1	0·6	0·6	62·4	19·1	11·4	5·8
9..........	20 6 — 22 1	2·6	16·7		0·0	0·0	0·3	0·4	73·6	12·3	8·7	4·7
10..........	22 1 — 23 3	2·4	15·8		0·0	0·2	2·0	2·2	67·4	13·0	10·4	4·8
11..........	23 3 — 24 9	1·7	15·6		0·0	0·4	2·5	2·7	58·4	18·6	11·6	5·8
12..........	24 9 — 26 2	1·8	15·8		0·2	0·3	3·5	4·3	55·1	19·4	11·7	5·5
Hole No. 15 Elev. 824·8												
	0 0 — 8 8	overburden										
Sample 1..........	8 8 — 10 3	8·5	10·0		0·1	0·1	1·7	1·7	31·5	31·6	27·1	6·2
2..........	10 3 — 12 0	4·7	12·6		0·0	0·2	1·4	1·7	37·3	28·1	25·1	6·2
3..........	12 0 — 13 11	2·3	11·9		0·0	0·7	2·6	2·7	37·3	26·6	23·8	6·3
4..........	13 11 — 15 5	1·2	13·7		0·4	2·4	5·0	2·9	31·3	24·3	26·7	7·0
5..........	15 5 — 17 4	2·6	13·0		0·1	1·5	3·6	2·3	35·5	15·8	31·0	10·2
6..........	17 4 — 18 5	2·2	16·0	5·1	0·0	0·1	0·2	0·2	18·2	27·9	43·9	9·5
7..........	18 5 — 20 4	1·7	17·4		0·0	0·0	0·1	0·1	14·4	26·4	48·6	10·4
8..........	20 4 — 21 11	2·6	10·5		0·0	0·1	0·5	0·5	54·1	16·6	16·5	11·4
9..........	21 11 — 23 11	2·6	9·8		0·0	1·2	3·0	2·5	55·8	14·9	11·7	10·9
10..........	23 11 — 25 5	2·9	12·2		0·0	0·5	2·0	1·7	72·6	12·7	5·4	5·1
11..........	25 5 — 26 9	3·4	14·2		0·0	1·2	4·2	3·4	57·6	16·9	8·8	7·9
12..........	26 9 — 27 8	1·7	15·6		0·0	0·4	1·8	1·9	59·9	19·5	10·4	6·1

TABLE VI—Concluded

Logs of Six Test Holes in Sec. 14, Tp. 89, R. 9

Hole, elevation, and sample No.	Depth	Moisture in sample as received	Bitumen content: (dry-sand basis)	Sulphur content of (water-free) bitumen	Screen analyses of dry extracted sand: Held on 10 mesh	Passing mesh 10	20	30	40	80	100	200
Hole No. 16 Elev. 822·8	′ ″ ′ ″	%	%	%	%	%	%	%	%	%	%	%
	0 0 — 7 9	overburden										
Sample 1	7 9 — 9 9	7·4	8·0		0·0	0·3	2·2	1·2	21·6	30·9	24·5	19·3
2	9 9 — 11 2	4·8	11·5		0·0	0·2	1·2	0·8	27·0	38·2	26·4	6·2
3	11 2 — 12 10	2·8	14·1		0·0	0·2	0·9	0·7	25·7	33·2	32·3	7·0
4	12 10 — 13 11	3·0	14·5		0·0	0·7	2·7	1·2	23·4	32·5	31·2	8·3
5	13 11 — 16 0	5·5	16·6		0·1	1·0	2·3	1·1	12·5	15·6	55·9	11·5
6	16 0 — 17 9	3·7	12·9	5·3	0·0	0·1	0·4	0·9	34·8	31·1	26·8	5·9
7	17 9 — 19 7	2·0	16·7		0·0	0·0	0·1	0·2	26·2	32·7	34·2	6·6
8	19 7 — 20 7	3·3	16·4		0·0	0·0	0·1	0·1	15·1	34·6	41·9	8·2
9	20 7 — 22 6	4·4	8·5		1·2	2·5	5·1	2·5	47·1	11·8	16·6	13·2
10	22 6 — 24 2	3·1	12·8		0·0	0·2	0·4	0·4	71·1	13·4	8·9	5·6
11	24 2 — 26 1	2·4	16·9		0·1	0·1	0·3	1·7	74·9	10·3	7·4	5·2
12	26 1 — 27 4	1·9	16·6		0·2	0·1	0·7	4·2	78·0	6·6	6·1	4·1
Hole No. 17 Elev. 825·8												
	0 0 — 10 0	overburden										
Sample 1	10 0 — 11 7	4·3	9·3		0·0	0·2	2·3	1·5	29·1	27·5	30·1	9·3
2	11 7 — 12 10	2·1	10·6		0·1	0·5	2·7	2·4	32·0	26·2	28·7	7·0
3	12 10 — 14 10	2·7	11·0		0·0	0·5	7·2	6·7	39·8	18·3	20·3	7·2
4	14 10 — 16 8	2·5	10·1		0·0	0·9	10·1	7·0	39·5	16·3	19·9	6·1
5	16 8 — 17 10	2·3	12·5	5·6	0·2	3·2	11·5	5·5	25·3	13·1	31·5	9·7
6	17 10 — 19 4	7·5	10·9		0·3	2·7	9·2	6·6	28·8	11·1	28·9	12·4
7	19 4 — 21 2	6·7	10·3		0·0	1·3	6·1	2·6	37·6	18·5	21·6	12·3
8	21 2 — 22 11	8·8	8·6		1·0	1·1	2·3	1·4	37·3	13·8	26·0	17·1
9	22 11 — 24 3	6·4	13·0		0·1	0·5	2·7	2·0	57·4	21·9	10·8	4·6

