CANADA

DEPARTMENT OF MINES

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MINES BRANCH

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Petroleum and Natural Gas Resources of Canada

IN TWO VOLUMES

VOL. II.

DESCRIPTION OF OCCURRENCES.

PART 1, EASTERN CANADA
PART 2, WESTERN CANADA

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and Others

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PART 1

CANADIAN FIELDS IN DETAIL

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PETROLEUM AND NATURAL GAS RESOURCES OF CANADA

VOL. II

DESCRIPTION OF OCCURRENCES

PART 1

Canadian Fields in Detail

EASTERN CANADA

CHAPTER I

NOVA SCOTIA

GEOLOGY[1]

Stratigraphy

The Canadian Geological Survey recognizes the occurrence, in Nova Scotia, of bed-rock geological formations ranging from the Pre-Cambrian to the Triassic. The Pre-Cambrian rocks of Nova Scotia occur only in Cape Breton, underlying about one half the island. The rocks of this group include gneisses, schists, crystalline limestones, and granites and other intrusives. The next youngest series of rocks is often called the Gold bearing series. They were formerly regarded as Lower Cambrian, but Mr. Faribault[2] now believes that they should be classified as late Pre-Cambrian. This series forms an almost continuous belt along the whole length of the Atlantic coast of Nova Scotia; this belt is about 270 miles in length, varies in width from 10 to about 75 miles, and underlies more than one third of the total area of the province. The series consists of a great thickness of conformable quartzites and slates, closely folded in long east and west anticlines and intruded by many large batholiths of granite and some dikes of diabase. In the vicinity of granite intrusives the sediments have been metamorphosed into gneisses and schists. A series of

[1]Paragraphs on geology by Alfred W. G. Wilson.
[2]See Guide book No. 1, International Geological Congress, 1913, p. 258.

Post -Cambrian batholithic intrusives, largely Devonian granites, occupy the western and central portions of the province and also occur in a number of more or less isolated areas in the eastern and northern parts of the mainland. The main mass of Devonian granite occupies the southwestern part of the province and extends as far east as Halifax. It has a length of about 115 miles and a width of about 30 miles. The next largest area lies south of the Cobequids in Cumberland county and occupies a strip of territory about 10 miles in width and 75 miles in length. Smaller areas occur east of Halifax and scattered through the interior as far east as Canso.

Strata classed as Cambrian are confined to a small area in Cape Breton island.

A series of strata, consisting of shales, quartzites and associated volcanic rocks, destitute of fossils, outcrops in the Cobequid mountains; a similar series extends eastward to the strait of Canso and into Cape Breton island. Because of their stratigraphic position they are tentatively classed as Ordovician.

Silurian rocks occur in a number of isolated localities in Nova Scotia. A small area outcrops on the north side of the Cobequids, between Wentworth and Waugh river. Two smaller areas, covering about five and a half square miles, occur in Pictou county about 10 miles southeast of Tatamagouche, and four other smaller areas occur in the southeastern part of the same county, about four miles south of New Glasgow. Larger areas occur in the eastern part of Pictou county and in the adjoining portion of Antigonish county, extending east as far as Malignant cove, 3 miles beyond Arisaig. These rocks occupy about 96 square miles in all. The Silurian rocks differ in character in different parts of the province; sandstones, shales and limestones occur, and occasionally these have been metamorphosed by dynamic action or igneous intrusion.

Devonian rocks occur in a strip of territory which extends from Minas basin to the strait of Canso and thence across the southern portion of Cape Breton island. Mississippian rocks (Lower Carboniferous of the earlier surveys) occupy more or less isolated areas along this same belt of territory. The best known of these occur in the vicinity of Windsor and east of Truro. The Pennsylvanian or Upper Carboniferous series comprises the coal bearing rocks of Nova Scotia. These rocks occupy a number of basins which extend from Cumberland county in the vicinity of the Bay of Fundy to the southeast of Cape Breton island. Important coal bearing strata occur in Cumberland north of the Cobequid hills in the vicinity of Minas basin and Cobequid bay, in Pictou, in Antigonish, in Guysborough, in Richmond, Inverness, Victoria and Cape Breton counties.

Rocks which are classed as Permo-Carboniferous border Northumberland strait on the south in Pictou and Cumberland counties. Deposits classed in the same horizon occur in the west of Cumberland county along the coast of Chignecto bay. The Triassic rocks of Nova Scotia outcrop along the south shore of the Bay of Fundy. They are associated with, and partly buried beneath a series of Post-Triassic diabase flows. These trap sheets are a prominent topographic feature of the Fundy shore.

GEOLOGICAL STRUCTURE.

Nova Scotia lies within the region of Appalachian folds. The central and southern portion of the province consists of a core of granite, formed largely by Devonian batholiths, bordered by the more or less intensely metamorphosed rocks of the Gold bearing series. As has already been noted this formation now lies in a series of closely folded east and west anticlines, which have also been subjected to great denudation and degradation. The rocks of the succeeding periods to the base of the Carboniferous have also been subjected to folding, plication, and metamorphism. The Carboniferous and later strata are comparatively undisturbed, though they are thrown into minor undulations or folds and are faulted. They usually occupy synclinal basins which are bordered by the folded and metamorphosed rocks of the earlier periods. The Permo-Carboniferous and Triassic rocks are little disturbed and occur in nearly flat lying or only slightly undulating beds.

HISTORY OF DRILLING OPERATIONS.

In Nova Scotia, as reported by Brumell, efforts were made about 1864 to find oil by the Pioneer Oil and Salt Company near Lake Ainslie in Cape Breton, where oil had been seen to rise on the water for many years. The wells were sunk 600 feet and only traces of oil were found. At a later date a test well was sunk to a depth of 500 feet at Baddeck with no better results. Several companies were organized about that time to test for oil in the vicinity, namely, Pioneer Oil and Salt Co., the Victoria Oil Co., Cape Breton Oil and Mining Co., Inverness Oil and Mining Co., and American Oil Co.

In July, 1912, it was reported that the Lake Ainslie Oil Co. of Lake Ainslie, Cape Breton, was putting down a number of wells and had struck a 75-foot oil sand. This report has not been substantiated and it seems probable that instead of 75 feet of oil sand, the drill must have penetrated 75 feet into an oil shale either of that thickness or cutting across the beds of the rocks dipping at a fairly high angle.

Indications.—The only indications known in Nova Scotia are showings of oil reported by Brumell, as seen frequently on the waters of Lake Ainslie, and scums on the surface of swamps and springs in the vicinity. Oil-bearing shale, however, is now becoming generally known in portions of Nova Scotia, and promises to furnish material for as flourishing an industry as the oil shales of Scotland.[1]

POSSIBILITIES OF OIL AND GAS IN NOVA SCOTIA.

General Statement.

Up to the present time oil and gas have never been found in commercial quantities in Nova Scotia, and it is improbable that more than showings will be found anywhere; although small pools may not be impossible. Some seepages have been reported at various times, and in certain limited areas formations occur which contain oil and gas in other parts of the world, but which are here, as a rule, not structurally favourable.

[1]Gilpin reports the presence of indications of oil at Cheverie, Hants county, permeating the gypsum and limestone of that locality. They are believed to have risen from underlying bituminous shales. A.W.G.W.

GENERAL GEOLOGICAL DISCUSSION.

Throughout the entire southeastern half of Nova Scotia we may safely say that there is absolutely no chance of finding oil or gas in quantity, since the formations consist entirely of Pre-Cambrian crystalline rocks and Post-Cambrian intrusive volcanic rocks, which never contain oil pools. This portion of the country which is absolutely unfavourable covers Shelburne, Queens, Yarmouth, Lunenberg, Halifax, and Digby counties entirely, and all except a narrow strip along the north side of Annapolis, the southern corner of Kings, the southern edge of Hants, and the southeastern half of Guysborough.

It should not be understood that the portion of Nova Scotia lying outside the counties mentioned is favourable, because such is not the case. The remaining portion of Annapolis county along the Bay of Fundy consists of a belt of Triassic formation in which no oil fields have ever been found. The greater part of Kings county consists of the same formations, and in addition there is an area in the eastern corner of the county, adjacent to Minas basin, where the surface consists largely of Devonian and Lower Carboniferous formations, in which oil and gas exist to a certain extent in New Brunswick.

The northern half of Hants county consists also mostly of Devonian and Lower Carboniferous formations, as does a large portion of Colchester, Pictou and Antigonish counties, and the northern half of Guysborough. The western end of Colchester county consists largely of Triassic formation, in which oil and gas fields have never been found, and throughout the southern half of Cumberland county are large masses of volcanic intrusive formations, the vicinity of which is rendered particularly unfavourable by their presence. Intrusive volcanic formations are also present in the eastern part of Pictou county.

The northern half of Cumberland county, a small area in the northern end of Colchester, and at the northwest corner of Pictou county, consist at the surface mainly of Middle Carboniferous and Permian formations, which do not contain oil and gas in the Dominion of Canada, but which in New Brunswick are occasionally underlain by oil and gas producing formations. However, it is believed that these formations will not be productive in Nova Scotia, for the reason that structurally they are so much broken up and contorted. Some areas of the Lower and Middle Carboniferous rock occur in Cape Breton island and in Cape Breton and Inverness counties, but these areas are in close proximity to large masses of Laurentian rock, which outcrops extensively throughout Cape Breton in very irregular patches, and, consequently, it is not believed that conditions in Cape Breton are any more favourable for oil and gas than in other portions of Nova Scotia.

POSSIBILITIES OF THE OIL-SHALE INDUSTRIES IN NOVA SCOTIA.

According to R. W. Ells[1], the bituminous oil-bearing shales of Nova Scotia are richer in oil and by-products than the Scotch oil shales.

Regarding the history of the industry in Scotland, Ells says:—

> The Scotch shale industry was first started nearly 60 years ago in the district a few miles west of Edinburgh. About 1850 the discovery of a small spring of rock oil in connection with a coal bed led to attempts to manufacture burning oils by refining, and the presence of this oil with coal led further to the inference that in some way oil and coal beds were associated; so that after the exhaustion of the small quantity of native oil, attention was directed to the distillation of crude oil from coal itself, with a fair amount of success. The discovery of the peculiar mineral at Torbane hill, which on examination was found to be very rich in hydrocarbons, and to yield from 120 to 130 gallons crude oil a ton, gave a fresh impetus to the industry. The bed of Torbane hill mineral lasted about twelve years, or to 1862, when it became exhausted, having been worked down to a thickness of about three inches. Attention was thereupon directed to the shales themselves, of which a number of oil-bearing bands or strata were found interstratified with grey, black, red or brown sediments, comprising marls, thin limestones, sandstones, etc. In all some 10 to 12 beds of oil-shales were found in a thickness of rather more than 3,000 feet. The process of retorting and distilling these shales commenced with the exhaustion of the Torbane hill mineral, and from a small industry at first, has, with many ups and downs, continued to the present day, until now the manufacture of crude oil and sulphate of ammonia with their subsequent refining into the various by-products, is one of the leading industries of Scotland. The production of crude oil in Scotland yearly is

[1] Ells, R. W., Trans. Min. Soc. Nova Scotia, vol. XIV, pp. 1-5 (1910).

now more than 62,000,000 gallons from shale alone, and of sulphate of ammonia over 50,000 tons, with more than 22,000 tons of paraffin wax, the amount of shale mined annually for many years being more than 2½ million tons. It will be readily seen therefore that this enterprise, starting in a comparatively insignificant manner, has through the enterprise, thrift, perseverance, and intelligent management of a few Scotch capitalists reached very large proportions.

The industry, as may well be imagined, has passed through many stages, some of failure and others of success. Competition from foreign countries has been sharp, not only from the United States but from the Russian and other fields, where crude oils obtained by boring were produced more easily and cheaply than would seem possible by the manipulation of oil-shales obtained by mining; yet with the continued improvements made in the process of retorting and the subsequent treatment of crude oils, and by the utilization of the various by-products, success has eventually crowned their work, and the shale-oil industry of Scotland has been for some years on a thoroughly satisfactory basis and giving good returns on capital invested. It may be said, however, that of the many companies engaged in the business of oil-shale development, aggregating more than 100 companies, the greater part of these have long since ceased operations, some by direct failure, others by absorption by other and stronger companies, until at the present time the number of companies engaged in the oil-shale industry is only seven, and of these only four possess fully equipped refineries, the others manufacturing crude oil and sulphate of ammonia only. In spite of this great decrease in numbers of persons operating, it may be said that the production of crude oil and sulphate of ammonia, as well as other by-products, shows a manifest increase with each succeeding year, owing to the great improvements constantly being made in methods of working, in perfection of plants, in better organization, etc. Thus while for some years the profits of the industry were very uncertain, and often the manufacturer was entirely without profitable returns, the dividends on the work for the last few years have been very satisfactory, those of the four refining companies for the last year (1908) being from 7, 15, 17½ and 50 per cent. As illustrating the extent of the industry also it may be said that the wages paid are about 3½ million dollars annually, the men employed being about 8,300, including nearly 4,000 miners.

He says further that:—

Near the close of the Scotch workings on the Torbane hill mineral the discovery of the very similar mineral named stellarite was made on the Acadia Coal Company's property at what is now Stellarton, the name of the town being taken from the name given to the mineral found there in 1859, This bed of coal and shale is found near the base of the coal measures below the McGregor seam, and is divided into three parts, as follows:—

Bituminous coal	1 ft. 4 in.
Stellar oil-coal	1 ft. 10 in.
Bituminous shale	1 ft. 10 in.
	5 ft.

The Stellar oil-coal resembles very closely the Torbane hill mineral of Scotland, which also occurs near the base of the Coal Measures in that country. The yield of crude oil is very similar in both cases, the Scotch mineral being from 90 to 130 gallons per ton, the stellarite from 125 to 130 for a part of the bed and from 60 to 65 for the other parts, while selected samples are reported as yielding nearly 200 gallons. Such a seam in the Scotch industry would certainly be regarded to-day as a bonanza, since the torbanite was worked till it reached a reported thickness of only a few inches before it was finally abandoned. The nearest approach to this mineral in New Brunswick was the vein of albertite found in Albert county, which by analysis gave 100 gallons crude oil per ton, but this mineral occurred in vein form and not in a bed like the oil shales of Scotland and New Brunswick or Nova Scotia.

The bed of stellarite was worked for a couple of years, in all about 4,000 tons being taken out, most of which went to the United States for distillation or for admixture with bituminous coals in gas making.

About the same time several of the oil shale areas in New Brunswick were opened and at Baltimore in Albert county a retort and still were erected in which several thousands of tons of a rich oil shale found in the vicinity were used in the manufacture of crude oil which was afterwards refined and used very generally in this province and in Nova Scotia. The shale mined on the Memramcook river at Taylorville was shipped to Boston to the retorting works erected in that city. Its value as a producer of oil was readily recognized, but the discovery of the great oil wells of western Canada and of the United States, with their cheap production of crude petroleum, soon closed the shale industry both in Nova Scotia and New Brunswick. Owing to the crude nature of the retorts and stills in that early stage of the industry it is no wonder that entire satisfaction did not attend these early attempts. The same hardships were encountered in the early days of the industry in Scotland, and only by persistent improvements in plants, by the exercise of rigid economy along all lines, and by close attention to the business end of the undertaking have the promoters at last achieved success.

Ells in the same connexion says that the

> Scotch companies have successfully combatted the opposition arising from the native oils of the United States, of Russia, and other foreign countries, and to-day are not only able to point to an ever increasing annua output of oil of the highest possible grade, with the attendant by-products, but to an ever increasing dividend sheet as well, and for some years the amount of oil produced from a limited area of the oil shales a few miles west of the city of Edinburgh is several times larger than that obtained from all the oil wells of Canada.

In Nova Scotia, as stated by Ells,[1] the oil shales occupy a similar position geologically that they do in Scotland and are

[1]The Oil shales of the Maritime Provinces—Nova Scotia, Min. Soc. Jour. Vol. 14, pp. 1-12, 1910.

similar in general character. In Nova Scotia, these oil shales are unconformably overlain by limestones probably to the Perry sandstone formation of the upper division of the Devonian of Eastern Canada. These oil shales are interbedded in less bituminous shales which in some places are calcareous or sandy. The oil shale bands vary in thickness from a thin film up to several feet.

In 1909, Ells[1] made a rather detailed study of the oil shales of eastern Canada, and found that a number of the localities in Nova Scotia referred to by Campbell in Howe's Mineralogy contained too low a percentage of hydrocarbons to be of value for crude oil or ammonium sulphate.

Ells says further that there are great thicknesses of black and greenish shales between Split Rock along the south coast of Minas basin, at the mouth of the Avon and the villages of Walton and Noel. "On the west side of the Avon," Ells goes on to state, "similar dark shales are well exposed at Horton Bluff, Locharville, and the vicinity of Hantsport." But he says that these deposits about the Avon are in most cases deficient in hydrocarbons, the shales although often black are carbonaceous rather than bituminous. In the field tests made by Ells, most of these shales showed but slight tendencies to ignite.

Pictou County.

"The outcrops of Pictou oil shale," as stated by Ells[2], "are comparatively numerous in the Pictou coal basin. They are indicated on the recent map of the Pictou coal field by Dr. H. S. Poole, 1904, and can be seen at several points in Stellarton on the property of the Acadia Coal Co.; on McLennan's brook below the old fulling mill bridge formerly opened by Andrew Patrick; on Marsh brook opened by Haliburton's pit; on Shale brook; on Steep brook; and elsewhere, the large body of black bituminous shale forming a conspicuous feature at

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[1]Ells, R. W., The commercial value of the oil shales of eastern Canada, based on their contents by analyses of crude oil and ammonium sulphate. Trans. Min. Soc. Nova Scotia, Vol. XV, pp. 20-57. 1910.

[2]Trans. of the Min. Soc. of Nova Scotia, Vol. XIV, 1909-1910, p. 10.

several places." Ells says further that the black shales at Pictou belong to a higher geological horizon than those of Antigonish, the Avon river, Cheveris and Walton.

H. E. Coll[1] says, "in the Vale coal mine in Pictou, oil has been dripping from the roof. This has been going on for some years." It appears that these oil shales may become saturated with oil to such an extent that the oil oozes out in the form of springs or drippings from a mine, but will not flow or seep fast enough to yield oil in commercial quantities by drilling.

Ells[2] says that:—

In a section given by Logan along Marsh brook, mention is made of a bed of oil shale, the thickness of which is not clearly defined but is said to be four feet. A small pit was sunk on this seam by a Mr. Haliburton. During our examination of this area last year this pit could not be definitely located, but several tests were made of shales along Marsh brook, though no deposits as rich as these found on McLellan's brook were seen. The analyses of three samples of the shales from this area will be found in the list given of analyses made from samples taken along McLellan's brook.

On a map issued by the Geological Survey, of the Pictou coal field, 1904, which is largely the work of Dr. H. S. Poole, the locations of several outcrops of oil shale are given. It was, however, found somewhat difficult to locate these outcrops on the ground so as to secure specimens for analysis. A number of locations were, however, selected at various points along McLellan's brook and in the vicinity, including Marsh and Shale brooks, and samples were taken from what were regarded as the most promising outcrops. These have been analysed by the Department of Mines at Ottawa, to determine the contents in crude oil and ammonium sulphate.

In all, eight samples were selected for analysis, the results of which are as follows:—

[1]Trans. of the Min. Soc. of Nova Scotia, Vol. XIV, 1909-1910, discussion following Ells' paper on oil shales, p. 12.

[2]Ells, R. W., The commercial value of oil shales in eastern Canada, based on their contents by analyses in crude oil and ammonium sulphate. Trans. Min. Soc. of Nova Scotia, Vol. XV, pp. 45-46, 1910-1911.

Analyses of Samples.

	Crude Oil (Imperial gallons).	Sulphate of Ammonia (pounds).
McLellan's brook, near New Glasgow, a branch of East River of Pictou; from Patrick's old slope, 27 chains below the old fulling mill	42	41 per ton
McLellan's brook, Black's old mill site............	14·5	35 "
Marsh brook, the lower end at the fork with McLellan's brook..................................	8	undetermined
Marsh brook, 150 feet above McKay's house......	3	"
Marsh brook, 300 feet above McKay's house, from area blasted................................	14	"
Shale brook, upper end.........................	4	"
Shale brook, near forks with McLellan's brook.....	9	"
From bed of black shale, one mile west of Woodburn station, in small brook 500 feet north of railroad track, from bed 10 feet thick...........	14·3	"

It will be seen from the above list of analyses that most of the samples selected are not sufficiently rich in hydrocarbons to repay any attempt at development, but that in the case of the stellarite found at Stellarton and at Patrick's slope on McLellan's brook, the results of the several analyses made would appear to warrant further investigation, sufficient at least to prove conclusively the extent and thickness of the oil shale deposits at these places.

Antigonish County.

Regarding the oil shales of Antigonish county Ells[1] says:—

Of the shale deposits of Antigonish county, it may be said that several of the tests recently made showed a sufficiently high percentage of crude oil and sulphate of ammonia to warrant the expenditure of capital in the development or further testing of certain portions.

This remark applies more particularly to outcrops seen in Hallowell grant along Sawmill brook, which is about ten miles north of the town of Antigonish. Other areas in the vicinity do not seem, from the tests recently made at Ottawa, to contain sufficient hydrocarbons to warrant much expenditure in development work. The shales, while black and highly carbonaceous, resemble many of those seen along

[1]Ells, R. W., The commercial value of the oil shales of eastern Canada, etc. Jour. Min. Soc. Nova Scotia, Vol. XV, pp. 46-50 (1910).

the lower part of the Avon river, and are too poor in hydrocarbons to render the extraction of the crude oil or sulphate of ammonia profitable under the most favourable circumstances.

Hallowell grant or Big Marsh, includes a number of outcrops of shale. They are alluded to in the report of Mr. J. Campbell already referred to, in Howe's Mineralogy of Nova Scotia, 1868. From the description there given, it was at one time hoped that large and valuable deposits of hydrocarbons would be found. Black carbonaceous shales outcrop along the post road extending north from the town of Antigonish to Big Marsh post office. They cross the road in several well defined bands, have a general east and west strike, and near the post office contain irregular beds of a dirty bituminous coal, associated with black and grey shales and greyish sandstone. These have been opened up to some extent in search of a fuel supply. The analyses of the coal were made by the Mines Branch, Ottawa, several years ago, but the results, as then published, were such as to discourage further development at the time. The percentage of ash in the coal ranged from 27 to 46 per cent being such as to render the coal practically valueless as a fuel. The volatile combustible ranged from 21·5 to 29 per cent. A careful examination of a number of outcrops of shale, supposed to be of the oil bearing series, was made during the past season.

Attempts were made in the field to test the value of several of these outcrops by ignition in stoves, forges, and even by the blowpipe, but in some cases even the last named test failed to produce a flame. As a last resort a number of samples carefully selected from the most promising looking beds, were sent to the laboratory of the Mines Department to ascertain the exact value of these in crude oil and ammonium sulphate.

In all, samples from eight localities were chosen, in order to give the shales as fair a test as possible over a considerable area. It was found that the black matter of the shales themselves was almost entirely carbonaceous and not due to the presence of hydrocarbons. In fact it has been observed in the adjacent province of New Brunswick, that the shales richest in hydrocarbons were grey rather than black, as can be seen in the case of the grey shales of Turtle creek, Albert county.

The first test of the Antigonish shales was made from a deposit of black shales, including both the plain and curly varieties, located on a farm of Mr. Dan McDonald, near the forks of the road going east a short distance north of the Big Marsh post office. Here a pit had been sunk many years ago, referred to in Campbell's paper, 1868, to a depth of 60 feet, of which the upper 40 feet seemed to be a plain black carbonaceous shale. This appeared to be almost incapable of ignition by ordinary test. The lower 20 feet was of the curly variety, and when tested in the forge kindled with difficulty. In the laboratory at Ottawa, the test by Mr. Leverin gave 4·8 imperial gallons of crude oil and 8·7 pounds of ammonium sulphate per ton, the yields in both cases being insufficient to render the mineral of value for economic use.

A short distance east of the forks of this road a small brook, known as McLellan's, crosses the road to the south. On this both varieties of shale, the curly and the plain, occur. Samples selected and analyzed at Ottawa gave for the curly variety six gallons of crude oil per ton, but the ammonium sulphate was undetermined. The samples of plain black shale gave neither oil nor ammonia. The next brook, going east, crosses this road a short distance beyond the house of John Boyd. From the presence of a sawmill at the road crossing near Boyd's house the stream was named Sawmill brook for convenience or reference. The banks are frequently steep in many places and are composed of black and grey shales, some of which is of the curly variety, other parts are plain, as stated by Mr. Campbell in 1868.

A number of these shale beds were tested in the field by the application of heat. Some portions kindled fairly readily and burned quite freely. Several outcrops of both varieties, both black and brown, are seen; and at one place, known locally as the "Banks," the shale forms cliffs of 100 feet or more in height. Much of this is quite bare of vegetation, the forest growth having been destroyed some years ago by fires, which in places burned to a considerable depth in the shale itself. The fire is reported as having burned in the shale for some months before it could be extinguished. The shale deposits at this place appear to possess considerable value. A number of samples were taken, and were analyzed in Ottawa with fairly satisfactory results, as follows:—

Analyses of Samples.

Description of Sample	Crude Oil, (Imperial gallons)	Sulphate of Ammonia (pounds)
From the surface at the Banks: curly variety....	11	22
From bed of Sawmill brook near by: curly shale ..	10	38
Plain shales..................................	10	34
From branch of Sawmill brook, adjacent: sample of freshly mined shale......................	10	17

It would appear from these tests, which include the shales over a considerable area, that much of the material so tested is not sufficiently rich in hydrocarbons to give profitable returns either in crude oil or in sulphate of ammonia, though the percentage of the latter is fairly high in several cases. Possibly the fact that parts of the area had to some extent been burned over may have reduced the percentage of crude oil. This place on Sawmill brook, in so far as our examinations in Hallowell grant extended, seems to be well worthy of further investigation.

Farther east near the shore of George bay, at a place known as the Beaver settlement, several holes have been sunk on bands of black shales regarded as oil bearing. One of these areas was examined and the rocks were found to be a very black carbonaceous shale, which contained the remains of plant stems and fish scales. Parts of these black shales kindled in the forge quite readily, and the deposit at this place seemed to be quite extensive, being exposed from east to west for several miles. The samples collected were from the farm of Hugh McInnis, near the shore of the bay, and on analysis at Ottawa, the black shale gave 7·45 gallons of crude oil per ton, but the percentage of ammonia sulphate was not determined.

On the commencement of the examination of the black and grey shales of the formation just described, which is known as the Horton series, and is widely distributed over Nova Scotia, it was hoped that the deposits of Cheverie, Hantsport, and other districts in that vicinity, including Newport, Truro, etc., might on careful examination show well defined areas sufficiently rich in hydrocarbons to be utilized in the distillation of crude oil and the manufacture of ammonium sulphate on a large scale. More especially was this hoped for from the fact that all geological determinations on these rocks had showed conclusively that these shales of the Horton series were the equivalents, as regards horizon, of the shales of New Brunswick, so rich in hydrocarbons. In this examination, I may say I was greatly aided by the late Mr. Hugh Fletcher, whose intimate knowledge of the geology of the province was of the greatest assistance in work of this kind. In so far, however, as our field work on these shales was concerned, the absence of hydrocarbons seemed to be so general that in many cases it was deemed unnecessary to submit samples of them to detailed examination by analysis in the laboratory at Ottawa.

Kings County.

Dark shales which outcrop along the south side of Minas basin, supposed to have been of value commercially for oil and ammonium sulphate, have been shown by Ells[1] to contain too low a percentage of oil to justify their use for commercial purposes.

Hants County.

Shales supposed to have been of commercial value for oil occur along the south side of Minas basin, but according to Ells they contain too low a per cent of hydrocarbons to be of value for oil or ammonium sulphate.

[1]Ells, R. W., Commercial value of oil shales, etc. Trans. Min. Soc. of Nova Scotia, Vol. XV, p. 33, 1910-1911.

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CHAPTER II

PRINCE EDWARD ISLAND

GEOLOGY[1]

Stratigraphy

The Upper Carboniferous or Permo-Carboniferous rocks which occur in southeastern New Brunswick and along the south shore of Northumberland strait, pass beneath the strait and re-appear in Prince Edward Island. These are overlain conformably by a series of conglomerates and red sandstones, impure limestones and shales, which underlie the greater portion of the island.

Dr. J. W. Dawson thus describes the geology of the island[2]:—

The principal addition to our knowledge of this formation[3] is that contained in the Report of Dr. Harrington and myself published in 1871[4]. In this we separated as Upper Carboniferous, or 'Permo-carboniferous', an underlying series of red and grey sandstones and shales, holding carboniferous plants, extending from near Cape Wolfe toward the north point, and a similar series found at Governor's Island and Gallas Point in Hillsborough Bay. These are undoubtedly extensions of the Carboniferous of Nova Scotia. All the rest of the island is occupied with Triassic rocks; in one place, Hog Island in Richmond Bay, associated with trap. The general relations of these rocks are seen in the sections.

The beds of the Triassic series, as seen in Prince Edward Island, consist chiefly of soft red sandstone, with some buff-colored beds and red and mottled clays. Associated with them are conglomerates and hard calcareous and concretionary sandstones, passing into bands of arenaceous limestone, which is, in some places, a dolomite. The following section in Orwell Bay and its vicinity shows the beds resting on the Upper Carboniferous of Gallas Point, and may be taken as typical. It is in ascending order:

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[1]Introduction by Alfred W. G. Wilson.
[2]Dawson, J. W., Acadian Geology, 4th edition, Appendix 1, pp. 28-30.
[3]Triassic.
[4]Report on the Geological Structure and Mineral Resources of Prince Edward Island—Dawson and Harrington.

		Feet
1.	Bright red sandstones with white bands	30
2.	Red shales with white stains and red sandstones with cylindrical casts of fucoids	60
3.	Red and purplish sandstones with grey bands and layers of ferruginous conglomerate with obscure remains of plants	88
4.	Beach, probably representing soft beds	48
5.	Red flaggy sandstone, with conglomerate and concretions of red oxide of iron, containing remains of plants	50
6.	Bright red sandstones and red shale with greenish stains	30
7.	Marsh, probably soft beds	24
8.	Red shale and green bands capped with bright red sandstones	75
		405

(Here the section is broken by Orwell Bay, which probably represents some thickness of soft beds.)

9.	On the high cliffs near Belfast are very bright red sandstones and shaly beds, with grey blotches and cylindrical fucoids—about	120
10.	Over the last are seen, in the country east of Belfast, soft red sandstones with beds of conglomerate with rounded quartz pebbles and arenaceous cement (thickness uncertain)	
		525

As seen in this section, the whole thickness of these beds cannot much exceed 500 feet. Of this the lowest 270 feet, being Nos. 1 to 5 inclusive, of the above section may be referred to the lower division, or 'Bunter,' and the remainder to the upper division of the formation, or 'Keuper'. The dips are so low, and the beds so much affected by oblique stratification, that those of the Trias cannot be said to be unconformable to the underlying Carboniferous rocks; and for this reason, as well as on account of the similarity in mineral character between the two groups, some uncertainty may rest on the position of the line of separation. What is stated above depends on fossils, or a somewhat abrupt change of mineral character, and on a slight change in the direction of the dip. These beds spread over the greater part of the island, presenting a nearly horizontal attitude, or lying in very flat synclinals and anticlinals. They are well seen in the coast cliffs in many places.

Structure.

The rocks of Prince Edward Island either lie in low folds or are gently inclined. A low anticline has been mentioned by Dawson and others extending through Gallas point, and other slight anticlines are known to exist elsewhere on the island.

HISTORY OF DRILLING OPERATIONS.

In 1908 the Geological Survey of Canada put down a test well and, later, four others for the purpose of ascertaining, if possible, the depth of coal beds which were supposed to exist

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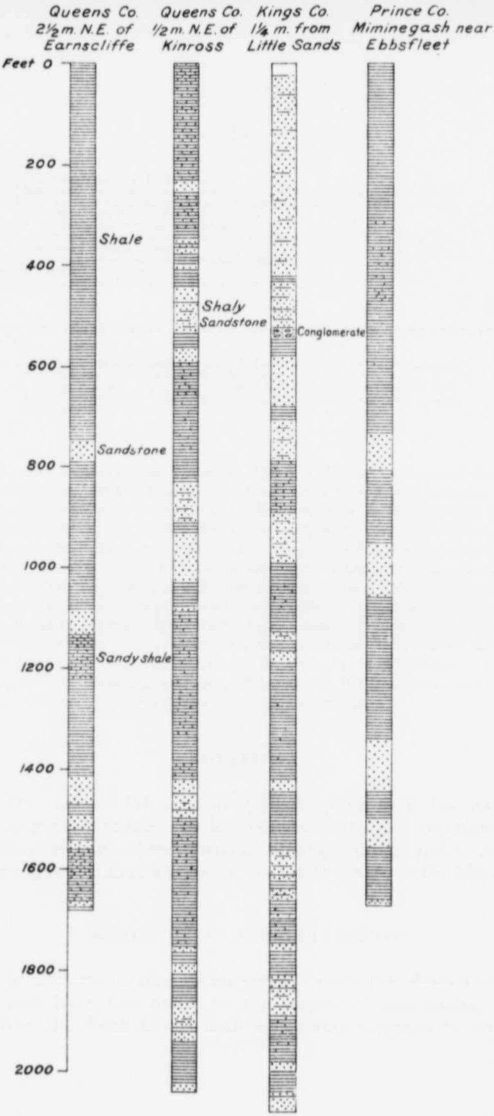

Fig. 1 Prince Edward Island, Geological sections.

in the Carboniferous rocks underlying the island. The Government also desired information regarding the possibility of oil and gas in the island.

The region selected for this drilling was the low anticline extending through Gallas point, this being an exposure of the oldest rocks on the island, so that it was hoped the coal-bearing beds might be reached in a shorter distance than in any other part of Prince Edward Island. No oil or gas was struck in any of these wells.

The following log gives the conditions found in the first boring:—

Log of well drilled on the James Twedie farm, on Gallas Point.

Material.	*Top Feet*	*Bottom Feet*
Red sandstones. Soft water	0	65
Red shales. Soft water	65	145
Red sandstones	145	205
Red shales	205	295
Blue shales	295	395
Light red sandstone	395	405
Blue sandstone. Small amount of fresh water	405	435
Red shales. Salt water	435	635
Red shales. Salt water	635	995
Red sandstone	995	1015
Red shale	1015	1125
Grey shale	1125	1155
Red sandstone	1155	1165
Red shale	1165	1170
Red sandstone	1170	1190
Grey shale	1190	1195
Grey sandstone	1195	1205
Red shale	1205	1355
Red shale	1355	1395
Red sandstone	1395	1415
Red shale	1415	1620
Red sandstone	1620	1660
Red shales	1660	1725
Fine red sandstone	1725	1750
Red shales	1750	1870
Red sandstone. Salt water	1870	1875
Red sandstone	1875	1880
Grey, porous sandstone. Salt water	1880	1910

The well records shown in the accompanying figure represent drillings at four locations in Prince Edward Island.

OIL AND GAS POSSIBILITIES IN PRINCE EDWARD ISLAND.

No oil or gas have ever been found on Prince Edward Island, and it is a question whether they will be found, although, judging from the geological structure, conditions should be more or less favourable for these substances at a considerable depth in localities which are geologically suitable.

The surface of the island is composed of rocks which are known as the Permo-Carboniferous, which is believed to be underlain by an extension of the Carboniferous Coal Measures of Cape Breton and Nova Scotia, but which is so deep that it has never been reached by boring, and a definite statement of the presence or absence of coal, as well as of oil and gas, cannot be made.

As has already been noted in a preceding paragraph, in order to learn whether the island had deep-lying mineral resources, particularly oil, gas or coal, five bore holes were sunk in recent years by the Dominion Government, under the direction of the Geological Survey, with the object of learning something about the underlying formations. A contract was let to an experienced driller for 10,000 feet of boring, to be done with a standard drilling rig. These holes were located at points where geological investigations had shown that anticlines crossed the island. Not only would the arches of these anticlines be more favourable for the accumulation of oil or gas, but the boring would naturally start in the lowest exposed geological formation, materially reducing the total thickness of beds which it would be necessary to penetrate to reach the underlying oil bearing strata, if such exist. Judging from the geological work of Sir Wm. Dawson and Dr. Ells, the Gallas Point anticline appeared to be the best location for the initial drilling. The location of the several wells was as follows:—

Well No. 1, on the James Twedie farm, a little south of the anticlinal axis.

Well No. 2, two miles north on the opposite side of the axis.

Well No. 3, near Kinross, on same anticline about seven miles inland.

Well No. 4, near Little Sands on the next recognized anticlinal axis.

Well No. 5, near Miminegash, on the west side of the island, close to the axis of the most westerly anticline.

Three of these wells were started 18 inches in size, the remaining two being 13 and 10 inches respectively. Complete well logs of these borings were kept by Mr. E. D. Ingall of the Geological Survey of Canada, and are reported by him with necessary descriptions[1].

It will be noted that no results were obtained from any of the borings, with the exception of finding large flows of water at various depths, which at great depths became brackish and salt.

The greatest depth reached was 2,082 feet, but none of the wells are known with certainty to have penetrated to the underlying Carboniferous. One of the deeper holes was abandoned owing to caving and the burying of the tools. Consequently, neither the Carboniferous Coal Measures nor the possibilities of the island for oil or gas have been tested. There appears to be no particular reason why further drilling should not be done to much greater depths in the future with the idea of finding oil or gas, although it cannot be stated that the oil measures which outcrop on the New Brunswick mainland would be found at a prohibitory depth. In order to show the general character of the formations on Prince Edward Island, a log is given on the deepest boring on the island.

Log of well No. 4, 1½ miles from "Little Sands," Kings county[2].

Material	*Top Feet*	*Bottom Feet*
Sandy clay	0	25
Firm, red, shaly sandstone	25	420
Bright red, firm shale	420	430
Firm, red, shaly sandstone	430	442
Firm, red sandstone	442	450
Shaly sandstone, red	450	520
Conglomerate of coarse-grained sandstone	520	540
Firm, bright red shale	540	580
Red, shaly sandstone	580	680
Firm, red shale	680	710
Coarse, red sandstone (conglomerate)	710	740
Shaly sandstone, red and firm	740	790
Red shale	790	800
Red, sandy shale	800	880
Coarse, shaly sandstone or conglomerate	880	890
Shaly, red sandstone	890	990
Firm, red shale	990	1020
Firm, red sandy shale	1020	1100
Firm, red shale	1100	1130
Shaly sandstone, red	1130	1150
Firm, red shale	1150	1170
Shaly sandstone	1170	1190
Firm, red shale	1190	1360
Firm, red sandy shale	1360	1420
Sandstone, somewhat shaly	1420	1450
Shale, red	1450	1560
Sandstone	1560	1595
Shaly sandstone	1595	1620
Shale	1620	1640

[1]R. W. Brock, Sum. Rept. Geol. Survey, Canada, for 1909, pp. 30-37.
[2]*Op. cit.* pp. 34-35.

Material	*Top* *Feet*	*Bottom* *Feet*
Shaly sandstone	1640	1660
Sandy shale	1660	1690
Sandy shale	1690	1720
Shale	1720	1730
Sandy shale	1730	1740
Sandstone	1740	1760
Sandy shale	1760	1770
Shale	1770	1790
Shaly sandstone	1790	1810
Sandstone	1810	1820
Shaly sandstone	1820	1830
Shale	1830	1840
Shaly sandstone	1840	1880
Shale, sandstone	1880	1885
Shale, red and firm	1885	1970
Red, sandy shale	1970	1980
Red, shaly sandstone	1980	2000
Red, sandy shale	2000	2010
Firm, red shale	2010	2040
Shaly, red sandstone	2040	2050
Firm, red sandstone	2050	2082

Water was encountered in this well as follows:—

	Depth *Feet*
Large flow of fresh, hard water	35
Salt water here first noticed to affect the freshness of the water in the hole	150
Water quite saline; and level in well is affected by rise and fall of the tide	200
Above water cased off	442
Salt water encountered, but not enough to flood the well	450
Great flow of salt water in conglomerate or coarse sandstone—too much to handle with bailer; rises and falls with tide	540
Above cased off	890
Fresh water struck in this layer	910
Flow of water increasing and becoming too great to bail out; drilling continued under water	950
Water becoming brackish	1010
Water decidedly saline	1140
Water up to tide level	1190
Above cased off	1414
Fresh water in small quantity	1430
Considerable flow of fresh water	1560
More water	1610
More water, too heavy to bail out	1650
Above cased off	1713
A little brackish water	1750
Quite a large flow of brackish water	1820
Large flow of brackish water, too great to be bailed out	1860
Above cased off	1895
Moderate flow salt water	1990
Heavy and increasing flow of salt water	2060

This hole was cased with 10 inch pipe to 890 feet; with $8\frac{1}{2}$ inch casing to 1414 feet; with $6\frac{5}{8}$-inch casing to 1713 feet; with $5\frac{1}{4}$ inch casing to 1895 feet.

At the lowest depth, 2082 feet, the pressure of the large flow of water was so great that drilling could not be continued.

CHAPTER III

NEW BRUNSWICK

GEOLOGY[1]

Stratigraphy

GENERAL STATEMENT

The oldest rocks in New Brunswick form a broad complicated belt along the southern coast of the Province. North of this is a broad basin of the younger, Carboniferous rocks, with a northeast-southwest axis, and widening greatly toward the Gulf of St. Lawrence. This central basin is flanked on the northwest by a northeast-southwest belt of older rocks reaching from Chaleur bay to the River St. Croix. Northwest of this belt and occupying the northwest third of this Province is a great region of steeply dipping altered slates and limestones chiefly of Silurian age. The following table, after Ells[2], gives the principal divisions of the geological column, as recognized by the more recent surveys—compared with surveys made in 1870. From the same report most of the following notes on the geologic formations have been taken.

GEOLOGICAL DIVISIONS IN NEW BRUNSWICK.

Comparison of Nomenclature of Report 1870-1 with that of 1907.

	1870-1	1907
Triassic........	New Red Sandstone.........	Trias of the south coast.
Carboniferous..	Middle and Upper Carboniferous......................	Millstone-grit, Upper or Permo-Carboniferous of the east coast, the productive coal measures of Nova Scotia being apparently absent.

[1]By F. G. Clapp.
[2]R. W. Ells, The Geology and Mineral Resources of New Brunswick. Geological Survey of Canada, 1907, p. 16.

Carboniferous	Lower Carboniferous	Marine limestone, gypsum, conglomerates at base, shales, sandstone, etc., below the Millstone-grit.
	Perry Sandstone group; Lower Carboniferous	Upper division of the Devonian, including the "Albert Shales." Perry conglomerate, shale and sandstone.
Devonian	Mispeck	Mispeck shales and conglomerate.
	Cordaite	Cordaite shale and sandstone.
	Dadoxylon	Dadoxylon sandstone and shale.
	Bloomsbury	Bloomsbury division at base.
	Pale argillite series	Devonian not yet divided.
Silurian	Dark argillite series	Upper Silurian, in part metamorphic.
	Mascarene series	Siluro-Devonian.
Cambrian	St. John group	Cambrian, Etcheminian, div. O at base, Cambrian divs. 1, 2 and 3.
Pre-Cambrian	Huronian, Kingston, Coldbrook, Coastal	Pre-Cambrian with associated igneous masses.
	Laurentian	Pre-Cambrian, in part igneous and in part altered Silurian and Devonian.
	Intrusive Rocks	Granite, gabbro, diorite and diabase, felsite, etc., of various ages.

DESCRIPTION OF GEOLOGICAL FORMATIONS.

Pre-Cambrian.—The areas of altered slates and quartzites, associated with crystalline limestones and various granites and other igneous rocks in the southwest part of the Province which were correlated with the Laurentian, have been recently determined to be metamorphic phases of younger formations so that no true Laurentian is recognized in the Province. The Huronian of the southern region has been divided into the Kingston, Coldbrook, and Coastal series, but these upon later work are found not sharply demarked and the succession can not be made out. They are made up of mica schists, felsites, argillites, thin limestones, slate conglomerates, and chloritic gneiss, as well as gabbro, diabase, diorite, and volcanic agglomerates. The Huronian occupies a broad belt in Charlotte, Kings, and St. John counties, adjacent to the Bay of Fundy. This belt is marked longitudinally by six anticlines which bring up the Pre-Cambrian rocks, the intervening synclines being occupied by Cambrian slates.