A. Typical exposure of bituminous sand on Beaver river (sec. 25, tp. 93, R. 11) showing light gravel overburden.

B. Drilling rig erected in sec. 25, tp. 93, R. 11. In foreground is a tractor used for handling drill rods, casing, etc. Another tractor belted to the draw-works is seen to the right of the derrick.

A. Typical exposure of bituminous sand on Beaver river (sec. 25, tp. 93, R. 11) showing light gravel overburden.

B. Tractors moving drilling equipment.

IV

PRELIMINARY REPORT ON MOULDING SANDS IN EASTERN CANADA

C. H. Freeman

Canada, in the past, has been largely dependent upon the northern part of United States for moulding sands; for although a number of Canadian deposits have been worked to supply local demand, these have never been able to supply the total requirements of the country. Nevertheless it seems likely that Canada should also have equally workable deposits of moulding sands, as geological features in parts of southeastern Canada are similar to those in the northeastern United States. Prospecting with soil maps would aid in the finding of sands having moulding sand characteristics. Moreover, in the United States considerable study has been given to the exploitation of these sands, consequently producing companies in that country are in a much better position to supply Canadian requirements than local concerns that are not so highly organized. In the last few years the prices of moulding sands have advanced, due undoubtedly to increased demands and partly to diminishing supplies. Moulding sands enter Canada duty free.

The Mines Branch of the Department of Mines began an investigation of the sands and sandstone resources of Canada in 1914 under the supervision of L. H. Cole. Field work was continued until 1918. Wherever moulding sand was encountered samples were shipped to Ottawa for testing purposes. The results of this investigation may be found in Summary Report Mines Branch, Department of Mines, 1916, pp. 35-55, and Summary Report Mines Branch, Department of Mines, 1918, pp. 66-68.

Since 1918 a few countries have made their resources of moulding sands the subject of special inquiry as it is evident that the better deposits are becoming worked out. In United States a joint committee on moulding sand research under the auspices of the American Foundrymen's Association and the Engineering Division of the National Research Council was formed in 1921. The duty of this committee was to secure data on foundry sand resources of the various states and to work out and ascertain the best methods for testing sands so that a uniform set of tests could be adopted for general foundry practice. The joint committee as organized represented in addition to the American Foundrymen's Association and the National Research Council, the following organizations:—

U.S. Bureau of Standards,
U.S. Bureau of Mines,
U.S. Geological Survey,
American Society for Testing Materials,
Mines Branch, Department of Mines, Ottawa, Canada.

The writer was instructed to make a study of occurrences of moulding sands suitable for foundry purposes in Ontario, Quebec, and the Maritime Provinces. Large-scale samples were to be obtained for tests in the Mines Branch laboratory.

In order to visit, in the least possible time, all localities that were producing and most of those that had produced moulding sands in the territory covered, the writer consulted the following sources for information:—

(1) Published accounts of the Mines Branch enumerating moulding sand localities in the Summary Reports 1914-1918.
(2) Sand and gravel schedules of the Dominion Bureau of Statistics.
(3) Different foundries in Canada who advised whether at any time local sands had been used or tested.

In reference to this last item considerable information was secured. At various times moulding sands had been submitted to different foundries for trial. Quite often such sands had been rejected due to their unsuitability, but there is always the probability that had an experienced man visited the localities from which these samples came, other sands might have been found which would have proved suitable.

ONTARIO

In Ontario the development of moulding sand deposits has progressed farther than in any of the other provinces. In the Niagara peninsula the industry has operated over a period of thirty years. In Wentworth county, just east of Hamilton, Stony Creek, Bartonville, and Fruitland have been responsible for the greater part of the production. In Welland county, Stamford, Niagara Falls, and Ridgeville have also contributed; and at present deposits are being worked in Brant county, around Brantford; and in Wentworth county, near Carlisle and Millgrove. Also in this latter county about fifteen years ago a deposit near Copetown produced. In the eastern part of the province deposits have been worked for over the past fifteen years in Leeds county, 2½ miles west of Brockville, and in Stormont county, 2 miles north of Moulinette. In Addington county, near Colebrook, a small amount has been produced for over the last forty years. In Glengarry county, one mile north of Bainsville; in Grenville county, 2 miles west of Cardinal; in Hastings county, one mile south of Crookston; and in the northeast of Prince Edward county, deposits of sand exist which may be suitable for moulding purposes.

QUEBEC

In that part of Quebec, north of the St. Lawrence river, moulding sands have been recorded from a few localities, but on examination most of these have proved to be of low bonding power and the probability is that they will never be utilized. Moulding sands from near St. Gabriel de Brandon in Berthier county, from near St. Sulpice in L'Assomption county, and from Pont Rouge and Deschambault in Portneuf county, are being used. As yet no investigational work has been carried on south of the St. Lawrence river, but foundrymen state that certain sands having the properties of moulding sands have been tried.

NEW BRUNSWICK

At one time moulding sand was produced from Notre Dame and Sunny Brae, 19 and 3 miles respectively, north of Moncton. At the present time the industry is dormant, most foundries using sands from Albany, N.Y.

NOVA SCOTIA

This province has had a small but steady production of moulding sands. The most outstanding deposit is in Inverness county at Melford near River Denys. Here, sands suitable both for iron and steel foundries have been produced. In Hants county, 3 miles north of Elmsdale, and in Colchester county near Belmont, good quality sands have been used by different foundries. In Kings county, at Kentville, a deposit beneath a foundry has been successfully used for years. In Kings county, near Avonport, and in Cumberland county, near North Middleboro, and Pugwash River moulding sands of a different grade than those mentioned above have been produced; but at present are not being used.

EXAMINATION OF MOULDING SAND DEPOSITS

In the field work the examination of deposits was made by the use of the following equipment, viz., augers, shovels, small microscope, and surveying instruments.

When samples were obtained from promising localities a post-hole auger, 6 inches in diameter, was used. By this method a representative sample of a section could be easily obtained. From pits that were operating or had previously operated, channel samples were collected from the faces of the pits with a shovel. In all cases samples averaging 50 pounds in weight were collected and were placed in canvas sacks for shipment. Whenever possible, particularly so in pits that were operating or had operated, the services of the man or men who supervised the loading of the sand for the different foundries were secured. The samples thus obtained gave a better average of the product of the pits.

In the examination of a deposit several important features must be taken into account. A sand deposit which is not favourably located with respect to consuming centres or easily accessible for development or transportation purposes, may otherwise be perfectly satisfactory and yet not be a commercial possibility. In all examinations the following features are noted:—

(1) Nature and extent of deposit.
(2) Grade or grades of sand.
(3) Accessibility.
(4) Ease of development.
(5) Market locations and demands of same.

During the course of field work sixty-eight large-scale samples were secured for testing purposes. Most of these were from present operating deposits; a few were from deposits at present idle. A small number were from localities which the writer in the course of his work examined by field tests. No prospecting of ground apart from the regular course of collecting samples from known deposits was attempted. If some of these samples should show sand possessing moulding properties, prospecting in such localities where such samples were obtained might profitably be done.

LABORATORY TESTS

Over a period of years moulding sands have been subjected to various tests. Different investigators used a different series of tests and it was difficult to correlate results on various sands. One foundry might be interested in compression tests whereas another would feature tensile tests. Even sand producers had no uniform system of grading their products. For instance a No. 2 sand from one company might be fairly similar to a No. 1 or No. 3 sand from other companies. To secure comparative results the American Foundrymen's Association started a movement, as mentioned before, to have a body of engineers and foundrymen who were acquainted with sand problems submit tests for the various physical properties of moulding sands. From all of these a tentative standard series has been adopted.