The Pre-Cambrian rocks of northern New Brunswick greatly resemble those already described. They occupy an extensive tract of country extending diagonally across the northern portion of the province, reaching nearly from the main southwest Miramichi river to the Tobique river and northeastward to Chaleur bay.

Cambrian.—The rocks of the St. John group are intimately associated structurally and geographically with the Pre-Cambrian rocks as already described. The lowest rocks of the group consist of purplish quartzose sandstones and conglomerates with shales. These are succeeded by red and greenish argillites, often micaceous, light to dark grey sandstones and shales, the latter often fossiliferous.

In the northern part of the Province, the Cambrian consists of grey, red, green, and black slates with quartzose sandstones, sometimes schistose. Certain bands of red and green slates are persistent for long distances and can be traced from Chaleur bay southwestward into York county nearly across the Province. These slates flank both sides of the Pre-Cambrian area in this section.

Ordovician.—The Ordovician rocks include formations between the Potsdam sandstone and the Hudson River or Lorraine shales. No subdivisions of the series have been made in New Brunswick owing to the impossibility of separating them from the rocks of the Cambrian, likewise metamorphic. They form a broad belt, flanking the older rocks in Charlotte, Kings, and Queens counties in southern New Brunswick, and in the northern part of the Province occupy a large part of York county and extend into the adjoining part of Maine. The rocks are slates and sandstone, in places metamorphosed into schists and gneisses by the larger areas of syenite and granite which intrude them, sending off dikes and veins in all directions.

Silurian.—Rocks of this system occur at several places in the southern part of the Province. Along the coast of Charlotte county they are found in lenticular basins infolded in other rocks, the relation being very often intricate and obscure as in the case of the Mascarene series. Certain fossiliferous beds, however, are probably of Niagara age. These beds extend in a continuous belt along the south side of the granite area from Oak bay as far east as New River. They also occur along the St. John river near the line between Kings and Queens counties. In the northern part of the Province, however, the Silurian rocks are by far the most extensive of the older systems. They occupy the entire county along the St. John river above Woodstock, together with much of the valley of the Tobique river as well as extending across the Restigouche and to the Lake Temiscouata region and eastward to Chaleur bay, continuing into the southern part of the Gaspé peninsula as has been noted. The rocks are slates and limestones much altered but here and there fossiliferous.

Devonian.—This system has a considerable development in the southern part of the Province, being noted for the plant remains yielded by some of its members. It is made up of five groups, viz: The Bloomsburg series is made up of reddish conglomerates, sandstone, and shales associated with large masses of igneous rocks. This series is followed by the Dadoxylon, grey sandstone and shales, abounding in plant remains as well as those of insects and crustaceans. The Cordaite division, next above, consists of greenish and purplish shale and sandstone with abundant remains of Cordaites. These rocks pass upward without apparent break into the Mispeck division of purplish tinted conglomerates. The uppermost division, the Perry series, consists of reddish brown sandstones and conglomerates, changing upward into grey sandstones and shales with plant remains. The Devonian of the northern part of the Province occurs in isolated areas lying unconformably upon the older rocks in Charlotte, St. John, Albert, and Westmorland counties. A larger area extends from Maine to the St. John river and has a width of 12 miles in Charlotte county. Another area is found in Carleton county.

In the northern part of the Province there are but limited areas of Devonian rocks, mostly in the vicinity of Chaleur bay, excepting areas in Charlotte and Victoria counties.

Carboniferous.—This system displays three divisions: Lower, Middle and Upper. The Lower Carboniferous division is made up of marine limestones and gypsum deposits with top and basal members of greenish or reddish conglomerates. The Albert oil shales form the basal member adjacent to the older rocks of southeastern New Brunswick. Thick beds of ash rocks, conglomerates, and breccias, together with various traps, are associated with the rocks of this division in many places. The Lower Carboniferous forms a broad bonding band, not much disturbed by folding, around the central Carboniferous basin of the Province, and lies between it and the older rocks along the southeast coastal border. In the northern part of the Province the Lower Carboniferous division is represented by the Bonaventure formation of conglomerates and red sandstones, which lies horizontally on this upturned Silurian and reaches its greatest development in the Gaspé peninsula.

The Middle Carboniferous rocks occupy the triangular central basin reaching from near the southwestern corner of the Province to Chaleur bay in the north and to the eastern point of the Province, enclosing an area of about 10,000 square miles. These rocks belong to the Barren or Millstone Grit series, the productive Coal Measures of Nova Scotia being wanting in this Province. A thin seam of coal, rarely thicker than 20 to 24 inches, extends over the greater part of the area. The thickness of the series over the central part of the basin is not great, as shown by borings and by the projecting masses of underlying metamorphic slates. In the vicinity of Dorchester, in Westmorland county, a thickness of 1000 feet has been measured.

The Upper Carboniferous series underlies the foregoing in the vicinity of Dorchester and extends over a considerable portion of the eastern part of Westmorland county. In places the Upper Carboniferous rests directly upon the Lower Carboniferous.

Triassic.—The Triassic rocks consist of bright red, rather soft, sandstone which inland is associated with pebbly conglomerates and with interstratified sandstone and shale. Areas of these rocks occur on the north side of the Bay of Fundy about 20 miles east of St. John, in Albert county on the shore of Salisbury bay, and between Red Head and Gardner creek. These rocks also occur on the island of Grand Manan.

Igneous Rocks.—The principal igneous rocks not intimately associated with the sedimentary series are the intrusive granites and syenites and the later trap rocks. The former are much the more important. Two belts of these intrusives enter the Province from the State of Maine. The southern belt extends from Passamaquoddy bay to St. John river, with isolated areas to the eastward. The northern belt is of greater extent, reaching from the St. Croix lakes to within 35 miles of Chaleur bay. Several areas of granite occur also on the shore of this bay. These granites are clearly intrusive. They have metamorphosed the Silurian rocks but are not found in the conglomerates older than Devonian, hence are supposed to date from about the beginning of Devonian time.

The trap rocks which are largely developed along the lower Restigouche river, and along the upper part of Chaleur bay, are also for the most part of Devonian age.

Superficial deposits.—These deposits consist of glacial till or boulder clay, unmodified drift constituting the lowest member of the series, upon which at places are found stratified gravel and sand representing old shoals and banks, and raised beaches.

Structural Geology.

The Pre-Cambrian rocks of southern New Brunswick are arranged in a series of six parallel northeast-southwest folds which bring these rocks to the surface while the Cambrian slates occupy the synclines between. The location of these folds is plainly shown on a geological map of the Province and need not be further outlined here.

Where the Devonian and Lower Carboniferous rocks abut against the Pre-Cambrian rocks in Albert and Kings counties, they dip steeply to the north, but this inclination flattens out northward and the Middle Carboniferous rocks of the central basin lie nearly flat, though thrown in a system of gentle folds. These occur also in the northern and eastern parts of the Carboniferous area. Among these gentle folds, there are four more important than the others, which should be located. The first extends in a northeasterly direction from the Miramichi river to Bathurst; a second fold extends from the head of Grand lake to the vicinity of Richibucto head on Northumberland strait; a third passes north of Moncton and reaches the strait a few miles north of Shediac; the fourth anticline, which is confined to the extreme southeastern portion of the Province, follows the Aulac ridge to Bay Verte and Cape Tormentine.

The older rocks which border the Pre-Cambrian area northwest of the central basin region are naturally folded and plicated sharply, and the same is true of the great expanse of Silurian rocks in the northwestern portion of the Province.

OIL AND GAS DEVELOPMENTS.

Historical.

Surface indications of oil in the form of seepages from the Albert shales have long been known in Albert and Westmorland counties, and by 1859 had aroused the interest, not only of local people, but of oil men in the United States as well. In the year mentioned, Dr. H. C. Tweedel, an oil chemist and refiner of Pittsburgh, Pa., secured the lease of certain properties near Dover and St. Joseph in Westmorland county, and drilled four wells, none of which exceeded 190 feet in depth at the former locality, and one at the latter. Considerable flows of gas are reported to have been encountered in each well and small amounts of oil secured, but owing to inability to shut off the fresh water entering them, the wells were quickly ruined and the enterprise abandoned, nothing further being done in the way of development for 15 years.

In 1876, H. A. Whitney succeeded in again interesting American capital in the field, and two companies—the St. Joseph Petroleum Company and the Emery Oil Company—were organized to undertake its development. The former company, under the direction of R. S. Merrill, sunk one well at St. Joseph and one at Dover in 1879; while the latter, under Lewis Emery of Bradford, Pa., sunk five wells (exact location not stated) in the same districts. Some of the wells reached a depth of 1,000 feet or over and several of them yielded oil in commercial quantities. Owing partly to the low price of petroleum resulting from the rapidity increasing production in the United States, and partly to the limited production of the wells, in addition to the many difficulties encountered in drilling and the ruin of the wells by the entrance of water, the developments did not prove profitable and the enterprises were abandoned. Prof. John F. Carll, state geologist of Pennsylvania, advised drilling at some distance from either of the then producing fields, but no steps were taken toward sinking the well recommended.

The next move looking to the development of the oil and gas in this district was in 1899, when Matthew Lodge of Moncton interested the Provincial Government in oil and gas development, the result being the passage by the legislative session of that year of "An Act to encourage the Discovery and Development of Oil and Natural Gas within the Province of New Brunswick." In accordance with this act, oil and gas were declared to be minerals under the general meaning of the Mining Act.

Thereupon, the New Brunswick Petroleum Company, Limited, organized with Frederick W. Sumner as president and Matthew Lodge as secretary, applied for and obtained in

1899 a license from the Crown to prospect and develop oil and gas over an area of 18,000 square miles within the Province for five years, with the right of an extension of five years if certain conditions—one of which was that the Company should expend $100,000—were complied with. At the end of the latter period, the Company, if the conditions imposed by the government were fulfilled, had from the goverment the drilling rights on 10,000 square miles for a term of 99 years, with privilege of renewal for a like additional period.

Following investigations by Prof. N. S. Shaler, H. B. Goodrich, F. H. Oliphant and others, the New Brunswick Petroleum Company, Limited, commenced drilling in 1900 to 1901 and continued until 1906, expending in its operations, it is claimed, over $200,000. The period of greatest activity was from 1903 to 1905. In all, 72 wells were drilled in the Dover and St. Joseph districts in Westmorland county, one at Beersville in Kent county, and four on the west shore of the Petitcodiac between that river and the present gas field in Albert county. The wells in Kent and Albert counties were without result, but of those drilled in the St. Joseph and Dover fields, about half produced oil in commercial quantities. The majority yielded from $\frac{1}{2}$ to $2\frac{1}{2}$ barrels per day, although one well is stated to have produced at a rate of 50 barrels a day at the start. In all, several thousand barrels are reported to have been pumped and marketed.

In 1906 negotiations were begun with English and Scottish capitalists to take over the drilling of the New Brunswick company, and after geological investigations by Sir Boverton Redwood, Dr. J. A. L. Henderson, O. P. Boggs and others, a syndicate known as the Maritime Oilfields, Limited, was organized, and on November 4, 1908, acquired the drilling rights of the New Brunswick Petroleum Company, Limited, for a period of six years, with the option—in consideration of certain payments —of taking over at or before the expiration of that period, the full rights of the aforesaid Company included in the 99 year lease granted it by the Crown under date of August 16, 1907.

The authorized capital is £100,000, in 99,000 ordinary shares of £1 each, and 20,000 deferred shares of 1s. each; all the shares are issued and fully paid. The capital was increased from £41,000 to the present amount in July, 1901, and is shortly to be again increased by creation of a further 50,000 ordinary shares in order to acquire the head lease of the property. A royalty of five per cent is payable on the value of the output of oil and natural gas. The Moncton Tramways, Electricity and Gas Company, in which the Maritime Oilfields, Ltd., holds about a sixth interest, has agreed to purchase for 39 years all the gas required by them for supplying the various markets in southern New Brunswick.

Drilling was begun almost immediately under the direction of Dr. J. A. L. Henderson, petroleum engineer and technologist, the fieldwork being in charge of General Manager O. P. Boggs, an oil man of wide experience. Three unsuccessful holes were drilled in Westmorland county, including one near Leger's Corner, three miles east of Moncton, one four miles west of Memramcook, and one near Dover. The next well to be brought in (No. 3 of the present field) obtained some oil and 150,000 cubic feet of gas per day, and was followed by well No. 5, with 1,000,000 cubic feet. After this, producing wells came in rapid succession. Up to September, 1913, 33 wells had been drilled in the Stony Creek field and several more were drilling. Of the completed wells, eight were dry holes. Of the 25 producing wells, 11 produced both oil and gas, 12 gas alone, and 2 oil alone. The original yield of gas ranged from 17,000 to 7,000,000 cubic feet per day, but the production of oil was generally only a barrel or two per day. All of the wells are still producing oil or gas, although in diminishing quantities.[1]

In September, 1913, drilling was in progress at Sussex, about halfway between Moncton and St. John, and 40 miles south of west of the Stony Creek field. A depth of 1,000 feet had been reached and small pockets of oil had been struck at 140 feet and 450 feet. Sussex is situated on an anticline in Lower Carboniferous rocks and structurally has about the same relation to the southern Pre-Cambrian area as the Stony Creek field has to Caledonia mountain.[2]

[1]Up to January 1, 1914, this company had put down 42 wells, on three of which drilling was still in progress. There were 31 wells producing oil or gas or both.

[2]This well was abandoned on striking hard limestone.

Areal Distribution and Geology of the Albert Shale Series.

Since it is the sandstone members of this series of oil shales which yield the oil and gas found in New Brunswick, the distribution and geology of that formation will be described before taking up the individual fields.

Caledonia mountain forms the northeastern termination of the Pre-Cambrian area, stretching northeastward from St. John. The Albert shales dipping sharply northward, outcrop along the north flank of the Caledonia mountain and, except where covered by the transgression of the Lower Carboniferous rocks, extended westward in a belt averaging half a mile wide for more than 25 miles to the vicinity of the village of Elgin, and have been recognized in isolated outcrops for a distance of 50 miles to Apohaqui station. The anticlinal nose of the eastern point of Caledonia mountain brings the Albert shales to the surface in the vicinity of Albert Mines, and again on the east side of the Petitcodiac river opposite Edgett landing, and also on the Memramcook river in the vicinity of upper Dorchester. All of these areas show anticlinal structure.

Another anticline brings the Albert shales to the surface in a belt from 1 to 2 miles wide reaching from College Bridge station near the Memramcook river to Dover, on the Petitcodiac river. On the south flank of this anticline are located the St. Joseph, Dover, and Stony Creek oil and gas fields. The south slope of this anticline east of the Petitcodiac river is marked by highly inclined strata, the dips ranging from 30° to 60°. On the north slope the dips are lower, ranging from 10° to 20°. West of the Petitcodiac river the dips are lower and the rocks less disturbed, the dips ranging from 5° up to 15°.

A second belt parallel with the above, is also indicated by exposures along the north side of Indian ridge, 8 miles north of Moncton and 16 miles north of Dover and Memramcook, but the shales so far observed at this point are less bituminous than those of the districts last named, and it is not known to what extent they underlie the extensive Carboniferous area to the north. Borings near Coal Branch in Kent county, about midway between Biersville and Mt. Carlisle, are reported to have struck oil and gas at a very moderate depth. Should this report be confirmed, it would, by indicating the existence of oil-bearing strata beneath the rocks of the great central coal basin, increase enormously the area from which possible future supplies of petroleum in New Brunswick may be drawn[1].

The age of the Albert shales has been a matter of dispute as may be noted from the table of formations already given. In 1870-1871 they were thought to be Lower Carboniferous while in 1907 they were held to be Upper Devonian. In Ells' report on the "Oil Shales of New Brunswick and Nova Scotia" published in 1910 they are given as Devonian. On the map (Map 35A) issued by the Geological Survey in 1911, they were regarded as Devonian. However, in 1913, Young[2] on evidence cited, correlates the Albert shale series with the Horton series as of Lower Carboniferous age.

The Albert shale series consists of a group of thinly bedded, usually dark coloured slates, calcareous slates, limestones, and sandstones. Interbedded with these, whether or not at more than one general horizon has not yet been determined, are slates relatively rich in hydrocarbons and of a distinctive appearance. These so-called oil shales, when retorted, yield varying amounts of crude oil and nitrogen—about 27 to 56 imperial gallons of crude oil and about 30 to 110 pounds of ammonium sulphate per ton. In these oil shales and associated beds, in places, are numerous remains of fishes. ....From the Albert series have been recovered several species of plants.

The stratigraphic character of Albert shales is best shown by the following logs of deep drill holes in the vicinity of the Old Baltimore Oil Works at Rosedale 10 miles south of west of Hillsborough, given by Ells[3]. Some 40 years ago works were in successful operation here extracting oil from the shale, but the opening of the great oil fields of Ontario and the United States reduced the price of oil until these works were compelled to close.

Boring No. 1, diamond core-drill.

Elevation above sea-level, 710 feet, April, 1900.
H. B. Goodrich, geologist in charge.
This hole was located on the flat of the east branch of Turtle creek, 1800 feet northeast of the corner at Rosedale post office. The boring evidently commences in the overlying Lower Carboniferous sediments, and the log is as follows:

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[1]Bailey, L. W., Geol. Survey of Canada, 16th Ann. Rep. New Ser., 1904, pp. 288-289A.
[2]Young, G. A., 12th Inter. Geol. Cong. Guide Book No. 1, Part II, issued by the Geological Survey of Canada, 1913, pp. 355-356.
[3]Ells, R. W., Oil shales of New Brunswick and Nova Scotia, Part II, Geological Survey of Canada, 1910, pp. 14-16.

	Thickness (Feet)	Depth (Feet)
Gravel, surface drift	—	7
Green and red, coarse and fine conglomerate	60	67
Red marly shales, occasional pebbles	14	81
Conglomerate	4	85
Red clay shale	6	91
Unconformity, dips of above, N. 10-15 deg. representing the Lower Carboniferous formation.		
Albert shale series		
Fine sandstone, shale layers	7	98
Shale, calcite veins, holds oil and will burn	9	107
Shale with fine sandstone	4	111
Banded shale, calcite, pyritous, small quantity of oil	13	124
Oil shale, contains much oil and burns readily	3	127
Oil shale, burns, but not so readily	7	134
Bituminous sandstone and shale	10	144
Oil shale, but not a true oil shale	1	145
Bituminous shale, oil-bearing, burns more or less freely	27	172
Slightly bituminous claystone with shale bands	32	204
Shales and fine sandstone	10	214
Very fine sandstone (claystone) with shale layers	36	250
White sandstone	1	251
Black bituminous shale, with sandy layers, burns	19	270
Very fine-grained, probably calcareous sandstone	22	292
Black bituminous shale, burns freely	77	369
Black bituminous shale with sandstone beds	24	393
Fine dark sandstone with 3 feet shale	14	407
Light brown oil-stained sandstone	3	410
Fine sandstone, with shaly streaks, brecciated	20	430
Black bituminous shale, bands of fine sandstone	49	479
Very fine brown sandstone, in part rich in oil	27	506
Black shale rich in hydrocarbons	11	516
Sandstone and shale, slightly bituminous	47	563
Fine grained sandstone	12	575
Fine black shale	27	602
Fine white sandstone	17	619
Clay shale, slightly bituminous	10	629
Fine white sandstone	2	631
Grey clay shale	8	639
Fine white sandstone	9	648
Black shale	46	694
Fine white sandstone	8	702
Black shale	7	709
White sandstone	5	714
Shale and sandstone	11	725
Fine sandstone to bottom	21	746

It will be seen that the lower part of this boring traversed a considerable thickness of white sandstone. This rock does not appear at the surface in any observed portion of the shale field of Albert county. The contact with the underlying crystalline rocks was, evidently, not reached.

Boring No. 2 at Baltimore, diamond core-drill.

Elevation above sea-level 891 feet. Begun September 1, 1900.
H .B. Goodrich, geologist in charge.
Location near summit of ridge west of Rosedale post-office near E. Steven's house.

	Thickness (Feet)	Depth (Feet)
Gravel and clay	—	20
Grey clay-shale, faulted, dips N. 15-20 deg	73	93
Quartzose mica sandstone, with thin shales	13	106
Micaceous fine grained sandstone with shales	26	132
Black clay shale	6	138
Oily sandstone	7	145
Whitish brown whetstone rock	5	150

	Feet Thickness	Depth
Sandstone and shale	8	158
Oil-bearing sandstone with oil streaks	22	180
Grey shale and white sandstone	5	185
Black and green shale, no oil, dip N. 15 deg	38	223
Quartzose sandstone	7	230
Shale and sandstone	12	242
Grey and green shale	36	278
Fine micaceous sandstone	11	289
Shale and white sandstone	4	293
Grey and green shale, faulted, dip 20 deg	37	330
Sandstone and conglomerate	9	339
Shale	4	343
Whitish sandstone with some shale	8	351
White micaceous sandstone with oil at bottom	22	373
Green shale and sandstone, no oil seen	80	453
Mostly grey sandstone with shale partings	27	480
Grey shale broken and faulted	39	519
Claystone and micaceous sandstone	28	547
Dark grey shale	26	573
Claystone with shale bands	7	580
Grey clay shale	27	607
Sandy reddish shale	7	614
Hard fine grey sandstone	8	622
Grey shale	7	629
Grey sandstone	10	639
Dark grey shale	17	656
Hard dark grey sandstone and shale	62	718
Sandstone and fine conglomerate	12	730
Grey shale	12	742
Grey shale or slate to bottom of hole	35	777

From the above log it will be seen that the chocolate coloured shale so characteristic of the Albert shale formation elsewhere was not recognized and that there are considerable thicknesses of sandstone, both grey and white. At the Albert mines, the sections from the shafts and along the brooks show the brown beds more abundantly, with but small areas of the sandstones.

Bore-hole No. 3, at Baltimore, with churn drill.

Elevation above sea-level, about 800 feet. Begun December 4, 1900.

Location is approximately 10 degrees southwest of a vertical line from face of big tunnel on the Baizley lot, and is at least 95 feet above level of that tunnel at collar.

	Feet Thickness	Depth
Soil		1
Shale slightly bituminous, close grained and brown	29	30
Hard claystone, or sandstone non-bituminous, brown bituminous shale, small showing of oil	13	43
Shale slightly calcareous and bituminous; grey shale or claystone, calcareous and bituminous; shale with streaks of fine bituminous sandstone; hard grey calcareous shale, slightly bituminous; grey shale slightly bituminous; calcareous bituminous shale with streaks of claystone, and sometimes with calcite veins, broken, with sandy layers	70	113
Brown shale, probably oil shale, bed of about 2 feet hard rock, probably rough claystone, calcareous shales, a bed of oil shale 2 feet thick	53	123
Grey shale, slightly bituminous, very bituminous shale, but probably not an oil shale, in places with calcareous bands; calcareous shale and claystone; grey calcareous slightly bituminous shale	47	170

	Feet	
	Thickess	*Depth*
Fine calcareous sandstone, with harder calcareous and bituminous shale and sandstone, passing into hard grey bituminous shale	43	213
Hard, very bituminous shales, possibly oil shale; calcareous shale and sandstone, faulted, bituminous claystone, calcareous shale and claystone slightly bituminous to bottom of hole	35	248

Hole for entire distance in bituminous shales and claystone; a slight find of gas was given off, but no flow of oil at surface.

Principal concentration of hydrocarbons appears to be at 112 feet to 123 feet; secondarily important at 212 feet to 214 feet.

The Oil and Gas Fields.

ST. JOSEPH OIL FIELD.

St. Joseph College is situated about 2 miles south of Memramcook and the oil field is known by both names although all but one of the wells have been within a half mile of the College. The first wells were bored by Dr. Tweedel in 1859 and, though not over 190 feet in depth, struck a small quantity of oil. Several other wells were drilled in this field in 1879-1880 by the St. Joseph's Petroleum Company. In 1900-1901, six wells were sunk in this territory by the company formed by Matthew Lodge. A description of these wells by Harold B. Goodrich is quoted from the 14th Annual Report of the Geological Survey of Canada, pp. 204-5 A, as follows:—

In May, 1900, the rig was removed to St. Joseph's College and Well No. 2 was put down to a depth of 1,040 feet. There was much gas, and at 365-370 feet an oil sand and flow of oil was struck. Several accidents made it impossible to take advantage of this oil, and the well was sunk further. At 670 feet, salt water was found. The drilling was entirely in the Albert shale series, which for the last 200 feet was mainly close-grained sandstone with shale bands.

No. 3 was begun one mile north of the College on February 27, 1901. The drilling was through hard and soft layers of Albert shale. A poor record was kept, and it is possible that a slight flow of oil or gas may have escaped the drillers' attention. No petroleum is shown by the record, although the shales were highly bituminous. At 555 feet the well was abandoned owing to quicksands. The last ten feet was in red sandy marl or conglomerate.

Well No. 4 was commenced in May, 1901, at a point 400 feet north of No. 2 at the College. The total depth was 408 feet. At 176 to 204 feet there were twenty-three feet of oil-bearing sandstone. This was not recognized at the time, so boring was continued. Later the hole was filled up to this depth; it was torpedoed and a pumping apparatus was placed. While it has not been pumped continuously to date, there has been a considerable product which shows no sign of decreasing. The oil is of excellent quality.

Well No. 5 was located, on August 5, 1901, 200 feet S.W. of No. 4. The geologic section is practically the same as the latter; bituminous calcareous shales, with small hard limestone beds. At 174-178 feet there was a sandstone with considerable gas. At 247-275 feet is an oil bearing sand (the same thickness as that of No. 4). No attempt was made to pump this well, but instead it was plugged and now awaits further development in the field.

The last week in August, No. 6 was located 100 yards N. by W. of No. 4. Up to date we have reached 226 feet and are still sinking. In that distance we have passed through three separate flows of gas. Almost the entire section is bituminous black shale. The present indications for a producer are excellent.

In Well No. 7, which was located on September 11, about 200 yards north of No. 4, we are now down to about 340 feet. The section was similar to that of No. 6. At about 190 feet we struck gas, which was later cased off. At 326 feet there was a flow of petroleum, probably from fissures in the shale. We decided to bore still further, hoping for an increase in the quantity of oil. However, as the well is in excellent condition we can at any time use the present supply.

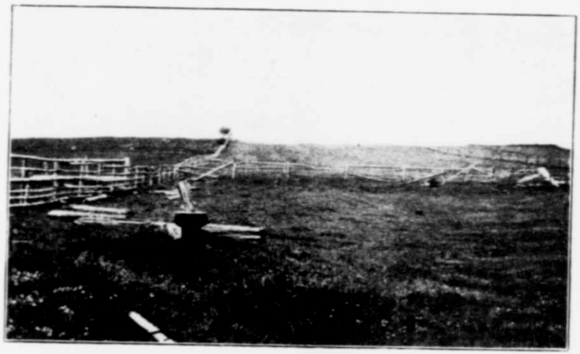
The above wells were visited in July at which time, with a 2½ inch pump, worked by steam, the yield was four barrels for a period of six hours, or at a rate of from eight to ten barrels per day. The oil was a heavy, dark green lubricating oil, well adapted as a machinery oil, and estimated as having a value of about $7.50 per barrel. Its specific gravity at 60° Fahr. is 0·860, while that of the American crude oil varies from 0·79 to 0·88. It is thought by those in charge that it will probably yield at least 30 per cent of burning oil, 15 per cent of lubricating oil, and 10 per cent of solid paraffin.

The complete logs of wells Nos. 4, 5, and 7 as furnished by Goodrich are given by Ells[1] as follows:—

	Feet	
	Thickness	*Depth*
Bore-hole No. 4:		
Surface soil		6
Grey shale with black bituminous bands	50	56
Shale with hard bands	21	77
Black shale	43	120
Close grained sandstone or claystone	33	168
Dark bituminous shale	16	169
Hard rock, probably fine-grained sandstone	7	176
Oil-bearing sandstone	28	204
Grey shale	41	245
Darker shale to bottom of hole	65	310
Bore-hole No. 5:		
Red clay and gravel		13
Hard grey shale	42	55
Hard grey shale and sandstone	5	60
Very hard shale with fine layers sandstone	40	100
Grey and black shale with hard limestone	26	126
Grey bituminous shale	4	130
Grey bituminous shales with sandy beds	10	140
Greyish and black bituminous shale	20	160
Greyish black bituminous shale with limestone	14	174

[1]Ells, R. W., The Bituminous or Oil shales of New Brunswick and Nova Scotia, Geol. Survey Canada, 1909, part 2, p. 17.

PLATE I.



Old Memramcook oilfield, Memramcook, New Brunswick.

	Feet Thickness	Depth
Sandstone with small show of gas and oil	4	178
Hard grey and black shale	42	220
Dark soft highly bituminous shale	20	240
Dark shale with sandstone	7	247
Oil sands	28	275
Shales to bottom of hole at	12	287
Bore-hole No. 7:		
Surface soil		20
Grey shale	92	112
Hard limestone	5	117
Grey and black bituminous shale	10	127
Hard rock, probably limestone	10	137
Grey and black, slightly bituminous shale	70	207
Hard rock sandstone or limestone with shale	16	223
Black shale	5	228
Hard sandstone or fine claystone	8	236
Black shale	3	239
Hard brown sandstone, flow of gas	17	246
Black close-grained shale, bituminous	27	273
Reddish shale	4	277
Black bituminous shale	46	323
Grey non-bituminous shale	47	370
Oil-bearing sandstone	37	407
Sandy shale to bottom of hole	4	411

During the winter of 1903-1904 there were 10 or 12 wells in the St. Joseph field which were regularly pumped, and the yield of oil was about 2500 barrels. Operations have been entirely suspended in this field, at present, and the only evidence of the former existence of an oil district are the old conductors and the ruins of an old refinery at Memramcook.

DOVER OIL FIELD.

Dover is situated just where the belt of Albert shales strikes the Petitcodiac river. Just above Dover a well was sunk in the early days of drilling but without much success. Another shallow well was drilled a mile below Dover but abandoned. The site of the old Dover field is between 2 and 3 miles south of east of the village. Here on the south flank of the anticline some 30 wells have been drilled. The whole field is now entirely abandoned, and nothing remains but the stumps of the old conductors. Some of the wells are full of oil but none are flowing. The wells average 300 to 400 feet apart.

There are three groups of oil sands, of which the upper one comes to the surface along the crest of the anticline in the west bank of Petitcodiac river. The oil sands groups range up to over 100 feet in thickness. Some of the wells yielded as much as 24 barrels daily, and one is reported as high as 50 barrels, but the majority of the wells ran from ¼ to 2½ barrels per day. The oil came to the surface alternately with a very strong brine, from which it was separated in the tanks.

The crude oil is of a dark green colour, its composition being[1]:—

68 to 70 gravity naphtha	5·5	per cent
Refined oil distillate	27·0	" "
Wax distillate	37·0	" "
Cylinder stock	29·4	" "
Loss	·008	" "

Since the discovery of gas in the Stony Creek field, the operating company, the Maritime Oilfields, Limited, has discontinued operations in the Dover field as having less chance to yield propitious returns, owing to the greater disturbance of the oil-bearing strata in the latter field offering greater opportunity for leakage and escape of the hydrocarbons.

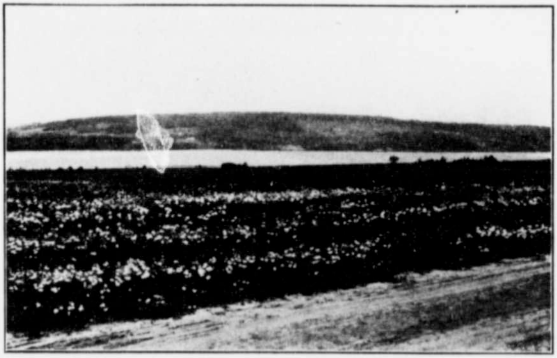
The location of the wells in the Dover field, as well as in the Stony Creek and St. Joseph fields, is shown on the accompanying map, which also shows the distribution of the Albert shales and the relation of the oil and gas fields to the geological structure of the region.

STONY CREEK GAS AND OIL FIELD.

Location and extent of producing territory.—The Stony Creek gas field is located on the west side of the Moncton-Hillsboro highway, about 9 miles south and a little east of Moncton and about 4 miles north of Hillsboro. The most easterly of the producing wells is 3,000 feet from the west shore of the Petitcodiac river, while the most westerly well is approximately 17,000 feet from the water, making the length of the field about 14,000 feet or 2¾ miles. The northernmost producing gas well in the eastern section of the field (No. 17) is about 4,000 feet and the southernmost (No. 12) about 7,050 feet south of Stony creek, giving this section of the field a width of about 3,500 feet. The general trend of the group of producing wells is approximately N. 70 degrees W. or S. 70 degrees E. The field, as at present developed, is slightly narrower at the western end than at the east.

[1]Bailey, L. W., Geol. Survey, Canada, 16th Ann. Rept., New Series, 1904, p. 288A.

Views in Old Dover oilfield, Dover, New Brunswick.



Looking across Petitcodiac river toward Stony Creek oilfield from Dover oilfield, New Brunswick.

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Geology of Eastern Albert County.—The geological formations of eastern Albert county, compiled originally from the reports of the Geological Survey of Canada (Ann. Rept., 1885, Pt. E, p. 33, etc.) are, in descending order, as follows:—

Geological Column, Eastern Albert county.

Age.	Series.	Thickness (feet).	Character.
Middle Carboniferous.	Millstone grit (Pottsville).	500	Grey quartz conglomerate and freestone with coal streaks.
Lower Carboniferous (Mauch Chunk and Pocono).	Upper conglomerate series.	1,950	Red and grey conglomerate, grey limestone and gypsum.
	Red shale series........	450	Red and grey calcareous shale with thin sand and conglomerate.
	Lower sandstone and conglomerate series.	700	Grey, micaceous, and petroliferous sandstone with some reddish conglomerate.
Lower Carboniferous or Devonian.	Albert series............	850	Grey and brown calcareous or bituminous shales and sands.
Lower Carboniferous or Devonian.	Basal conglomerate......	200	Greenish conglomerate with slate fragments, etc., often absent.

The thicknesses shown in the foregoing table were calculated mainly from surface exposures, which are scattered and often inconclusive and the actual maxima are likely to be largely in excess of the figure given. Thus in the Company's well at Baltimore Siding (No. 27) the upper conglomerate series is more than 2,650 feet deep; in well No. 22 the red shale series is about 600 feet thick; while in well No. 9 about 1,800 feet of the Albert series was penetrated. On the other hand, the thickness of any of the beds may be locally greatly reduced by unconformities.

Relations of formations.—The successive formations are not found in an uninterrupted and parallel series, but are separated by breaks or unconformities at three horizons, (1) at the base of the Millstone grit; (2) at the top of the Albert series; and (3) at the base of the Albert or basal conglomerate series. These unconformities frequently cut out certain portions of the section which might be expected to be present.

The unconformity between the Millstone grit and the Lower Carboniferous conglomerate is the highest, but least conspicuous of the three, and is indicated by the fact that the Millstone grit is found resting upon formations of varying ages at different points rather than by any appreciable difference of dip between it and the underlying formations. In the Stony Creek field the unconformity is indicated by the greatly reduced thickness of the Lower Carboniferous conglomerate, the thickness of which ranges from 150 to 700 feet as compared to over 2,650 feet at Baltimore Siding (Well No. 27).

The second unconformity is very pronounced and is marked by both erosion and structural differences. Following this deposition the beds of the Albert series were uplifted and folded, often quite strongly, and were then deeply eroded before the deposition of the succeeding formations. In the Stony Creek field the old erosion surface is marked by the contact between the shales and the conglomerates east of Well No. 15 and by the contact of the grey Albert shale with the red shales or marls west of this well. Its altitude at Well No. 9 on the east is about 200 feet above tide, while in Well No. 33 it is nearly 700 feet below sea-level. The old land mass seems to have stood above sea-level, while the lower sandstones and conglomerates of the general section were being deposited elsewhere; and for this reason, the latter are apparently not represented in the Stony Creek field. The great thickness of greyish shales below the red shales or conglomerates suggests, it is true, that the lower sandstone and Albert shales may be combined, but as there is only one unconformity at this horizon—namely at the top of the Albert series—and as this is represented by the break between the Albert series and the red shales, the assumption that the lower sandstones are many seems to be the only tenable hypotheses.

The third unconformity, or that at the base of the Albert series or the basal conglomerate, represents the long period of erosion and disturbance preceding the deposition of these formations. It is not exposed at the surface in the vicinity of the Stony Creek field, nor has it been reached by wells at this point.

Character and correlations of producing sands.—The producing sands in the Stony Creek field are chiefly somewhat soft, medium grained, grey to brown sandstone of varying thickness, capped by blue or grey calcareous shales or shaly limestones. The producing sands appear to belong entirely to the Albert series, although shows of oil and gas are occasionally found in the coarser sandstones or conglomerates of the overlying Lower Carboniferous.

The producing sands are often very variable in composition and texture, changing rapidly in places from sandstone to shale and limestone or vice versa. The variations are more sudden and noticeable in the western part of the field than in the eastern, and are more pronounced across the strike than parallel to it. The sands bear a striking physical resemblance to many of those of the Chemung in the northern Pennsylvania, which formation includes the Bradford and other well known oil and gas sands of that country.

According to our interpretations of the well records, there are in addition to occasional "stray sands," three groups of sands in the eastern section and two in the middle and western sections; although in the extreme western portion of the field, the sands occur as isolated beds difficult of correlation rather than in well defined groups.

Local geology.—The following additional notes descriptive of local geology are taken from Young[1].

The present developments of the Stony Creek field are confined to an area about 2 miles long by 1½ miles broad, fronting on the west bank of Petitcodiac river and lying between Stony creek on the north and Weldon creek on the south. Between the two creeks the land rises rather sharply from the level of the tidal river to an altitude of 460 feet. Of the 23 wells drilled by the Maritime Oilfields Company, 4 are on the steep east front of the hill and the remaining 19 are scattered over the top of the hill.

[1]Young, G. A., Twelfth International Geological Congress; Guide Book No. One. Issued by the Geol. Survey, Canada, 1913, pp. 359-361, part II.

Along the river front, strata of the Albert series are visible at low water over a stretch of about 2 miles. At the north end of the section, they are overlain by coarse, red conglomerate; proceeding southward, at the first exposures they lie nearly horizontally, beyond this they dip in various directions between south and west, at angles of 10° to 20°. The measures consist of thin-bedded limestones and dark shales with sandstone beds which in places are impregnated with hydrocarbons. The measures apparently lie on the crown of an anticline but there are indications that in places the strata are crumpled and faulted.

The lower slopes of the ridge facing the river to the east and the valley of Weldon creek to the south are occupied mainly by nearly horizontal coarse red conglomerates and sandstones with some shales. These measures are conformably overlain by the quartz conglomerate, and over this, by the light-coloured sandstone of the Millstone Grit. Possibly the lower red strata belong to the Millstone Grit. But it may yet be proved that they are considerably older. On the north side of the ridge along the valley of Stony creek, the measures underlying the pale-coloured Millstone Grit beds consist of red and green shales, and sandstones, with beds of grey sandstone, quartzose conglomerate, etc. Thus the Albert series out-cropping along the eastern base of the hill extends westward under it, as shown by the borings, and is overlain by red strata capped by grey beds. The Albert series is of very early Carboniferous age, the grey beds of mid-Carboniferous age. The exposures indicate, in general, that the measures of all the divisions have relatively gentle dips.

The wells stand at elevations varying between 250 feet and 460 feet above sea-level, and in depth they range from 1,200 to 2,060 feet. After passing through a thickness of overlying formations usually amounting to about 350 feet, they enter the Albert series, of which a maximum thickness of 1,800 feet has been penetrated without encountering any signs indicating the approach of the base of the formation.

The strata of the Albert series, as found in the various wells, consist mainly of thinly-bedded, shaly beds, usually black or dark green in colour and varying in composition from argillite to limestone. Besides the shaly strata, fine-grained quartzose sandstones are comparatively common, the numbers of individual sandstone beds in a single well varying from 3 to 15. In thickness the individual sandstone beds vary from a few feet to 100 feet or more. There is rather a general tendency for the sandstone beds to occur in groups, in a number of instances three such groups separated by intervals of 150 to 350 feet of shale being encountered in a single well. The aggregate thickness of a single group of sandstones may rise to 180 feet but more often lies between 3 and 90 feet. The individual beds of a group of sandstones may be separated by shaly layers varying in thickness all the way from a few feet to 30 feet or more.

Though slight traces of oil or gas have been found in the shaly beds and, in one instance, in strata overlying the Albert series, the oil and gas are confined, practically, to the sandstone beds in the Albert series. In the case of one well which the drillers recorded as apparently passing through disturbed, broken strata, practically all the sandstones are free from oil or gas. In the producing wells, a small number of sandstone beds do not afford any trace of oil or gas. Usually the number of such dry beds is small in comparison with the total number of sandstone beds in a well, and the dry beds, as a rule, occur towards the top of the well, but such beds are also recorded as occurring beneath others with showings of oil or gas. Usually by far the greater number of the sandstone beds are recorded as at least showing oil or indicating the presence of gas, and in some of the wells, sandstone beds of two different horizons yield large volumes of gas.

In the case of about one half the number of wells, all the sandstone beds (except such as are dry) of each well are recorded on the logs as being either all oil sands or all gas sand. In the remaining cases, oil and gas sand irregularly alternate or they occur in two groups of which, in some wells, the oil sands form the higher group while in others the gas sands form the higher groups.

In two wells, strong flows of salt water were recorded. In one case, the salt water was struck near the bottom of the well, being first met in a 12 foot sandstone bed lying 68 feet below an oil sand that, with other immediately overlying sands, yielded oil at the rate of 5 barrels per day. In the second instance, after having passed through two sands, both giving indications of oil, and one giving a small show of gas, a salt-water sand was struck at a depth of about 810 feet. This well was continued to a depth of 1,250 feet, and in the additional distance of 440 feet passed through four beds of sandstone with an aggregate thickness of 245 feet but which were barren of oil or gas except in the case of the lowest bed which was said to give a "show of gas".

From seven of the wells the total calculated yield of gas, as derived from measurements made with a Pitot tube, was nearly 4,000,000 cubic feet per day, the closed pressure of the individual wells varying from 20 to 200 pounds per square inch. From twelve other wells, varying results were obtained. One well had a closed pressure of 525 pounds, rising in three days time to 610 pounds, and an estimated flow of 3,695,000 cubic feet per day; a second had a closed pressure of 475 pounds and an estimated flow of 8,893,000 cubic feet per day; and a third had a closed pressure of 560 pounds with an estimated capacity of 6,417,000 cubic feet per day. In these three cases the volume was estimated from observing the rate of rise and of pressure at one minute intervals. As regards oil, in the case of one well, 60 barrels accumulated in 20 hours; from another after an interval of 7 days 87 barrels were pumped; while a third gave an estimated yield of 40 barrels in 25 hours. The above figures have been taken from the records of the Maritime Oilfields Company who are developing the field.

The sands are reported to be dry of water, and the gas has collected in them at points of local undulations, that is, in secondary anticlines. The oil wells in the Stony Creek field are seldom shot and the gas wells are never shot. The first wells were drilled about 600 feet apart but now they are up to one-half a mile apart. The rock pressure is lowest near the river and highest toward the west end of the field, where it was over 700 pounds per square inch in some wells. The oil from the wells (some yielding as little as one gallon or so per day) is piped to a loading tank by the roadside from which tank wagons distribute it. The oil is retailed locally for $4 per barrel, but most of it is sold to the Intercolonial railway at Moncton for $1.75 per barrel to make Pintsch gas and for other purposes.

Petroleum production of Stony Creek field.—As none of the wells were systematically pumped or bailed for oil, it is difficult to make a reliable estimate of the original yield. Some of the wells filled with oil to a height of 500 feet or more at the start and from some of them from 50 to 80 barrels were bailed out; but the production after the start was probably rarely over a few barrels per day. The field manager has estimated the yield for the field, after the first excess was removed, at 30 barrels per day.

Quality of oil.—The oil produced in the Stony Creek field is of a clear dark green colour, about 39 degrees Baumé. This is somewhat heavier than some of the Pennsylvania oils, which average about 40 degrees Baumé. In the following table, in addition to the two Stony Creek oils, three from the Dover-St. Joseph fields, and one from Pennsylvania are given for comparison:—

Analyses of New Brunswick and Pennsylvania Oils.

Stony Creek Oils. (Recd. Apr. 18, 1910.)	Dover-St. Joseph Oils. (Recd. Apr. 18, 1910.)				Pennsylvania Oil.	
Commercial Product.	No. 3.	No. 5.	No. 1.	No. 2.	No. 3.	Average.
Benzene and gasoline...	14·0	15·2	2·0	3·2	None	15·0
Kerosene..............	37·6	38·0	23·5	29·1	27·3	47·0
Heavy oil and paraffin..	42·4	42·0	67·0	61·7	69·8	32·0
Coke and loss..........	6·0	4·8	7·5	6·0	2·9	6·0
Specific gravity........	·8392	·8363	·857	·852	·862	·824
Flash point...........	68F°	68°F	40°F	....	95°F	....

Of the above samples, the two from the Stony Creek field were analyzed by Dr. J. T. Donald, official analyst to the Canadian government, Montreal, while the three from the Dover-St. Joseph fields appear to have been analyzed in the office of Sir Boverton Redwood, London. The United States Geological Survey is the authority for the figures showing the average of the Pennsylvania oils.

Disposal of oil.—Nine of the oil wells are pumped by the rod system from a pumping plant located near Well No. 5 at the east end of the field and close to the Moncton-Hillsboro road. Others have individual arrangements for pumping. The oil is collected in wooden tanks at the wells and in a series of covered wooden tanks at the pumping station, from which the product is shipped in barrels or tank wagons.

It is used for rough lubrication, as a wood preservative, and as a welding fuel at the Intercolonial railway shops at Moncton, etc. It has also been used by the railroad in the manufacture of Pintsch gas.

Quality of gas.—The composition of the gas is somewhat variable, as indicated by the following analyses by Dr. J. T. McDonald, analyst to the Dominion government, Montreal:—

Analysis of Gas from Stony Creek Field.

Components.	First Sample. (Submitted Mar. 10, 1910.)	Second sample, Well 12. (Submitted Nov. 22, 1913.)
Sulphuretted hydrogen	....	None.
Carbon monoxide	None.	None.
Carbon dioxide	None.	None.
Oxygen	Trace.	None.
Nitrogen	Trace.	7
Illuminants	None.	None.
Methane	73	85
Ethane	27	8
Hydrogen	....	None.
Total	100	100
Properties.		
Specific gravity (air 1)	·686	·614
Weight of 1,000 cu. ft	55 pounds.	49¼ pounds.
B.T.U. per 1,000 cu.ft	1,280,000	1,063,000
Large calories	320,000	....

Equivalency of 1,000 cu. ft. to pounds of Pittsburgh coal	95
Equivalency of 1,000 cu. ft. to pounds of anthracite coal	85

A sample of gas from Well No. 3 analyzed for gasoline by Frank F. Peterson, chief chemist of the Bessemer Gas Engine Company, Grove City, Pa., January 18, 1912, showed "hydrocarbons in excess of CH_4" 34 per cent; carbon dioxide, none; oxygen, 2 per cent; the "estimated yield based on two stage condensing pressures not lower than 250 pounds per square inch," being equal to ½ gallon of gasoline per 1000 cubic feet. Up to the present time the attempt is not made to extract such small amounts of gasoline.

Disposal of the gas.—The gas from the Stony Creek field is piped to Moncton through a 9⅝-inch pipe, 10 miles in length, and to Hillsboro through a 4¼-inch pipe (inside diameters) 6⅝ miles long. The former is laid 3½ feet and the latter 1½ feet below the surface. The gas at Moncton is distributed by the Moncton Tramways, Electricity and Gas Company.

The gas is sold by the distributing company at 38 cents net per 1000 cubic feet and 15-16 cents net for commercial purposes. The maximum consumption to date, including both Moncton and Hillsboro, was in February, 1913, when approximately 98,000,000 cubic feet were used, or about 3,400,000 per day. In August, which was the month of lowest consumption to the time of this investigation, about 48,000,000 or 1,600,000 cubic feet daily were supplied. Approximately one-fifth is used for domestic purposes, the balance being used for fuel and other industrial purposes by the Intercolonial railway shops, etc.

Volume and pressure of gas in Stony Creek field in New Brunswick.—Up to September, 1913, the total number of wells which had been completed in this field was thirty; and three wells were drilled at that time. The amounts of gas found in these thirty wells ranged from 0 up to a maximum of 7,000,000 cubic feet per day initial volume, and the total initial volume of all the wells was about 50,000,000 cubic feet per day. It should not be assumed, however, that the field ever reached this maximum production at any one time. The original rock pressure in this field ranged from 30 pounds up to 725 pounds per square inch, according to the location of the well and to the depth and identity of the producing sand.

The present capacity of the gas wells is much less. In September, 1913, the volume, as determined by the Associated Geological Engineers in Pitot tube measurements, was about 10,000,000 cubic feet per day.

PETROLEUM PRODUCTION IN 1911-12.

The following figures give the reported production of petroleum in New Brunswick, the figures being taken from the reports of the Canadian Department of Mines[1].

Year	*Barrels*	*Value*
1911	2,461	$3,019
1912	2,679	3,799

NATURAL GAS PRODUCTION IN 1911-12.

The quantity of natural gas produced in New Brunswick in 1912 is reported as 173,903,000 cubic feet, and its value is given as $36,549. No natural gas was sold in this Province previous to 1912, the output from 1909 to 1911 inclusive being used in further drilling. The production in 1913 is estimated as 800,000,000 cubic feet. During the year ending September 30, 1913, eleven new wells were begun in the Stony Creek field, two of them being still in progress of drilling. The following is a detailed statement of the depth and initial production of these new wells:—

Well No.	Depth feet	Initial Flow cu. ft. per day	Remarks
31	2,050	33,624	
32	1,115	6,896,640	
33	2,120	38,500	
34	1,745	65,000	
35	1,362	2,500,000	
36	1,640	2,168,480	
37	2,141		Work temporarily suspended
38			Drilling proceeding
39			" "
40	1,230		Abandoned. Hard limestone
41	1,130	884,520	

[1]John McLeish, Sum. of Min. Production of Canada for 1912. Canada Dept. of Mines, Mines Branch, p. 28.

Cost of Wells and Kinds of Casing.— The following are the average lengths and weights of casing used in this field:—

Size	*Weight*	*Length*
in.	*lb.*	*ft.*
13	54	150
10	32	400
8	24	1000-1500
$6\frac{5}{8}$	17	1200-2000
$5\frac{3}{16}$	17	

NOTE: If they obtain salt water below the gas this size of casing is used, but salt water was only found in one well, and hence the $5\frac{3}{16}$" casing has only been used in one well.

The cost of wells in this field is about $10,000 each. They use a rubber packer made by Broter, of Kane, Pa.

The Albert Mines.

In 1849 Dr. A. Gesner discovered on Frederick brook near the present site of the Albert mines, a vein or bed of a bright, jet-black, shiny mineral, afterwards identified as mineral pitch or bitumen, and called albertite. This mineral proved on investigation to be of great value and was mined for nearly 30 years at great profit. The records of production were destroyed but it was known that in each of the years 1865 and 1866 the output of albertite was 20,500 tons, while the total from 1863 to 1874 amounted to 154,800 tons, and during the entire period of working it was probably not far from 230,000 tons.[1] The prices ranged from $15 to $20 per ton.

Albertite is a solid bitumen representing the residuum of petroliferous seepages. It occurs in veins in the Albert shales at several points in Albert and Westmorland counties. While in itself an indication of petroleum in past times rather than at present, it is generally associated with petroliferous shales, and in the Albert mine liquid petroleum was actually collected in buckets from seepages from sandy beds included in the shales associated with the albertite. Albertite is not a coal, notwithstanding the opinions of certain interested parties or legal decisions, but is a petroliferous residuum and therefore to be classed among the indications of oil, at least to the extent indicated above.

[1]Ells, R. W., The Bituminous or Oil Shales of New Brunswick and Nova Scotia. Geol. Surv. Canada, 1909, part 2, page 9.

The following description of the occurrence of this mineral is taken from Young[1]:—

The Albert series at Albert Mines outcrops over an area about 1¼ miles long in an east and west direction and having a variable width of from ¼ to ¾ mile. The strata are comparatively well exposed in the eastern part of the area, along the various branches of Frederick brook. The measures, in general, dip to the south with angles varying from 15 degrees to nearly 90 degrees. On one branch of the brook, the crown of an anticlinal fold is visible, and it has generally been stated that the measures lie in an anticlinal fold whose axis strikes east and west. The strata as exposed consist chiefly of dark, thinly bedded shales, and thin beds of dark limestones. At certain horizons occur oil shales heavily impregnated with hydrocarbons. Two main varieties of oil shale are present. In the case of one variety—"curly shales"—the rock is compact, splintery, and the bedding planes in many instances are minutely crenulated. In the case of the second variety—"paper shales"—the beds split into thin, slightly flexible sheets.

The mining operations at one time carried on in this area and the extent of which is indicated by the large dumps, were conducted for the purpose of winning the substance albertite, fragments of which are abundant in the mine dumps. Albertite, by many authorities classed with asphalt, and supposed to be a solidified form of petroleum, is a black substance, having a conchoidal fracture and a hardness of about 2 on the ordinary scale of hardness. It is easily fusible and readily ignites in an ordinary flame. It is essentially composed of hydrogen and carbon with about 3 per cent of nitrogen, 2 per cent of oxygen, and a trace of sulphur. The mineral occurs filling fissures, usually narrow, not only in the Albert series but in younger Carboniferous strata. Most of the reported occurrences of such veins have been within a radius of a few miles from Albert Mines. The only large vein ever discovered was that occurring at Albert Mines. This vein, it is said, was mined over a distance of about ½ mile to a depth of 1,100 feet or more, beyond which it became too narrow to be profitably worked. The vein was nearly vertical and followed an almost straight course along the general direction of the anticlinal axis in the country rock, but varied in width up to 15 feet and sent apophyses into the adjoining strata.

Regarding the origin of the albertite oil shales, and natural gas and petroleum occurring in the accompanying sandstones as developed in the Stony Creek oil fields, two general views have been held. On the one hand, it has been thought that the various hydrocarbons are of secondary origin, derived from sources outside of the Albert series. The second view is that the hydrocarbons are indigenous to the shales and that they have been derived from organic matter entombed in the sediments. This latter view of the origin of the hydrocarbons seems particularly applicable to the known facts in connexion with the Albert series.

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[1]Young, G. A., Twelfth International Geological Congress; Guide Book, No. 1. Issued by the Geol. Survey, Canada, 1913, pp. 366-367. Part II.

OIL AND GAS INDICATIONS.

Oil springs.—Oil springs or seepages are of widely distributed occurrence in New Brunswick. They are naturally most abundant where the petroliferous Albert shales come to the surface, especially along the rim of the Carboniferous basin in Albert and Westmorland counties. The localities characterized by pronounced seeps in the counties mentioned include the Stony Creek, Weldon, Hillsboro and the Baltimore shale district of Albert county, and the Belliveau, Dover, Memramcook, Dorchester, Pré d'en Haut and Rockland districts on the east side of the Petitcodiac river in Westmorland county.

Oil seeps are not, however, limited to the areas of Albert shales, nor even to the vicinity of the edge of the Carboniferous basin. Among the seeps or stains reported in the higher Carboniferous rocks at some distance from the rim of the basin may be mentioned those near Rockport (Sackville), Lakeburn and Legers Corner (Moncton), and Barachois (Shediac), in Westmorland county, Coal Branch Station, Kent county, Coughlan (Blackville), S. Renous (Blissville), Doaktown, and possibly other localities along the Miramichi valley in Northumberland county, and Shippigan island, Gloucester county, located close to the outcrops of the sands, but generally many miles distant. Where traces of oil are found on the outcrop, it is because they have moved outwards from distant pools, or are the relics of some ancient pool, the balance of which has often escaped years ago. Therefore, no large oil pool should be expected in the vicinity of the Old Dover and Memramcook pools, where the sands reach the surface, or where the Albert shales outcrop.

In some countries, as in Mexico, oil seepages are of different types, reaching the surface through faults or fissures, and in such localities, particularly if the formations are of recent age, good oil pools are frequently found directly below; but this type of seepage is not known in New Brunswick.

Gas springs.—Gas emanations, although less noticeable, are presumably even more numerous than oil seeps, with which they are often associated. In Albert county, gas emanations

TABULATED ANALYSES

No.	OIL (gals. per ton)	AMMONIUM SULPHATE (lbs. per ton)
1	42-47	85-101
2	27	29
3	30-49	50-80
4	30	38
5	40	41
6	54	110
7	40	77
8	49	67
9	56	30
10	30	75
11	4	
12	14	

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occur in the vicinity of Stony Creek oil field, near the Albert Mines, water wells penetrating the sandy shales at Elgin, and at various other points. In Westmorland county, gas emanations are said to occur in the vicinity of the old oil developments. Near Sussex, Kings county, gas is reported in a quarry in the hills one mile southeast of the town and south of the railroad, the flame running along the bedding plane of the freestone for several feet when ignited.

The foregoing are all within a short distance of the border of the Carboniferous basin. Gas emanations from the higher Carboniferous rocks at some distance from the boundary have been reported at Legers Corner and Chartersville (Moncton), Westmorland county, at Buctouche, Kent county, at Shippegan island, Gloucester county, etc.

The statements concerning the futility of drilling near oil springs apply equally in the case of natural gas, which is practically never found in large quantities near the outcropping of the containing stratum.

Petroliferous shales and sands.—Petroliferous shales, containing from 20 to 50 gallons of oil per ton, are found at a number of points in the north and east foothills of the Caledonian range in Albert county. The beds, which are referred to the Albert shale series, lie against the great mass of Pre-Cambrian crystalline rocks, giving rise to the range of hills mentioned, and are strongly folded and faulted. All dips up to vertical are noted. The best known localities are the Baltimore or Rosevale district in southwestern Hillsboro parish, and the Albert Mines and other localities in Hillsboro and Coverdale. Oily shales or petroliferous sands of the same series are noted at numerous points along the Petitcodiac river from Shepody bay to Stony creek in Albert county. A large area of non-petroliferous shales of the same general type occurs near Elgin.

In Westmorland county oil shales and sands occur at intervals along the Petitcodiac from Dover to its mouth, while the same series, although not so petroliferous, extends from the Petitcodiac river south of Dover to the Memramcook river between Memramcook and College Bridge station. Outliers of the same shales are mapped at Dorchester, near Taylors

Village, and opposite Edgett landing, and possibly occur at other scattered localities. Shales of similar general character, but essentially non-petroliferous, are brought up by the strong anticline near Indian mountain, north of Moncton.

TEST BORINGS FOR OIL AND GAS.

Distribution of test borings.—Although a considerable number of scattered borings have been put down in search for oil and gas in New Brunswick, a large percentage were sunk for water or in testing for coal. Those sunk in search of oil or natural gas are limited mainly to the Dover and St. Joseph oil fields between the Petitcodiac and Memramcook rivers, and the Stony Creek gas field across the Petitcodiac from the Dover oil developments. The Maritime Oilfields, Limited, has, however, drilled a few wells in outlying territory, as noted elsewhere.

In selecting sites for drilling, the presence of oil or gas springs or the outcrops of petroliferous shales and sands seem to have been the determining factors in a majority of cases. Geologically, the wells of the developed oil and gas fields are located, with the exception of a number of the St. Joseph oil wells, on slopes intermediate between the axes of the adjacent anticline and syncline. In the outlying territory the same principle seems to have been followed by the Maritime Oilfields, Limited, the wells being in no case located on the crest of known anticlines.

Results of drilling in the Dover and St. Joseph oil fields.—The number of wells in these two fields was approximately eighty. About half of the wells are stated to have been commercially productive, the original yield varying from $\frac{1}{4}$ to 50 barrels a day. A total of several thousand barrels is reported to have been pumped by the New Brunswick Petroleum Company. The production fell off rapidly, however, and all wells were abandoned in the course of a few years.

The early wells were only about 190 feet deep, but the majority of the later ones were from 500 to 800 feet, while several were from 1000 to 2000 feet or over in depth and one was 3000 feet in depth.

The upper sands of the St. Joseph and Dover fields may be regarded as having been tested with reasonable thoroughness, but in general the wells failed to reach the deeper sands, while owing to the failure to effectually shut out the water, the yield of most wells was below the normal; nevertheless, the yield was probably fairly typical of that to be expected elsewhere in the Province where the geological conditions are similar.

Results of drilling in the Stony Creek field.—The Maritime Oilfields, Limited, began operations in this field in 1909, and to date have drilled between 35 and 40 wells, the majority of which have produced gas in paying quantities, the original yield ranging, it is stated, from 17,000 to nearly 7,000,000 cubic feet per day. The aggregate initial yield of the first 23 wells was about 50,000,000 cubic feet daily, but the present production (September, 1913) is about 12,000,000 cubic feet per day. The rock pressures run as high as 725 pounds per square inch, which may be taken as about the maximum original rock pressure in the deep sand.

In addition to their yield of natural gas, many of the wells have supplied small quantities of petroleum, the original production sometimes being several barrels per day. In September, 1913, from 250 to 300 barrels per month were being pumped from the wells of this gas field.

The yield of gas and petroleum is probably fairly representative of the possibilities of a field developed in disturbed areas along the margin of the Devono-Carboniferous basin.

Table of New Brunswick Test Borings.

(For locations, see map, and Figs. 2 and 3).

County.	Locality.	Depth.	Remarks.
Gloucester...........	Shippigan Island......	300	Entered bituminous shales with shows of oil and gas.
Northumberland......	Chatham............	400	Bottom in Lower Carboniferous red shale, probably about 100 feet below Millstone Grit. No record of oil or gas.
	Chatham (pulp mill)..	800+	"Mostly in freestone." No oil or gas is reported.
Kent...............	Beersville (New Brunswick Petroleum Co.).	350	In Middle Carboniferous sandstone. Shows of oil and gas. Well shot, but no commercial production secured.
	Buctouche (between Buctouche and Richibucto.	600	"Stevens" well. Oil shows reported to have been found.
	Cocagne (3 miles west of Lower Bridge).	857	Mostly in freestone. No record of oil or gas.
Westmorland.........	Canaan (Well No. 30 of Maritime Oilfields, Limited).	1,230	Struck dark micaceous granite at 1,098 feet. Upper portion is red shales.
	Lutz Mt. (John Harris lot).	735	Grey to red sandstone and shale. No record of oil or gas.
	Lutz Mt. (Peter Wilson lot).	624	Grey to red sandstone and shale. No record of oil or gas.
Westmorland.........	Legers Corner (Well No. 1 of Maritime Oilfields, Limited, 3 miles east of Moncton).	1,220	Mainly in Middle Carboniferous shales and conglomerate. Did not penetrate Albert shale. No oil or gas.
Westmorland.........	Dorchester parish (Well No. 2 of Maritime Oilfields Limited) between Memramcook and Dover.	2,400	Red conglomerate (Middle Carboniferous) 0-208 feet; shales, prevailingly red. (Lower Carboniferous) 208-1,768; shales, presumably black (Albert series?) 1,768-2,250; red sandstone 2,250-2,400. No oil or gas.
Westmorland.........	Taylor's village (Well No. 29 of Maritime Oilfields, Limited).	750	Mainly blue and grey shale, of Albert series. Dips high. Oil horizons not encountered.
Westmorland.........	Dover (Well No. 4 of Maritime Oilfields, Limited, lying directly east (magnetic) from Well No. 3 of Stony Creek field.	1,675	In Albert shales, similar to Stony Creek field. Sands present but not productive.
Westmorland.........	Dover (Well No. 1 of New Brunswick Petroleum Company, Limited, one mile north of village.	(?)	First 400 feet in dark shales, balance in reddish sandstone and feldspathic rocks.
Albert..............	Turkey creek (west of Rosevale).	(?)	Oil seeps from two diamond drill borings in oil shales.
Albert..............	Baltimore siding (Well No. 27 of Maritime Oilfields, Limited).	2,645	Entirely in red conglomerate and interbedded shales and sandstones, presumably of Middle and Lower Carboniferous. No oil or gas.
Kings..............	Dunsinane (between Petitcodiac and Sussex).	1,292	Middle Carboniferous sandstone and conglomerate. Some coal, but no record of oil or gas.
	Sussex (Bank of Nova Scotia).	700	Two or more pockets of gas. Rig burned by ignition.
	Sussex (mineral well).	250	Sufficient gas to burn. Stated to have been hydrogen sulphide.
	Sussex (Maritime Oilfields, Limited, Well No. 40).	1,200+	Mainly in hard grey shales, only small pockets of gas encountered.
Queens.............	Newcastle Bridge.....	171	Sandstone and shale. No record of oil or gas.
	Newcastle Bridge.....	366	Lower 150 feet in hard grey sandy slate, with quartz and calcite veins.
Sunbury............	On Little River (Sheffield parish).	399	Lower 139 feet in hard grey sandy slate with quartz and calcite veins. No record of oil or gas.


Westmoreland Co. 2000' N.E. of Canaan Sta. Maritime Oilfields Co. Well Nº 30.
Westmoreland Co. Taylor Village Maritime Oil-fields. Well Nº 29.
Westmoreland Co. Moncton. Parish 3 m. W. of Moncton Maritime Oil-fields. Well Nº 1.
New Brunswick Petroleum Co. Well Nº 80.
New Brunswick Petroleum Co. Cain Powell Farm. Well Nº 75.
New Brunswick Petroleum Co. Well Nº 36
New Brunswick Petroleum Co. Powell Farm Well Nº 43.
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8¼"

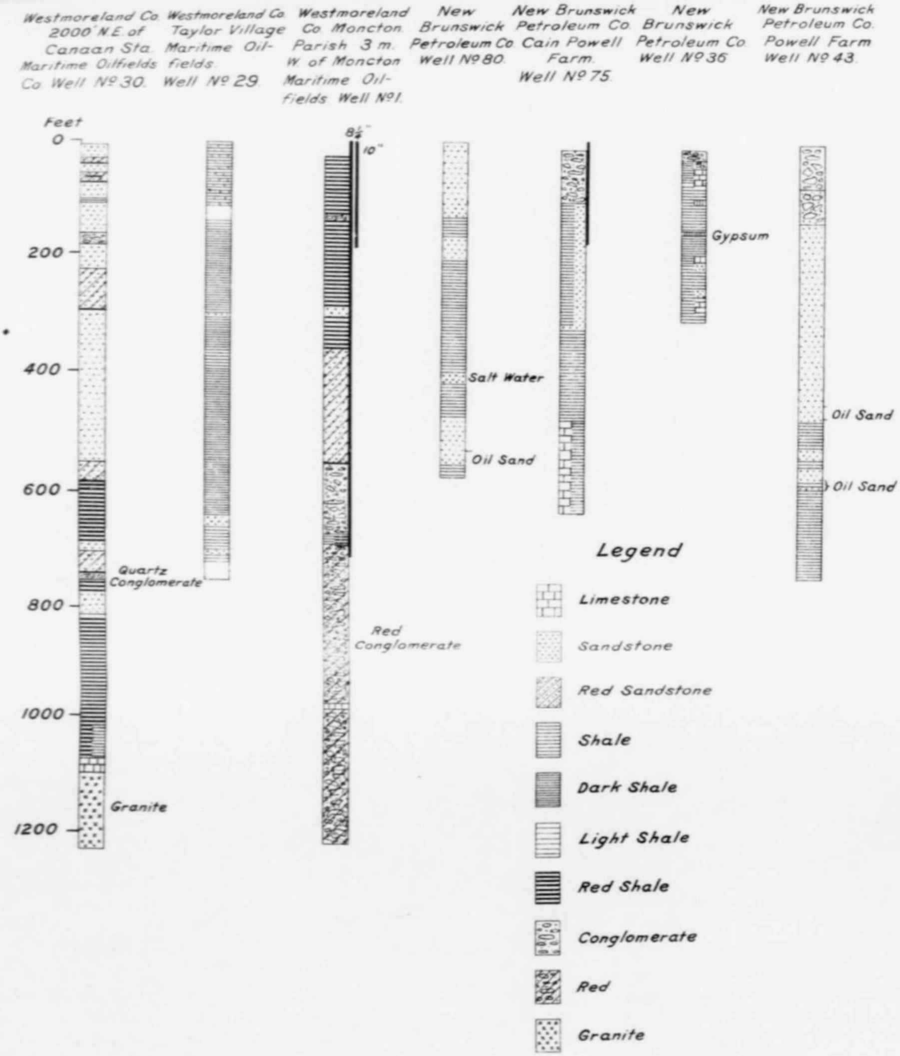

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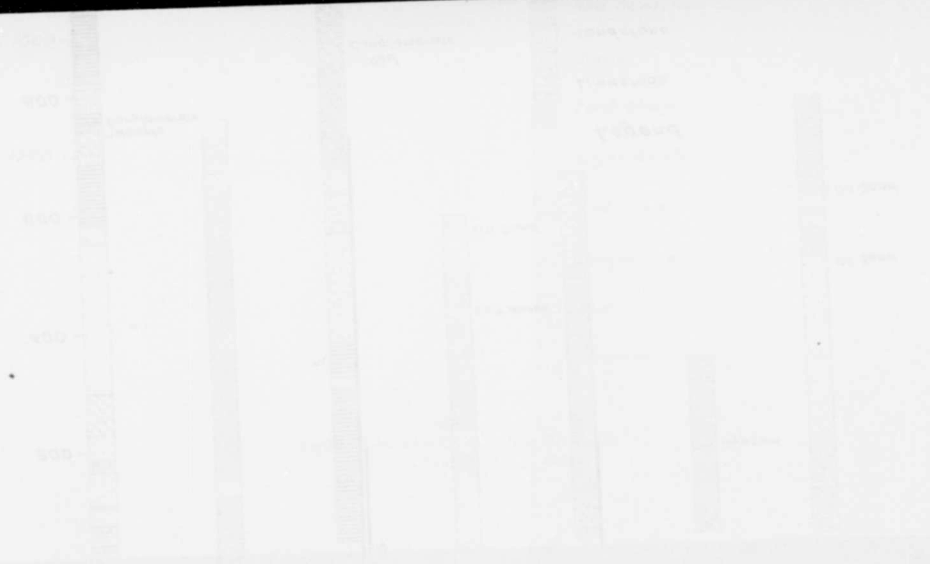
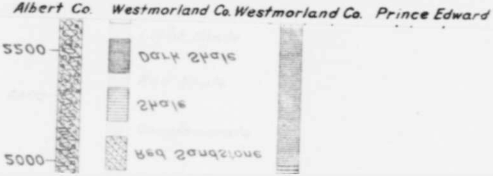
Fig. [redacted] Selected well logs in New Brunswick.
(By F. G. Clapp and M. L. Fuller)





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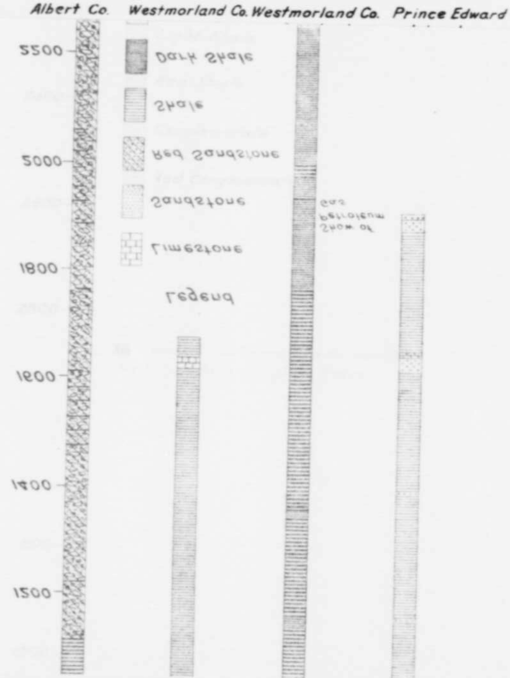
Albert Co.
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Westmorland Co.
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Show of petroleum gas

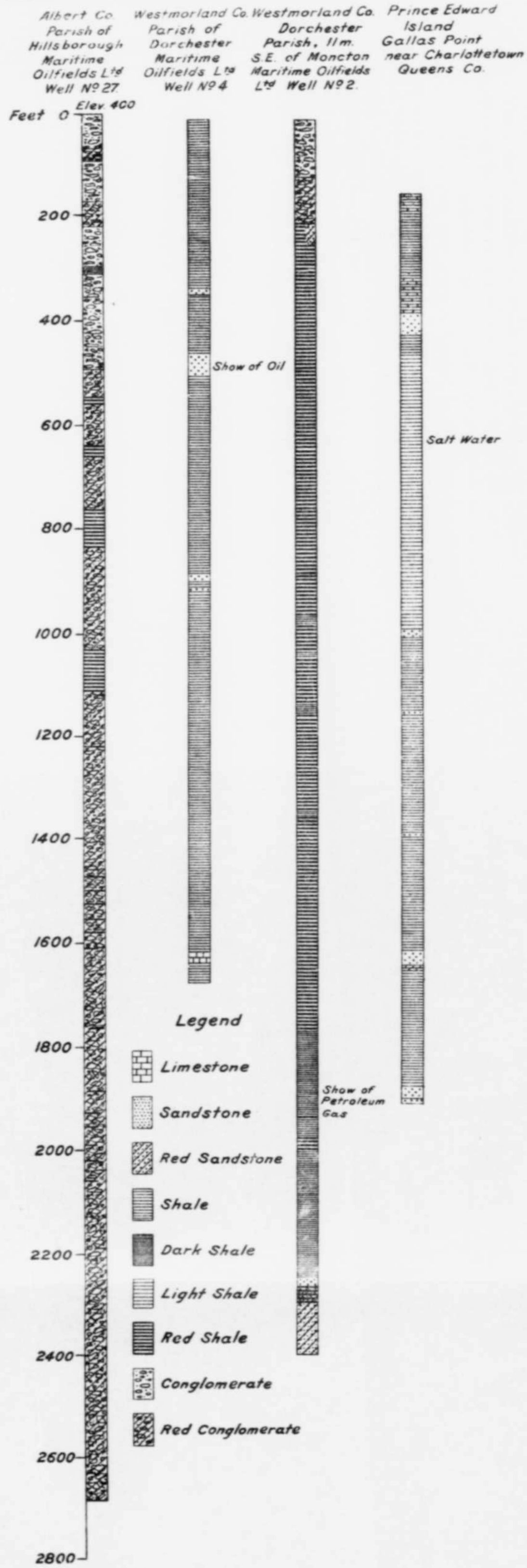

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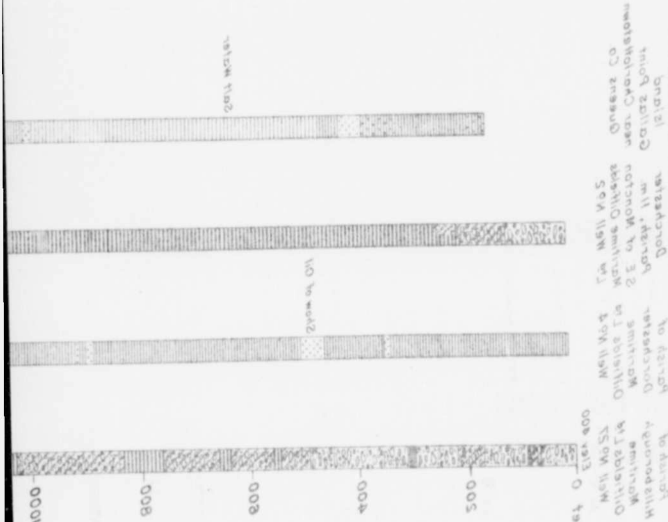
Fig. [redacted] Selected well logs in New Brunswick.
(By F. G. Clapp and M. L. Fuller)



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The above depths of borings, except those on the Maritime Oilfields, Limited, are based largely on those given in the reports of the Canadian Geological Survey. Common reports often erroneously give much greater depths.

GENERAL CONCLUSIONS.

In general it may be said that outside the developed oil and gas fields the borings so far made have not afforded, because of insufficient depth or poor locations, any real test whatsoever of the oil or gas possibilities within the Province of New Brunswick. To be conclusive, new borings located in accordance with approved structural principles and carried to the Albert shales, or in their absence, to the underlying crystalline or metamorphic rocks, will be necessary to establish the presence or absence of petroleum or natural gas.

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CHAPTER IV

PROVINCE OF QUEBEC

GEOLOGY[1]

Stratigraphy

GENERALIZED SECTION

A generalized section of the formations occurring in Quebec will include the following[2]:—

Period.	*Formation.*	*Thickness.*	*Material.*
Devono-Carboniferous	Bonaventure	1200+feet	Red conglomerates and sandstones.
Devonian	Gaspé sandstone	7000– "	Red, brown and grey sandstone.
"	Various limestones	2000 "	Limestones and calcareous shales.
Silurian	Silurian		Limestones, clay-slates, and sandstones.
Ordovician	Lorraine and Richmond	2000 "	Greyish shales and sandstones.
"	Utica	300 "	Black bituminous shales.
"	Trenton-Black River	600 "	Limestones.
"	Chazy	300 "	Mostly limestone.
"	Beekmantown	300–450 "	Magnesian limestone.
Cambrian	Potsdam	300–700 "	Sandstones.
Pre-Cambrian Laurentian Huronian, etc.			Mostly gneisses, limestones and granites.

[1]Edited and revised by Alfred W. G. Wilson.
[2]Table of formations compiled by F. G. Clapp.

DESCRIPTION OF GEOLOGICAL FORMATIONS.

Laurentian and Pre-Cambrian: The greater part of the territory north of the St. Lawrence river, and as far north as Hudson strait, with the exception of a very narrow strip close to the river and extending from near Quebec to Calumet island on the Ottawa river, is underlain by highly crystalline igneous and metamorphic rocks. These rocks comprise batholithic granites, gneisses, anorthosites, gabbros, crystalline limestones and quartzites. This type of rock never holds oil or gas in commercial quantities.

The Geological Survey maps the larger part of this area as Laurentian and undivided Pre-Cambrian. Within this territory are, however, a number of areas underlain by rocks of sedimentary origin, the youngest of which are mapped as Keweenawan or Animikie. One of these areas lies along the basin of the Kaniapiskau, and has a lineal extent of over 500 miles Smaller areas occur east of this near Lake Miskikamau and on the Naskaupi river above Lake Melville. Two other small areas, one in the vicinity of Lake Mistassini and the other bordering Richmond gulf on the east side of Hudson bay, are also shown.

Potsdam Sandstone.—This sandstone is the lowest sedimentary formation recognized in the basin of the St. Lawrence in the province of Quebec. Where contacts are found it is seen to rest directly upon the underlying floor of Pre-Cambrian crystallines. On the island of Montreal the total thickness developed varies from 300 feet to 700 feet.

Beekmantown Limestone.—This formation rests immediately upon the Potsdam. It varies somewhat in character from a dolomite or magnesian limestone to an arenaceous and cherty one. It appears to be from 300 to 450 feet in thickness.

Chazy Limestone.—This formation immediately succeeds the Beekmantown and consists of limestone of varying character interstratified with which are shaly layers. In the vicinity of Montreal the thickness of the Chazy is about 300 feet.

Black River and Trenton Limestones.—The Chazy merges upward insensibly with the Trenton group, which consists of limestones of Black River and Trenton age, from which it cannot always be differentiated, since they appear to merge with each other. The Trenton is the formation which contains large quantities of oil and gas in northwestern Ohio and northeastern Indiana, and which has good showings of gas in certain parts of Ontario. While it underlies a large part of the St. Lawrence valley, it also outcrops extensively on both sides of the valley, and there is no great probability that it will be found productive of natural gas or oil in the Province of Quebec. The Trenton group is supposed to be about 600 feet thick in the province. In places, this group rests directly on the granite and gneiss, but in other localities it is separated from the crystalline rocks by Potsdam, Beekmantown, and Chazy.

Utica Shales.—Resting immediately upon the Trenton limestone is the Utica, which forms the cap rock, over the oil and gas in the Ohio and Indiana fields. The Utica consists of black and frequently bituminous shales, its maximum thickness being about 300 feet.

Lorraine Shales.—The Utica passes upwards into the less bituminous and somewhat sandy shales of the Lorraine formation, which have a thickness in the Province of Quebec of about 2,000 feet.

Richmond and Gamachian.—Recent investigations of Schuchert and Twenhofel, on the Island of Anticosti, have resulted in the recognition of a characteristic Richmondian fauna. The strata assigned to this series consist chiefly of shales and thin-bedded limestones prevailingly grey or greenish grey in colour, and have a total thickness of about 1,150 feet. Overlying the Richmond series is about 180 feet of strata, chiefly thin-bedded grey limestones with shale partings and distinct zones of shale, but also containing some sandstone beds. This series has been named the Gamachian series. This name is intended to include all American deposits later in age than the youngest Richmondian of Indiana and Ohio and older than the Anticosti series, which in the United States is thought to have its basal equivalent in the typical Medina and Edgewood stages.

Elsewhere in the province strata that are now classed as Lorraine may, on more careful study, be found to belong to the Richmond.

Silurian.—Isolated areas of Silurian rocks occur in synclinal basins southeast of the St. Lawrence river. They are composed chiefly of limestones characterized by a coral fauna. The main area of Silurian rocks, however, forms a belt from 4 to 10 miles wide reaching from the coast near the mouth of Grand river to the Temiscouata river in New Brunswick. This belt is made up of sandstones and shales of Niagara age, and white sandstones and calcareous rocks of Lower Helderberg age. The rocks of this belt dip steeply and are closely plicated, while the whole series passes unconformably beneath the Devonian formation of the synclinal basin of the central Gaspé region.

Devonian.—The Devonian rocks outcrop in the Gaspé region, and consist of impure limestones in the lower portion followed by purer limestones and both overlain by the Gaspé sandstone which covers a large portion of the region. The latter formation consists of a heavy mass of red, grey, and brown sandstones with many coarse pebble layers. The thickness of this sandstone was estimated by Logan at 7,000 feet but Ells thinks this figure is too high on account of the extensive faulting. The formation contains abundant plant and invertebrate remains which shows its age to be middle Devonian.

Carboniferous.—Skirting the southern margin of the Gaspé peninsula is a great mantle of red conglomerates and sandstones unconformably overlying the Gaspé sandstone and lower formations. The formation is almost horizontal throughout its extent. Its thickness is not known though sections 1,200 feet in height are exposed. Its conglomerates are largely made up of blocks and boulders of the fossiliferous rocks underlying, from Cambrian to Devonian. These blocks and boulders are often of enormous size. The formation was described by Logan as of Carboniferous age, but is now generally believed to represent the later stages of the Devonian as well as the early part of Carboniferous time.

Volcanic Intrusions.—In the southern part of the province of Quebec, occurring as isolated more or less conical hills sometimes several miles in diameter, are a number of masses of syenite and similar volcanic rocks, which constitute the roots or necks of ancient volcanoes. Frequently dikes of similar rock radiate from these masses. These occur in the counties of Hochelaga, Chambly, Rouville, and Shefford. Mount Royal at Montreal is one of the most interesting hills of this type. Large masses of other igneous rocks occur in outlying portions of the Province, in Terrebonne and Montcalm counties toward the northwest, and extending north from the northern edge of Lake Memphremagog. While it is a fact that oil fields are found in Mexico and some other parts of the world where volcanic necks of this type rise up out of sedimentary formations in the midst of a broad depression, it is believed that such conditions do not prevail in the Province of Quebec, because the rocks are ancient and are more or less faulted and porous, and the oil and gas must have leaked away ages ago. If they existed now, they would undoubtedly be evinced by seepages.

Geological Structure.

As that portion of Quebec lying northwest of the St. Lawrence river is underlain by the ancient crystalline rocks without the possibility of the occurrence of oil deposits, its geological structure need not here be described. Between the St. Lawrence river and the southeast border of the Province, the rocks are thrown into a series of long parallel folds with faulting. In the Gaspé region, these anticlinal folds are five in number, named as follows beginning at the north: Forillon, Haldimand, Tar Point, Point St. Peter, and Malbaie or Percé anticlines. These are described more in detail in the section on developments in Gaspé county. In the plain of the St. Lawrence, northeast of the Champlain fault, Palæozoic sedimentary strata occur in very considerable thickness. In certain localities, so far as surface indications go, a number of low anticlinal structures have been developed. Preliminary drilling operations have shown the existence of natural gas in association with one of these folds. Further and deeper exploration is necessary to determine if either gas or oil occurs in commercial quantities.

Gaspé County.

GENERAL DESCRIPTION OF FIELDS.

Gaspé, the most northeasterly county of the peninsula of Gaspé, is the only county in Quebec which has ever produced oil in commercial quantity; and this field was so unsuccessful as never to have been profitable.

The surface of the country, a short distance inland, is usually very rugged, with high ranges of hills, reaching in places, elevations of 1,200 to over 1,500 feet. The country itself is genererally densely wooded and except along the lower portion of the several rivers entirely unopened for settlement. Owing to forest covering, and the heavy deposits of drift, which are found over much of the area, good rock exposures are rarely met with off the lines of the principal streams. On many of the side streams also the banks are composed of clay, gravel or other drift. The thickness of these drift deposits has been found in some of the boring locations to be nearly 100 feet.

The area in which boring has been done extends in a northwesterly direction from Seal cove on the south side of Gaspé bay to Falls brook, a branch of the York river, 33 miles distant.

HISTORY OF DEVELOPMENTS.

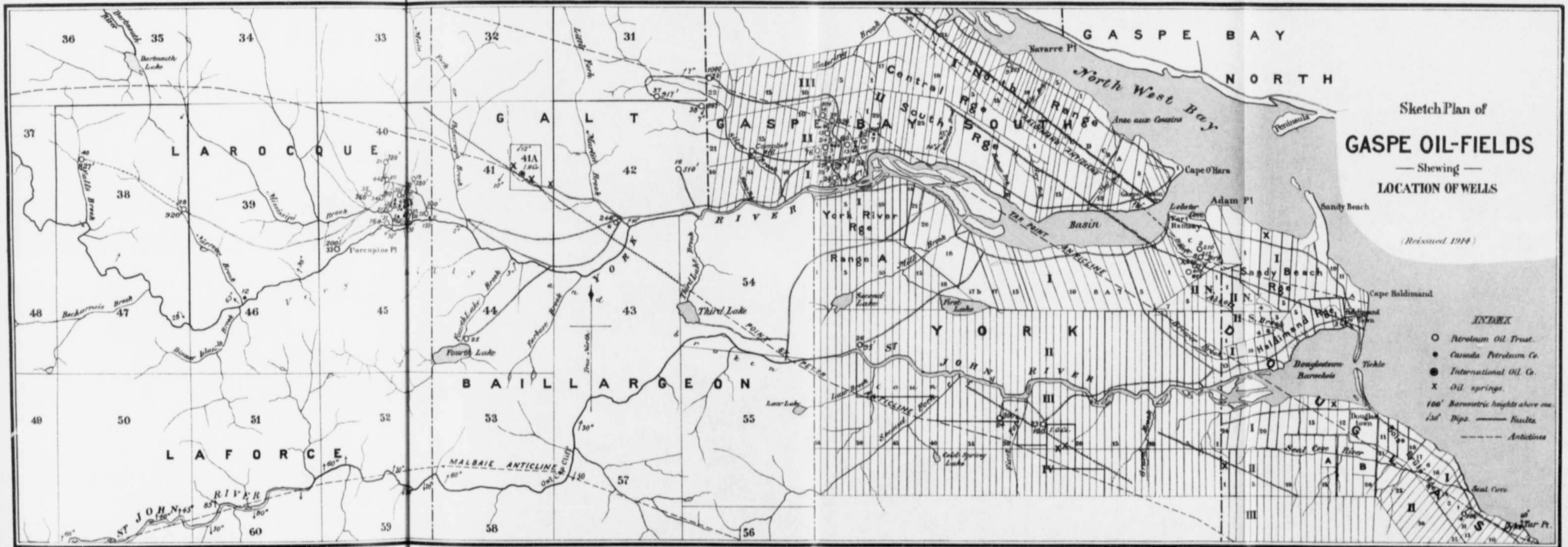
Wells were sunk in this locality as early as 1868, when the Sandy Beach well was drilled to a depth of 684 feet and was abandoned. In 1889-91 five wells were sunk in the same vicinity by the Petroleum Oil Trust of Montreal, their operations being continued until 1901 and more recently. In one of the wells situated at Seal cove, the total depth was about 3,000 feet. A small show of light green oil, yielding in all about 20 barrels, was obtained in one of the wells.