In the testing of the samples collected from the field work previously mentioned the tests laid down by the above association in the year 1928 have been followed. Time was also given to see if shorter methods could be devised for some of the present tests. For instance the test for securing clay substances or bond is laborious and takes considerable time to perform. A short test for such would be welcome.

The examination of the moulding sand entails tests for the following characteristics:—

(1) Durability or life of sand.
(2) Fineness.
(3) Permeability.
(4) Strength, cohesiveness or bonding power.
(5) Moisture content.

Durability or Life of Sand

The durability or life of a moulding sand is one of the most important features which must be taken into account. If this is not possessed to a fair degree, any other quality that it does have, such as fineness, permeability or bonding power, need not be considered. If a moulding sand has the ability to withstand the severe heat subjected to it by only a few castings obviously the initial cost would forbid its use. At times apparently good sands after a few burnings have the greater part of their bonding power destroyed. In all moulding sands there is always some loss of sand due to part of it which is in close proximity to the hot metals being burnt or fused. When this takes place fresh sand must be added to the piles; such renewal should not be excessive.

Fineness

Fineness of grain is quite important as on this depends whether the sand is suitable for fine light castings or rough heavy castings. Fine-grained sands are used for the light castings whereas the coarse-grained sands are for the heavy castings. Light castings require a smooth surface more so than the heavy ones; in these soundness of structure is essential. In large castings more gas is generated consequently a coarse-grained sand favours the escape of same. Each sample will undergo a screen analysis. From this a grain fineness number will be obtained.

Permeability

Permeability of a sand refers to that property that it possesses in reference to the ease with which gas or steam escapes from the mould. Naturally there is a direct relationship between the fineness of the sand and its permeability. Generally, the coarser the grains of the sand are, the greater is its permeability. The texture is also a factor. Permeability is greater in a sand that has rounded or sub-angular grains than one that has angular grains. Also a sand having grains of uniform size favours this condition as the voids between the grains will not be filled with smaller sizes. An excess of clay, the bonding substance, and also of silt, lowers the permeability.

Strength, Cohesiveness or Bonding Power

The bonding power or strength of a moulding sand depends chiefly on its clay substance content and the manner in which it is distributed. The ideal condition is one where every individual grain of sand has a coating of a highly refractory clay with very little left over to fill up the voids. The texture of the sand grains is important. Generally, sands that are fine and angular or sub-angular in shape are more cohesive than those that are coarse and rounded. The approved test for cohesiveness is one in which the compression strength is measured.

Moisture Content

It is essential for foundrymen to know the exact amount of water which is necessary to add to a moulding sand so as to have it rightly tempered. A certain amount will produce maximum permeability and bond strength. Generally, between 4 and 8 per cent water must be added to give the correct results.

MARKETS

The market for Canadian moulding sands has been chiefly local, but producers in the Niagara peninsula of Ontario have shipped to the following places, viz., Hamilton, Toronto, Peterborough, Kingston, and Montreal. Producers in the vicinity of Brantford found their chief market in that city. Moulding sand from near Carlisle has been trucked to Guelph and Galt; and from around Millgrove to Hamilton.

In Quebec the sand produced from west of St. Sulpice, by two operators, is transported to L'Assomption, a distance of 5 miles. That at Pont Rouge has been used there by two foundries.

In New Brunswick moulding sands produced at Notre Dame and Sunny Brae have been used in Moncton. Shipments from both places have been made to as far as St. John.

In Nova Scotia moulding sands from Melford, 10 miles from River Denys station, have been shipped to Sydney and New Glasgow. Belmont sand is shipped to New Glasgow, Truro, and Amherst. This latter sand has been blended with United States sand at times.

In the two latter provinces the greatest cost of imported moulding sands is due to transportation. Seventy-five per cent of all costs can be charged to this item. Formerly most of the sand came in by rail but recently water shipments have been made.

There is no doubt but that some of our moulding sands should find a wider market than they now enjoy. Some sands from around Hamilton are shipped over 375 miles and are in competition with Albany sands. Cases are on record where perfect castings weighing as much as 16 tons have been made in these sands. Many moulders vouch for Canadian sands and say that they serve their purpose well and some prefer them to imported sands. Considerable prejudice against domestic sands exists as many moulders have the impression that good moulding sands are not to be found in Canada. This impression is partly fostered by moulders who have worked in foundries south of the border and have used only sands that are produced in United States.

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 free 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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