Most of the drilling in Gaspé county was done in 1891 and 1892. A number of wells were also sunk (forty in all) by the Canadian Petroleum Company. Some of these wells

Canada
Department of Mines

Hon. L. Coderre, Minister; R.W. Brock, Deputy Minister.

GEOLOGICAL SURVEY



C.O. Senécal, Geographer and Chief Draughtsman.
V. Perrin, Draughtsman.

Scale 2 miles to 1 inch

Chains — Miles

Location of wells and tracks from plans supplied by the Petroleum Oil Company

Reprinted for Mines Branch, to accompany Report on "Petroleum and Natural Gas Resources of Canada", by Frederick G. Clapp. Map No 295.

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obtained small amounts of oil, and were pumped for a month or more. The depths were frequently over 2,000 feet.

According to the Geological Survey of Canada, fifty-two wells were drilled altogether in this field. There is no doubt but that the property was very badly managed.

Of the wells drilled in this county, thirty-nine were sunk by the Petroleum Oil Trust of London, twelve by the Canadian Petroleum Company, and one by the International Oil Company.

Wells were still drilled as recently as 1901 by the Canadian Petroleum Company; well No. 28 being sunk in 1898, five miles west of the York river, and two and one-half miles south of St. Peter anticline, the total depth being 3,525 feet, without result. A large amount of salt water was found in most of these wells, Most of the wells range in depth from 1,500 to 2,600 feet.

The greatest depth of any well in the Gaspé field is reported to have been 3,700 feet.

OPERATING COMPANIES.

The Oilfields of Bonaventure, Limited, with office at 66 Broad Street Avenue, E. C., London, England, was registered January 17, 1898, as the Irish Proprietary Oil Fields of Gaspé, Canada, Limited, and owns 1,500 acres of freehold land and 500 acres of mining rights in the Province of Quebec, also two acres of wharfage land at Gaspé. In December, 1899, the name of the company was changed to the Oilfields of Gaspé, Canada, Limited, and in June, 1912, to the present title. Three wells have been sunk and oil struck at 1,000 feet. Negotiations are in progress for the acquisition of rights over 5,000 acres in the Bonaventure portion of the oilfield.

The Eastern Canada Company, Limited, with office at 62 London Wall, London, E.C., England, was registered June 30, 1911, to acquire the oil and mining rights over 60,000 acres in the Gaspé region. The licenses are held in perpetuity from the Quebec Government, subject to a rental based upon 12,000 acres only and a royalty of 30 per cent of the petroleum produced. Boring operations are in progress; depth of No. 1 well in

February, 1913, 570 feet; formation, grey sandstone. In May, 1913, this well had reached a depth of 2,500 feet from the surface.

FORMATIONS PENETRATED BY THE DRILL.

The geological formations forming the surface, immediately below the Glacial Drift, in Gaspé county consist, to the north, of Utica and Lorraine shales, which form a belt with a maximum width of five miles along the extreme northern border of the county. The next succeeding belt to the south is the Sillery formation of Cambrian age, the surface width of which ranges from four miles at the eastern end to twenty miles near the western end. A complicated area of considerable size in the western corner of the county consists of Pre-Cambrian, Cambrian and Silurian rocks; and in the southern corner of the county there are perhaps 150 square miles of Cambrian metamorphic rocks. Along the southeastern edge, bordering the Gulf of St. Lawrence, is a belt not over two miles in width of Carboniferous rocks belonging to the Bonaventure formation. The remaining portion of the county, consisting of more than half its area, is of Silurian and Devonian rocks, with occasional local dikes of trap. As noted on a preceding page, the Devonian rocks consist of impure limestones below, passing upward into purer limestones, these being overlain by the Gaspé sandstone. This series of limestones and sandstones is involved in the folding described below, the axis of the folds exposing Silurian and Devonian limestones, the synclines and flanks of the anticlines being made of the Gaspé sandstone.

GEOLOGICAL STRUCTURE.

The geological structure of the formation occupying the sedimentary areas in Gaspé county is naturally very complex, there being numerous anticlines and synclines and considerable faulting. It might be supposed that the conditions would be very favourable for the existence of oil and gas fields. However, there are a number of extremely unfavourable circumstances, among which may be mentioned the frequently very steep inclinations of the rocks, ranging from 20° to 80°. Moreover, the rocks are much broken, and presumably allowed the oil and gas to escape long ago, except locally. A great many igneous intrusions or dikes exist, in the vicinity of which important oil or gas fields seldom exist in Canada.

The general structure of the Gaspé peninsula is a great syncline, with five anticlines traversing the valley longitudinally. These anticlines from north to south taken in order are as follows:

1:—The Forillon anticline, overthrust and faulted, trends northwest, parallel to the south shore of the St. Lawrence and swings to the southwest with the change in direction of the shore. The overthrust at the eastern end of the fold abuts the Devonian upon the Cambrian.

2:—The Haldimand anticline extends from Cape Haldimand northwest, parallel to and south of Cape Bay and the Forillon anticline, also swinging to the southwest.

3:—The Tar point anticline starts from Tar point on the south shore of Gaspé bay and trends northwest parallel to and at a distance of from 4 to 6 miles from the Haldimand anticline. On the south slope of this fold, about 7 miles west of Gaspé village, a small oil field was developed. The Tar point and Haldimand anticlines show dips ranging up to 200°.

4:—The Point St. Peter anticline starts from the shore at Point St. Peter and trends northwest for about 35 miles, where it swings to the west and south of west. The crest of this fold averages about 5 miles distant from the preceding fold. The considerable oil development near the juncture of the Mississippi brook with York river is on the southern slope of this anticline.

5:—The Malbaie or Percé anticline starts from near Point Percé and trends northwest parallel to the preceding anticlines until it strikes the St. John river at Owl Gap cliff, after which it swings to the southwest up the valley of that river. The flanks of this fold show dips of 30 to 80 degrees, and the area between this fold and the preceding is also marked by steep dips.

South of the Percé anticline, along the coast, the folds have been more or less obscured by the mantle of the Bonaventure formation, which, where present, lies everywhere on the almost vertical edges of the grey and blue limestones of the Ordovician and Silurian. In the interior the structure is not well known, but the rocks have generally very high dips.

Local structural details are given in the notes regarding the wells in later pages. In this region the wells drilled on anticlines found no oil, all the productive wells being in synclines. This seems to be an indication that the breaking of the strata has long ago caused leakage of most of the oil.

INDICATIONS OF OIL.

Indications of oil were noted in the Gaspé peninsula at a very early date and were recorded by Sir W. E. Logan in 1844 and in 1863, by Dr. T. Sterry Hunt in 1865, and by Dr. R. W. Ells in 1888-89 in the Reports of the Geological Survey of Canada. The following is a summary of the indications of oil in the Gaspé as far as known in 1863[1]:—

PRODUCING FORMATIONS.

At the oil spring at Silver brook, a tributary of York river, the petroleum oozes from a mass of sandstone and arenaceous shale, which dips southeastwardly at an angle of 13° and is nearly a mile to the south of the crown of the anticlinal. The oil, which here collects in pools along the brook, has a greenish colour and an aromatic odour, which is less disagreeable than the petroleum of western Canada. From a boring which has been sunk in the sandstone to a depth of about 200 feet there is an abundant flow of water, accompanied with a little gas and very small quantities of oil. Farther westward, at about twelve miles from the mouth of the river, oil was observed on the surface of the water at the outcrop of the limestone. Petroleum is met with at Adams' oil spring, in the rear of lot B of York, nearly two miles east of south from the entrance of Gaspé Basin. It is here found in small quantities floating upon the surface of the water and nearby is a layer of thickened petroleum, mixed with mould, at a depth of a foot beneath the surface of the soil. A mile to the eastward, at Sandy Beach, oil is said to occur, and, again, at Haldimandtown, where it rises through the mud on the shore. These three localities are upon the sandstone and on the line of the northern

[1]Logan, Sir William E., Geol. Surv. of Canada, Rep. of Progress 1843-1863, p. 788.

anticlinal and about two miles west of Tar Point, which takes its name from the petroleum found there, another oil spring is said to be found, three-quarters of a mile south of Seal cove. On the south side of the Douglastown lagoon, and about a mile west of the village, oil rises in small quantities from the mud on the beach. A well has here been bored to a depth of 125 feet in the sandstone, which dips to the southwest at an angle of 10°, but traces only of oil have been obtained. Farther to the westward oil is said to occur on the second fork of the Douglastown river. Traces of it have also been observed in a brook near St. George's Cove, on the northeast side of Gaspé bay. In none of these localities do the springs yield any large quantities of oil, nor have the borings which have been made in two places been as yet successful. The above indications are, however, interesting, inasmuch as they show the existence of petroleum over a considerable area in this region, some part of which may perhaps furnish available quantities of this material.

CHARACTER OF THE OIL.

According to analyses reported by Sir Boverton Redwood, the specific gravity of the Gaspé oil ranges from ·847 to ·949; ten different tests having been made, both in seepages and from oil recovered in three different wells. The sulphur in these oils ranged from ·09 to ·20 per cent, there being no disagreeable odour. The flash point ranged from 46° to 280° F. The oil from sandy portions of the strata is a light amber, while that from the lower Calciferous rocks is a heavier dark oil.

PRODUCTION OF THE WELLS.

The production of all the Gaspé wells was extremely small. The best well in the field is said to have produced in all about 2,000 barrels of oil. Most of them were nearly dry, but oil would percolate slowly into them. In other wells the outcrop was irregular. The average output in 1902 was two gallons per well, from the wells which still produced.

RECORDS AND DEPTHS OF WELLS.

Record of wells bored in Gaspé county may be found in the report of R. W. Ells[1].

[1]Ells. R. W., Can. Geol. Surv.; Ann. Rept., Vol. 15, 1902-3, Pt. A, pp. 346-362.

FUTURE PROSPECTS OF THE GASPÉ FIELD.

The following conclusions published a number of years ago are just as applicable at the present time[1]:—

> From a careful consideration of all the data at present to hand regarding this field as a producer of oil in economic quantities, it must be said that the outlook can scarcely be regarded as favourable. There are no well-defined oil-sands, such as are recognized in the true oil territory, and where oil had been obtained in reported large quantities it would seem to occur in isolated pockets only, since the continuation of the borings to a greater depth have given no favourable results. That oil in small quantities exists in different portions of the sandy strata, and occasionally also in the limestone, is evident from the records, but so far it is plain that nothing which can be regarded as of economic value has been found.

Developments in other Counties.

In 1885 a well was drilled to a depth of 1115 feet near St. Maurice, in St. Maurice county, and a fair quantity of gas was obtained at different depths. In 1906 and 1907 the Canadian Gas and Oil Company drilled a number of wells in the vicinity of Louiseville, Yamachiche, and St. Barnabé in the same county. These wells were only from 225 to 300 feet and the gas was obtained from the superficial deposits or drift. The gas was piped to St. Barnabé, Yamachiche, Louiseville, and Three Rivers.

Following the operations in St. Maurice county, a Canadian company, known as the Combustible Gas Company, with Mr. Cyrille Duquet, of Quebec, as president, secured from the Government the exclusive privilege of utilizing natural gas in the Province. This company made a boring of 1,500 feet at Maisonneuve, near Montreal, and three others of 500 to 600 feet at Louiseville, but with little success.

In 1908 the Quebec Fuel Company was organized for the purpose of testing favourable localities in the Province of Quebec, in search of natural gas, but operations were suspended in 1912. Wells were drilled in Yamaska, Richelieu, and Verchères counties, but only small wells and dry holes resulted.

[1]Ells, R. W., The oil fields of Gaspé. Geol. Survey Can., 15th Ann. Rept., new series, 1902-3, p. 362A.

Some other efforts have been made at various times to find natural gas in paying quantities in the Province of Quebec, ten or more shallow wells having been drilled north of the St. Lawrence river, obtaining small gas wells from a depth of about 800 feet. Seven or eight holes were drilled south of the St. Lawrence river, about forty miles east of Quebec, by the Canadian Oil and Gas Company, but no results were obtained.

FUTURE POSSIBILITIES OF THE PROVINCE.

There appears to be nothing of a favourable nature regarding possible future oil or gas fields anywhere in the Province of Quebec, and drilling is not advised.[1]

Anticosti Island.

In Anticosti, shales and shaly limestones of the Richmond, nearly 1200 feet in thickness, extend nearly the entire length of the island along the north side, while the succeeding formations to the south represent the whole of the Niagara group in a general way. These Silurian rocks are about 1400 feet thick, and are made up chiefly of limestones, with some shaly beds. Both series of rocks dip to the south, varying from a few feet to 200 feet to the mile. The geologic structure of the island is not unfavourable, but the superposition of limestones above shales is not likely to favour the accumulation of oil deposits, and the prospects are therefore unfavourable.

Argenteuil County.

This county is absolutely unfavourable for oil or gas. The greater part consists of crystalline rocks of Laurentian and Pre-Cambrian age, while a small area in the southeastern corner, having Potsdam and Beekmantown rocks at the surface, is too closely related to the crystalline rocks and too low in the geological scale to offer any prospect of oil or gas.

[1]This is a personal opinion of Mr. Clapp and is not in accord with the opinion of the Provincial Mineralogist of Quebec, or that of some of the officers of this Department. Recent field work by the Geological Survey has shown the existence of low anticlinal structures in the plain between the St. Lawrence river and the Champlain fault. The depth of the Trenton is probably over 2,100 feet, and there is the possibility of the development of a small gas field in this locality. The accuracy of this surmise can only be determined by further exploratory drilling. At present natural gas from one well is being used to furnish power for the sinking of a second well near St. Barnabé, St. Hyacinthe county,

Arthabaska County.

Rocks of the Trenton age form the surface in the extreme northwestern part and in the southeastern part of Arthabaska county, but near its northwestern edge a fault of considerable magnitude has brought the Sillery formation, consisting of red, grey, and green shales and greenish-grey sandstones, to the surface over a considerable area. There appears to be no probability of oil or gas in this district.

Bagot County.

The prevailing surface rocks in Bagot county are Lorraine, Trenton and Upper Cambrian sedimentaries, consisting of slates and sandstones, which are considered too low in the series to offer prospects of oil or gas. The Trenton, which is the only formation which contains large quantities of oil or gas elsewhere, is only present under cover in the western part of the county. Moreover, two great faults cross the county.

In several localities wells 100 feet or less in depth have found small showings of gas, but not in any quantity. Some of these borings were in clay and consequently without significance.

Beauce County.

The surface formations in Beauce county are of Pre-Cambrian and Ordovican age; and structural conditions are so complicated that there is no chance of finding commercial deposits of oil or gas.

Beauharnois County.

This county occupies a rather central position in the St. Lawrence basin, and its surface, underlying the drift, consists of sedimentary rocks largely of Beekmantown age; but the north-eastern portion of the county is crossed by a considerable area of Potsdam sandstone. Since the formations which commonly contain oil and gas in paying quantities in other fields are not present here, there appears to be no hope of finding deposits of value.

Bellechasse County.

This county lies in the St. Lawrence basin, and is crossed by northeast-southwest belts of Silurian and Cambrian formations. There may be some chance for small showings of oil and gas, but owing to the presence locally of Pre-Cambrian and other intrusive rocks, and to the narrowing of the basin in this direction, conditions are not believed to be particularly favourable.

Berthier County.

Throughout the greater part of Berthier county, conditions are unfavourable, since the formations are of Laurentian and Pre-Cambrian age, in which oil and gas in quantity never occur. An exception may be the Cambrian and Ordovician formations, which outcrop at the surface throughout the southeastern twenty miles, more or less, of the county, in which showings of gas have been reported in shallow wells, and which dip in a general way toward the southeast. These formations occur in the same belt geologically as that in which small wells were found at Louiseville and Yamachiche; but since conditions are no more favourable in Berthier county, it is believed that the wells here will be as short-lived and financially unsuccessful as the others.

Some years ago borings for natural gas were made near the villages of St. Justin and St. Barthelemi, and gas was reported in small quantities 60 to 80 feet from the surface, presumably in the Trenton limestone[1], but according to these reports, not of commercial value.

Bonaventure County.

In the western and northern parts of this county, the Silurian and a little of the Devonian formation is present, but they consist of sharp anticlines and synclines with high dips, ranging from 30° to 80°; consequently the county is not at all favourable for oil or gas in quantity, although it is just possible that small

[1]R. W. Ells, Geol. Survey Canada, Ann. Rept., Vol. II, Pt. J. 1900, p 61.

amounts may be found. Surrounding the western edge of Chaleur bay is a considerable area of trap, intrusive in the sedimentaries, and having minor dikes in the Devonian in some localities. Farther east in the county, areas of Cambrian metamorphic rocks exist.

Brome County.

The geological formations of Brome county are complicated, ranging in age from the lower Helderburg backward to the Pre-Cambrian. The region is considerably faulted, with many igneous intrusions, and rocks which contain oil or gas in other regions are generally absent. Consequently there is no chance for obtaining oil and gas in commercial quantities.

Chambly County.

The geological formation at the surface in this county consists mostly of shales and occasional thin limestones of Lorraine age. There is, however, a belt from one to three miles in width, bordering the St. Lawrence river, which is of Utica age. In the eastern part of the county is an intrusive mass, from one to two miles in diameter, of volcanic rock. While it is believed that the chances are not particularly good for either oil or gas in this county, there is no doubt that in the Trenton limestone—which occasionally contains these substances in small quantities in Ontario, and in large quantities in Ohio and Indiana—it is present beneath the whole county—there might be some chance for finding oil or gas were it not that all tests at Montreal on the opposite side of the river have been of negative result.

Champlain County.

The greater part of Champlain district consists of gneissic and granitic formations such as never contain oil or gas in quantity. A belt ranging from seven to twelve miles in width bordering the St. Lawrence river across the southeastern end of the district is of a different character, consisting of sandstones, shales and limestones, ranging in age from Potsdam, Beekmantown, Chazy, Black River, Trenton, Utica to Lorraine, and in this belt it has been supposed in the past that some chances of natural gas might exist. All the formations are of Ordovician age except the first mentioned, which is a member of the Cambrian. The dip is everywhere towards the south. The geology of this district is described in some detail by Ells [1]. As has been occasionally the case in other parts of the Province, a find of natural gas was reported in Champlain township, Champlain county, in 1899 on lot 503, but this proved to be only a surface accumulation in the drift formations underlying a bed of clay.

A well at St. Genevieve drilled several years ago is said to have reached a depth of perhaps 1800 feet, but was unsuccessful so far as oil or gas was concerned. A well drilled to a depth of about 250 feet is said to still produce a small quantity of gas, this being the only one left of several shallow wells which produced sufficient gas for individual houses.

From what is known of the stratigraphy and the geological structure, together with the insignificant results of drilling, it is not believed that either oil or gas exists in large quantity in Champlain county.

Charlevoix County.

This county is absolutely unfavourable for oil or gas, since the formations consist of crystalline rocks of Laurentian and Pre-Cambrian age, in which oil or gas are never found in quantity.

Chateauguay County.

The formations occupying the surface in the central part of Chateauguay county are entirely of Potsdam age, but in a belt from three to six miles in width along the northeastern side of the county and also in a small patch in the western end of the county the Beekmantown is present at the surface. The Chazy formation just touches the extreme northern point of the county. Since these formations are all older than rocks which claim oil or gas in commercial quantities, there is no hope of commercial results by drilling.

[1] R. W. Ells, Rept. on the Geology of the Three Rivers Map Sheet, Geol. Survey Canada, Ann. Rept., Vol. XI, Pt. J. 1900, p. 70.

Chicoutimi County.

This county is underlain by crystalline rock of Laurentian and Pre-Cambrian age, which never contains oil or gas in quantity.

Compton County.

The geological formations of Compton county range in age from Pre-Cambrian to Trenton, and include some areas of metamorphic and other areas of intruded igneous rocks. Owing to the great complications in the geology, and to the fact that the formations containing oil and gas are not at present under cover, there is no hope of oil or gas in quantity in Compton county.

Dorchester County.

The geological formations of Dorchester county are somewhat varied, ranging in age from Pre-Cambrian to Silurian, and forming belts extending in a northeast-southwest direction across the county. There are, however, some intrusive rocks, and, owing to this fact, to the general broken nature of the structure, and to their proximity to the crystalline border, it is not believed that there is any particular chance of finding oil or gas in quantity.

Drummond County.

Crossing the centre of Drummond county in a northeast-southwest direction is a region of anticlinal structure, which is bounded on the northwest, according to the Canadian Geological Survey, by an extensive fault line, and which is not far from the St. Lawrence and Champlain fault, a few miles farther northwest.

Along this anticline, the formation at the surface consists of Sillery shales and sandstones for a breadth of one to five miles. On both sides of this outcrop the Trenton and Black River limestones outcrop throughout extensive areas; while on the northwestern edge of the county, and separated by the St. Lawrence and Champlain fault, is a belt of Lorraine shales. It might be assumed that in this county the anticlinal structure would be favourable for natural gas; but owing to the presence of fault lines and to the fact that the Trenton and underlying formations occupy extensive areas at the surface, it seems rather improbable that any important field will be found.

Gaspé County.

This county is the only one in Quebec which has produced oil in commercial quantities. The geology and oil developments of Gaspé county have already been described.

Hochelaga County.

The surface formation in Hochelaga county consists almost entirely of Trenton limestone, but the Chazy outcrops in a small area west of the city of Montreal and the Utica shale touches the west side of the St. Lawrence river south of that city; all the formations have a generally moderate eastward dip. Several localities some square miles in area in this district are, however, composed of dikes of eruptive rock.

A few showings of natural gas have been reported at various times in the vicinity of Montreal, but in all cases they were of insignificant size and generally insufficient even for individual houses. Many wells in the city of Montreal have been drilled from 300 to 2,000 feet in depth entirely in the sedimentary rocks; and while good water wells have been obtained, no gas of consequence has been struck or is it to be expected. The water wells are described by O. E. LeRoy[1].

Running northwest from the volcanic neck which constitutes Mount Royal, there is a gentle anticline which might be productive were it not that other conditions are unfavourable for gas. Minor anticlines are reported in various parts of the island.

[1]Geol. Survey Canada, Ann. Rept., Vol. 14, Pt. O, 74 pp.

The wells drilled on the island were for the purpose of obtaining water, since the question of water supply on an island with a large population is of great importance. In the paper published by Adams and LeRoy[1] it is stated that 89 holes had been drilled up to the close of 1903, and the list was believed to be complete at that time. Much drilling has been done since, however. Owing to the peculiarly fissured character of the rocks in this locality, and to the presence of Mount Royal, the root of an old volcano having a great many dikes connected with it, the courses of underground waters on this island are very devious. Owing to the fact that the geology of the island is complicated, there is believed to be no prospect of finding oil or gas in quantity in this or adjoining counties.

In eleven wells the water is reported to have overflowed the surface in the past. The maximum thickness of the sedimentary rocks on the island has been estimated by the Canadian Geological Survey as at least 4,300 feet. Few detailed well records are available; but the following will suffice as an example:—

Log of Turkish Bath well at Montreal[2].

Formation	*Top Feet*	*Bottom Feet*
Pleistocene	0	50
Trenton group	50	640
Chazy	640	1425
Beekmantown	1425	1550
Total depth		1550

The depths of a few typical deep wells on the island of Montreal as given in the aforementioned report are as follows:—

A few deep Montreal water wells.

Name	*Location*	*Depth*
Turkish Bath	St. Monique St	1550
Messrs. Viau et Frère	Longue Pointe	1500
Stanley Dry Plate Company	610 Lagauchetière St	1300
Montreal Cold Storage Co	610 St. Paul St	1020
Dawes Brewing Company	Lachine	1003
Excelsior Woolen Mills	967 Ontario St	812

[1]Adams, Frank D. and LeRoy, O. E. The Artesian and other deep wells on the Island of Montreal, Ann. Rept. Geol. Survey Canada, Vol. 14, Pt. O, 1904, 74 pp., 3 plates, 6 figs.

[2]Frank D. Adams and O. E. LeRoy, Geol. Survey Canada, Ann. Rept., Vol. 14, Pt. O, 1904, p. 73.

Huntingdon County.

The formations occupying the surface in Huntingdon county are entirely of Beekmantown and Potsdam age; and since these are lower stratigraphically than any rocks which hold commercial deposits of oil and gas, there is no hope of finding the substances here in quantity.

Iberville County.

The formations at the surface in Iberville district are almost entirely of Ordovician age, and are too low in the geological scale to offer much hope of getting oil or gas below them. Moreover, no evidence of these substances is known, and the district may be considered as unfavourable.

Jacques Cartier County.

The formations underlying Jacques Cartier county consist largely of Trenton and Black River limestone; but in the western third of the county the Chazy and Beekmantown formations reach the surface. In general, it may be said that the conditions in Jacques Cartier county are very similar to what they are in Hochelaga county; and, consequently, there is no hope of finding oil or gas, except possibly very small showings of gas, suitable for supplying single residences.

Joliette County.

The greater part of Joliette county is entirely unfavourable for oil or gas in quantity, since the rocks consist largely of ancient crystalline formations of Laurentian and Pre-Cambrian age, in which oil and gas fields never occur. Crossing the southeastern end of the county there is a belt of Cambrian and Ordovician strata which is a continuation of the belt in Maskinonge and St. Maurice counties, where small gas wells were obtained. Since, however, the wells which were found in the counties mentioned were very short-lived and were failures so far as any financial result was concerned, there appears to be no wisdom in drilling wells for oil or gas in Joliette county.

Kamouraska County.

The formations occupying the surface in Kamouraska county are largely, or entirely, of Cambrian and lower Ordovician age. It is probable, in view of the fact that this county occupies the whole width of the St. Lawrence basin, which is only about forty miles here—being nearly at its narrowest portion—that there is little chance of oil or gas in quantity.

Labelle County.

The conditions in Labelle county are entirely unfavourable for oil or gas; the formations are largely of Laurentian and similar ancient crystalline rocks, and are, therefore, unfavourable for oil or gas.

Lake St. John County.

This county is underlain throughout by crystalline rocks of Laurentian and Pre-Cambrian age, which never contain oil or gas in quantity.

Laprairie County.

The formations occupying the surface in Laprairie county range in age from the Lorraine shales downward to the Beekmantown, the dip being generally toward the northeast. Like the rest of the St. Lawrence valley, this county is not particularly favourable; and particularly as the Trenton formation, which is the lowest known formation producing oil or gas in large quantities, outcrops in a belt across the centre of the county. It is improbable that anything more than showings of oil and gas will be found. The thickness of the formations in this locality is very great, as shown by the fact that a well at Laprairie reached a depth of 2,700 feet, and did not pass out of the sedimentary rocks.

L'Assomption County.

The formation throughout the central part of this county consists of limestone of Trenton and Black River age. There is, however, an area of perhaps sixty square miles on the eastern side of the county, which is Utica shale; and in the extreme western corner of the county there is a belt of Potsdam, Beekmantown and Chazy rocks bordering the Laurentian rocks to the west. Owing to the fact that the formations which might contain oil or gas outcrop within the county, and, consequently, that the substances must have leaked away, it is improbable that anything more than showings will ever be found in L'Assomption county. In the southwestern corner of the county also is as area of crystalline rock less than ten square miles in area.

Laval County.

The formations underlying the central part of Laval county are of Chazy age; while in the northern and eastern borders and in a small patch on the southern border they consist of the Trenton and Black River limestones, and are in a small patch on the southwestern edge of the Beekmantown. The conditions in Laval county are in general similar to those of Hochelaga county, and, consequently, no oil or gas should be expected in quantity.

Levis County.

The formation forming the surface in Levis county is of Cambrian and Ordovician age, and the sediments are of considerable thickness; but, owing to their proximity to the crystalline border, and to other unfavourable features, it is not believed that anything more than showings of gas will be found in this county.

L'Islet County.

The formations occupying the surface in L'Islet county are largely or entirely of Cambrian and lower Ordovician age.

It is probable, in view of the fact that this county occupies the whole width of the St. Lawrence basin, which is only about forty miles here—being nearly at its narrowest portion—that there is little chance of oil or gas in quantity.

Lotbinière County.

Lotbinière county is situated in the St. Lawrence basin in the belt which has been predicted occasionally by geologists as probably favourable for oil or gas fields. The formations are of the anticlinal and synclinal structure to a certain extent and are of Cambrian, Ordovician and Silurian age, having in some places the Trenton under cover. Since this formation contains oil and gas in quantity in the United States, there is a chance of pools existing; but, judging from the unsuccessful prospecting which has been done in fully as favourable territory in other counties in the vicinity and in Ontario, it is not believed that there is much chance in Lotbinière county.

Maskinongé County.

The greater part of this district is absolutely worthless for oil or gas since it consists of granitic and gneissic rocks of Pre-Cambrian and Laurentian age, in which neither oil nor gas ever exists. Along the southeastern edge of the county, however, is a belt ten to twelve miles wide, in which the surface rocks consist of sedimentaries ranging from Cambrian to Lorraine age, and which might be supposed favourable for gas, but which are presumably too shallow and too near the border of the basin to contain any large amount.

In the early eighties, following the discovery of gas at St. Maurice, four wells 500 to 600 feet in depth were drilled at Louiseville.

Mr. William Bell, manager of the Wallace-Bell Company of Montreal, states that the depth of the wells drilled by his company about twenty-nine years ago at Louiseville were as follows: No. 1, 550 feet; No. 2, 300; No. 3, 660; No. 4. 340 feet. Some gas was found in all of the wells, but was not worth piping for the town.

In 1906 and 1907, several wells were bored in the vicinity of Louiseville and Yamachiche by the Canadian Gas and Oil Company. What was supposed to be a good flow of gas was struck in superficial deposits at depths of 225 to 300 feet, and pipe lines were laid to supply the aforementioned towns, with an additional 8-inch line to the city of Three Rivers in St. Maurice county, thirteen miles distant. The prediction had already been made by Mr. Obalski, Superintendent of Mines for the province of Quebec, in his report of the same year, that the gas, being in superficial deposits, would be of short duration; and his prediction was fulfilled when the supply became practically exhausted in a few months. Further boring operations were undertaken in the vicinity, but with little result.

Some years ago borings for natural gas were made near the villages of St. Justin and St. Barthelemi. Gas is reported to have been found in small quantities at depths from 60 to 80 feet from the surface, being presumably in the Trenton limestone[1].

Megantic County.

The formations occupying the surface in Megantic county range in age from Ordovician to Pre-Cambrian; but conditions are rather complicated, and there is no hope of finding any deposits of oil or gas in quantity.

Missisquoi County.

The formations outcropping in this county are in age Utica and Trenton, west of the St. Lawrence and Champlain fault, and are Trenton, Chazy, Cambrian and Pre-Cambrian throughout the remainder of the county. The geological structure is rather complicated, and being without much cover and so near the crystalline outcrop, there is very little, if any, chance for oil or gas in commercial quantity.

Montcalm County.

Conditions in Montcalm county are entirely unfavourable for oil and gas, because the rocks are largely of Laurentian

[1]R. W. Ells, Geol. Survey, Canada, Ann. Rept., Vol. 11, Pt. J. 1900, p. 61.

and Pre-Cambrian age, which are hard and never contain oil or gas in quantity. The Cambrian and Ordovician strata cross the extreme southeastern end of the county, but not with sufficient thickness or structure for holding important deposits of oil or gas.

Montmagny County.

The Cambrian and Ordovician formations are the principal ones occurring in this county, but there is a little Pre-Cambrian. Owing to the narrowing of the basin in this locality and to the general age of the rocks being earlier than common oil and gas bearing formations, there is no hope of finding oil or gas in this county. Moreover, some years ago, eight dry holes were drilled in the St. Lawrence basin, reported about forty miles east of Quebec. It is probable that they were in this county or in its immediate vicinity, in the same geological belt.

Montmorency County.

Montmorency county, like the other counties on the north side of the St. Lawrence, is unfavourable for oil or gas in quantity. The greater part of the county consists of crystalline strata of Laurentian and Pre-Cambrian age, and the area of Ordovician strata along the river is so narrow that nothing can be expected of it.

Napierville County.

This county occupies a rather central portion of the St. Lawrence basin, and the formations at the surface consist from north to south of the Trenton, Chazy and Beekmantown rocks, with a small area of Potsdam sandstone touching the eastern edge of the county. A fault of some prominence also crosses the eastern corner of the county and owing to this fact, and the fact that the formations which commonly claim oil and gas elsewhere are absent, there is presumably no chance for these substances in quantity in this county.

Nicolet County.

The geological formations of Nicolet county consist largely of Lorraine shale with their accompanying thin limestones, except in several belts occupying rather central localities in the county, where Medina shales form the surface. In the extreme southern corner of the county, south and east of St. Leonard Junction, is an area of perhaps fifty square miles of Trenton and Black River limestones. This area is separated from the remainder of the county by the St. Lawrence and Champlain fault, which extends in a northeasterly direction. On the extreme eastern edge of the portion of the county which lies east of St. Leonard Junction is another fault, beyond which lie the Sillery slates, sandstones and conglomerates.

A small quantity of gas was found in the year 1885 at St. Gregoire in Nicolet county, in a well which was drilled to a depth of 1,115 feet on the Hilaire Trudel farm, lot 501 of the cadastre[1].

The flow of this well was estimated by Mr. Obalski in his report for 1885, to be 250,000 cubic feet per day. The well was still flowing in 1887.

The following is the log of the formations reported:—

[1]Theo. Denis, Rept. on Mining Operations in the Province of Quebec, during 1910. Dept of Colonization, Mines and Fisheries, Mines Branch, pp. 71-72.

Log of well near St. Gregoire[1].

Material.	Formation.	Top. Feet.	Bottom. Feet.
Surface........................			
Clay...........................		0	48
White sand.....................	Pleistocene (?).......	48	53
Heavy gravel (gas and water)....		53	68
Black sand (water).............		68	75
Hard sandstone.................		75	155
Harder, fine grained sandstone...		155	215
Red shale......................		215	290
Red shale......................		290	300
Nearly black shale..............	Medina (?)..........	300	316
Dark brown schist (show of gas)...		316	370
Red shale (more gas)............		370	475
Red schists.....................		475	525
Softer red schists..............		525	580
Gas in red shale................		580	640
Dirty lime......................		640	660
Calcareous rock.................		660	720
Calcareous oily rock............	Hudson River (?).....	720	820
Black schist (show of gas).......		820	860
Compact black schist...........		860	1,115
(Gas)...........................		....	1,115
Total depth....................	....	....	1,115

Some other drilling was done in Nicolet county years ago. In a more recent boring made at St. Gregoire, in 1899, very salty water was found at 605 feet, but no gas in economic quantity. The borings in this and other counties on the southern side of the St. Lawrence river were described in 1887 by La Flamme[2].

It has been assumed by many geologists that there were good prospects for gas in the Deschambault anticline, which is supposed to extend in a northeast-southwest direction through this part of the Province; but since large deposits of natural gas, seldom, if ever, occur in the vicinity of fault lines, the prospects are rather problematical. If oil or gas exist, they would seem to be more probably present in regions of gentle warping in the basin rocks some miles northwest of these faults.

[1]Selwyn, Geol. Survey Canada, Vol. 3, Pt. A, 1887-88, p. 33-34.
[2]Transactions Roy. Soc. Canada, Vol. 6, 1887.

Pontiac County.

No deposits of oil or gas should be expected in Pontiac county, since the conditions are entirely unfavourable, the rocks consisting of the Laurentian and similar hard formations.

On Allumette island, Que., directly north of the town of Pembroke, and entering the adjacent part of Ontario on the east, there is a small area underlain by Beekmantown, Chazy, Black River and Trenton formations, one hundred square miles in area; but this is not extensive enough to be important as a possible oil or gas producing area.

Portneuf County.

The greater part of this county is absolutely unfavourable for oil or gas, since the formations in its northern part are hard and crystalline and almost entirely of Laurentian age—not being suitable for oil or gas. Along the southern edge of the county is a belt some miles in width, which consists of Ordovician strata; and in this belt, some showings of gas have been found in shallow wells. It is not believed that anything better will be found than the showings already made.

Several low and narrow anticlinal ridges exist in the southern part of the county, and the Utica shales are impregnated with oil; but since the anticlines are rather sharp, and since the formation is in general synclinal, it is improbable that any large amount of oil or gas exists.

Pointe aux Trembles, Portneuf County. Reports have crept into print at various times regarding oil near Pointe aux Trembles. It is extremely improbable, however, that any oil of importance occurs in this locality, since the Utica shales and underlying limestones form a synclinal basin with only a few low and narrow anticlinal ridges, which are too near the Archæan outcrop to offer any probabilities.

Quebec County.

The greater part of Quebec county, like other counties on the north side of the St. Lawrence river, is absolutely unfavourable for oil or gas, since the formations, largely of Laurentian age, are hard and crystalline. The Ordovician strata just touch the southeastern corner of the county, around the city of Quebec; but these are so near the crystalline border as to be unfavourable.

Richelieu County.

The geological formations immediately underlying the surface drift in Richelieu county consist almost entirely of Lorraine shales and limestones.

The geological structure in parts of the county has been considered by many geologists of the Canadian Geological Survey as favourable for gas, along the line indicated by Sir W. E. Logan many years ago as a course of the Deschambault anticline.

Several years ago the Quebec Fuel Company drilled a well in this county to a depth of 2,950 feet, but without success.

Richmond County.

The geological formations occupying the surface in Richmond county are very complicated, ranging in age from Trenton to Pre-Cambrian; and since the region is much faulted, having high dips and some intrusions of igneous rock, there is no chance for oil or gas in quantity in the county.

Rimouski County.

There is a possibility of some oil or gas being found in this county, but it is improbable that pools of any value will be developed. The county is crossed by Cambrian rocks in a belt about fifteen miles wide along the northwestern side, and by a belt of two to ten miles of Pre-Cambrian through its centre, while the southeastern half of the county consists of Devonian and Silurian rocks. The formations are much disturbed and warped into steep anticlines and synclines, having prominent dips, frequently as high as 45° to 90°; but in a few instances as low as 5° to 15°.

Rouville County.

Although Rouville county lies in an extension of the belt which has been considered in the past as favourable for the occurrence of oil and gas, there is believed to be little chance for commercial results within it. The formation occupying the surface throughout the greater part of the county is of Lorraine age, so that the Trenton limestone, which contains oil and gas in some parts of the county, is largely under cover; but nevertheless this formation outcrops on the eastern side of the St. Lawrence and Champlain fault, which crosses the county about five miles from its extreme eastern end, and owing to this fact, and to four intrusions of volcanic rock several square miles in area, the conditions do not appear particularly favourable. There is some chance of small gas wells being obtained. An area of about fifteen square miles in the eastern part of the county consists of Sillery slates and sandstones of Cambrian age.

It is reported that showings of oil were found at St. Paul d'Abbotshood in 1908.

Saguenay County.

This county is underlain throughout by Laurentian and similar crystalline rocks, which are entirely unfavourable for holding oil or gas, and is not worth consideration.

Shefford County.

The geological formations occupying the surface in Shefford county range from Trenton and Black River limestone, which occur in belts running in a northeast-southwest direction across the centre of the county, to Cambrian and Pre-Cambrian formations which occupy most of the remaining portions. The rocks in this county are much faulted and intruded by several igneous masses, and altogether conditions are extremely unfavourable.

Sherbrooke County.

The geology of Sherbrooke county is rather complicated, the hard rock formations consisting of Ordovician, Cambrian, and Pre-Cambrian rocks. Owing to the structural complications produced by intrusions of igneous masses, and to the fact that formations which commonly contain oil or gas are not under cover here, there is no chance for oil or gas in quantity in Sherbrooke county.

Soulanges County.

The formation occupying more than half of the surface in this county is of Potsdam age. There is, however, a considerable area of Beekmantown strata in the southwestern corner of the county; consequently, the formations are earlier than those which commonly claim oil and gas elsewhere, and no results should be expected.

St. Hyacinthe County.

The geological formation in this county consists largely of shales and limestones of Lorraine age, immediately underlying the surface drift everywhere. The geological structure in parts of this county has been considered by many geologists of the Canadian Geological Survey as favourable for gas, along the line indicated by Sir W. E. Logan many years ago as a course of the Deschambault anticline, but few favourable results are reported.

Small amounts of gas are reported to have been found at St. Barnabé in this county in 1910. In the same year, a well was drilled six miles northeast of the town of St. Hyacinthe on the farm of Joseph Fontaine, St. Amable range north, cadastral division 164, the depth of the well being 1880 feet. The reported log is as follows:—

Log of well drilled at St. Hyacinthe.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface deposits	Pleistocene	0	125
Reddish, slightly calcareous shales	Medina (?)	125	900
Dark grey calcareous shales	Hudson River (?)	900	1860
Harder rock (show of gas)	Hudson River (?)	1860	1865
Dark shaley rock	Hudson River (?)	1865	1880
Total			1880

The well is supposed to have penetrated the Medina formation and passed almost to the base of the Lorraine shales, but not to have reached the Trenton limestone, which may be expected about 200 feet deeper. The rock pressure of this well, as reported[1] by the Mines Branch of the Province of Quebec, measured 275 pounds per square inch four months after the well was drilled.[2]

St. Johns County.

This county, like the adjacent ones, is not favourable for oil or gas. An important fault line crosses it from north to south, the rocks on the eastern side consisting of Utica shales, while to the west they are of Trenton, Chazy, Beekmantown and Potsdam age. Owing to the fact that no formation is under cover here which commonly contains oil or gas in other fields, there is no chance for commercial results by drilling in this county.

St. Maurice County.

Natural gas in small quantities was discovered many years ago in the vicinity of Louiseville. The first attempt to procure gas for commercial usage was made in 1880, when a well was sunk near Saint Maurice to a depth of 50 feet, without gas being found. In 1883 a strong flow of gas was obtained at a depth of some 70 feet, and in 1885 a company was organized and a well sunk at a depth of 1,115 feet. A fair quantity of gas was obtained from different depths, as shown in the following log:—

Record of well in St. Maurice County[3].

Top	*Bottom*	
0	75	Clay and sand, with some veins of inodorous gas and water.
75	215	Sandstone, somewhat calcareous.
215	640	Red and brown schists, soft, with abundant emanations of gas having the odour of kerosene at 316, 370, 580, 640 feet, the 580 feet vein being most productive.
640	820	Impure limestone, oily beneath; a vein of gas at 820 feet.
820	1115	Black, compact schist.

[1]Theo. Denis, Mining Operations in Province of Quebec during 1910, Dept. of Colonization, Mines and Fisheries, Mines Branch, P.Q., p. 73.
[2]A measurement taken 8 months later is reported to have shown a pressure of 426 pounds. A.W.G.W.
[3]Min. Res. U.S., 1887, pp. 501-2.

In the years 1906-1907, boring was undertaken in the vicinity of Yamachiche and Louiseville in this county and in Maskinonge county by the Canadian Oil and Gas Company. What was supposed to be a satisfactory supply of gas was encountered at depths of 225 to 300 feet in the superficial deposits. In 1907, the Company had a dozen producing wells and several pipe lines. There was a two-inch line 2 miles in length to St. Barnabé, a 7½ mile pipe line 3 inches in size to Yamachiche, and a 9½ mile pipe line 4 inches in size to Louiseville. The Three Rivers line was 13 miles long and 8 inches in size.

The price charged for the gas in Three Rivers while the supply lasted was 20 cents per thousand cubic feet for public buildings; 25 cents for factories; and 30 cents for residences. Thirteen producing wells in that field are reported to have struck gas in commercial quantities. The wells were six inches in diameter and obtained gas at a depth of 225 to 300 feet, presumably in the Lorraine formation. A dry hole was drilled on the Yamachiche river, north of St. Barnabé, which passed through 50 feet of Trenton limestone and then 200 feet of sandstone into the Laurentian gneiss.

The pipe line to Three Rivers was completed in the summer of 1907. The old gas company was bought out and pipes for natural gas were laid in the streets. The gas is reported to have been non-sulphurous.

At various localities in this and adjacent counties, wells 2 inches in size are bored at private houses and supply small amounts of gas.

In the early part of 1907 there were 80,000 to 100,000 cubic feet of gas per day being supplied from the St. Barnabé field. In addition, a well two miles northwest of Three Rivers, reported to be 1,200 feet in depth, supplied some gas with 50 pounds per square inch pressure. The pipe line from St. Barnabé to Three Rivers has now been taken up, but some individual families at Yamachiche and St. Barnabé still have sufficient gas for their own use. The prediction had already been made by the Superintendent of Mines for the Province of Quebec that the gas, being in superficial deposits, would not be lasting; and this prediction was fulfilled when the supply became exhausted in a very few months.

Stanstead County.

The formations occupying the surface in this county range in age from lower Helderburg downward through the Trenton, Cambrian and Pre-Cambrian formations to the Huronian. The geological structure is complicated, much broken up and intruded by igneous masses, and there appears to be no chance for oil or gas in quantity.

Temiscouata County.

The formations forming the surface under the drift in Temiscouata county are by Cambrian, Ordovician and Silurian age; and the St. Lawrence basin is at this locality considerably wider than it is in the counties immediately to the southwest. This county is not believed to be particularly favourable for the occurrence of oil or gas pools; but there is no positive evidence to the contrary.

Terrebonne County.

The northwestern two-thirds of Terrebonne county is underlain almost entirely by Laurentian gneiss and anorthosites, in which oil and gas never exist. The southeastern third of the county is crossed successively in passing from northwest to southeast, by sedimentary formations of Potsdam, Beekmantown, Chazy and Trenton age. These are all so near the base of the geological series, and the entire county is so close to the outcrops, that there appears no chance for oil or gas of commercial quantity within this county.

Two Mountains County.

This county also appears to be unfavourable, although the geology is rather varied. In the northwestern corner beyond the Canadian Northern railway, the formation consists entirely of Laurentian crystalline rocks and associated anorthosites. In the southern corner of Two Mountains county, bordering the lake, is an eruptive mass six miles in diameter consisting of syenite and associated rocks. Along the northeastern side is a large area of Beekmantown rocks, which also outcrop in another area in the centre of the west side. Most of the remaining areas, occupying in general the central portions, consist at the surface of Potsdam sandstone. It will be noted that most of the formations which commonly contain oil or gas in quantity are absent, consequently nothing should be expected of this county.

Vaudreuil County.

Vaudreuil county is likewise rather unfavourable, and it is probable that no extended deposits of oil or gas will ever be found in it. The formation occupying the surface in the eastern half of this county is entirely Potsdam sandstone. In the western part of the county the geology is more varied, there being in its central portions a mass of syenite and associated igneous rocks about twenty square miles in area, northwest of which, occupying the northwestern part of the county, are outcrops of Beekmantown and Chazy age. The remaining portions of the county consist mainly of Potsdam sandstone.

Verchères County.

This county has been considered as rather favourable for oil and gas occurrences, and may be worth further testing. The formations underlying the surface drift consist largely of Lorraine shales and limestone; but in a strip sometimes as much as four miles in width along the St. Lawrence river, the Utica shales are exposed at the surface. Several years ago the Quebec Fuel Company drilled two wells in this county to reported depths of 2,450 and 2,300 feet respectively. Small amounts of gas are reported, with a rock pressure of 250 pounds per square inch, but this report has not been verified.

Wolfe County.

The geological formations of Wolfe county are very complicated, ranging in age from Pre-Cambrian to Trenton, and including some intrusions of igneous rock; consequently, there is no chance of finding commercial deposits of oil or gas.

Wright County.

Conditions in Wright county are entirely unfavourable for the occurrence of oil or gas in any quantity, for the reason that the rocks are mostly Laurentian and crystalline in character, which never contain oil or gas, except where the Ordovician strata touch the extreme southern end of the county, northwest of Ottawa.

Yamaska County.[1]

The geological formations which outcrop in Yamaska county are the Lorraine and Medina. The Lorraine consists of greyish sandy shales and shaly sandstones with occasional thin bands of dolomitic limestone. Near the St. Lawrence the strata lie in a nearly horizontal position, but in the southeastern part of the county they are affected by several faults and folds, and some of the strata stand at high angles. The breadth of the formation is about 16 miles. Two small areas of reddish sandy shales, and sandstones, classed as Medina, occur within the borders of the county. These deposits apparently rest conformably upon the underlying Lorraine.

The Champlain fault probably crosses the southeast corner of the county.

The underlying formations, Utica and Trenton, do not appear to outcrop within the county, though they occur in adjacent counties.

No records of trial borings in this county are available. A small quantity of gas was found in one well in Nicolet county, to the north.[2] The results of recent geological studies in this district are not available, and may be such as to discount the following suggestion. The earlier geological maps suggest the existence of a low anticlinal structure about the middle of the county. An exploratory well located somewhere on a line passing north and south about midway between St. Elphége and St. Zéphirin, and sunk to tbe Trenton, might well be worth while.

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[1] Written by A. W. G. Wilson.
[2] See this volume, page 85.

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CHAPTER V

PROVINCE OF ONTARIO

GEOLOGY[1]

Description of Geological Formations

The Pre-Cambrian crystalline rocks of Ontario cover much of the territory north of the main line of the Canadian Pacific railway and north of Lakes Huron and Superior, extending to beyond the Hudson bay divide South of the Canadian Pacific railway in the older settled part of the province there is also a considerable area of Pre-Cambrian rocks, which extends as far south as a line running between Georgian bay and Kingston. South of this line the Ontario lowland and the peninsula between Lakes Erie and Huron are occupied by sedimentary rocks, all belonging to Palæozoic horizons. East of Kingston a spur from the main area of crystalline rocks to the north crosses the St. Lawrence river and connects with the area of similar rocks in the Adirondacks. The basin of the Ottawa river as far northwest as Calumet island, is also occupied by Palæozoic sedimentary rocks. East of a line between Brockville and Ottawa the whole width of the province is covered by the same rocks, which extend eastward beyond the provincial boundaries and underlie the St. Lawrence plain in the province of Quebec. North of the Hudson bay divide, in the basin of the Moose river, Palæozoic rocks also occupy a considerable area, having a general gentle inclination towards Hudson bay. There are thus three sedimentary basins in Ontario, the Ottawa valley and St. Lawrence basin, the Ontario-Erie-Huron basin, and the Hudson bay basin. The following is a summary of the geological formations of Ontario with a statement of their minimum and maximum thicknesses and probable average thickness:—

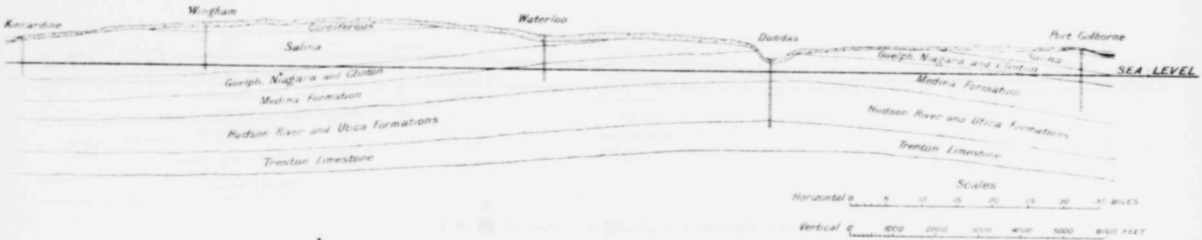
[1]By Alfred W. G. Wilson.

Geological Formations in Ontario[1].

Period.	Formation.	Thickness.		
		Minimum	Maximum.	Average.
	Pleistocene (drift)...	0	150	50
Devonian....	Portage and Chemung (Genessee).	25	200	100
	Hamilton..........	150	350	250
	Onondaga..........	160	300	230
	Oriskany...........	6	25	15
	Monroe............	500	900	
	Salina.............	300	1600	1000
	Guelph............	140	160	150
Silurian.....	Niagara...........	100	130	115
	Clinton............	30	150	90
	Medina............			
	Cataract...........	60	400	300
	Lorraine...........	100	400	300
	Utica..............	150	400	300
	Collingwood........			
Ordovician..	Trenton...........	600	750	675
	Black River........			
	Chazy............	0	150	50
	Beekmantown......	0	300	100
Cambrian...	Potsdam...........	300	700	400
Pre-Cambrian				

The average total thickness of these formations, all of which belong in the Palæozoic system, may be about 4,000 feet. Descriptions of the sedimentary formations in the older part of the province follow in ascending geological order.

[1]Table of formations by F. G. Clapp.



4
Fig. [redacted]. Section from Port Colborne to Kincardine, Ontario. (After Brumell)

Geological Formations in Ontario.

Period	Formation	Thickness		
		Minimum	Maximum	Average
	[illegible]		170	80
Devonian	Portage and Che-[illegible]			
	[illegible]	[illegible]	100	100
	Hamilton	[illegible]	[illegible]	[illegible]
	Corniferous	[illegible]	[illegible]	[illegible]
	Oriskany	[illegible]	[illegible]	[illegible]
	Monroe		600	
	Salina	[illegible]	1,000	[illegible]
	Guelph	[illegible]	[illegible]	[illegible]
Silurian	Lockport	[illegible]	[illegible]	[illegible]
	Clinton	[illegible]	[illegible]	[illegible]
	Medina			
	Cataract	[illegible]	[illegible]	[illegible]
	Lorraine	[illegible]	[illegible]	[illegible]
	Utica	[illegible]	[illegible]	[illegible]
	Collingwood			
Ordovician	Trenton	[illegible]	[illegible]	[illegible]
	Black River			
	Chazy	0	[illegible]	50
	Beekmantown	0	[illegible]	100
Cambrian	Potsdam	[illegible]	700	400
Pre-Cambrian				

The average total thickness of these formations, all of which belong to the Palaeozoic system, may be about 4,000 feet. Descriptions of the sedimentary formations in the older part of the province follow in ascending geological order.

Data of thickness by [illegible]

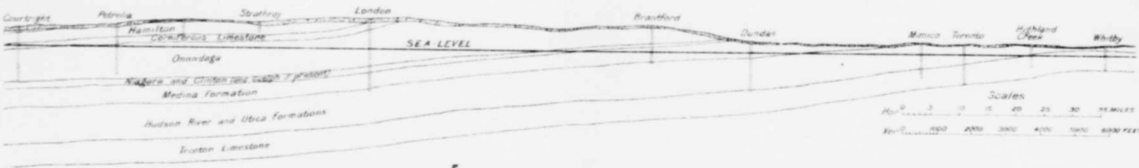


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Fig. [redacted] Section from Whitby to Courtright, Ontario.

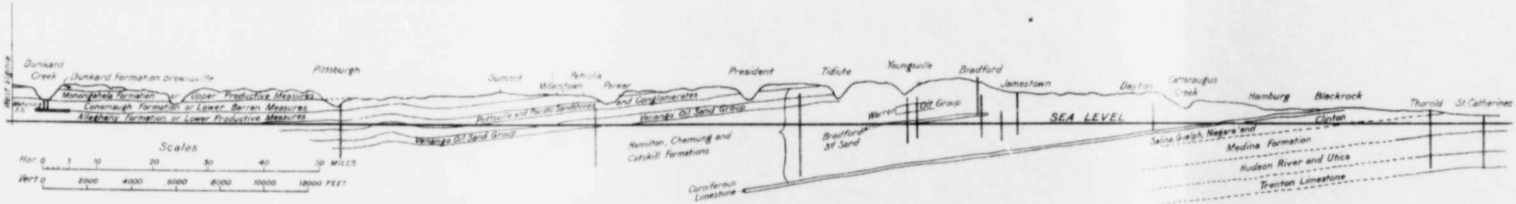

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Fig. [redacted]. Section from Eastern Ontario through Pennsylvania.

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Potsdam sandstone.—The Potsdam sandstone consists largely of hard grey, or sometimes reddish sandstone. It takes its name from the town of Potsdam in northeastern New York state where it occurs and was first described. The Potsdam is believed to underlie all of the latter sedimentary formations of southern Ontario. It outcrops in the Ottawa-St. Lawrence basin in a belt along the border of the Laurentian area in Frontenac, Leeds, Lanark, and Carleton counties, and is also exposed in the vicinity of the Thousand Islands and northwest of Kingston. A though its total thickness cannot be stated with certainty, it appears to run from 300 to 700 feet.

Beekmantown formation.—The name Beekmantown is derived from the type occurrence of this formation at Beekmantown in New York state. The formation was formerly called Calciferous from the general calcareous character of the rocks. The formation does not occur extensively in Ontario but it is known to outcrop between Brockville and Ottawa in the counties of Leeds, Grenville, Lanark, Carleton, and Russell. It is largely a bluish grey magnesium limestone and varies in thickness up to 300 feet.

Chazy formation.—This formation is named from a town of the same name in New York state. Although not important in Ontario, it occurs below Pembroke in the basin between the Ottawa and the St. Lawrence rivers. Small outliers also occur elsewhere. Its thickness runs as high as 150 feet and it consists of greyish limestones, sandstones, and shales.

Black River formation.—This formation, although separate from the Birdseye in New York state, appears to be identical with it in Ontario. The Black River was named from a stream of the same name in northern New York state where the formation is well developed. The formation as developed in Ontario, varies in thickness from 150 to 200 feet. It consists of bluish and dark grey, bituminous limestones with interstratified shales. The formation is well developed around Kingston, and northwest along the edge of the Palæozoic escarpment to Georgian bay. It also occurs in patches in the Ottawa valley in the counties of Russell, Stormont, and Carleton, and along the north channel of Lake Huron.

Trenton formation.—The Trenton limestone is one of the most important formations in Ontario so far as petroleum and natural gas are concerned. The name of the formation is taken from Trenton in New York state. The formation underlies the whole of southern Ontario and outcrops farther north in a broad belt between Georgian bay and Lake Ontario, extending from Matchedash bay to Collingwood harbour on the west, and from Newcastle to Amherst island on the east. In Carleton county there is an outlying geological basin in which the Trenton is the uppermost rock. The principal parts of the limestone cliffs at Ottawa are of Trenton limestone. In the Ontario-Huron basin the Trenton limestone dips southwest at a moderate rate and passes beneath Lake Erie. Its total thickness is about 600 feet. In character the Trenton is a fossiliferous bituminous limestone generally of a dark grey colour, and it is interstratified occasionally with bituminous shales.

Utica formation.—Overlying the Trenton limestone occurs about 100 feet of black bituminous shale known as the Utica formation, named from Utica, New York, where it is typically developed. This shale is believed to have composed the original cover which held the oil and gas in the Trenton limestone. In Ontario the Utica shale outcrops in the northern part of Grand Manitoulin island and on the south side of Clapperton island. It also is well exposed west of Collingwood harbour, from whence the formation trends southeast toward Lake Ontario, outcropping again between Whitby and Newcastle. Utica shales also occur in the Ottawa valley in small areas around the city of Ottawa.

Lorraine formation.—Succeeding the Utica there are about 700 feet of bluish or drab shales interbedded with calcareous and arenaceous bands which constitute the Lorraine shales. This formation outcrops in northern Manitoulin island on the southwest side of Georgian bay and extends southeast, widening toward Lake Ontario, where it outcrops at a few points on the lake shore between Port Credit and Pickering, and northwest of Toronto along the Humber river. An outlier of this formation outcrops in Carleton and Russell counties in the Ottawa valley.

Medina formation.—A formation of some importance as regards the oil and gas which it contains is the Medina, named from a city of that name in New York state. It consists of red and green shales interbedded with several layers of light grey to reddish sandstone and capped by a bed of light coloured sandstone known as the "grey band." The Medina formation outcrops on the southwest side of Georgian bay and increases in thickness southward towards Lake Ontario. The thickness ranges from 200 to 600 feet, being greatest near the shore of Lake Ontario, where it extends from Dundas to the Niagara river. This formation contains the upper and lower Medina sands of the well drillers known as the White and Red Medina respectively.

Clinton formation.—Although this formation as developed in Ontario is of importance for the oil and gas which it contains, there is no certainty that it is identical with the Clinton sandstone which is productive of oil in Ohio; the latter is believed to correspond with one of the Medina sands. The true Clinton formation outcropping in Ontario is named from Clinton county, New York, and consists of green and drab-grey shale, with thin limestone beds, totalling 80 to 180 feet in thickness. The formation contains a very ferruginous red band, being the Clinton iron-ore bed of New York and other localities. The outcrop of the Clinton extends through the centre of Manitoulin island, along the southwest side of Georgian bay and south along the Niagara escarpment to the head of Lake Ontario, from where it runs east along the base of the escarpment to the Niagara river.

Niagara formation.—Overlying the Clinton is the Niagara; this is the principal formation outcropping at Niagara Falls, and is one of the most important formations in Ontario. It extends through the Manitoulin islands, and the Bruce peninsula, across Central Ontario to Hamilton and through Niagara peninsula to New York state, lying near the crest of the escarpment which runs between the Bruce peninsula and Niagara. Its thickness varies from 240 feet at Hamilton to about 450 feet on Manitoulin island. This formation decreases in thickness towards the south and east, while the underlying formations increase in thickness; except in the vicinity of the Niagara river, the formation is composed almost entirely of dolomite. It is crystalline and of a light grey to dark grey colour. Topographically the Niagara is one of the most important formations in Ontario on account of the development of its prominent escarpment extending across Ontario from west of Collingwood south to Hamilton and east to the Niagara river. This limestone forms the upper part of the Blue mountains, and the upper part of Niagara Falls. At Niagara, however, the limestone composes only 164 feet of the formation, while the lower 80 feet consists of shale.

Guelph formation.—The Guelph formation is named from the city of Guelph in Ontario. Its maximum thickness is about 160 feet, in the central part of the western peninsula, and it diminishes in thickness toward the Niagara river and toward Manitoulin island. It consists of buff to grey granular dolomite, which is sometimes bituminous and even crystalline.

Salina formation.—The Salina formation contains the great salt deposits of Ontario and Ohio. Where exposed at the surface it consists mainly of thin bedded dolomites, pale grey or yellowish coloured, and greenish calcareo-argillaceous shales with some reddish layers. On the east shore of Lake Huron this formation outcrops infrequently between Goderich and the mouth of the Saugeen river from which it turns east and south "rounding the northern end of a wide syncline between Southampton and the head of Owen Sound and running thence southeasterly to the Grand river, from which it takes an easterly course to the Niagara."[1] The thickness of the Salina formation ranges from about 300 feet at Niagara Falls to 508 feet at Kincardine and 775 feet at Goderich. The lower part of the formation contains great deposits of gypsum and rock salt, the latter furnishing the salt in the wells drilled at Kincardine, Wingham, Blyth, Clinton, Goderich, Exeter, and Seaforth. The salt ranges from grey to white in colour. The salt of the Salina formation constitutes one of the most valuable mineral resources of southwestern Ontario. The gypsum contained in this same formation outcrops in some places along the banks

[1]Probably some beds belonging to the Monroe are here included.

of the Grand river. The same formation probably occurs in the Moose River basin, because gypsum beds are exposed on the banks of the river which are from 10 to 20 feet in height. Gypsum also outcrops east of the Abitibi river near mile 276 on the Ontario-Quebec boundary.

Monroe formation[1].—The Monroe formation, which is a marine series of sediments that succeeded the Salina, does not cover a very large surface area in Ontario. In the southwestern part of Essex county, immediately beneath a dolomitic limestone carrying an Onondaga fauna, is a bed of high grade limestone followed by brown dolomites. These beds have been correlated with the upper Monroe of the adjacent state of Michigan. Other rocks which possibly belong to this formation occur along the Lake Huron shore in the vicinity of Goderich and northward. The total area exposed at the surface is small. These rocks, however, are probably encountered in drilling wells. So far as the well records are concerned they do not appear to have been distinguished from the underlying Salina.

Oriskany formation.—The Oriskany formation, the lowest in the Devonian system, is represented in Ontario by about 25 feet of grey and brown sandstones. It outcrops in various places between the township of Windham and the Niagara river.

Onondaga formation.—This formation is one of the most important in Ontario as regards the occurrence of oil and gas deposits. It was formerly known as the Corniferous, deriving its name from the occurrence of nodular masses of chert or hornstone, which it frequently contains. The Onondaga formation outcrops at several points on the shore of Lake Erie between the mouth of the Niagara river and Port Rowan, and isolated areas occur farther west in Essex county. The base of the formation extends northeast from near Goderich to Greenock township, where it curves around the north end of a wide syncline, and then takes a southerly course to Burford township, and then strikes eastward to Bertie township. The Onondaga in western Ontario consists chiefly of grey bituminous limestone

[1]The geology of Western Ontario has recently been revised by officers of the Geological Survey, but the results of the field work are not yet published. The surface distribution of this formation and the other associated formations above and below, has all been re-mapped, and this work clears up many previously obscure points in the geology of the Ontario peninsula.

beds, characterized by the occurrence of large numbers of silicified fossils, some of them in masses of considerable size. The thickness of the Onondaga formation, as shown by well records, ranges from 209 feet, one mile southwest of Belle River, to 310 feet at Leamington, 320 feet at Port Lambton and 248 feet to 378 feet at Petrolia. Owing to the uncertainties existing in all well records, it is not possible, however, to draw a definite line in the records between the base of the Onondaga limestone and the top of the Oriskany formation. The oil in the Enniskillen field is derived from the Onondaga limestone.

It is interesting to note that in the extreme northern part of Ontario in the region southwest of James bay, the Onondaga formation outcrops at a number of points throughout an area greater than all the western peninsula of Ontario. The outcrops in that region consist mostly of porous and cavernous grey fossiliferous limestone which rest directly upon the Archæan. No oil deposits have, however, been discovered in this region in the vicinity of James bay with the exception of a few seepages.

Hamilton formation.—The Hamilton formation is named after the city of Hamilton in the state of New York. It consists of bluish and greyish calcareous shales (called soapstone by the well drillers) with occasional thin limestones and sandy beds. The estimated thickness of the Hamilton formation in Ontario is about 350 feet.

Chemung formation.—The Chemung formation of New York state is represented in Ontario only by a few feet of black bituminous shales which occur in southern Huron and northern Lambton counties. This formation is immensely more important in the oilfields of the United States and is sometimes several hundred feet in thickness.

Pleistocene formations (superficial)[1].—The superficial formations are those which consist of unconsolidated clays, sands, marls and gravels deposited sometimes in the stratified form and sometimes as heterogenous mixtures, overlying the bedrock and forming the loose surface soil. These formations include what is commonly termed "the drift" which was deposited during the great ice age by the ice sheets which once covered

[1]By F. G Clapp.

the northern half of North America. The "sands" of the well drillers are not, however, synonymous with the sands of the drift for the reason that the well drillers have given the term "sand" to all sorts of sandy formations which are encountered by the drill and which—although in a consolidated state—are broken up by the drill and appear at the surface in a granular form.

In discussing the superficial formations, it is essential to state that they are in a geological sense unconformable with the formations below them. In other words, no stratification which is found in the superficial formations or drift is parallel or continuous with stratification in formations which constitute the solid rocks. After the formation of the solid rocks mentioned in the preceding articles, and preceding the deposition of the drift, a great period of time, which may have to be measured in millions of years, is supposed to have elapsed during which the hard rock formations were indurated by subterranean agencies, elevated and subsequently denuded by surface agencies, consequently, at the time the great ice age began, the solid rock formations differed much from their original form. The sands, gravels and clays deposited during the ice age or at its close spread over the solid rocks in various forms as boulder clays (till), sand plains, stratified clays, moraines, kames, and eskers, greatly modifying the original topography. This is the reason why, in many cases, a great length of drive-pipe is necessary in drilling wells, in order to shut off leakage of water from the superficial formations overlying the hard rock. The drift formations contain a great many boulders, sometimes of large size, which are a detriment in drilling wells.

HISTORY OF OIL DEVELOPMENT.

The development of the Ontario fields followed closely upon the discovery of oil in Pennsylvania. In fact, Williams in 1857 drilled a deep well in Ontario with successful results before Drake's lucky find at Titusville. In 1860 hundreds of derricks were put up at Black Creek, the depth being seldom over 100 feet and the annual production something less than 150,000 barrels. In 1862, Shaw struck a gushing spring, the daily production of which was estimated at 1,500 to 2,000 barrels. In the beginning, large quantities of oil were allowed to flow to waste. There was naturally great excitement, which served the useful purpose of stimulating search for oil indications.

Another large well was struck at Bothwell, Kent county, and in 1867 at Petrolia other productive wells were drilled, which as late as 1885 were yielding 10,000 to 12,000 barrels monthly. These drew enthusiastic prospectors from the Oil Springs fields, where the first wells had caused great excitement, to the region of Petrolia, which has proved to be the largest pool in Lambton county.

In 1867 there were 25 oil refineries in operation in Ontario, having a weekly capacity of 480 barrels. From this time the production of oil grew rapidly. It is estimated that in 1889 there were 3,500 wells being pumped, 2,500 of which were in the Petrolia field and the remainder in the Oil Springs field, from which latter there was an approximate monthly production of 20,000 barrels.

In 1891 oil was discovered in Welland and Essex counties.

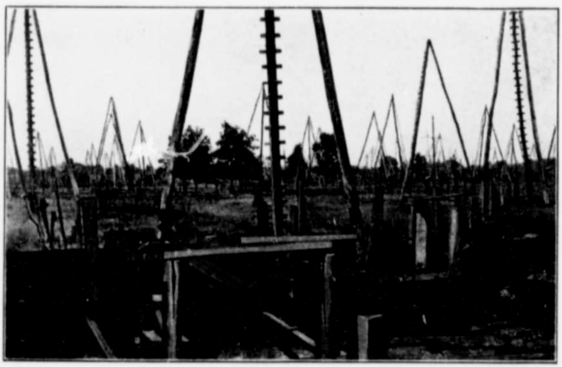
In 1902 Kent county came to the front with a gusher struck at Chatham, and the same year more than thirty shallow wells were drilled in Elgin county.

REFINERIES.

The first refinery in Canada was established at Petrolia about 1861. In the winter of 1867–1868, the Great Western railway was built to Petrolia, making it possible to haul the oil away in tank cars. Much of the oil was exported to England, but the English business dropped off on account of the developments in the United States.

At one time, there were six refineries at Oil Springs, Ontario. That was between 1862 and 1865, but in 1867 the last of these was closed, owing to a lack of crude oil.

In 1868 the principal refining works in Ontario were at London. In 1870, there were over 40 refineries situated mostly at London and Ingersoll. In 1887, there were in operation in Ontario thirteen refineries, nine of which were situated in Petrolia, two in London, one in Hamilton, and one in Sarnia.



Canadian oilfields.

the shortage in the east by a drain on the Tilbury field. This has led to a clash in the courts of Ontario between the Union Natural Gas Company, operating largely in the western field, and the Doherty interests, operating largely in the eastern section. The wise thing to do would be to at least prevent the use of this ideal fuel under boilers and in factories, thus conserving it for domestic consumption where it will do the greatest good to the greatest number.

Productive formations.—The oil produced in the Bothwell, Thamesville, Northwood, and Charing Cross fields is derived from the Onondaga limestone, as was the case with the old Tilbury-Romney field. The natural gas and the upper oil strata in the large gas field in the southern part of Kent county, known as the new Tilbury-Romney gas field, is produced from a dolomite in the lower part of the Salina formation, similar in age to the rock in which the oil is found in the new Tilbury East pool, in the vicinity of Fletcher. The lower oil strata here belong in the Guelph formation.

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Surface materials	Pleistocene	0	43
Black shale	Portage and Chemung	43	223
Limestone	Hamilton	223	235
"Soapstone"	Hamilton	235	407
Limestone	Onondaga	407	482
Sandstone	Onondaga	482	526
Hard limestone	Onondaga	526	605

At the southern end of the county a typical section is as follows:—

Formations penetrated by well in Lot 10, Concession IX, Tilbury East township[1].

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Boulder clay	Pleistocene	0	95
Grey sand	Pleistocene	95	100
Clay and gravel	Pleistocene	100	128
Blue clay shale ("Upper soapstone")	Hamilton	128	165
Middle limestone	Hamilton	165	175
Blue clay shale ("Lower soapstone")	Hamilton	175	242

[1]Coste, Eugene, Jour. Can. Min. Inst., Vol. X, 1907, p. 77.

Material	Formation	Top Feet	Bottom Feet
Yellow limestone................	Onondaga ("Big lime")..........	242	400
Grey, drab, brown, and blue dolomite with gypsum and flint. Shales with darker shaly dolomites and more gypsum 835 to 1135........................	Salina..........................	400	1420
Bluish-white dolomites, limestone, oil at 1426.....................	Guelph..........................	1420	1429

In the Tilbury-Romney field as many as four horizons of gas are sometimes found in the bottom of the Salina formation, and below them oil is frequently struck.

Depth of wells and formations penetrated.—The total depth of wells in Kent county ranges from 350 to 2,000 feet. The depth to the top of the oil-bearing formation (Onondaga) ranges from 220 feet to 400 feet. The wells in the Bothwell field are only about 400 feet, while a dry hole in Harwich township is reported at about 2,000 feet. The depth to natural gas in the Tilbury-Romney field ranges from 1,100 to 1,400 feet, according to what part of the field and what gas horizons are desired, being found in the lower part of the Salina formation. In the north end of the Tilbury-Romney gas field oil is found at a depth of about 1,400 feet below the gas and not far from the top of the Guelph formation.

The best information regarding the geological formations can be gathered from well logs; and while many of these have been poorly kept, a large number of logs are available in which the formations have been rather accurately recorded by the drillers, so that it is possible to make geological correlations from point to point between the wells. In most of the wells it has been possible to distinguish approximately between the Portage-Chemung, which is recorded by drillers as being composed of black shale, and the Hamilton formation, which is recorded as a soapstone. One must understand in this connexion that the rock is not in reality soapstone, since true soapstone is a very different kind of rock. The soapstone of the oil drillers is a light coloured soapy shale.

The well records in Kent county reveal a thickness of 30 to 610 feet of superficial clayish deposits, which overlie 20 to 200 feet of Portage-Chemung shale. In some instances the

Portage-Chemung is cut out by erosion. The Portage-Chemung in turn rests upon 100 to 150 feet of Hamilton shale, which, judging from well records and from geological outcrops in other localities, contains occasional beds of interlaminated thin limestone. Below the Hamilton lies 150 to 250 feet of a hard fossiliferous limestone, known geologically as the Onondaga, and to the well drillers as the "Big Lime." This is the formation which has produced most of the oil in Kent county; and in fact, the only field which did not derive its oil from this formation is the new Tilbury-Romney field in the vicinity of Fletcher. Below the Onondaga limestone lies a thickness of Salina formation, consisting of limestone, gypsum and salt beds, which, although 1,600 feet in thickness in the Petrolia field in Lambton county, runs only about 1,000 feet in the Tilbury-Romney gas field. Much salt water is encountered in this formation. The lower part of this thickness contains frequent flows of gas in the Tilbury-Romney gas field in the townships named. The deepest formation yet penetrated by the drill in Kent county is the Guelph limestone, which directly underlies the Salina, and in which some oil is found in the new Tilbury-Romney gas field, and oil in the vicinity of Fletcher.

The following well record is typical of the formations encountered in the north side of the county.

Formations penetrated in well at Dresden, Gore of Camden[1].

Material	*Top Feet*	*Bottom Feet*
Surface	0	43
Shale, black	43	223
Limestone	223	235
"Soapstone"	235	407
Limestone	407	482
Sandstone	482	526
Limestone, hard	526	605

As shown, the production in the Tilbury-Romney field almost quadrupled itself from 1906 to 1907, since which date it has declined. The Bothwell field has declined slowly but steadily; while in the Thamesville field no figures have been reported since 1907.

Pressure and volume of the gas.—The best description of

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, 1889-91, Pt. Q.

the Kent county gas field has been published by the Ontario Bureau of Mines[1]. Unfortunately no exact figures are available of the production of gas in this county. The capacity of wells, however, is much greater than it is in any other field in Ontario. The initial open flow capacity of the wells in this field was in one instance as high as 7,000,000 cubic feet per day. The initial rock pressures range up to 650 pounds per square inch.

The production of this field during 1912 was reported unofficially to be 15,000,000 cubic feet per day.

Markets for the gas.—The various municipal supplies in Kent county are derived from the following sources: Wallaceburg is supplied by the Northern Pipe Line Company; and the United Fuel Supply Company[2], Limited, has lines into Sarnia and Petrolia from the Tilbury-Romney gas field. The gas from this field is piped to Chatham, 14 miles distant, Windsor, 45 miles distant, Sarnia, 55 miles, Blenheim, 14 miles, Ridgetown, 23 miles; taking in Tilbury, Merlin and smaller places on the way. A population of about 50,000 people is served with gas from this field.

Most of the Ontario towns are paying 30 cents a thousand cubic feet for natural gas. At St. Catharines the price is 70 cents.

Operating companies.—Among the companies operating in Kent county are the Roth-Argue-Stearns-Barnard Company, Ltd., operating in the new Fletcher field, the Union Natural Gas Company, Leamington Oil Company, Reserve Oil and Gas Company, Limited (drilling for gas), and the Beaver Oil and Gas Company, Limited (drilling for gas). The Standard Oil Company of Canada also has some good producers in the Fletcher field.

In 1912 to 1913 there was a great change in the names and management of some of the largest gas companies operating in Ontario, extensive purchases being made by Henry L. Doherty and Co., of New York city. The most extensive single transaction in this business was the sale of the entire holdings of the Dominion Natural Gas Company to the firm

[1]Mickle, G. R., 19th Ann. Rept., 1910, Vol. XIX, Pt. 1, pp. 149-153 (1 map).
[2]Gibson, Thos.W., 21st Ann. Rept., Bureau of Mines, Ontario, Vol. XXI, Pt. I, 1912, p. 35.

above mentioned. The Natural Gas plants at Brantford, Woodstock, Dunnville, and that of the Beaver Natural Gas Company of Chatham were also acquired by this firm. They are now delivering to Hamilton about 80 per cent of the natural gas consumed in that city. The National Natural Gas Company was recently awarded a competitive franchise for the city of Hamilton.

Quality of petroleum.—The oil in Romney township is of a heavier grade than in Tilbury township. It is dark green oil with a density of 0·8330—0·8187 and contains sulphur, similar to that of the Lima oil. In the Romney pool, however, it is 0·8860—0·8750 in density. The oil in the Bothwell pool is at present about 35° Baumé, having been formerly 38° to 40° B. In the oil of the Tilbury fields a similar amount of sulphur is present to that in the case of the Lima, Ohio, oils.

Quality of natural gas.—An analysis of the natural gas produced from a well drilled some years ago by the Volcanic Oil and Gas Company, on the David Holiday farm on lot 1, concession VI, Raleigh township, is given below; the gas was struck at a depth of 1,470 feet, at the bottom of the well, 7,000,000 cubic feet of gas per day with a rock pressure of 650 pounds per square inch were produced. The quality was as follows:—

Analysis of gas from David Holiday well, Lot 1, Con. VI, Raleigh township[1].

	Per cent
Hydrocarbons (principally methane)	92·20
Carbon dioxode (CO_2)	1·40
Oxygen	Trace
Carbon monoxide (CO)	0·21
Hydrogen	0·40
Nitrogen	5·59
Hydrogen sulphid (H_2S)	0·20
	100·00

Old Tilbury East oil pool.—Oil was first struck in the old Tilbury pool in December, 1905, on the John Kerr farm by the Acme Oil Company of Detroit, the first well producing both oil and gas. In 1907, the banner year, there were 150 wells in the field and a total of 411,588 barrels of oil were pro-

[1]Coste, Eugene, Jour. Can. Min. Inst., 1907, p. 77.

duced during that year. Since that time the field has declined. The producing formation was the Onondaga. Most of the recent production has come from the northeast extension of the field around Fletcher station, and the former oil field in Romney township has been practically exhausted. A brief record of the first well is as follows:—

	Feet
Gas	1360 to 1375
Oil and gas	1385
Second oil	1410
Third oil	1430
Salt water slightly below	
Total depth	1450

The oil was piped to Coatesworth station of the Père Marquette railway, from where it was hauled by tank cars to the refinery of the Imperial Oil Company at Sarnia.

Oil was struck also on lot 11, concession II, five miles southwest of the pool mentioned. It occurs in the Guelph formation at a depth of 1,290 feet, but was abandoned owing to the presence of too much salt water.

Tilbury-Romney gas field.—This is at present by far the most important natural gas field in Ontario. The gas was discovered in 1905 in a 1,450-foot well in searching for oil; the former being struck at 1,360 to 1,375 feet and the latter at 1,385 to 1,410. The waste of gas during 1906 and 1907 was very large, being estimated by Mr. G. R. Mickle, mine assessor for Ontario, at about 1,500,000,000 cubic feet[1].

The supply was preserved for use and opened up largely through the efforts of the Volcanic Oil and Gas Company and was turned into the Chatham mains on March 19, 1907.

In 1912 the estimated production of the field was 15,-000,000 cubic feet per day; and during 1913 good wells continued to be drilled.

The principal operators in this field are the Union Natural Gas Corporation of Canada, and the Beaver Oil and Gas Company. The gas is encountered at depths of 1,100 to 1,450 feet, in the bottom of the Salina formation. Several different gas-bearing strata are encountered throughout an interval of 250 feet. The average record of the strata passed through is approximately as follows:—

[1]Gibson, Thomas W., 21st Ann. Rept., Bureau of Mines, Ontario, 1912, Pt. I, p. 39.

Record of typical well in the Tilbury-Romney gas field.

Material	*Top* *Feet*	*Bottom* *Feet*
Surface	0	165
"Soapstone" (Hamilton)	165	270
(Onondaga)	270	840
"Big lime" (Salina)	840	1350
Limestone (gas and oil pay)	1350	1420
Total depth		1420

Very few dry holes are encountered in operations in the Tilbury-Romney gas field. The wells are drilled with American Standard drilling rigs, with derricks 72 feet high, and gas is used for fuel in drilling. Operations are still active in this field and wells of several million cubic feet per day are occasionally drilled. In the summer of 1913 nine sets of tools were drilling for gas.

A record showing the casing needed in these fields, though of a different well than that given above, is as follows:—

Record of I. Coatesworth well, Lot 186, Romney Township, drilled in 1911.

	Feet
10-inch drive pipe	190
6¼ " casing	776
3 " tubing	1354
First gas	1160
Second gas	1160
Second gas	1335
Total depth	1345

Drilling in Lake Erie.—In the Tilbury-Romney gas field in Kent county, the richest gas wells have been found close to the shore of the lake; these wells range in some instances from 3,000,000 to 10,000,000 cubic feet in volume. When the Union Natural Gas Co. was formed several years ago to take over the companies operating in western Ontario, certain parties secured a lease from the government of the lake shore in the Tilbury-Romney field and commenced drilling in front of rich leases held by the Volcanic Oil and Gas Company. An injunction followed, the Volcanic Company asking for an order restraining the defendants (Messrs. Simms and Chaplin) from completing the well on the ground that it was being drilled on territory on which the Volcanic Company held a lease. This injunction was in force in the early part of 1912.

During the early part of 1913 there was an interesting contest in the courts between the Glenwood Gas Company and the Dominion Government, the latter having served notice upon the compâny to stop all drilling operations in the lake until such time as the plans and specifications for such drilling could be submitted to and approved by the Governor General in council. The cause of the notice was a petition forwarded to the governor by some 200 residents along the lake shore, comprising farmers and fishermen, protesting against drilling operations. The claim was made that drilling interferes with fishing operations and effects the riparian rights of the land owners.

In the previous suits, namely, the Volcanic Oil and Gas Co. vs. Chaplin, the matter at issue was whether the company was trespassing on lands originally owned by the adjacent land owners and in the course of years washed into the lake. In that case the injunction was made perpetual, restraining the defendant from drilling within the territory described.

There is no doubt that the production of the wells becomes larger as the lake is approached, and it should be expected that such wells will be more prominent than those on land, since they draw not only from the limited area in their immediate vicinity, but the gas taken out will be replaced by that coming from perhaps a long distance through the producing sand beneath the lake. It has been erroneously stated, however, that the Tilbury-Romney field is continuous with the Ohio fields, since the fields in Ohio south of Kent county, Ontario, obtained their gas in the Clinton sand, which corresponds with one of the Medina sands instead of in the Guelph, as is the case in Kent county.

Several deep tests have been drilled. About 25 years ago a well was sunk in the Salina formation to about 1500 feet. Another deep well, situated on the Goodyear lease, was drilled by Messrs. Garmon and Fairbanks to a depth of about 900 feet. Both these wells are plugged off and are to-day producing from the Onondaga.

Many wells in this field have been drilled in the waters of Lake Erie.

Fletcher field.—The new oil wells in the vicinity of Fletcher station produce from the bottom of the formation in which gas exists in the Tilbury-Romney gas field. The recent production of the Tilbury East pool has been about 2500 barrels per month from the vicinity of Fletcher station. All the oil from this pool is shipped by tank cars to the Imperial Refinery at Sarnia. In the summer of 1913 five sets of tools were drilling for oil.

New Tilbury East field.—The first new well in this field did not come up to expectations, being short lived on account of drowning by water. Some difficulty was experienced in this connexion in 1905, but in later developments the drillers learned how to handle the water and stopped drilling before encountering it.

The best well was one belonging to the Central Oil and Gas Company, which had an initial flow of 1500 barrels per day of oil and salt water, of which 300 barrels was oil. Two months later this well was still producing 50 barrels of oil. Gas wells of large volume were found associated with oil, the most productive being one which had originally 7,000,000 cubic feet of gas with 650 pounds rock pressure and changed later to an oil well. Recently the Glenwood Gas Company has completed its third well good for 1,500,000 cubic feet per day. The Standard Oil Company has finished a big well on the Coatesworth farm with an estimated yield of 4,250,000 cubic feet per day.

North of the Michigan Central railway the lower part of the Salina formation is barren of oil, which is found in the Guelph instead.

New Romney oil field.—Seven miles southwest of the Fletcher field, in the northern part of lots 21, 22, and 23, concession IV, of Romney township, a small pool of oil was discovered in 1905, occurring about 180 feet from the top of the Big Lime (Onondaga limestone) at a depth of 200 to 270 feet from the surface.

The first well had a daily production of 40 barrels of oil and 500,000 cubic feet of gas; a second well gave only 8 to 10 barrels, and a third 60 barrels. One well in the beginning gave easily 300 barrels of oil and 1200 barrels of water. The oil sands lie at 1393, 1418, and 1430 feet depth. Up to January, 1907, 150 wells had been drilled on a surface of two to five miles, and only three or four were without results.

Zone township.—In the Bothwell pool 150 oil wells gave a small production. A few properties have been neglected, but the scarcity of abandoned wells is remarkable, the tenacity of production since the discovery of the pool is exceptional, and constitutes an example of very favourable und ergroundconditions and careful scientific economy in producing methods. Most of the oil is pumped to nearby loading racks, and shipped by tank cars to refineries at Wallaceburg and Sarnia. Some oil, however, is allowed to accumulate in tanks on the lease, and once a month is hauled by wagon to the receiving station at Bothwell.

A typical record of a well in this field is as follows:—

Record of a typical well in Zone township.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface		0	90
Black shale	Portage	90	167
"Soapstone"	Hamilton	167	359
Limestone	Onondaga	359	479
Total depth			479

Raleigh township pool.—Oil was struck in Raleigh township on lot 18, concession II, in November, 1902, at a depth of about 320 feet, or about 200 feet from the top of the Onondaga limestone. This was the first flowing well in the township. By April, 1903, 60 wells had been completed. The first well was known as the Gurd gusher from the name of its owner. It is estimated that while flowing it produced over 1000 barrels per day. About 200 wells were drilled in this pool. The former production at Charing Cross has ceased, and the wells have been practically abandoned; but a little oil is still pumped from less than a dozen wells in concession IX. In 1912 a deep test well was drilled by the Standard Oil Company of Canada midway between Merlin and Lake Erie and was stopped at a depth of about 1700 feet, being a small gas well.

In 1913 wells were still being drilled in southeastern Raleigh township. The structure of the Raleigh field is reported to be[1] anticlinal with a dip of 60 feet to the mile.

[1]Gibson, Thomas W., Ann. Rept. Bureau of Mines, Ontario, 1903, p. 41.

PLATE VIII.

Old well in Raleigh township, Kent county, Ont.

Harwich township.—Three miles southeast of Chatham, along the trolley line, on the Blakely and McIntosh properties, are 25 to 30 wells, which produce from 150 to 165 barrels per month. They are 400 to 440 feet deep and obtain oil from the Onondaga limestone. The pool was opened seven or eight years ago, and 17 or 18 wells have already been abandoned and plugged. The locality is known by oil men as "broken" or "freakish." Another group of wells, one and one-half miles east, was developed about the same time. All have been abandoned, although the pumps are still on the ground. The pool never produced much oil, and was badly managed.

Very little gas has been found in Harwich township, the best showing being presumably in the LaCope well of the Union Natural Gas Corporation, situated one mile west of Blenheim, which had an estimated production of 100,000 cubic feet per day. A test about 2000 feet deep was drilled on the Bisnett farm south of Blenheim and proved a dry hole. In the past years considerable testing of the shallower formations has been done in the vicinity of Blenheim, with few results. There is no oil or gas production in this vicinity at present.

The character of the formation in Harwich township is illustrated by the following dry hole.

Record of well drilled in Harwich township[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface materials	Pleistocene	0	78
Black shale	Portage and Chemung	78	138
White shale		138	161
"Soapstone"		161	171
White limestone		171	186
Shale		186	256
Grey limestone	Hamilton	256	276
White shale		276	376
"Soapstone"		376	396
White limestone		396	420
White shale		420	440
White limestone	Onondaga	440	445
Grey "		445	555
Blue "			570
Total depth			570

Orford township.—There never has been any oil or gas production in Orford township, although dry holes have been drilled.

[1]Brumell, H. P. H., Geol. Survey Canada, Ann. Rept., Vol. V, 1889-91, Pt. Q, p. 74.

The stratigraphic conditions are illustrated by the following record drilled years ago on the Raney farm by Hiram Walker and Sons.

Record of dry hole drilled on Lot 10, Concession XI, Orford township[1].

Material	Formation	Top Feet	Bottom Feet
Surface materials	Pleistocene	0	160
Limestone	Hamilton	160	241
White shale		241	311
Grey limestone	Onondaga	311	401
Limestone		401	555
Fine white sandstone	Salina	555	585
Grey sandstone		585	630
Grey limestone		630	915
Fine sandstone		915	1000

Casing	915
Big flow of sulphur water	630
" " salt water	965
Show of oil	470
Surface elevation	740
Total depth	1000

Chatham township.—There never has been any production in this township. Many years ago a well was drilled at Chatham to a depth of 1000 feet[2]; the complete log is not preserved but the log of a shallow well is given herewith for reference.

Record of well on Concession VII, Chatham township.

Material	Formation	Top Feet	Bottom Feet
Clay	Pleistocene	0	48
Black shale	Portage	48	148
"Soapstone"	Hamilton	148	400
Limestone	Onondaga	400	595
Total depth			595

Camden township.—In the vicinity of Thamesville, a small pool was opened, known as the Klondike pool. Most of the wells have been abandoned and the 25 wells which are still rigged for pumping are now small producers and none were being pumped when visited in 1912. A number of dry holes have been drilled in this township. A typical well log is as follows:—

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 73.
[2]Hunt, T. Sterry, Geol. Survey Canada, Rept. of Progress, 1866, p. 247.

Record of dry hole on Lot 2, Concession III, Camden township[1].

Material	Formation	Top Feet	Bottom Feet
Sand	Pleistocene	0	13
Clay	Pleistocene	13	53
Hardpan	Pleistocene	53	60
Black shale	Portage	60	80
Limestone	Hamilton	80	110
"Soapstone"	Hamilton	110	314
Limestone	Onondaga	314	431
Sandstone	Onondaga	431	477
Hard limestone	Onondaga	477	500
Big flow of salt water		431	
Total depth			500

Gore of Chatham.—There is no production or drilling in the Gore of Chatham with the exception of a little shallow gas encountered in drilling water wells. It is sometimes used a short time for domestic purposes.

In 1896 a deep hole was drilled in lot 5, concession I. The report recorded is as follows:—

Record of dry hole in Gore of Chatham[2].

Material	Formation	Top Feet	Bottom Feet
Surface materials	Pleistocene	0	140
Limestone and shale	Chemung and Portage	140	685
Shale and limestone	Hamilton	685	850
Light limestone	Onondaga	850	1000
Fine-grained dolomite and gypsiferous dolomite	Salina	1000	1700
Dolomite	Guelph	1700	1820
Limestone	Niagara	1820	1925
Calcareous and arenaceous shale	Clinton	1925	2020
Sand and shales	Medina	2020	2085

Bothwell pool.—The Bothwell pool in Zone township, which lies for five miles along the Thames river, and is half a mile wide, was opened in 1864, wells of large production being encountered at a very shallow depth. The pool was later abandoned, owing to the decline of the shallow sand production. In 1896, however, a revival took place, and by 1898 there were 150 producing wells and the field was extended northwest to the present main Bothwell pool. In 1898 this pool produced 4000 barrels per month, from 150 wells. In 1901 there were

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 72.
[2]Geol. Survey Canada, Vol. XI, p. 138s, 1898.

from 200 to 240 producing wells, and 5000 to 6000 barrels of oil per month were produced. At present there are about 370 producing wells, very few of which have been abandoned since the field was opened. About 3000 barrels per month are still produced, and the field shows no signs of complete exhaustion. In July, 1912, there was only one drilling rig in operation in the Bothwell field. The principal oil horizon is found at a depth of 400 feet, in the Onondaga limestone.

About twenty-five years ago a deep test was drilled to a depth of about 1500 feet. The subsidiary pool, west of the main pool, is hereby considered a part of the same. The principal operators in the Bothwell pool are:—

Warren Oil Company,
Crottey and Elliott,
Walker Oil and Gas Company,
Carmon and Fairbanks,
C. O. Fairbanks,
Puddicomb and Brewer.

The oil from the Bothwell pool was pumped to a neighbouring loading rack and was shipped in tank cars on the Grand Trunk railway to Wallaceburg and Sarnia for refining.

A typical record of the wells in this township is as follows:—

Record of "Clinton oil well," Zone township, drilled in 1886[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface materials	Pleistocene	0	155
"Soapstone"	Hamilton	155	168
Black shale		186	190
"Soapstone"		190	222
Limestone	Onondaga	222	370
Show of oil			370
Total depth			370

Howard township.—There is no production in Howard township. A dry hole was once drilled south of Ridgetown by the Union Natural Gas Corporation. It went through the Red Medina sand into the red shales having a total depth of about 2000 feet. No record of it is available. A record of a shallower hole on the line of Orford township is as follows:—

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 245.

Record of dry hole in Concession IV, Howard township.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Clay	Pleistocene	0	95
"Soapstone" and light shales with a black band near the base	Hamilton	95	350
Bluish limestone	Onondaga	350	510
Grey sandy limestone	Salina	510	707
Total depth			707

Dover East and Dover West townships.—No oil or gas has ever been produced in these townships. The following log of a well one mile west of the Grand Trunk railway station at Chatham, gives the general conditions:—

Record of dry hole at Chatham.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface clay	Pleistocene	0	60
Black shale	Portage	60	178
"Soapstone"		178	378
Limestone	Hamilton	378	396
"Soapstone"		396	433
Limestone	Onondaga and Salina	433	1000
Casing			260
Show of oil			475
Big flow of salt water			700
Total depth			1000

10-inch drive pipe to 138 feet.
8-inch casing pipe to 243 feet.
6½-inch casing pipe to 835 feet.

A number of additional well logs are given under the various townships; and a number are reported by Brumell[1].

In order to illustrate the stratigraphy in a graphic way, a number of the most interesting known records in this county are shown in Figs. 14 and 15, and correlations made with wells in Lambton, Essex, and Elgin counties.

Geological structure of the fields.—Although the surface of southern Ontario is covered by drift, the outcrops so few, and the country so flat, that little geological structure is determinable on the basis of outcrops alone, it is possible to make some general statements by a comparison of the well records. For instance, the logs in the new Tilbury-Romney gas field show that the formations do not lie as deep in this field as in other localities in Kent county, notwithstanding the situation of the field in the southern part of the county, where greater depths

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, pp. 70-76.

might be expected. Consequently, we have evidence that the Tilbury-Romney gas field lies on a prominent anticline or dome or combination of such structures, presumably the northward continuation of the Cincinnati anticline of northwestern Ohio. Again, in Zone township, the geological structure is evident, the fields consisting of alternating anticlinal and synclinal axes[1], which consist of one main axis and several subordinate ones trending in a common direction, and another series which crosses at a wide angle. The productive oil wells are believed to be situated at the intersection of the two sets of anticlines. Since the dip of the strata is more gentle on the southern slope of the anticlines than on the north, the oil occurs lower on the southern side. In a general way, we may say that the top of the Onondaga limestone ranges in elevation from 250 feet below sea-level to 450 feet above that datum.

Production of petroleum.—The production of these fields has declined during the past few years, the rate in Kent county being as shown in the table.

Production of Petroleum, 1907-1912[2].

(in barrels)

Date.	Tilbury and Romney field.	Bothwell field.	Thamesville field.	Raleigh field.	Richardson Station (Chatham).	Zone pool.
1898		66,404				901
1899		65,044				
1900		47,405				
1901		52,873				
1902		50,141		2,462		
1903		48,880		1,161		
1904		47,654	5,027	3,274		
1905		47,959	2,463		1,249	
1906	106,992	44,827	175			
1907	411,588	42,727	237			
1908	201,283	39,228				
1909	124,003	38,092				
1910	63,058	36,999				
1911	48,707	35,243				
1912	44,727	34,486				

[1]Chalmers, Geol. Survey Canada, Ann. Rept., Vol. XIV, Pt. I, 1901, p. 162A.

[2]Gibson, Thos. W., Rept. Bureau of Mines, Ontario, Vol. XXI, Pt. I, 1912, p. 35. Vol. XXII, Pt. I, 1913, p. 42. Min. Res. U.S., 1905, p. 890.

Gore of Camden.—Several wells were drilled at Dresden about twenty years ago and one or two of them showed oil but they did not prove of much value. A general record of the formations penetrated at this place is given on page 157.

Future prospects in Kent county.—As stated in connexion with the various townships, the oil pools of Kent county are practically exhausted with the exception of the new pool in the vicinity of Fletcher, which is producing from a deep sand. The gas pool in the southern part of the county is also producing from the deep sand as practically outlined. Although a few dry holes have been drilled into the Salina formation in other parts of the county, large untested areas of deep sand territory still exist, and presumably areas in which the geological structure may be favourable, and consequently it is to be expected that some small oil or gas pools may be found in the Salina or in other sands in the county.

As stated in the report on this gas field[1] it will presumably be long lived, the opinion being based not only on the rock pressure of the gas, the thickness of the porous formation and the amount of pore space, but also taking into account the fact that the gas field extends under Lake Erie, presumably for a considerable distance, and consequently the higher pressure under the lake will serve to equalize the pressure while using the gas beneath the land.

Pelee Island, Kent county.—In 1912 a deep well was being drilled on Pelee island, and it was said that the Trenton rock had been practically reached; the well was being drilled on the Finlay farm by Messrs. Jasperson and McKay. A little oil had previously been found in shallow wells on that island at a depth of about 750 feet.

Ridgetown, Kent county.—In 1911, a showing of gas was found at a depth of 300 feet in a water well at Ridgetown. The pressure is said to have been 40 pounds per square inch. Similar shallow showings of gas have been found in surface gravels in Kent and other counties.

[1]Mickle, G. R., The Kent gas field, 19th Ann. Rept., Bureau of Mines, Ontario, 1910 Pt. I, pp. 149-152.

Lanark County.

Oil or gas in commercial quantities will never be found in Lanark county, since the county is largely occupied by formations of Laurentian, Potsdam and Beekmantown age, which, being low in the geological scale, and without cover, are unfavourable.

Lambton County.

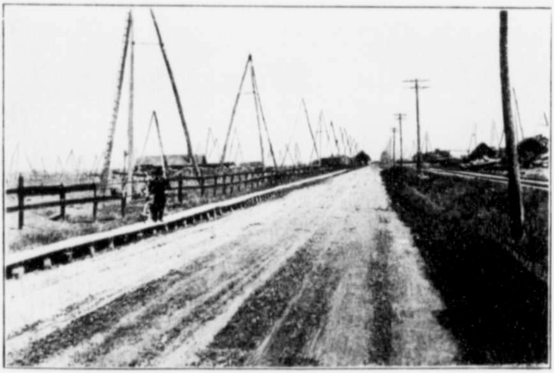
Description of fields.—The most important oil field in Ontario is the Petrolia field in Enniskillen, Sarnia, and Moore townships. The second most important field, commonly classified as part of the Petrolia field, is the Oil Springs pool in southern Enniskillen township. In addition there have been very small pools developed at Shetland in Euphemia township, near Florence in Dawn township, London Road in Plympton township, and on Kettle point in Bosanquet township.

A small and short lived supply of gas is found at numerous places in the western part of Lambton county, in the gravel and shales which lie underneath the Erie clay, but there is no gas field in the county.

History of developments.—The first attempt at utilizing the petroleum in Lambton county, was in 1859, the effort consisting of the extraction of a liquid from gum oil, which found its way to the surface at Oil Springs in what was known as the gum beds. The first wells were surface wells 4 or 5 feet in diameter, dug to a depth of 40 to 60 feet, reaching a bed of gravel, from which the oil would flow into these. Similar wells were dug at Petrolia.

The first rock drilling in Ontario was by Mr. Tripp at Oil Springs about 1861 in search of water. The procedure was to sink and crib a shaft four feet in diameter to the rock in order to protect it from caving. After the cribbing period in the Petrolia fields the surface materials were bored through with an auger. Most of the drilling was done by hand power. In the winter of 1861-2 some very productive flowing wells were struck, the first by James Shaw on February 19, 1862, and several produced

Oil wells and creamery, Petrolia, Ont.



Centre street, oilfields, Petrolia, Ont.

thousands of barrels each per day. Naturally, since these wells were obtained rather unexpectedly, the greater part of the oil was lost through flowing into the creek on account of lack of storage facilities.

At one time there were at least twenty flowing wells in the field. The nearest railway station was then at Wyoming, twelve miles distant, and naturally there was not such great excitement as occurred in other fields which were easier of access. The transportation problem at first was difficult. A few thousand barrels of oil were floated down the creek, but then a plank road was built to the railway and the oil hauled out by wagon. It was manifestly impossible to provide adequate facilities as rapidly as needed, and there was great waste of oil. The flowing wells changed to pumpers in a year or two and water frequently took the place of oil. Some years later Oil Springs became practically deserted.

Petrolia was settled in 1839. Oil was first struck in 1862 at 160 feet in a water well. The principal development was about 1865, within the present corporation limits, but no flowing wells were obtained until 1866, when they were struck in what was known as the King district a little west of the present town. In this field the production of single wells sometimes ran as high as 400 barrels per day. At Oil Springs, however, one well, known as the Black and Mathewson well, flowed about 6,000 barrels per 24 hours for a few days. In the Petrolia fields the wells changed to pumpers in a short time.

As in many oil towns, an oil exchange was opened in Petrolia in the early days, the object being for buyers to meet at a certain hour every day, as in a stock exchange.

The first refinery was established at Petrolia about 1861, being one of the first refineries in Canada. In the winter of 1867-8 the Great Western railway was built to that town, making it possible to transport the oil in tank cars. Originally much oil was exported to England, but this business dropped off on account of the better and cheaper oil produced in the United States.

There were formerly eight large refineries in the vicinity of Petrolia, the output of which, when operating to capacity, would be between 5,000 and 6,000 barrels of refined oil per week. The Crude Oil and Tanking Company afforded ample facilities for storing crude oil in underground tanks, as also did the Crown Producers Company.

An estimate of the total capital invested in the oil business in the Petrolia-Oil Springs district in 1887 was $2,750,000, divided as follows:—

Cost of wells, exclusive of the value of land	$1,500,000
Cost of engines, and other machinery to run the wells	300,000
Storage tanks	150,000
60 miles of pipe line with forging machinery	150,000
The cost of refineries is placed at	500,000
Cooper shops, barrels, chemicals, etc	250,000
Cost of sinking wells, which were sunk some 475 feet, was about	500

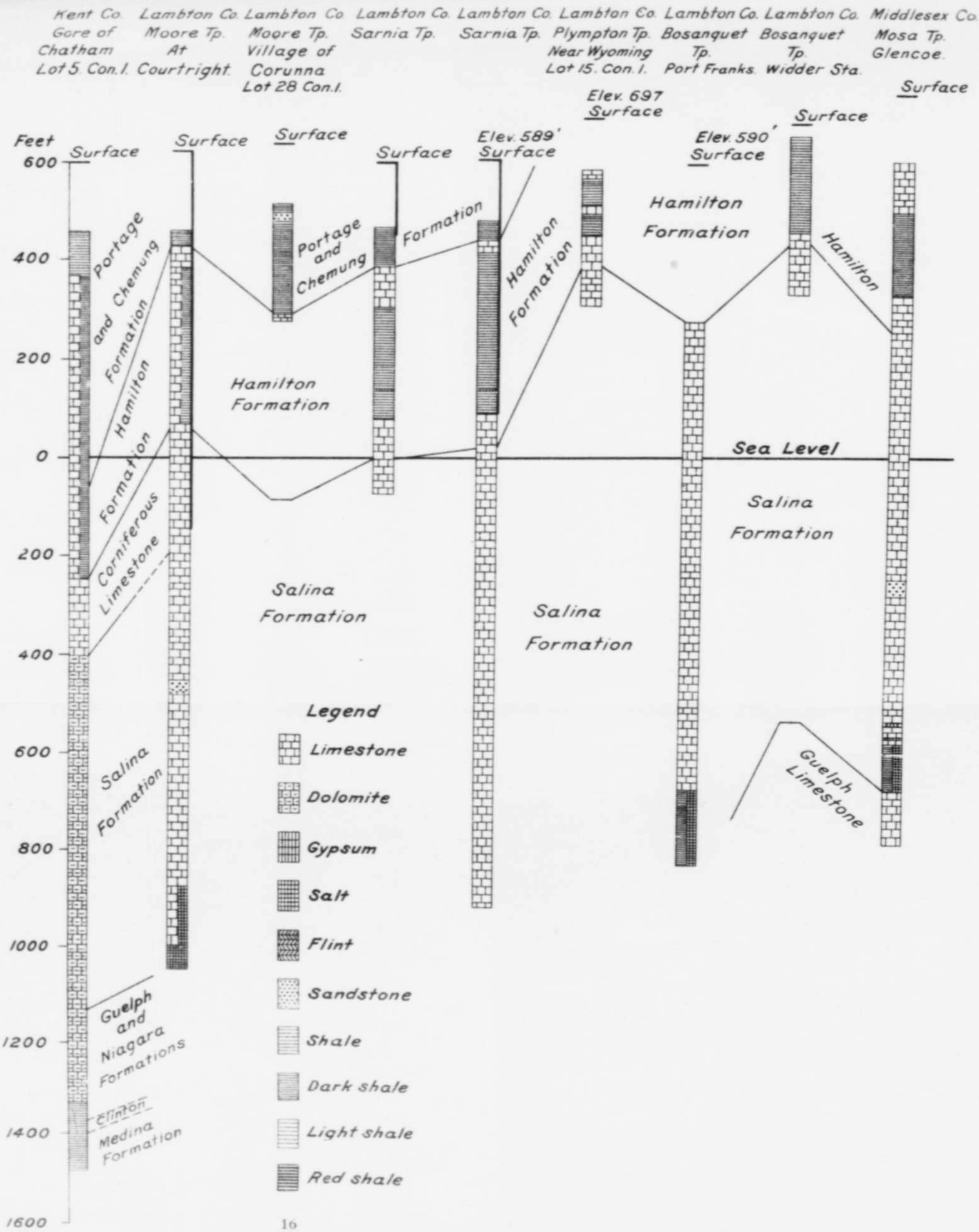
Productive formations.—The oil in the Lambton county pools has all been found in the Onondaga limestone. In the Petrolia and Oil Springs fields the pay is struck from 250 to 500 feet below the surface, or about 60 feet from the top of the Onondaga. In character it is a porous dolomitic phase of the limestone, from one to six feet in thickness, brownish and very soft.

Depth of wells and formations penetrated.—In depth the wells of Lambton county range from 300 to 3770 feet. The depth of the oil-bearing stratum is from 250 to 500 feet in the Onondaga limestone, averaging about 65 feet from the top of the formation in the centre of the town of Petrolia. In the Petrolia field the wells average 470 feet in depth, and in the Oil Springs about 370 feet. All wells drilled more than 500 feet deep were failures below that depth.

The best geological data in the county are derived from well logs, which are abundant and occasionally rather detailed. In many of these wells it is difficult to distinguish between the Onondaga and Salina formations; but in others the change is rather marked. The detailed character and changes of the Salina are seldom recorded, however. In the case of the Hamilton formation the term "Upper" and "Middle" limes and "Upper" and "Lower" soapstones are recorded. We must understand, as previously stated, that the term soapstone is not used in the geological sense, but is the drillers' name for a light soapy shale.

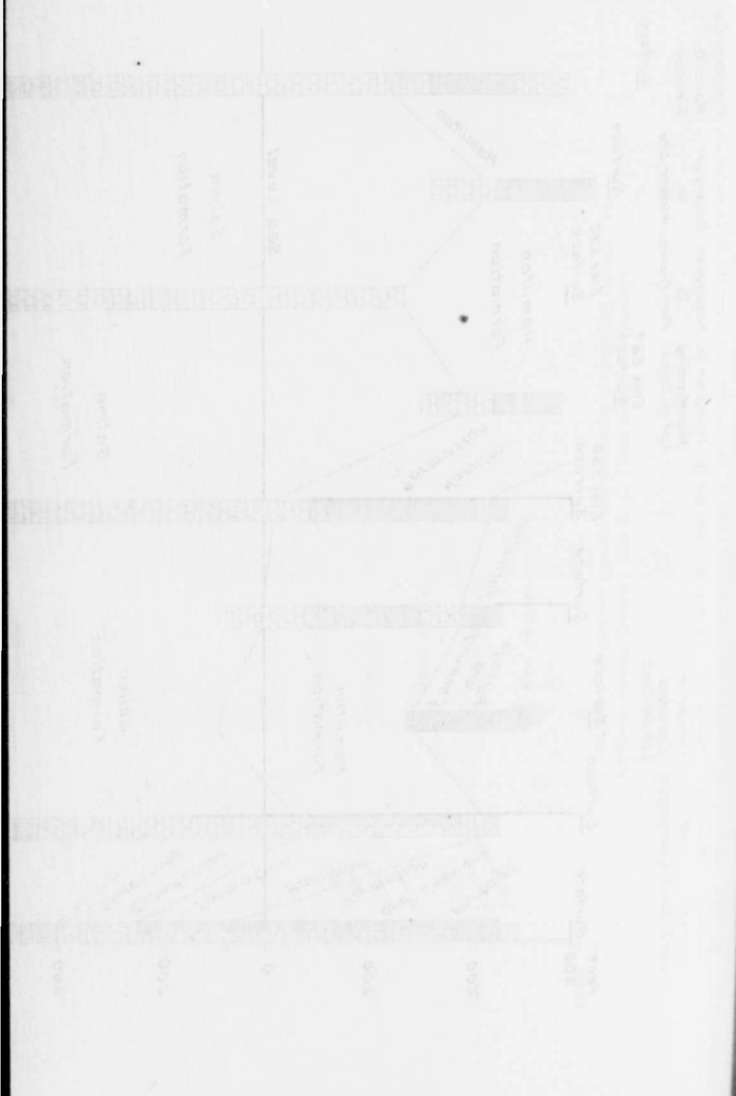
A few typical well records of this county are plotted on Figs 16 and 17. The records of the county reveal a thick-

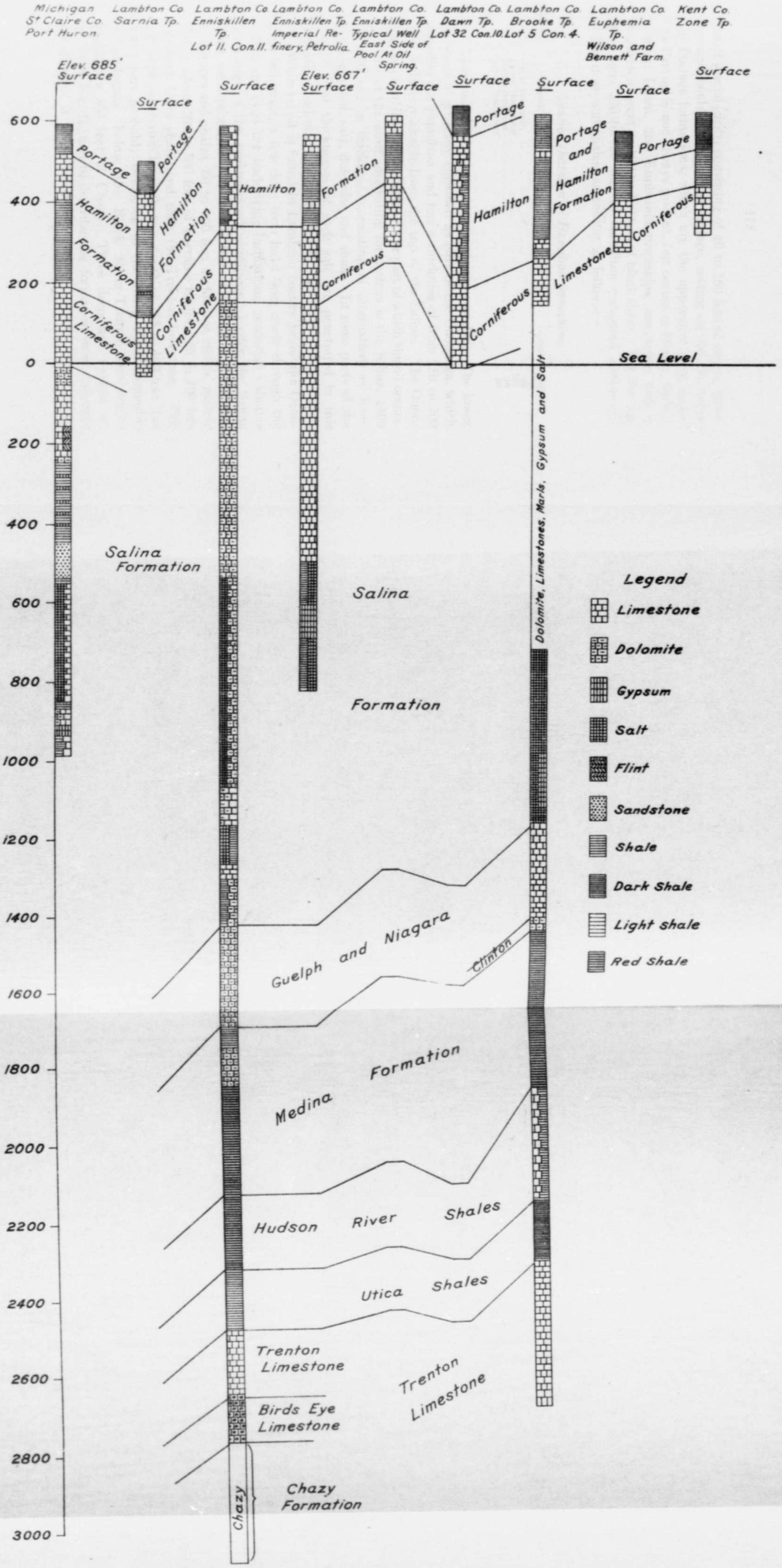
Kent Co. Lambton Co. Lambton Co. Lambton Co. Lambton Co. Lambton Co. Lambton Co. Lambton Co. Middlesex Co.



16

Fig. [redacted]. Selected well logs, showing correlation of formations through Lambton county, Ontario. (By F. G. Clapp and L. G. Huntley)





17
Fig. [redacted] Selected well logs, showing correlation of formations through Lambton County, Ontario. (By F. G. Clapp and L. G. Huntley)

ness of glacial drift, consisting of 40 to 160 feet of gravel, sand, clay and boulder clay at the surface, resting on the Hamilton and Portage formations, which are the uppermost hard rocks. The Portage is not always present, but occurs in Moore, Sarnia, Sombra, Dawn, and Euphemia townships, sometimes with a thickness as great as 100 to 200 feet of black shale. The Portage rests upon 290 to 400 feet of Hamilton composed alternately of limestone and shales, somewhat as follows:—

General character of Hamilton formation.

Material	*Common thickness* *Feet*
Upper limestone	40
Upper "soapstone"	200
Middle limestone	20
Lower "soapstone"	50

These subdivisions are, however, very variable. The lower limestone is generally classified as part of the Onondaga, which underlies the Hamilton and has a thickness of from 150 to 200 feet, indistinguishable from the top of the Salina. The Onondaga is a hard limestone, in the upper part of which the oil occurs.

One of the most interesting formations is the Salina, 1400 to 1600 feet in thickness, consisting of alternations of limestone, gypsum, salt, dolomite, and shale. In some parts of the county great thicknesses of rock salt are penetrated in this formation, and many salt wells exist.

While no oil is found in Lambton county below the Onondaga limestone, a few deep tests have been made through the Salina and even the underlying formations, rendering valuable knowledge of the underground conditions. Under the Salina these wells penetrate 220 to 300 feet of Guelph and Niagara limestones and shales, 60 to 400 feet of Medina shales, mainly red in colour, 200 to 300 feet of Lorraine shales, 150 to 200 feet of Black Utica shale, and then the Trenton limestone. This has been penetrated by wells to a depth of 285 to 400 feet, the lower part probably belonging to the Black River formation of geologists. Below the Black River-Trenton one record penetrates 300 feet of Chazy. Three deep well records are given on Fig. 16, and to describe the formation more minutely the deepest is given below:—

Record of deep well drilled in 1902, on R. I. Bradley Estate, Lot 11, Concession XI, Petrolia pool.

Formation	Material	Top Feet	Bottom Feet
Pleistocene	Surface	0	90
Hamilton	Streaks of limestone and shale	90	330
Onondaga	Limestones	330	520
Salina	Streaks of brown, grey and black dolomite	520	1210
	Salt strata and streaks of dolomite	1210	1640
	Salt strata and streaks of dolomitic limestone	1640	1747
	Salt strata and grey dolomitic lime and shale	1747	2105
Guelph and Niagara	Guelph and Niagara dolomitic limestone	2105	2380
	Niagara shale (red and dark)	2380	2440
Clinton	Clinton	2440	2530
Medina	Red Medina	2530	2805
Utica	Lorraine shales (light)	2805	3010
	Utica shales (dark)	3010	3175
Trenton	Trenton	3175	3345
	Birdeye	3345	3460
	Chazy (Canadian)	3460	3770
	Total depth		3770
	13-inch conductor		98
	7¾-inch casing		186
	6¼-inch casing		1015

A record which is not so deep, but shows the Portage, is as follows:—

Log of well at Agricultural Works in Sarnia[1].

Formation	Material	Top Feet	Bottom Feet
Pleistocene	Surface	0	130
Portage	Black shale	130	210
Hamilton	Limestone	210	290
	Shale	290	450
	Limestone	450	455
	Shale	455	515
Onondaga	Limestone	515	665
	Total depth		665
	Show of gas		515
	Salt water		645
	Cased to		140
	Plugged at		640

Limestone is struck in the Petrolia field at about 100 feet and it is sometimes 35 to 40 feet thick, with streaks of soapstone. Below the limestone is 120 feet of soapstone which is soft and similar to blue clay. Then comes the middle lime, which averages 15 to 18 feet and is not hard. Below this is the lower soapstone. which is a light shale about 40 feet thick. Then 20 to 80 feet of limestone is encountered.

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, p. 889-91, p. 70.

Below 400 feet from the surface, the formation is a sandy limestone or calcareous sandstone extending to about 470, where the oil rock is struck. This is brown, soft and porous, some of it being of a honeycomb nature, with occasional crevices into which the tools drop. The best wells in the early days at Petrolia were obtained in crevices.

Casing.—Water in shallow wells in the Petrolia field was generally shut off by casing to an average depth of about 270 feet, to the top of the so-called middle limestone. Several deep tests have been cased to depths of 500 to 1,000 feet, however, some being cased into the Salina formation.

Geological structure of the fields.—In structure the Petrolia field is known to be anticlinal. The formations dip, in a general way, towards the west and south, in that the top of the Onondaga limestone ranges all the way from 200 feet below sea-level in the southwest corner of Sombra township, to sea-level at Corunna, 300 feet above in the Euphemia pool, 450 feet above at Oil Springs, 350 feet above at Petrolia, 400 feet at Wyoming, and 450 feet in parts of Bosanquet township. That the rise and fall of the strata is not entirely regular is shown by the fact that a single bed varies as much as 200 feet in elevation within the limits of a single township.

The Oil Springs and Petrolia pools are known to be separated by a distinct syncline in which no oil exists, since the upper beds of the Hamilton formation are overlain by the black shales of Portage age, which have at Oil City, between Petrolia and Oil Springs, a thickness of 40 feet, and these shales are absent in both the Petrolia and Oil Springs fields.

The top of the dome structure in the strata is near the northwest corner of the town of Petrolia, and the strata descend in all directions.

Production of petroleum.—In 1867 the daily production in the Oil Springs pool ranged from 100 to 7,500 barrels per day per well from 33 flowing wells; there being a total daily production of 55,300 barrels, or an average of 1,600 barrels from a well.

In 1891 there were, in the Petrolia and Oil Springs pools, 2,700 to 3,000 pumping wells with a total annual production of 600,000 barrels. In 1898, 8,600 wells gave a total monthly production of 57,000 barrels. The production of oil in Lambton county, as elsewhere in Ontario, has declined slowly during the past few years.

Production of Petroleum in Lambton County[1].

Date.	Petrolia field.	Oil Springs field.	Moore pool.	Plympton pool.	Dawn pool.	Euphemia pool.
1898	513,179	133,366	......	25,000	5,923	....
1899	528,641[2]	107,487[3]	......	....	......	....
1900	501,435	99,019	......	....	......	....
1901	432,906	76,059	......	....	......	....
1902	397,628	60,747	......	....	......	....
1903	350,390	56,405	......	....	......	....
1904	278,299	75,530	36,971	....	......	....
1905	250,701	78,125	93,815	....	......	....

Production of Petroleum, 1907-1912[1].

Year.	*Barrels.*
1907	304,212
1908	265,368
1909	243,123
1910	205,456
1911	184,450
1912	150,272
Total	1,352,881

The average daily supply from a well in the Petrolia fields in 1890 was 5 or 10 barrels of mixed water and oil, but the oil in this averaged less than a barrel a day. All flowing wells had been abandoned before that time. In the main part of the Petrolia pool, Doctor Fairbanks puts the average present production per well at about 10 gallons per day, in the better managed properties. The wells in the outlying parts of the pool of course reduce this average. Wells are pumped on six days every week.

[1]Gibson, Thos. W., Rept. Bureau of Mines, Ontario, Vol. XXI, Pt. I, 1912, p. 35. Vol. XXIII, Pt. I, 1913, p. 42.
Min. Res. U.S., 1905, p. 890; 1900, p. 587.
[2]Includes production from Plympton pool.
[3]Includes production from Dawn and Euphemia and from Zone township, Kent county.

The output of petroleum for the last six months of 1887, measured by shipments, which is the only basis for estimating the production in Canada, was the largest ever known in the same length of time, aggregating 510,352 barrels.

Quality of the oil.—The present petroleum from the Oil Springs pool is from 35 to 36 degrees Baumé, while that from the Petrolia pool is from 28 to 31 Baumé. No trouble is experienced from the waxing of rods, or from the formation of sediments either at the surface or underground, except to a small extent in the northwestern part of the field, where salt water is encountered.

The oil in Lambton county is dark brown, and has a density of 0·8695 to 0·8484. The amount of sulphur is 1·5 per cent, but the oil can be successfully cleaned.

Petrolia and Oil Springs fields (Sarnia and Enniskillen townships).—The paying wells in Lambton county are confined to a belt running northeast and southwest for about 20 miles, with a width varying from 1 to 4 miles. This belt is situated some 16 miles east of Sarnia and includes the two districts, Petrolia and Oil Springs. The area of the Petrolia field is 26 and of the Oil Springs pool 2 square miles. The length of the original Petrolia field was about eight miles east and west and from half a mile to two and one-half miles in width. In 1890 there were 2,500 wells in the Petrolia field alone. In the Oil Springs pool 244 wells were drilled in one year beginning July 1st, 1887; the total number of wells in operation on July 1, 1888, was 964. In concession I, of Enniskillen, in 1890, there were 258 wells and in concession II there were 206 wells.

A typical oil well in the Petrolia field had the following record:—

Log of well near Imperial Refinery, Petrolia[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	104
Upper limestone	Hamilton	104	144
Upper "soapstone"		144	274
Middle limestone		274	289
Middle "soapstone"		289	332
Hard white limestone	Onondaga	332	400
Soft white limestone		400	440
Grey white limestone		440	465
	Total depth		465
	Oil at		465

[1]Geol. Survey Canada, Vol. IV, p. 795.

The following is a typical record of a well in this pool:—
Log of well on east side of Oil Springs pool[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	60
Upper limestone	Hamilton	60	95
Upper "soapstone"	Hamilton	95	196
Middle limestone	Hamilton	196	223
Lower "soapstone"	Hamilton	223	330
Lower limestone	Onondaga	230	370
	Total depth		370
	Oil at		370
	Salt water		252

A number of deep tests have been drilled in Lambton county, the records of which are given on page 175.

The Oil Springs and Petrolia pools are continuing to prove among the most remarkable oil districts in the world, on account of the slow decline of production. From about 7,000 wells in 1897 and 1898, there are approximately 4,000 wells still producing in the Petrolia pool; while the proportion abandoned in the Oil Springs pool is slightly less. No drilling rigs are in operation at present anywhere in Lambton county.

The Oil Springs and Petrolia fields are contracting from the outer edges inward. No water problem has developed, except in the extreme northwest extension of the field, east of Sarnia. Wells on the outer limits are exhausted and abandoned from time to time, and no new production is taking their place. This field exhibits a comparatively rare example of an oil pool declining from the single cause of the exhaustion of the underground supply of oil. The decrease is not complicated by the exhaustion of gas pressure or consequent encroachment of water; nor is the oil of such a character that obstructive waxes and sediments have accumulated at the bottom of the well. The oil rock is open and rather vesicular, and apparently allows the complete exhaustion of the oil in the sand in the vicinity of a well or group of wells, before their abandonment. It has been possible to pump all wells alike, by shackle power, while in some other fields complicating underground factors make each well a separate problem. Careful producing methods

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q. 1889-91, p. 62.

have been used on most leases, the casing and pumps have been carefully watched, and even after the power has been disconnected from a well, it is sometimes pumped or bailed by hand from time to time. Thus the field is unique in its long life, and in the characteristics of its decline.

The best wells at present are found in the comparatively new extension which was developed during 1903 and 1904, in the northeastern part of Moore township. There are still some 200 to 300 wells producing in southeastern Sarnia township, although those in the London Road extension of the field, northeast of Sarnia, have practically all been abandoned. All oil from the Oil Springs and Petrolia fields goes to Sarnia, 16 miles distant, through a 3-inch pipe line for refining at the Imperial Refinery.

The salt water encountered throughout the main Oil Springs and Petrolia pools has diminished in quantity from former years, and is not encroaching at any part of the fields.

Plympton township.—Attempts to extend the Petrolia field into this township resulted in a few wells which produced some oil east of Sarnia, along the London road. With a few exceptions these have been abandoned. Drilling in the vicinity of Wyoming and elsewhere resulted in small shows of oil, and considerable salt water, and was generally successful. There is no production in Plympton township at present. A typical record in this township is as follows:—

Record of well in Lot 15, Concession I, near Wyoming[1].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	104
Black shale	Portage	104	108
Limestone	Hamilton	108	148
Shale	Hamilton	148	178
Limestone	Hamilton	178	193
Shale	Hamilton	193	236
Limestone	Hamilton	236	304
Limestone soft	Onondaga	204	344
Limestone grey	Onondaga	344	380

Small quantities of oil in this well are accompanied by copious flows of saline water.

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 64.

Bosanquet township.—There was some drilling in this township immediately following the discovery of the Petrolia and Oil Springs fields; but no pools were discovered. Showings of gas are reported to have been obtained, however, in the base of the Hamilton formation or top of the Onondaga. A few wells still produce oil on the Kettle Point Indian Reserve, but they are of no importance. An English syndicate which held a lease on this reserve for the extraction of oil from shales, has allowed the lease to lapse, evidently believing the project to be commercially unprofitable, notwithstanding some good laboratory tests made on samples of this shale.

A typical log of the formations in the county is as follows:—

Log of dry hole at Widder Station, Bosanquet Township[1].

Material	Formation	Top Feet	Bottom Feet
Clay	Pleistocene	0	34
Soft shale	Hamilton	34	230
Limestone	Onondaga	230	350
Total depth			350
Show of oil			196

Warwick township.—No oil has been developed in this township. There was some drilling immediately following the discovery of the Petrolia and Oil Springs fields, but no pools were discovered. Showings of gas are reported to have been obtained, however, in the base of the Hamilton formation or top of the Onondaga. Salt wells have been drilled at Kingstones Mills. A well at the Elarton salt works was once sunk to a depth of 1,400 feet. Salt was reported in it from 1,200 to 1,330 feet.

Euphemia pool and township.—In Euphemia township, 40 wells obtained only a small production; the greatest daily production of a single well was one barrel. At present this district produces only about 500 barrels monthly. This pool had only a few wells in 1896, and the production was only 150 to 200 barrels per month. In July, 1912, only about 100 barrels per month were being produced from Euphemia and Dawn townships together. This oil was shipped by wagon to the Bothwell and Newbury stations, from where it went by the Grand Trunk railway to the refinery at London, Ontario.

A typical well record is as follows:—

[1]Geol. Survey Canada, Rept. Prog., 1866, p. 248.

Log of well in Euphemia township[1].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	58
Shales	Hamilton	58	323
Limestone	Onondaga	323	326
Big flow of salt water			350

Dawn township.—A small pool of oil formerly existed between Langbank and Florence. This pool, together with that in Euphemia township, produced only about 100 barrels per month in 1912.

A typical well record is as follows:—

Log of dry hole in Lot 32, Concession X, Dawn township[2].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	50
Black shale	Portage	50	120
Limestone Shale and limestone	Hamilton	190	475
Limestone	Onondaga	475	700
Total depth			700
Salt water			625

Rock-salt is reported to have been struck at 1,100 feet in the vicinity of this well.

Moore township.—Eight wells were drilled at Courtright previous to 1890, but gas was only obtained in three of them. There are about 200 producing wells in the northeast corner of this township, which are probably the best producers in Lambton county at the present time. The wells produce from the same formation as those at Petrolia and Oil Springs, and are of about the average depth. Many wells were formerly drilled in this township in an attempt to extend the Petrolia field. Small shows of gas have been encountered at Courtright in the Onondaga limestone, and salt wells have been drilled through the Onondaga into the Salina formation. Salt wells have also been drilled at Corunna.

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 66.
[2]Brumell, H. P. H., Geol. Survey Canada, Vol, V, Pt. Q, 1889-91, p. 66.

The record of a well drilled by the Courtright Salt Company is as follows: –

Log of salt well at Courtright[1].

(Surface elevation 588 feet)

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Sand, etc.	Pleistocene	0	132
Hard-pan		132	160
Black shale	Portage	160	192
Limestone	Hamilton	192	232
Shale and limestone		232	542
White limestone		542	592
Grey limestone	Onondaga	592	692
White, hard limestone	Salina, including lower part of Onondaga	692	1062
Sandstone (probably dolomite)		1062	1094
Limestone		1094	1494
Limestone and gypsum		1494	1630
Salt		1630	1652
Gypsum		1652	1665
Total depth			1665
Salt water			680
Casing to			740

Sarnia township.—The Petrolia belt extends west far into Sarnia township. There are about 200 old oil wells, twenty to twenty-five years old, in the southeast corner of Sarnia township, still producing. No wells now exist in the vicinity of Sarnia. The wells north of this town were very small and short-lived. Some good showings of gas have been found at the Imperial refinery near Sarnia at depths of 330 to 515 feet, but all gas wells in that vicinity are abandoned.

The record of a well drilled in 1875 in Sarnia is as follows:—

Log of well at King's Grist Mill[2].

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Sand	Pleistocene	0	9
Blue clay		9	118
Hardpan		118	120
Shale, black	Portage	120	156
Limestone	Hamilton	156	186
Shale		186	449
Limestone		449	454
Shale		454	494
Limestone		494	554
Grey limestone	Onondaga, including upper part of Salina	554	654
Hard limestone		654	1200
Hard and flinty limestone		1200	1400
Limestone and gypsum		1400	1505
Total depth			1505
Fresh water			120
Small gas			400
Salt water			654
Cased to			495

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 68.
[2]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 69.

To illustrate the non-importance of the wells near Sarnia, it may be mentioned that the production of the Dickens well, which has been reported as the most important in that vicinity, only amounted to 20,000 cubic feet of natural gas per day. The gas was used for lighting several dwellings and street lamps in the immediate vicinity.

Sombra township.—A number of dry holes are known to have been drilled in Sombra township, but information regarding them is not available. It is known, however, that salt wells were drilled some years ago at Port Lambton. No oil has ever been produced.

Brooke township.—No oil has ever been developed in this township. A dry hole was drilled to the Trenton at Inwood. The record is as follows:—

Log of well in Lot 5, Concession IV, at Inwood.

Material	*Formation*	*Top* Feet	*Bottom* Feet
Clay	Pleistocene	0	60
Boulder		60	65
Shales		65	150
Upper limestone		150	165
Upper "soapstone"	Hamilton	165	370
Middle limestone		370	395
Lower "soapstone"		395	420
Limestone	Onondaga	420	535
Dolomites, limestone and marls with gypsum and salt	Salina	535	1835
Limestones and dolomites	Guelph and Niagara	1835	2060
Dark shales		2060	2075
Limestone	Clinton	2075	2110
Red shale	Medina	2110	2550
Light grey shales with limestone	Lorraine	2550	2835
Dark shales	Utica	2835	3000
Limestone	Trenton	3000	3380

Black sulphur water was encountered at 500 feet in the Oil Springs and Petrolia oil rock. Rock salt occurred from 1,410 to 1,655 in a solid bed with only three small layers of limestone, and another rock salt bed from 1810 feet to 1835 feet. No oil, gas or salt water was struck.

Deep tests in Lambton county.—Several deep tests have been drilled in Lambton county, all of which have been failures. The last one was sunk in 1902, to a depth of 3,770 feet, the record of which is given on page 176. Another deep well was started on the Fairbanks property at Oil Springs between the famous Shaw and Bradley wells, on the crest of the main anticline, in July, 1912. It was being drilled by local capital from Petrolia, to go to the granite.[1]

Wells drilled for salt.—A number of salt wells have been drilled at Sarnia, Corunna, Courtright, Port Franks and other places along Lake Huron and the St. Clair river. The records of a number of these are given elsewhere. The salt is obtained from thick beds in the Salina formation.

Leeds County.

No oil or gas in quantity is believed to exist in Leeds, since the geological conditions are exceedingly unfavourable. The strata occupying the surface throughout the northern half of the country consist mainly of Beekmantown rocks, while in the southern part they are mostly Laurentian and in the intermediate belt the Potsdam sandstones exist. These formations, being low in the geological scale and without cover, are not favorable for prospecting.

Lincoln County.

General statement.—Showings of natural gas have been found at several localities in Lincoln county, but no important field has been developed.

History of developments.—In 1888 a well 2,200 feet deep was sunk on Broderick's farm in lot 4, concession III, Louth township, by the St. Catharines Natural Gas Company. Showings of gas were found in the White Medina sand and in the Trenton limestone, but not sufficient to warrant utilization. Very little development of natural gas has been done since that time in Lincoln county, although a few shallow wells have been drilled at various times.

Formations penetrated in drillings.—The topography of Lincoln county is somewhat peculiar in that it consists, like Niagara county, New York, of a lower and an upper level. The lower level is composed of the pan-handle in which Niagara, Grantham, and Louth townships are situated and also the

[1] This well is reported to have obtained a good flow of oil in the Trenton. Details are not available.

northern half of Clinton township. The upper level consists of Gainsboro, Caistor, most of Grimsby, and the southern half of Clinton township. The elevation of the lower level ranges from 250 feet to 350 feet above sea level, and of the upper level, 600 to more than 650 feet; consequently, there is a marked difference in elevation along the line of the Niagara escarpment, which averages for the county about 350 feet, and crosses the county from east to west. Consequently about 300 feet of the formations which occur south of the escarpment are not represented north of it.

As in other parts of Ontario, a considerable thickness of Glacial Drift underlies most of Lincoln county. This is true both north and south of the escarpment, although the escarpment itself consists of a nearly vertical cliff formed of rocks of Niagara, Clinton and Medina age. North of the escarpment, the formation immediately underlying the drift is largely Medina shale; south of the escarpment, it is mostly Guelph and Salina, the latter appearing in the extreme southwestern part of the county, in Gainsboro and Caistor townships.

It is unfortunate that few good well records are available in Lincoln county, but there is a log of the original well which was drilled in 1888 in Louth township, the record being as follows:—

Log of well on Lot 4, Concession III, Louth township[1].

(Surface elevation 297 feet)

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	90
Red shale	Medina	90	638
Blue shale	Lorraine and Utica	638	1338
Black to blue shale	Lorraine and Utica	1338	1506
Limestone	Trenton	1506	2173
White quartz sand	Chazy (?)	2173	2200

In the white sand underlying the Trenton formation, about 4,000 cubic feet of gas per day was encountered at a depth of 2,185 feet.

Nothwithstanding the fact that few well sections are available, it is fortunate that excellent correlations can be made

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q. 1889-91, p. 32.

with the assistance of outcrops along the Niagara escarpment and of records in adjacent counties and in New York state. (See Fig. 18.) Geological sections have been measured by many geologists at various points along this escarpment, and give the most reliable data extant regarding the Niagara, Clinton, and Medina formations. The following is a section of the formations measured along the Niagara river:—

Geological section along Niagara River[1].

Material	*Formation*	*Thickness Feet*	*Total Feet*
Lockport, dolomite, cherts, etc.	Niagara	150	150
Rochester shale		68	218
Limestones and shales	Clinton	32	250
Grey band sandstones	Medina	7½	257½
Red sandstone, etc.		50	307½
Cataract shales and limestones		26	333½
Cataract sandstone		25	358½
Total section exposed			358½

A section of the same formation measured at Grimsby is as follows:

Geological section at Grimsby, Ontario[2].

Material	*Formation*	*Thickness Feet*	*Total Feet*
Lockport dolomite	Niagara	12	12
Rochester shale		45	57
Limestone and shales	Clinton	14	71
Grey band sandstones	Medina	5	76
Mottled red (Red Medina sand)		25	96
Cataract shale and limestone		74	170
Band Cataract sandstone (White Medina sand...)		6	176
Total section exposed			176

All the strata exposed on the Niagara gorge continue as far as Grimsby and even to Hamilton, but they decrease in thickness toward the west, and beyond Hamilton the Niagara shale, Clinton dolomite, and Medina red sandstone disappear.

All oil operators should visit the sections afforded by the Niagara escarpment and should study it carefully since it furnishes an excellent key to the underlying formations in counties to the south.

Possibilities for oil and gas.—It is a fact that where geological formations rise in a certain direction and disappear by

[1]Parks, W. A., The Palæozoic Section at Hamilton, Ontario, in Guide Book No. 4, Excursions in southwestern Ontario, Ottawa, 1913, p. 128.
[2]Loc. cit., p. 130.

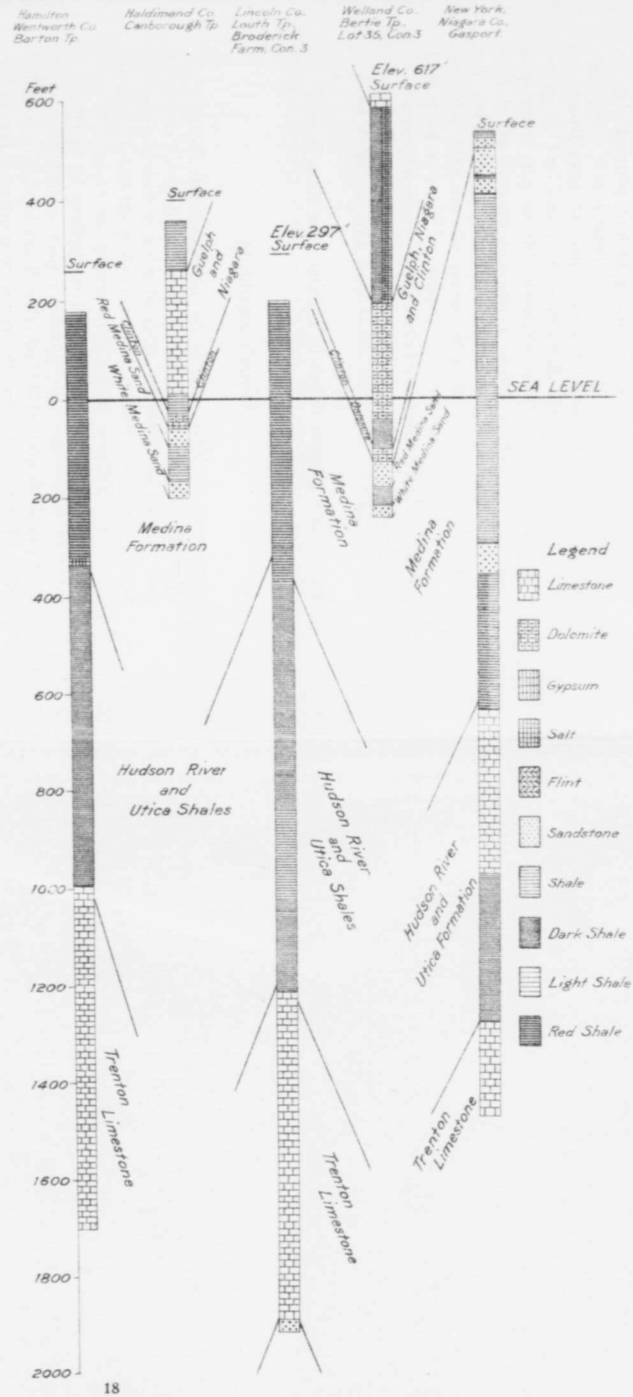


Fig. 18 [redacted]. Selected well logs, showing correlation of formations through Lincoln county, Ontario. (By F. G. Clapp and L. G. Huntley)

thinning out, such localities furnish an ideal structure for the accumulation of natural gas, as on an anticline (see discussion on page 94, Vol I). The Clinton dolomite and Medina sands disappear toward Wentworth county, and, consequently, the thinning edge of this formation constitutes a favourable structure for the accumulation of gas in the counties to the south and southwest. For a similar reason, it is apparent that natural gas should exist in Gainsboro and Caistor townships in this county. The cause of only small deposits being found is presumably due to the proximity of the outcrop of formations in the Niagara escarpment, owing to which the gas may have leaked away into the atmosphere. It is barely possible that this may be the reason why the wells in Haldimand county are so small in volume.

Caistor township.—Some wells have been drilled in Caistor township, but the average rock pressure in 1912 was 200 pounds, and the wells ran only from 46,000 cubic feet to 800,000 cubic feet.

Several wells were finished in the vicinity of Caistor and Warner in 1913.

Middlesex County.

General statement.—No oil or gas fields of commercial value have ever been found in Middlesex county. Showings have been struck in a few localities, as stated in the following paragraphs, but the wells may all be ranked as failures. There is no drilling at the present time in the county.

History of drilling in this county.—In the northwestern part of Middlesex county, during the excitement following the development of the Petrolia and Oil Springs fields in Lambton county, numerous wells were drilled throughout the townships of McGillivray, Williams East and West, and Adelaide.

No pools were discovered in Middlesex county, although showings of oil and gas were occasionally obtained at the base of the Hamilton or top of the Onondaga formation. In 1911 a number of wells were drilled at Delaware in Delaware township, obtaining small showings of gas and oil. The latter is of an amber hue, and has an asphalt base. A few other scattered wells have been drilled without result.

Formations penetrated by wells.—As in the other southwestern counties of Ontario, the surface is almost entirely covered by glacial drift, the thickness of which ranges from a few feet up to nearly 200 feet, and which in character is generally sand, gravel, clay or boulder clay. Underlying the drift, the uppermost hard rock formation in the northeastern part of the county is almost entirely Onondaga limestone; in the central part of the county it commonly consists of shales and limestone of Hamilton age; while in the extreme southwestern corner in Mosa township there is sometimes a thickness of 50 feet or less of black Portage shale.

In considering the formations to be penetrated, it is therefore necessary to take account of the portion of the county to be tested, because a well in the extreme northeastern part will not only start at an elevation 300 feet higher than the southwestern portion of the county, but it will begin in a lower formation geologically, since the formations rise toward the east and north. The Onondaga limestone, which constitutes the hard rock formation nearest the surface in Dorchester, Nissouri, Biddulph, and portions of Westminster and London townships, is consequently as much as 600 feet higher in elevation in parts of these townships than in the southwest part of Mosa township.

The Portage shales, occasionally present in Mosa township, seldom, if ever, exceed 50 feet in that township. Underlying these shales, lies sometimes as much as 280 feet of Hamilton limestones and shales, the latter being commonly known by the drillers as soapstone. The exact base of the Hamilton formation is not known with certainty in all well records, because some limestones occasionally occur near its base; but the contact of the lowermost soapstone with the underlying limestone is assumed to constitute the top of the Onondaga. Like the Portage, the Hamilton is absent in the northeastern part of the county.

Underlying the Hamilton is a thickness of 200 to 260 feet or more of Onondaga limestone, the exact demarkation of

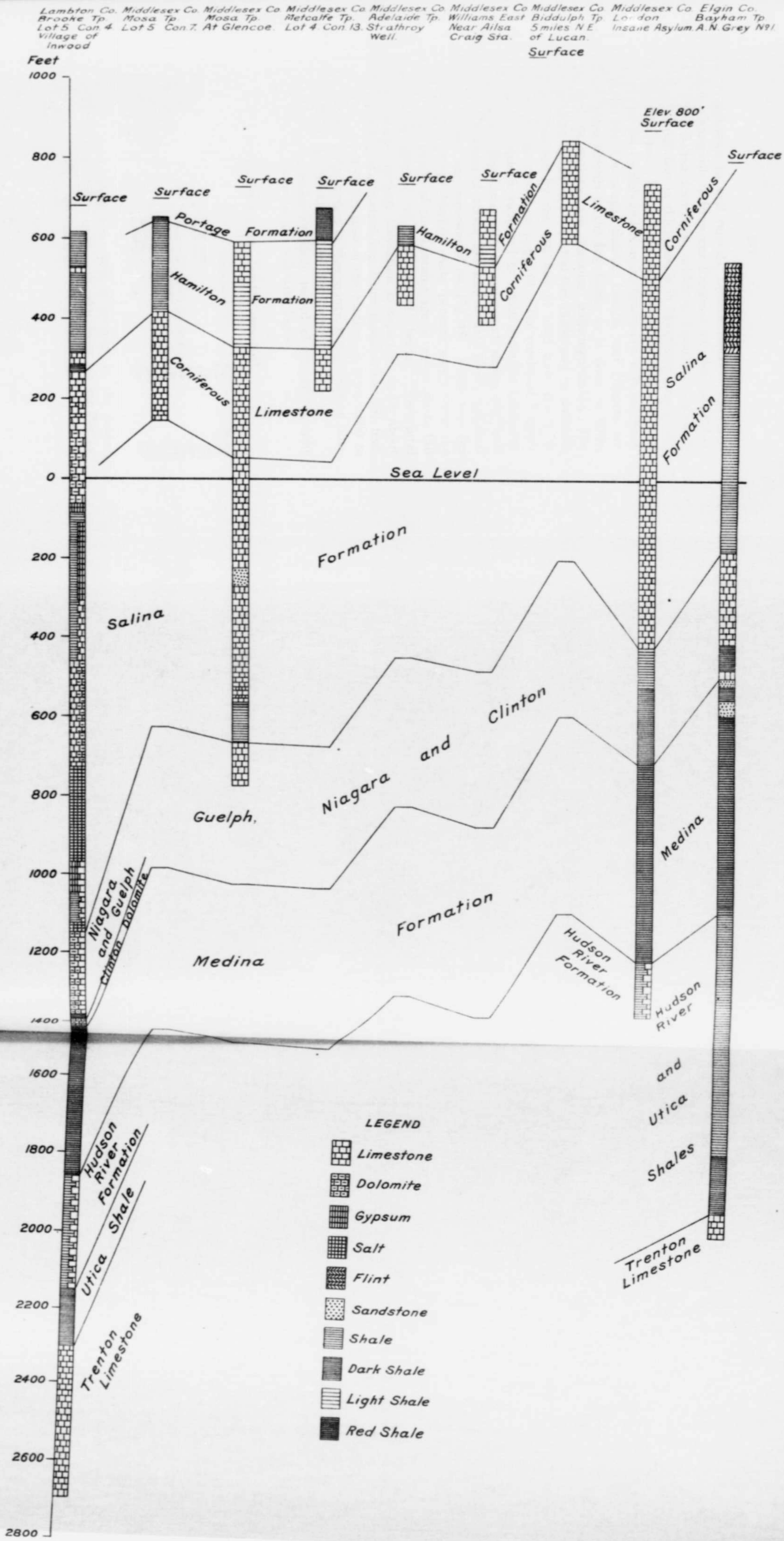


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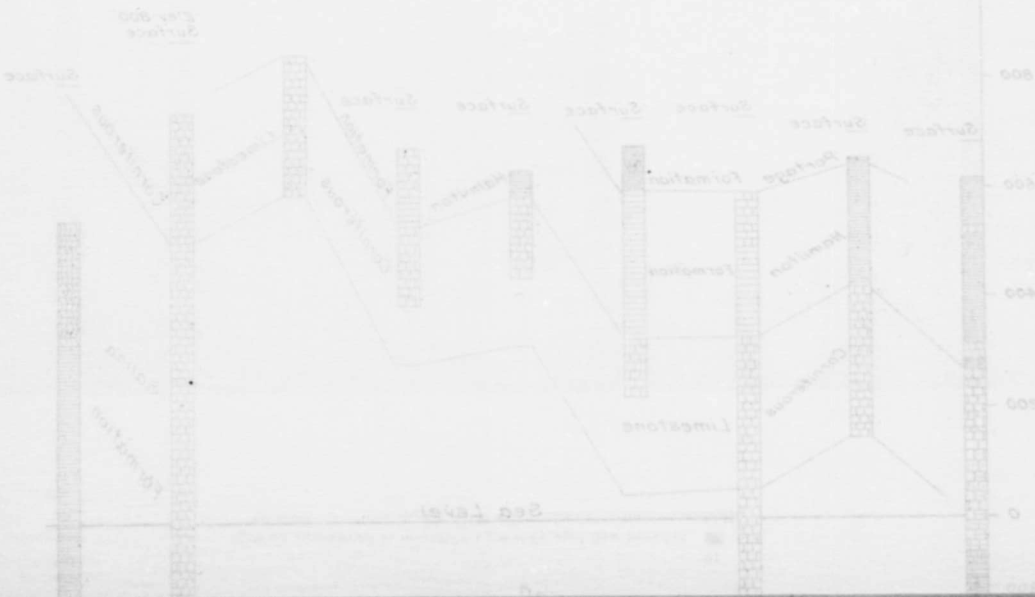
Fig. [redacted] Selected well logs, showing correlation of formations through Middlesex county, Ontario. (By F. G. Clapp and L. G. Huntley)



which is unknown in well records, because drillers have been unable to distinguish it from the limestone of the underlying Salina. The Salina formation, which in Lambton county is as much as 1,600 feet in thickness, is in Middlesex presumably not over 800 feet. Being indistinguishable in available well records from the Guelph and Niagara limestones, it is necessary to classify the Onondaga, Salina, Guelph and Niagara together in those records as the Big Lime, as is done in Ohio, where the formations are likewise indistinguishable. The Guelph is believed to be about 100 feet thick, and its dolomite may be represented by the 100 feet of hard rock shown at the bottom of the record on page 194. The combined Niagara limestone and shale is supposed to attain a similar thickness. Underlying the Big Lime with its attendant shales and salt beds is a thickness of about 200 feet of dark shale, supposed to be of Clinton age, represented on Fig. 19. Under this lies about 500 feet of red Medina shale, beneath which occur the shales and limestones of the Lorraine age of which about 150 feet are represented in the record below. The total thickness of the Lorraine formation is supposed to be about 300 feet, and of the underlying Utica shale about 150 feet. About 500 feet below the base of the Medina, or from 2,600 to 3,200 feet below the surface in this county, is the Trenton limestone, which may be 400 feet in thickness.

The most complete available record of the stratigraphy in this county is given by the following log:—

Record of well at Insane Asylum, London township[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	130
Hard limestone	Onondaga	130	330
Soft limestone	Salina with Guelph and Niagara, if present	330	600
Hard limestone		600	700
Limestone		700	1300
Salt and shale		1300	1400
Black shale	Clinton	1400	1600
Red shale	Medina	1600	2100
Limestone and shale	Lorraine	2100	2250

Since the foregoing deep well is situated in the eastern part of the county, where neither the Hamilton nor the Portage

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V. Pt. Q, 1889-91, p. 49.

formation is present, a shallow well record from the western part is appended to show the general conditions thereabouts.

Log of well on Lot 4, Con. XIII, Metcalfe Township[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Clay	Pleistocene	0	48
Black shale	Portage	48	123
Soapstone, etc	Hamilton	123	396
Limestone	Onondaga	396	500

Geological structure.—In a general way, the formations of Middlesex county may be said to dip from the northeast toward the southwest, but the inclination is modified locally by anticlines and synclines, which may be of only slight prominence. Owing to the general drift covering of the county and to its flat surface, the geological structure is not evident to the eye and cannot be deciphered except with well records. This can undoubtedly be done to a certain extent from existing records, but since oil and gas have not been found in commercial quantities in the county, the attempt has not been made.

Delaware township.—In 1911 nine wells were drilled at Delaware by parties from London, Ontario. These wells—which were of varying depths between 400 and 615 feet—entered the Onondaga limestone, and produced small amounts of gas and oil. The best showing of gas was obtained in the Harris well at Delaware, this being the first drilled. The well heads are from 725 to 730 feet above sea-level.

Caradoc township.—A well four miles northeast of Melbourne, between 500 and 600 feet deep, was drilled years ago, having a small showing of gas and oil. A shallow well was sunk in the summer of 1911 at Melbourne, into the Onondaga limestone, without results. Several shallow wells in Caradoc township had showings of oil.

Adelaide township.—Some shallow dry holes were sunk in this township immediately after the discovery of oil in Lambton county. The record of one of these is as follows:—

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 51.

Log of well at Strathroy, Adelaide township[1]

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	100
Soft shale	Hamilton	100	150
Hard limestone	Onondaga	150	300

Biddulph township.—A little shallow drilling was done years ago in this township, but no satisfactory well records are available, the best being as follows:—

Record of well 5 miles northeast of Lucan, Biddulph township[2].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	100
Limestone	Onondaga	100	360

Fresh water was obtained in the limestone, but no trace of oil or gas.

London township.—Previous to 1865 a well was drilled at London which struck a big flow of salt water at 114 feet, going to 765 feet, and ending in a soft magnesian marl of Onondaga age.

On lot 13, concession IV, the Sunnyside well drilled previous to 1866, went 400 feet deep, to the limestone, while previous to 1891 a hole was drilled 2,250 feet deep at the Insane Asylum in London, ending in the upper Lorraine formation. The record of this well is given on page 191. Several other dry holes have been drilled at various times in the vicinity of London.

Metcalfe township.—Some shallow drilling to the Onondaga limestone has been done in this township, but without success. The general character of the formations penetrated may be learned from the log on page 192.

Mosa township.—A number of shallow dry holes have been drilled to the Onondaga limestone at various times in Mosa township and in several of them showings of oil were obtained, but no production has been encountered. The following record supplied by Major John Savage illustrates the general character of the formations penetrated:—

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, p. 50, 1889-91.
[2]Brumell, H. P. H., Geol. Survey Canada, Vol. V. Pt. Q, p. 53, 1889-91.

Log of well at Glencoe, Mosa township.

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Surface	Pleistocene	0	134
Limestone	Hamilton	134	234
Soapstone		234	396
White limestone		396	476
White limestone		476	962
Sandstone		962	1000
Limestone		1000	1260
Gypsum	Onondaga and Salina	1260	1265
Hardpan		1265	1280
Gypsum		1280	1283
Hard rock		1283	1290
Salt and shale		1290	1394
Hard rock	Guelph	1394	1510
Total depth			1510

In the above record a portion of the Hamilton formation is represented as limestone, and the Portage is not mentioned. Hence, another record is appended to show perhaps a more common sequence of the strata:—

Log of well on Lot 5, Con. VII, Mosa township[1].

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Clay	Pleistocene	0	88
Black shale	Portage	88	94
Soapstone, etc	Hamilton	94	337
Limestone	Onondaga	337	514

A showing of oil is reported.

East Williams township.—Some wells were drilled years ago in this township; but only showings of oil were found. The following log illustrates general conditions:—

Log of well near Ailsa Craig station, East Williams township[2].

Material	*Formation*	*Top* *Feet*	*Bottom* *Feet*
Surface	Pleistocene	0	65
Limestone		65	70
Soapstone	Hamilton	70	76
Limestone		76	156
Soapstone		156	206
Limestone	Onondaga	206	330

West Williams township.—Some holes were drilled in this township following the development of pools in Lambton county;

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V. Pt. Q. 1889-91, p. 52.
[2]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 53.

but with the exception of several salt wells at Parkhill and elsewhere, none reached a depth of 500 feet, and but small showings of oil were obtained. No satisfactory well logs are at hand from West Williams.

The principal Parkhill well was sunk in 1884, by the Parkhill Salt Works Company to a depth of 1,300 feet, passing into the second salt bed. The surface deposits in this locality were 170 feet thick.

McGillivray township.—Some shallow wells were drilled in this township at the time of the Lambton county development, but only showings of gas were obtained, these being in the base of the Hamilton or top of the Onondaga formation.

Ekfrid township.—Some shallow dry holes have been drilled in this township. In 1912 a showing of oil was reported in Onondaga limestone in a well near Glencoe.

Deep tests.—Although most of the tests in Middlesex county have been comparatively shallow, at least two wells, situated in London and Mosa townships respectively, are of great depth; and, consequently, when considered in connexion with records in the adjoining counties, they give us a good clue to the underlying stratigraphy. The best known deep test is a well drilled years ago at the Insane Asylum at London, and which reached a depth of 2,250 feet. The log appears on page 191. None of these tests have reached the Trenton, which is supposed to be at least 350 feet below the bottom of the deepest well, and at least 1,300 feet below the bottom of the deep well in Mosa township.

Future possibilities.—While there is some possibility of oil or gas in the untested areas in Middlesex county, this county as a whole is believed to lie too near the Onondaga outcrop to offer any chances in that formation. In the Guelph, or Niagara, there might be some prospect were these formations of much value anywhere. The Clinton and Medina are entirely devoid of sands in the London deep well and are therefore unfavourable. The possibilities of the Trenton are untested, but this is too unfavourable, since it is not productive anywhere but on the Cincinnati anticline. Summarizing, we may say that Middlesex county as a whole is not promising, but that some small pools may exist.

Muskoka District.

Muskoka district lies entirely within the limits of the Laurentian rocks, which, being hard and crystalline, are unsuitable for containing oil and gas.

Nipissing District.

Nipissing district includes a large area in northern Ontario, which is entirely unfavourable for holding oil or gas, and in which the substances will presumably never be found in quantity. The geology of Nipissing district is somewhat varied, but in its southern part or as far north as Lake Timagami the surface formation is mainly Laurentian, beyond which it is an alternation of Huronian, Laurentian and intrusive igneous rocks. There is no chance of important oil or gas deposits in this district.

Norfolk County.

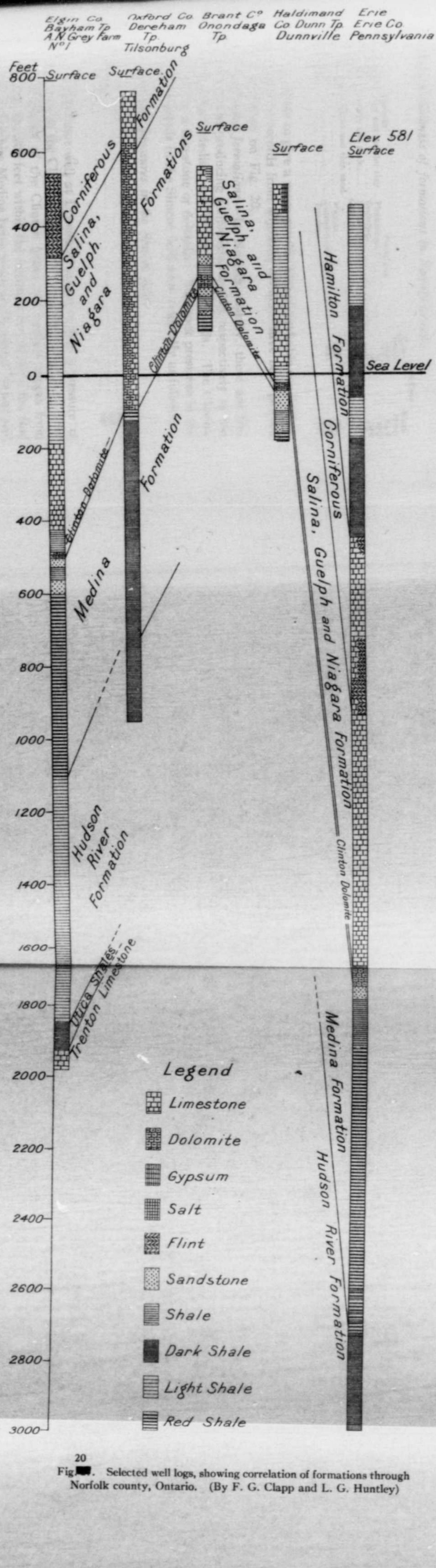
History of developments.—Numerous wells were drilled in Norfolk county prior to 1890, and showings of gas were encountered in places, especially in a well drilled in 1870 at Lynedoch on Big creek.

As in Elgin county, the Dominion Natural Gas Company is now making strenuous efforts in Norfolk county to obtain gas. In this county, 11 successful wells were drilled in 1910. Operations are now chiefly in the Simcoe field, south and southeast of the town of Simcoe, in the vicinity of Port Dover and Port Ryerse in Woodhouse township, and extending southwest to and around Port Rowan and Port Royal in Walsingham South. In 1913 small gas wells were still being completed occasionally at Port Dover at about 1,100 feet.

All wells drilled in Norfolk county previous to 1891 were failures.

Geological formations.—The surface formations in Norfolk county range from a few feet to 200 feet in thickness, consisting of sand, gravel, clay, and hardpan. Underlying these, the uppermost hard rock in the county is commonly the Onondaga limestone at the west end of the county, and the Salina formation in the north and east parts.


Elgin Co
Oxford Co
Brant C°
Haldimand
Erie



Fig[redacted]. Selected well logs, showing correlation of formations through Norfolk county, Ontario. (By F. G. Clapp and L. G. Huntley)

The Onondaga, where present, is less than 200 feet thick, except perhaps along the west side of Houghton and Middleton townships.

It is unfortunate that no well records are available to show conditions in Norfolk county. However, judging from a number of good records in adjoining counties, the thickness of the formations ranges somewhat as follows:—

Range in thickness of formations in Norfolk county.

Character	Formation	Thickness: Minimum Feet	Thickness: Maximum Feet
Sand, gravel, clay and boulder clay	Pleistocene	5	100
Limestone	Onondaga	0	200
Limestone, dolomite and shale	Salina, Guelph and Niagara	500	800
Dolomite	Clinton	25	35
Red and black shales and thin sandstones	Medina	600	700
Dark shales	Lorraine and Utica	800	900
Limestone	Trenton		650

In order to give a more graphic idea of probable conditions, a number of records from adjoining counties have been plotted and correlated on Fig. 20.

Producing formations.—In Norfolk county, there are frequently three producing formations, known respectively as the Clinton, Red Medina and White Medina sands. The Clinton is in reality a limestone or dolomite. The rock pressures in the respective sands in the Simcoe field were originally as follows:—

Original rock pressures in the Simcoe field.

Sand	Pounds per square inch
Clinton	475
Red Medina	500
White Medina	700

A 1300 foot well at Lynedoch, however, had a pressure of 650 pounds in the Clinton.

The depth of the Clinton below the surface ranges from about 500 to 1200 feet within the limits of the county, the Red Medina and White Medina being respectively about 30 feet and 130 feet deeper. In thickness the Clinton is 25 to 35 feet, the Red Medina 30 to 40 feet and the White Medina 10 to 30 feet. The best producing sand in the Simcoe field is the Red Medina. A general section of the producing formations is somewhat as follows:—

Typical section of gas sands.

Material	Formation	Thickness Feet
Depth to Clinton	Clinton	1000
Limestone (gas)		24
Shale		4
Red sand (gas)	Medina	45
Shale		40
White sand (gas)		15
White sand		12
Red shale		500
Total		1640

At Delhi all gas is produced from the Clinton.

Geological structure.—The formations in the Simcoe field dip southwest about 55 feet per mile, and this dip is rather constant throughout Norfolk county.

Simcoe field, Woodhouse and Charlotteville townships.—The production in this field is controlled by the Dominion Natural Gas Company, which, up to 1912, had sunk 36 producing wells and 17 dry holes, situated in a crescent shaped area back of Port Dover and south to Port Ryerse, being about four miles long. The dry holes all lie in the western part of the pool, while the best wells are about the centre lying 1½ miles from the lake. Most of the wells produce from the Red Medina, only three producing from the White Medina in 1912. Last fall the average pressure had dropped to 410 pounds in the centre of the field, from the original 500 pounds. At Port Ryerse two gas wells sprayed some little light oil from the White Medina.

At Port Dover about a dozen producing wells have been drilled within the village limits by a local gas company and are used for supplying the town.

The average depth to the top of the Red Medina in this field is 1057 feet, and the minimum depth about 973 feet. It is customary to drill about 10 feet through the sand to form a pocket.

Charlotteville township.—A 1300-foot well owned by the Dominion Natural Gas Company in the town of Lynedoch produces gas from the Clinton. The initial rock pressure was 650 pounds. It has only been drawn on slightly, and there are no other gas wells within 4 or 5 miles. A dry hole was drilled 1 mile southeast of Lynedoch, and a well was drilled three years ago at Vittoria to a depth of 3030 feet, but produced nothing.

Walsingham North township.—A dry hole was recently drilled at Langton, by the Dominion Natural Gas Company.

Windham township.—No wells exist between Simcoe and Delhi.

Middleton township.—Three years ago a good gas well was drilled in the south end of the village of Delhi. A local company was formed, which sold out in April, 1912, to Stroud Brothers. They now have six gas wells which produce together about 2,000,000 cubic feet per day, and have drilled three dry holes. Another company has drilled one gas well and one which produced water with a showing of gas. The initial pressure in the field ranged from 505 pounds to 560 pounds, but it had declined in June, 1912, to 375 pounds. The oldest well was then one year old, having been drawn on continuously. The entire gas production is used for domestic purposes and for fuel in a canning factory.

The gas at Delhi is found in the Clinton formation, although all wells were drilled through the White Medina. The depth to the Clinton ranges from 1150 to 1200 feet, and the wells are from 1300 to 1350 feet deep. All are located within the city limits. One well at the southeast end of the pool sprayed a very little dark coloured oil.

The wells are cased on top of the Clinton with from 1050 to 1080 feet of $5\frac{5}{8}$-inch casing. From 180 to 200 feet of drive-pipe is used, and the wells are drilled wet to near the top of the Clinton, where the water is cased off.

Townsend township.—Four wells, approximately 1000 feet deep, have been drilled in and near the town of Waterford. The first was sunk a number of years ago about $1\frac{1}{2}$ miles south of Waterford, and was abandoned. Another well near by went 100 feet and was stopped. A well was drilled a short distance east of Waterford to about 1000 feet. A pocket of gas was struck, but the well was abandoned. Another just northeast of Waterford struck sulphurous water at 120 feet; drilling was continued to 900 feet but no gas was found. The well still produces water. In the centre of the town a showing of gas was struck 1042 feet from the surface on the property of Col. York. The $5\frac{5}{8}$-inch casing is still in the well, and although it never produced, the odour of gas is still noticeable. No oil was encountered in any of the wells mentioned.

Houghton township.—In July, 1912, the Dominion Natural Gas Company drilled a well at Beech Lane. Messrs. Evans and King have two small wells at Beech Lane, and both this company and the Dominion Natural Gas have several dry holes in the vicinity.

Walsingham South.—At this town there were in July, 1912, three producing wells, one owned by Messrs. McManus and Peck and two by the Dominion Natural Gas Company. The pressures were initially 560, 575 and 650 pounds. The first of these, belonging to the Dominion Natural Gas Company, produces from the Clinton sand. Another, on the Barrett farm, found gas in a brown sand between the Clinton and the Red Medina. All three were drilled during the preceding two months. Three dry holes also exist. An older well in the village of Port Rowan started with a production of 550,000 cubic feet daily, but is now down to 15,000 cubic feet. Wells which make only 10,000 cubic feet daily are not abandoned in the Simcoe or Port Rowan districts. In 1912 a well was being drilled on the Clemens farm for the Port Rowan Natural Gas Company.

Future prospects for oil and gas.—Norfolk county has been so thoroughly tested that there seems no hope of finding any field of great volume. The best that can be expected is to obtain numerous small wells similar to those already existing.

Northumberland County.

No oil or gas deposits of commercial importance will be found in Northumberland county, since the surface is underlain almost entirely by limestones of Trenton age, which, having no suitable cover, cannot hold any commercial deposits here.

Ontario County.

General statement.—No oil or gas fields of commercial scale exist in Ontario county, or ever will be found there, since the geological conditions are unfavourable.

History of testing.—Notwithstanding the unsuitable conditions, some drilling has been done at various times in the county, beginning as far back as 1888, when a test was made by the Whitby Gas and Water Company in the town of Whitby on the west side of Byron street, to a depth of 728 feet. Traces of gas were found, being estimated, however, at only 2,000 cubic feet per day. A showing of gas, which is reported to have burned four feet in height, was also found in a water well drilled by the town many years ago. No other deep wells are known to have been drilled in Ontario county.

Formations penetrated.—The geological formations at the surface in Ontario county consist mainly of glacial drift, under which the northern half of the county consists entirely of Trenton limestone, with the exception of a belt of Birdseye and Black River formations, and possibly a little Laurentian, which touch the extreme northern end of the county. In the southern third of the county is an east-west belt of Utica shale several miles wide, and in the extreme south there are several square miles of Lorraine shale. (Fig. 5).

Consequently, the formations penetrated range from Lorraine downward to the granite. Unfortunately, only one well record is available, which is given below, for what it may be worth:—

Log of well drilled at Whitby[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	50
Shale	Utica	50	120
Limestone	Trenton	120	720
Arkose beds	Granite	720	728
Total depth			728
Showing of gas			400
Showing of gas			700

Oxford County.

General statement.—The only oil development in Oxford county consists of a few wells near Tilsonburg which were obtained in 1901, but which were soon abandoned. The oil was dark and heavy. It was found in sandstone underlying the Onondaga limestone, and being perhaps of Oriskany age. No drilling has been done in recent years.

[1]Brumell, H. P. H., Geol. Survey Canada. Vol. V. Pt. Q. 1889-91, p. 24.

Geological formations in this county.—The surface of Oxford county is largely covered with a thickness of 1 to 200 feet of glacial drift, below which the Onondaga commonly forms the surface rock. Some Hamilton may exist in western Dereham township.

It is unfortunate that good well records are not available, the best record of the formation being a well drilled in 1865 in Dereham township. The record is as follows:—

Log of well at Tilsonburg, Dereham township.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	36
Limestone	Onondaga	36	196
Dolomite and limestone	Oriskany, Salina, Guelph, Niagara and Clinton	196	890
Red marl	Medina and Lorraine	890	925
Dark shale		925	1750
Total depth			1750

In order to know the underground stratigraphy of this county, it is important also to study records in Middlesex and Elgin counties.

The Tilsonburg pool.—Considerable drilling was done succeeding the year 1860 in search of oil near Tilsonburg, the first well being sunk by Messrs. Watkins, Miles and Craigie, but with little success. Oil showings were found in the Onondaga limestone immediately underlying the first. The oil excitement was started by a story that the Indians of the district had for many years resorted to an oil spring southwest of Tilsonburg for medicinal purposes.

In 1865 and 1866 a well was sunk by Messrs. Hibbard and Avery at Tilsonburg to a depth of 854 feet for salt. A strong brine was encountered, but no rock salt, oil or gas. In 1873 it was carried to 1450 feet by the Tilsonburg Salt Company. In 1877 the well was deepened to 1750 feet, but still without results. The log is given above. In 1888 and 1889 drilling was commenced again in the vicinity, about four wells being sunk at that time, 200 to 400 feet deep, yielding traces of oil.

The development of oil started in the valley of Big Otter creek in 1901; the first well produced only 840 gallons per

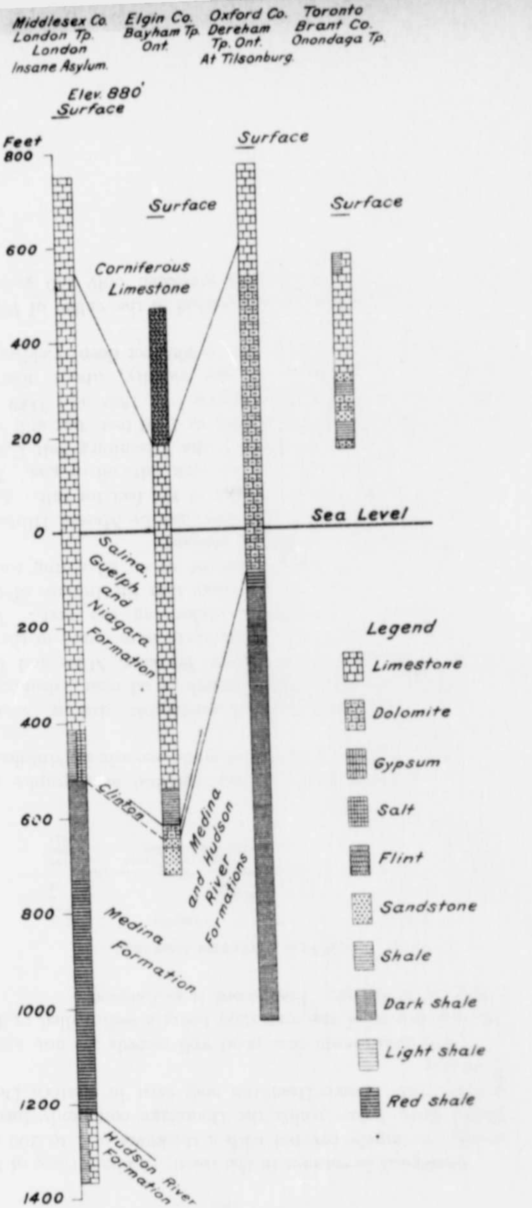


Fig. 21 [redacted]. Selected well logs, showing correlation of formations through Oxford county, Ontario. (By F. G. Clapp and L. G. Huntley)

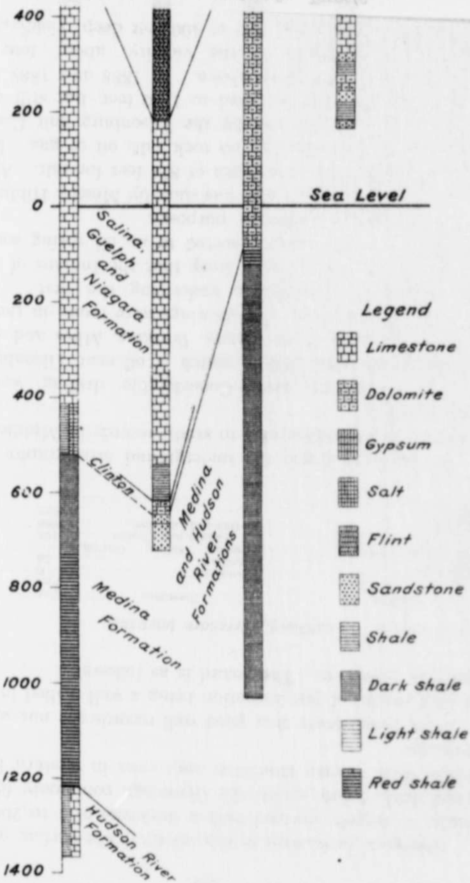


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Fig. [redacted]. Selected well logs, showing correlation of formations through Oxford county, Ontario. (By F. G. Clapp and L. G. Huntley) day, but later wells ran as high as 1 to 24 barrels, which soon fell off to one or two barrels per day per well. The oil was accompanied by water and by some gas. The depth of the wells ranged in some cases up to 270 feet. Showings of gas were found in the Onondaga. The field has been abandoned without developing any wells of commercial importance.

Drilling elsewhere in the county.—During 1865 and succeeding years, a number of wells were sunk in Dereham and adjoining townships, but without further success than obtaining small showings. A dry hole was drilled in the Salina formation in 1887 at Burgessville in Norwich North. In 1883 to 1885 a well was drilled at Norwich on the property of George A. Cook to 2000 feet, producing only water. We regret that no record could be obtained.

In 1887 a dry hole drilled at Burgessville by local capital went to 605 feet. No accurate record was kept, but a flowing well of sulphur water is known to have been obtained.

Future prospects for oil and gas.—Judging from the knowledge that the Onondaga limestone lies close to the surface, and that the Clinton and Medina formations are unsuitable for holding gas in the deep well drilled at Tilsonburg, there appears to be very little prospect of oil or gas existing in quantity in Oxford county.

Parry Sound District.

Throughout a large portion of northern Ontario an immense area is occupied by Laurentian and associated rocks, and these crystalline rocks are entirely unsuitable for holding oil or gas. Parry Sound district lies in about the centre of this unfavourable area; consequently, it is not worthy of consideration.

District of Patricia.

Conditions in this new district are not particularly favourable to the occurrence of large quantities of oil and gas, although some possibilities of showings exist in the eastern third of the area. The formations are of Silurian and Devonian age, being largely of limestone according to the reports which have been made, and in which favourable oil formations and covers are not known; however, on the lower Abitibi river some petroleum bearing limestone has been reported[1].

The entire central and western part of the District of Patricia consists of the formations of Laurentian and Pre-Cambrian age, in which conditions are particularly unfavourable, and consequently, no oil or gas will be found in this district.

Peel County.

General statement.—No oil or gas fields on a commercial scale have ever been discovered in Peel county, and it is improbable that they exist. Some small wells have been found, suitable for supplying one or more residences, and were used for that purpose.

History of testing.—Several years ago four wells were drilled near Cooksville on the Gordon, Romageau; John Price and Shephard farms respectively, but these have been abandoned. In August, 1913, a gas well was obtained on Romageau farm.

Formations penetrated.—The fourth well in this county was drilled on the Shephard farm near the hydro-electric station to a depth of 1350 feet. Unfortunately no log is available, but the well is presumed to have penetrated the Lorraine, Utica, and Trenton formations to the underlying Potsdam. The log given by Thos. E. Bull was as follows:—

Log of well at Cooksville.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface sand		0	5
Lorraine shale		5	560
Utica brown shale		560	710
	Trenton	710	1310
Sandstone	Potsdam	1310	1355
Gas (300 lbs. pressure)			1205
(Gas used in a small way in this and the other three wells.)			
Depth			1350

Two other wells were drilled at Cooksville by Mr. Bull, the reported rock pressure of Numbers 1 and 2 being reported 300 pounds and 200 pounds respectively, and the volumes of Num-

[1]Robert Bell, Rept. of Bureau of Mines, Ont., Vol. 21, Pt. 2, 1912, page 195.

bers 2 and 3 being reported 350,000 and 100,000 cubic feet per day respectively. The village of Cooksville has been piped for gas, but it has not been utilized. Recently a well said to have a flow approaching 1,000,000 cubic feet of gas a day was found.

Wells in various parts of Peel county are believed to have penetrated the Utica and Trenton formations, since the Lorraine is at the surface in the northern part of the county and the Medina in the southern part of the county.

Perth County.

General statement.—No oil or gas fields of commercial size have ever been found in Perth county, and it is quite certain that no such fields exist. Showings of gas have been struck in shallow wells, and it is presumed that other showings of the same sort exist, but are so small as not to be available for more than one or two dwellings.

History of drilling.—Notwithstanding the unfavourable conditions, quite a number of wells have been drilled, beginning as far back as 1863, at which time a test was sunk at St. Marys to a depth of 700 feet, and small traces of oil were reported. This was followed in 1873 by a test at Dublin drilled to a depth of 1396 feet for salt. Other salt wells were drilled about the same date at Mitchell and Listowel to depths of 2008 feet and 1200 feet respectively. No rock salt was found, and these three wells were failures in all respects. In 1890 a well was drilled by the Stratford Natural Gas Company at Stratford to a depth of 2,386 feet without finding gas. During 1909 reports appeared that natural gas had been struck in Perth county in commercial quantities, but investigation showed that the gas reported consisted only of traces found in shallow wells, and was of no commercial importance. Some other drilling has been done at various times in the county, but with no better success.

Formations penetrated.—The formations at the surface in Perth county consist mainly of glacial drift, beneath which the Onondaga limestone is nearly everywhere the uppermost hard rock. In the extreme northeastern part of the county, however, the Salina forms the surface; consequently, the drilling is mainly in the Onondaga and Salina formations. The wells drilled about 1873 for salt went as deep as the Niagara limestone, and one of them passed 300 feet into the Medina. Only one deeper well is known, which is the test sunk for gas at Stratford in 1890, finding the Trenton limestone at 2360 feet and a large quantity of salt water in this formation at 2384 feet. Unfortunately no exact well records are available in Perth county.

Peterboro County.

It is quite certain that no oil or gas in commercial quantity will ever be found in Peterboro county. The northern half of the county consists entirely of rocks of Laurentian age, in which neither oil nor gas ever exists. The southern half consists of limestones of Trenton age, associated with the Birdseye and Black River, which, having no cover, can not hold any commercial deposits of oil or gas here.

Prescott County.

Conditions in Prescott county are not favourable for the existence of oil or gas, and no fields are to be expected. The formation at the surface in the southern part of the county consists entirely of Trenton limestone, while along the northern edge it is of Chazy age. The exceptions are a narrow belt between the Chazy and Trenton, which is occupied by Birdseye and Black River limestones, similar to the Trenton; another exception is some patches of Utica shale, overlying the Trenton in the southwestern part of the county.

Since 1805 gas has been known to occur in mineral springs at the Caledonia Springs hotel. Dr. T. Sterry Hunt estimated[1] that 3,000 cubic feet of gas per day were given off from one of the springs. The surface deposits at that locality are about 100 feet thick, resting on Trenton limestone.

[1]Geol. Survey Canada, 1863, p. 535.

Prince Edward County.

No oil or gas in commercial quantity will be found in Prince Edward county, since it is occupied at the surface entirely by limestones of Trenton age, underlying the glacial drift, and since these formations have no suitable cover, they can contain only small and unimportant showings of gas.

Rainy River District.

This district, like other districts of northwestern Ontario, is entirely unfavourable for oil or gas, since it lies in a portion of the Province where the rocks are of Laurentian and Huronian age and are unsuitable for containing oil or gas.

Renfrew County.

Conditions in Renfrew county are not at all favourable for oil or gas, and it is quite certain that neither of these substances exists in quantity. The geological formations consist for the most part of Laurentian rocks, except in a few isolated localities, where the Chazy formation and limestones of Birdseye or Black River age exist.

Russell County.

No oil or gas pools exist in Russell county, since the geological conditions are very unfavourable. The formations in the west-central part of the county consist of Lorraine shales, surrounded by outcrops of Utica in certain places. Trenton limestone, with its associated Birdseye and Black River limestones occupy most of the remainder of the county. There are, however, small areas of Chazy rocks in the extreme north and south. Underlying conditions are somewhat complicated and wells would pass through rocks of various types, none of which are expected to be productive.

Notwithstanding the unfavourable conditions in this county, the Standard Oil Company drilled three holes in Cumberland township some years ago in the triangular area some five miles in extent, along the line of the Grand Trunk railway which runs to Montreal. It was naturally desired to find a supply of natural gas for Ottawa. The entire series of sedimentary rocks was penetrated as deep as the Potsdam formation, when drilling was discontinued on account of the great hardness of the sandstone encountered. Other borings did not reach below the upper part of the Trenton. Very small showings of natural gas were found.

Simcoe County.

General statement.—No oil or gas fields of commercial value have ever been found in Simcoe county, although a large amount of drilling has been done for salt, as well as for water and gas. Some light wells exist in the vicinity of Collingwood, but they are only sufficient in volume for supplying one or two residences.

History of developments.—While oil shale does not belong within the province of this report, it seems pertinent to mention that some attempt was made, commencing in 1859, for distilling oil from shale. In the year mentioned, works for shale were erected near Collingwood in Simcoe county, and seemed to have been for a time successful. The Utica shale was used, being quarried on lot 23, concession III, Collingwood township in Grey county.

Drilling for oil in Simcoe county was started as far back as 1888 when a well was sunk on lot 16, on the west side of Peel street, Collingwood, to a depth of 553 feet. Showings of gas were found, and other wells were subsequently drilled in Collingwood and its immediate vicinity, the depths ranging from 350 to 550 feet, but none of them obtained more than a showing.

At Collingwood and vicinity about a dozen wells have been drilled for oil and gas at various times since 1887. The deepest well in the town is presumed to be the well of E. R. Carpenter near the corner of Third and Oak streets, which was the second well drilled and was 541 feet deep, striking granite at 540 feet. A little gas was encountered at 144 feet from the surface. This well and another owned by Mr. Carpenter measured rock pressures of 18 to 45 pounds at the time the wells were drilled, the figures being taken from a diary kept by Mr. Carpenter. The volume, after being in use for two years, is reported to have measured 750 cubic feet in 24 hours, being exceeded by only one well in the town, which registered 756 cubic feet in 24 hours.

Several wells in the town have been abandoned, but some of them are still in use for lighting houses, and in one individual instance, the gas is used in a cook stove. The gas was insufficient for the fireplace or furnace, however. Other wells in Collingwood are situated at the office of the Collingwood Bulletin, at the Globe hotel, and at several residences.

The gas wells at Collingwood are not mentioned as being of any commercial importance, but for the reason that they are of some scientific interest, because the gas comes from the Trenton limestone, which is very productive on the Cincinnati anticline in Ohio and Indiana. Other small gas wells are reported at Delphi and at Craigleigh. An interesting feature of the Collingwood wells is that their flow is affected by the barometric pressure, and the volume is so small in all cases that this can be observed where it would not be possible in the case of more voluminous wells.

At an even earlier date than those at Collingwood, the Lilley well was sunk in the northern part of Beeton, Tecumseh township, to a depth of 1400 feet, but this well—like others—only resulted in showings. Occasionally seepages of gas in the vicinity were presumably responsible for the wells drilled in early days. In some cases water wells sunk in the surface clay at Beeton to a moderate depth had been rendered useless by the influx of gas. Other shallow wells were drilled in 1909 and 1910 near the village to the underlying granite, this being found at 540 feet in E. R. Carpenter's well at Collingwood, and 300 feet at Orillia, but it was not reached by the deep 1400-foot well at Beeton.

Possibilities for the future.—Since slight showings of gas are rather widely distributed throughout certain parts of Simcoe county, it might be supposed that there would be a chance of developing some field of importance in this county. It is believed, however, that since the Trenton outcrops in this very county under an extended area, and since natural gas in quantity is seldom found near the outcrop, that there is practically no possibility of finding a real gas field anywhere in the county.

Stormont County.

No oil or gas fields exist in this county since the geological conditions are particularly unfavourable. The formations in the northern half of the county consist mainly of Trenton limestone underlying the glacial drift, while in the southern and eastern parts the formations are of Chazy age. Intermediate between the Trenton and the Chazy is a belt of Black River and Birdseye limestone, which are commonly associated with the Trenton.

Sudbury District.

Throughout the greater part of Sudbury district the conditions are entirely unfavourable for oil or gas. The surface formations are mainly of Huronian and Laurentian age.

Thunder Bay District.

Thunder Bay district lies in a portion of Ontario which is mainly occupied by formations of Laurentian, Huronian, Nipigon, and Animikie age, which are entirely unfavourable for containing oil or gas, and where it is useless to drill for oil or gas. A very small area in the extreme northeastern corner of the district is reported on some reconnaissance maps to consist of Silurian rocks; but no oil or gas should be expected in quantity there.

Victoria County.

This county is one of the unfavourable ones, since the formations at the surface consist mainly of limestones of Trenton age, but at the northern end of the county is a small area where

Laurentian rocks occur fringed by a belt of Birdseye and Black River limestone. The Laurentian rocks are unfavourable for containing oil and gas, while the limestones mentioned will not hold it in commercial quantities in this county for the reason that no suitable cover exists.

Waterloo County.

General statement.—No productive oil or gas wells have ever been drilled in Waterloo county, but a number of dry holes have been drilled, principally at Waterloo, Berlin and Galt.

History of drilling.—The first deep drilling was in 1867, when a test was sunk in the town of Waterloo to a depth of 1120 feet, being deepened at a later date to 1800 feet. Another test was made in 1883, but no deep drilling is known since that time. Several years ago a test is reported to have been made at Galt but no record is available.

Formations penetrated by wells.—The holes drilled in this county have been mainly in the Medina formation, although the Salina, Guelph, Niagara and Clinton are penetrated before reaching it. Unfortunately, only one log is available, this being the record of the dry hole drilled in 1867 at Waterloo; it is given as follows:—

Log of dry hole drilled in Waterloo[1].

Material	*Formation*	*Top* *Feet*	*Botom* *Feet*
Surface	Salina	0	130
Limestone	Salina		
Gypsum	Salina	170	187
Shale	Salina	187	207
Limestone	Guelph, Niagara and Clinton	207	547
Blue shale	Medina	547	661
Shale red	Medina	661	1120
Bitter water			800
Bitter water			900
Total depth			1800

A record is also available of a test drilled many years ago half a mile east of the Grand Trunk Railway station in Berlin, the well being drilled for water. The formations penetrated are as follows:—

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 41.

Log of dry hole drilled at Berlin[1].

Material	Formation	Top Feet	Bottom Feet
Surface	Salina	0	187
Limestone	Salina	187	507
Hard rock	Medina	507	547
Limestone	Medina	547	747
Red shale	Medina	747	927
Green shale	Medina	927	1087
Blue slate	Medina	1087	1250
Total depth			1250
Casing			303
Mineral water			540

The correlations of well logs between this county and surrounding counties are shown in Fig. 13.

Welland County.

Description of fields.—No important deposits of oil have been found in Welland county. In the southern part of the county there has been in the past an extensive gas development, which has long since passed its best days.

History of development of Welland county:—Oil was first discovered in Welland county in 1891 by the Provincial Natural Gas and Fuel Company in their wells Nos. 20 and 28, on lots 11 and 12, concession III, Humberstone township. The oil was found in the White Medina sand at depths of about 780 feet. Only about two barrels per day from each well was produced.

The first successful gas well in Welland county was sunk in 1889, fourteen miles from Buffalo. The gas was encountered in the White Medina sand at a depth of 836 feet. Up to January, 1891, 142 wells were drilled and gas piped to Buffalo, Fort Erie and Bridgeburg.

The Welland county field has been practically abandoned, although 34 gas wells were drilled in it in 1910.

Quality of oil.—The gravity of the oil in Welland county is reported as about 45° Baumé, to be ruby red by transmitted light and dark olive green by reflected light.

Producing formations.—The main supply of gas in this county is obtained from the White Medina sand, although smaller quantities have been found in the Red Medina and in the Clinton, and showings prevail in the Niagara. In addition a show of gas was obtained in the Trenton in the deep well at Thorold.

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 42.

A small well 2940 feet deep is reported in the Welland county field, obtaining its gas in the arkose bed on top of the granite. This is known as the Souder well and is No. 61. It is unfortunate that no definite log of this well is at hand.

Formations penetrated by the drill.—Welland county consists of a nearly flat plain bounded by the Niagara escarpment on the north and by the Niagara river on the east. In the escarpment, along Niagara river and in a few other localities, the rock lies at the surface; but with these exceptions the surface consists of drift, ranging in extreme cases from fifty to one hundred feet in thickness. Below the drift the uppermost hard rock is Onondaga limestone in a few localities in Humberstone and Bertie townships; but elsewhere it consists of Salina in the south of the county, and of Guelph or Niagara to the north.

In the gorge of the Niagara river between Niagara Falls and Queenston the following section of the strata is exposed, all of the formations being penetrated in wells in this county.

Geological section along N. Y. C. & H. R. R. R. Grand Gorge trolley line, Niagara Gorge[1].

		Top *Feet*	*Bottom* *Feet*
Lockport dolomite	Niagara	130	130
Rochester shale	Clinton	68	198
Clinton upper limestone	Clinton	10	208
Clinton lower limestones	Clinton	15	223
Clinton shale	Clinton	5	228
Probable disconformity:—			
Upper massive, quartzose, whitish cross-bedded sandstones (Grey band of authors)	Medina formation	9	237
Reddish and greenish bedded sandstones, much cross-bedded and channelled	Medina formation	14	251
Thin bedded reddish sandstones, with shale partings	Medina formation	38	289
Grey sandstone with green shale partings	Medina formation	5	294
Disconformity:—			
Upper dark green shales	Medina	4	298
Thin bedded, green to yellow magnesia and argillaceous limestone	Medina	3	301
Middle green shales	Medina	10	311
Thin bedded argillaceous magnesian limestones	Medina	2	313
Lower green shales	Medina	7	320
Basal or Whirlpool sandstone	Medina	25	345
Hard, heavy bedded, grey, somewhat coarse, cross-bedded sandstones	Medina	5	350
Disconformity:—			
Brick red sandy shales		115	465

[1]Grabau, A. W., Bull. 45, N.Y. State Museum, 1901.

This is the most complete known section of the formations which contain the Clinton and Medina sands.

In order to illustrate the formations which overlie these in certain parts of the county, however, the following record is given of well No. 1 of the Provincial Natural Gas and Fuel Company, in Bertie township, drilled in 1889.

Log of well in Lot 35, Con. III, Bertie township[1].

(Surface elevation 618 feet).

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	2
Dark grey limestone	Onondaga	2	25
Grey and drab dolomites, black shales and gypsum	Salina	25	415
Grey dolomites	Guelph and Niagara	415	655
Black shales	Guelph and Niagara	655	705
White crystalline dolomite; grey toward bottom	Clinton	705	735
Red sandstone	Medina	735	790
Red shales	Medina	790	800
Blue shales	Medina	800	805
White sandstone	Medina	805	810
Blue shale	Medina	810	830
White sandstone (gas rock)	Medina	830	846
Fresh water cased off			284
Salt water			548
Cased to			596
Gas 1,000,000 cu. ft. per day			836

The shot increased this to 2,050,000 cubic feet per day.

As stated elsewhere, a well in Welland county or in its vicinity is reported to have been drilled to granite at a total depth of 2940 feet; but no log of it has been received. The deepest well of which the log is at hand is of a well in the village and township of Thorold, drilled by the Thorold Natural Gas Company in 1888, as follows:—

Log of well at Thorold[2].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	43
Dark brown limestone	Niagara and Clinton	43	50
Shale	Niagara and Clinton	50	120
Red sandstone	Medina	120	150
Shale	Medina	150	207
Grey sandstone	Medina	207	237
Shale	Medina	237	1050
Shale	Lorraine	1050	1750
Shale	Utica	1750	1905
Limestone	Trenton	1905	2430
Total depth			2430
Salt water			284
Show of gas			2430

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 36.
[2]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 33.

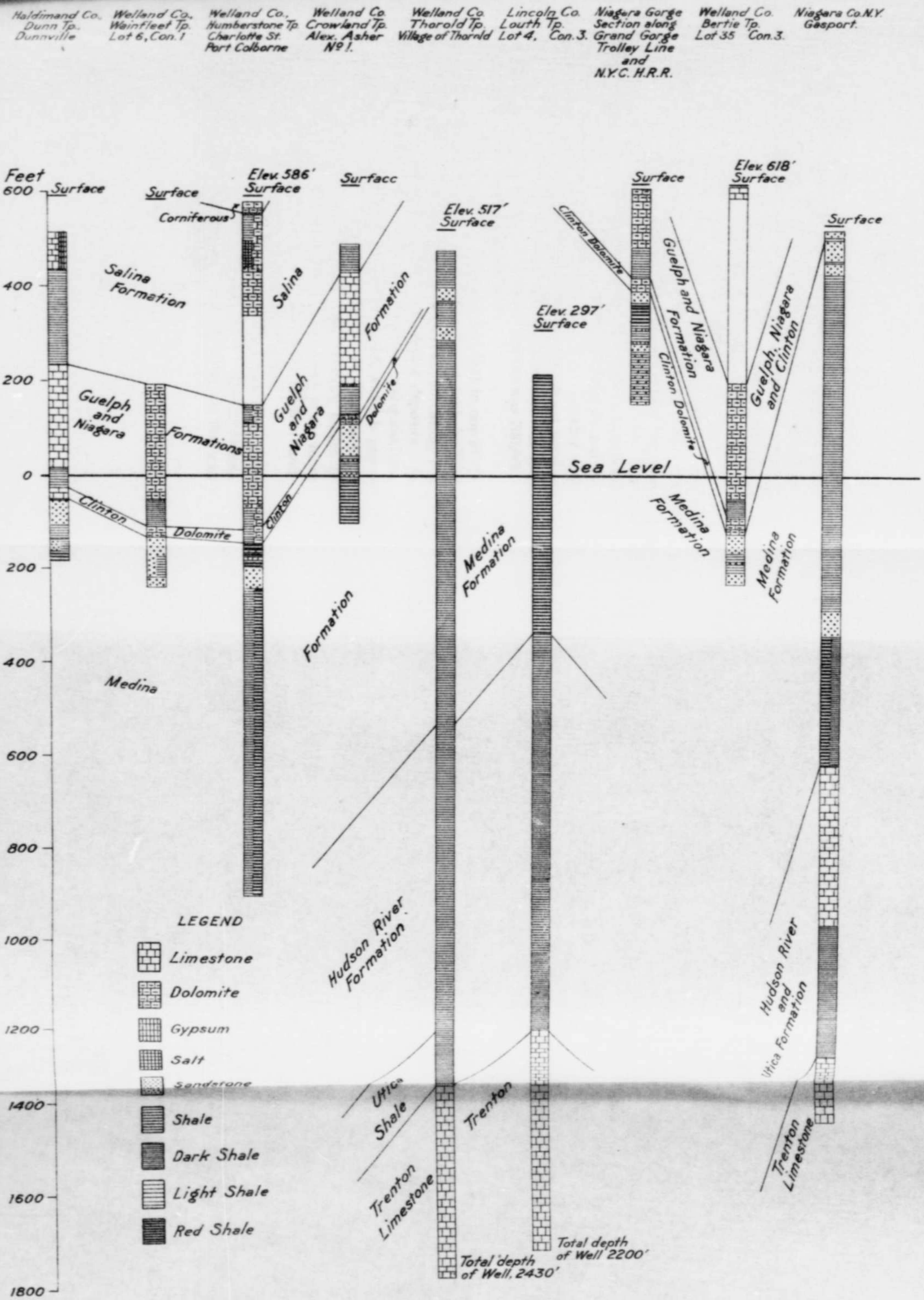

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Fig. [redacted]. Selected well logs, showing correlation of formations through Welland county, Ontario. (By F. G. Clapp and L. G. Huntley)

Geological structure.—The formations of Welland county dip from north to south and are practically flat east and west, the sands being 500 to 600 feet higher in Thorold and Stamford townships than they are near Lake Erie. Detailed surveys have not been made to determine whether or not any anticlinal reverses of dip exist; but enough wells have been drilled to determine this in considerable detail if desired.

Production of gas.—The daily initial production of the first Welland county well was 1,700,000 cubic feet, with 525 pounds per square inch rock pressure. By the end of the year 1891, the daily yield from 22 wells was 56,000,000 cubic feet. The 2,940-foot well referred to on page 213 is said to have been drilled by the Provincial Natural Gas and Fuel Company and the production to have been 250,000 feet per day. Another well half a mile north of it obtained 60,000 cubic feet of gas per day in the same sand and had 1,000 pounds rock pressure. In 1900 the total output of natural gas in Welland county was 700,000,-000 cubic feet per year, mostly exported.

Casing of wells.—It is an interesting fact that in one of the deepest wells drilled in this county, which was sunk in 1885 at Port Colborne to a total depth of 1,500 feet, no casing was used except as a conductor through the surface deposits. In most of the subsequent wells in the field, however, casing has been placed a few feet below a great flow of salt water, which is generally encountered in the Niagara limestone. In Humberstone and Bertie townships in the gas field, the ordinary length of casing was originally from 580 to 600 feet, but many of the more recent wells have been cased to the summit of the Medina sand, the total length of casing being from 700 to 800 feet.

Crowland township.—Considerable drilling has been done in Crowland township, and some gas obtained. The conditions are illustrated by the following log of a well drilled by the Welland Natural Gas Company near Welland.

Log of Asher No. 1 well in Crowland township[1].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	110
Shale	Salina	110	190
Lime	Guelph and Niagara	190	415
Blue shale		415	480
Lime	Clinton	480	500
Shale	Medina	500	505
Red shale		505	560
Shale		560	570
White sand		570	575
Shale		575	595
White sand		595	615
Red shale		615	712
	Total depth		712

Show of shale gas 300 and 512 feet.
Sulphur water . . . 220 feet.
Casing . . . 430 feet.

Midway between Welland and Brookfield, south of the Michigan Central railway, are several pumping oil wells. At Brookfield one gas well exists south of the railway. About two miles east of Welland on the north side of the railway, one small gas well exists.

Bertie township.—Midway between Stevensville and Brookfield several very small gas wells exist south of the railway.

Much drilling has been done in Bertie township and a great deal of gas has been found in the past in the White Medina sand. Consequently good well records are available. One of these is recorded on page 214. Another is given below, being a well drilled in 1891 by the Bertie Natural Gas Company:—

Log of well in Bertie Township.

Material	Formation	Top Feet	Bottom Feet
Flinty lime	Onondaga	0	60
Slate and gypsum	Salina, Guelph, Niagara and Clinton	60	100
Shale		100	105
Shale rock		105	135
Shale and gypsum		135	150
Shale		150	380
Lime		380	495
Sil. lime		495	510
Hard lime		510	620
Shale		620	670
Lime		670	680
Shale		680	690
Red shale	Medina	690	760
Shale		760	770
Shale		770	790
White shale		790	802
Red shale		802	820
	Total depth		870
	Gas		725
	Gas		840
	Water 100 and at various points to		250
	Cased to		660

[1] Geol. Survey Canada, Vol. VI, 1892-3, p. 108.

Many wells were drilled in this township in 1889 by the Provincial Natural Gas and Fuel Company, one being reported as high as 8,500,000 cubic feet per day.

Humberstone township.—This was the most productive township in Welland county. In the years preceding 1890 many wells were sunk here by the Provincial Natural Gas and Fuel Company, the Port Colborne Natural Gas, Light and Fuel Company, the Mutual Natural Gas Company, and by other parties. Showings of gas are found in various formations, but the chief production was from the White Medina, in a stratum known locally as the Second white sand.

The first well sunk in this township is believed to have been in 1866 when a hole 800 feet was sunk one mile west of Port Colborne under the direction of Mr. L. P. Carter. The tools were lost at the depth mentioned and the whole was abandoned, but showings of gas were obtained which were used for some years in a dwelling.

The town of Port Colborne in this township was the first town in Canada to use natural gas. The Port Colborne Natural Gas, Light and Fuel Company was organized in 1885 with Mr. C. McNeal of that place as president, and the first well was drilled in the same year on Charlotte street, Port Colborne. The principal flow of gas was found at a depth of 764 feet in one of the Medina sands. Sulphuretted hydrogen was encountered at 452 feet. No casing was used in this well except as a conductor through the surface deposits. Although much was made of the gas at the time, the daily flow was only about 25,000 cubic feet. The gas was used, however, for several years to light a number of stores and the hotel. Well No. 2 in the same village was drilled in the rear of a factory owned by Mr. H. Richardson about one mile from Well No. 1; the depth was 770 feet, about 25,000 cubic feet of gas per day being encountered 762 feet from the surface. The gas was used to heat and light several private residences. Well No. 3, known locally as the Hopkins well, was situated in the same village a short distance north of No. 1; the depth was 771 feet, gas being encountered at 765 feet. Other small wells were drilled in Port Colborne and vicinity in the years immediately following.

The developments of the Port Colborne Company were rapidly followed up by independent operators, some of the earlier wells drilled by other parties being the Carroll, near Hopkins No. 2, Cronmiller and White well.

When gas was struck by the Provincial Natural Gas and Fuel Company in Humberstone and Bertie townships, a contract was made with one of the gas companies in Buffalo, New York, and during 1890 a pipe line was laid to that city. Buffalo was supplied with natural gas from Canada for many years until 1898 when the exportation of natural gas from the country was forbidden.

Much of the gas from this county has in recent years been taken to Hamilton by the Dominion Natural Gas Company, where it is sold to the Ontario Pipe Line Company.

Log of Well No. 1 of the Provincial Natural Gas and Fuel Company, drilled on lot 35, concession III, Bertie township, drilled to a depth of 846 feet, is given on page 214. Salt water was encountered at 548 feet, but the well was cased to a depth of 596 feet. The initial flow from this well after shooting was 2,050,000 cubic feet per day. The gas is contained in the second White Medina sand. The following list may be of interest as giving the location of the first wells drilled by the Provincial Natural Gas and Fuel Company in this township:—

No. of Well.	Locality.	Depth.	Volume in cu. ft. per day.
1	Lot 35, Con. III	846′	2,050,000
3	" 1, " XV	836′	600,000
5	" 34, " III	842′	8,500,000
8	" 27, " III	840′	47,000
11	" 4, " XIV	816′	300,000
14	" 6, " XV	Over 1,600′	Failure
2	" 2, " II	851′	375,000
4	" 3, " I	875′	2,200,000
6	" 1, " I	897′	70,000
7	" 3, " II	840′	3,000,000
9	" 3, " II	851′	3,500,000
10	" 6, " I	870′	4,500,000
12	" 9, " II	843′	5,500,000
13	" 9, " I	900′	300,000

The general character of the formations in this township is illustrated by the following record of Well No. 20 of the Provincial Natural Gas and Fuel Company:—

Log of well in Humberstone township[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Drift	0	63
Drab and grey dolomite	Salina	63	345
Grey dolomite	Guelph and Niagara	345	585
Black shale		585	635
White crystalline dolomite	Clinton	635	665
Red shale	Medina	665	720
Red shale		720	730
Blue shale		730	735
White shale		735	740
Blue shale		740	760
White shale		760	782
Total depth			782
Salt water			540
Cased			582

Gas in second white sand (761—764) with two oil pays, 4 barrels each.

A little oil was found in this well.

Well No. 1 of the Port Colborne Natural Gas, Light and Fuel Company was sunk in 1885 to a depth of 1,500 feet, the log being given below:—

Log of well on Charlotte street, Port Colborne[2].

Material	*Formation* (Surface elevation 586)	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	12
Grey limestone	Onondaga	12	25
Grey limestone	Salina	25	35
Dolomite		3½	35
Shale and dolomite		35	90
Dolomite and gypsum		90	147
Dolomite		147	255
Shale and dolomite in gypsum		255	440
Shaly dolomite	Guelph, Niagara and Clinton	440	470
Brown dolomite and dark blue shale toward bottom		470	658
Marls and dolomite		658	730
Red shale and thin bands, white sandstone	Medina—main flow of gas 764 feet	730	780
Red and white sandstone		780	833
Soft red shale with bands of grey and green	25,000 cu. feet day—gas	833	1500

Wainfleet township.—Much drilling has been done in this township and some good gas wells obtained. It followed imme-

[1]Ingall, Geol. Survey, Canada, Vol. V, Pt. SS. p. 122.
[2]Brumell, H. P. H., Geol. Survey, Canada, Vol. V, Pt. Q. 1889-91, p. 34.

diately upon the development of gas in Humberstone, and on lot 6, concession I, the first well was drilled by John Reebe, obtaining a flow of 400,000 cubic feet of gas per day in the Clinton dolomite. A record of a typical well west of Port Colborne is as follows:—

Log of gas well on Lot 6, Concession I[1].

Material	Formation	Top Feet	Bottom Feet
Drab and grey dolomites, shales and gypsum	Salina	0	390
Grey dolomite	Guelph, Niagara, Clinton	390	630
Black shale		630	685
Dolomite		685	715
Red sandstone	Medina	715	760
Red and blue shale		760	800
White sandstone		800	820
Production of gas 400,000 cubic feet per day, 685 feet in Clinton limestone.			
Casing			630
Total depth			820

Productive formations.—In Wainfleet township, however, only one Medina white sand is present.

Stamford township.—Some drilling has been done in the past in Stamford township resulting in showings of gas. The first well known to have been drilled in this township was sunk at Niagara Falls South in 1888. Another well was sunk the same year in that vicinity, and showings of gas were obtained in both. Since the record of No. 1 well, sunk on the McGlashan farm, lot 158, is a fairly good one, it is given below.

The total depth was 840 feet. Well No. 2 drilled on lot 172 of the same township was carried to a depth of 1,000 feet, but no record was kept. Showings of gas were found in these wells 215 feet and 380 feet in the Clinton and Medina sands respectively.

A sample well log of McGlashan No. 1, drilled in 1888, is as follows:—

Log of well on Lot 158, at Niagara Falls South[2].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	43
Limestone	Niagara	43	186
Shale	Parts of Niagara, Clinton and Medina	186	210
Shale		210	350
White quartzite sand	Medina	350	374
Shale and sandstone		374	840
Total depth			840
Casing			160
Gas 4,000 feet per day at 215 feet in upper beds of Clinton formation.			

[1]Brumell, H. P. H., Geol. Survey, Canada, Vol. V, Pt. Q. 1889-91, p. 41.
[2]Brumell, H. P. H., Geol. Survey, Canada, Vol. V, Pt. Q. 1889-91, p. 36.

Thorold township.—Some drilling has been done in this township in the past, without success. A deep hole with a showing in the Trenton was drilled in 1888 by the Thorold Natural Gas Company at Thorold to a depth of 2,430 feet. Salt water was encountered at 284 feet, and a showing of gas at the extreme bottom of the well near the base of the Trenton limestone.

Willoughby township, Welland county.—In 1899 six wells were drilled in this township, some going as deep as 900 feet; all were good wells with pressures of 250 to 400 pounds per square inch.

Future possibilities.—Welland county has been so thoroughly tested that there appears little prospect of getting any new pools in the Clinton or Medina sands. The prospect of gas in the Trenton and underlying formations likewise appears small, since no prominent favourable structure is known; but there is just a possibility that the Trenton or the arkose zone may furnish some deep field.

Wellington County.

General Statement.—No oil or gas fields of commercial possibilities have ever been found in Wellington county, and it is believed that no such fields exist, since the geological conditions are not suitable.

History of testing.—Naturally very little testing has been done, but some holes were sunk as far back as 1888, when John Frazier drilled a well at Erin to a depth of 800 feet without success. It is also known that previous to 1866 a boring was made at Eden Mills on lot 1, concession I, to a total depth of 509 feet, nothing but salt water being found.

Formations penetrated.—The formations immediately below the drift in Wellington county consist in a small area in the eastern part of the county, of Niagara limestone; in the central part of the county they consist of Guelph limestone; and in the western part entirely of Salina. Unfortunately few good well records are available, but a record is given below of the test sunk in 1888 at Erin:—

Log of dry hole at Erin[1].

Material	*Formation*	*Top Feet*	*Bottom Feet*
Limestone	Niagara	0	95
Shale		95	195
Blue shale and sand	Medina	195	220
Red shale		220	700
Blue shale	Lorraine	700	800
Total depth			800

Wentworth County.

General statement.—No oil or gas fields or important deposits of either substance have ever been discovered in Wentworth county, although small showings of gas existed in several old tests. The thickness of glacial drift in this county runs from nothing up to 100 feet.

History of developments.—The city of Hamilton is supplied with natural gas by the Dominion Natural Gas Company from the Welland and Haldimand county fields. Since the early sixties wells have been drilled at various places in Wentworth county in search of a nearer supply, but none have ever produced either oil or gas in paying quantities. Several dry holes have been drilled in Hamilton itself, one in the yard of the Royal hotel being about 1,000 feet deep and showing little gas. Another well drilled in 1864 to 1865 on lot 11, concession VII, Barton township, was 873 feet deep, and ended in blue shale. It is said to have encountered small showings of oil. Another well at the Insane Asylum in Barton township was drilled on lot 17, concession V, by the Emerson Natural Gas, Light and Fuel Company to a depth of 1318 feet and was dry. At Dundas a well was drilled to a depth of 1,500 feet, encountering nothing but several small showings of gas.

Several comparatively shallow wells have been drilled in Flamboro township, finding a little gas and oil, but all were failures. Sulphurous gas is often encountered in the Niagara limestone, and on one occasion a little thick tarry oil was found. Five small gassers are reported drilled in this county in 1910.

Formations penetrated in the wells.—The thickness of glacial drift in this county runs from nothing up to 100 feet. Like Lincoln county, Wentworth is also divided topographically into

[1]Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 43.

	Bottom
	Feet
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	195
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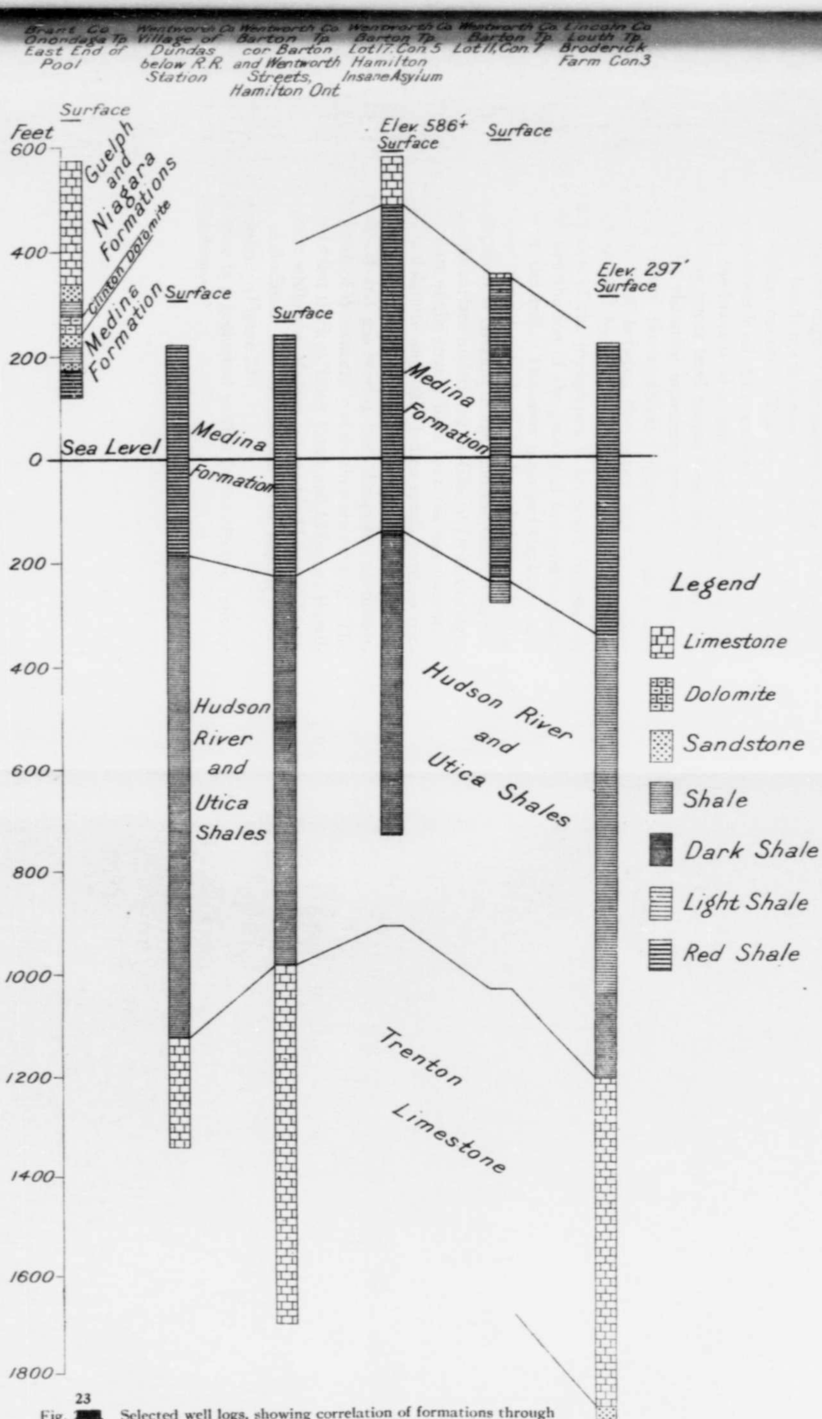


23

Fig. [redacted] Selected well logs, showing correlation of formations through Wentworth county, Ontario. (By F. G. Clapp and L. G. Huntley)

an upper and lower level, the demarcation being along the line of the Niagara escarpment. This presents nearly a straight front from the eastern edge of the county westward to beyond Hamilton, but then bends north across Flamboro West and East townships into Halton county. The city of Hamilton is built in the angle on the lower level at the western end of Lake Ontario.

In elevation, the lower level in this county ranges from 250 to 350 feet; and the upper level ranges from 640 to 1,000 feet above sea-level, the elevation increasing toward the northwest and decreasing toward the southeast. Along the escarpment the difference in level between the upper and lower plains amounts to about 300 feet.

This discussion of the topography is necessary in order to understand the distribution of the geological formations which are penetrated by the drill. The lower plain and the lower part of the escarpment consist entirely of Medina shales; while the top of the escarpment is Niagara in age; and the Guelph formation constitutes the surface underlying the Glacial Drift throughout the greater part of the county back from the escarpment.

The Clinton dolomite and the Medina sands outcrop conspicuously below the Niagara limestone along the escarpment, but these three oil and gas-bearing beds disappear northwestward, so that north of Wentworth county they are missing. The Clinton itself is 13 feet thick at Stony Creek and 12 feet at Hamilton and Ancaster; while the Medina red sand is 14 feet at Stony creek, 11 feet at Ancaster; and the Medina white sand is 10 feet thick at Hamilton. (Figure 23).

The following is a geological section in the electric railway cut above Hamilton:—

Section of the Niagara escarpment at Hamilton[1].

Formation.	Subdivision.	Material.	Thickness.	Total
Niagara	Lockport.	Chert beds	12	12
		Chert with shaly partings	5	15
		Crystalline grey dolomite with green shale partings	2½	17½
		Heavy dark dolomite with black shale partings	4½	22
	Rochester	Limestone and shale	4½	26½
		Shale, limestone and ferruginous band	10	36½
Clinton	Clinton	Heavy dolomite	4	40½
		Thin limestone	4	44½
		Fossiliferous band	2½	47
Medina	Medina	Grey sandstone and shale	12	59
	Cataract	Red and grey shale	70	129
		Blue limestone	10	139
		Grey limestone	10	149
	Queenston	Red shale (at least 200 ft. exposed)	200+	....

A photograph of the Niagara and Clinton formations in the locality mentioned is given in Plates X, XI, and XII.

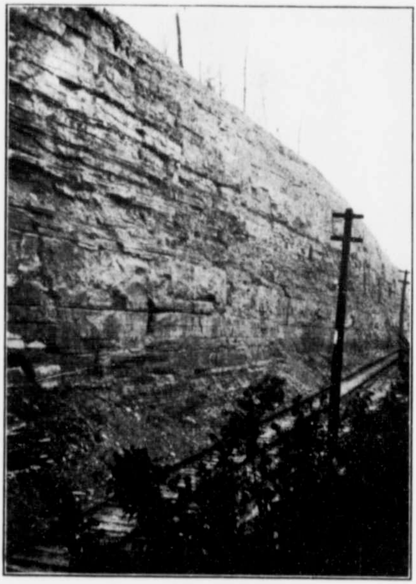
Formations penetrated.—In 1903 a well was drilled at the corner of Barton and Wentworth streets, Hamilton, to a depth of 1,950 feet, a record of which was furnished by Mr. M. D. Jepson and is given below, since it gives a fair account of the formations underlying the Medina sands.

Log of dry hole drilled at Hamilton.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Sandy loam	Pleistocene	0	12
Red shale	Medina	12	480
Black shale	Lorraine and Utica	480	500
Blue shale		500	1250
Trenton limestone	Trenton	1250	1950
	Total depth		1950

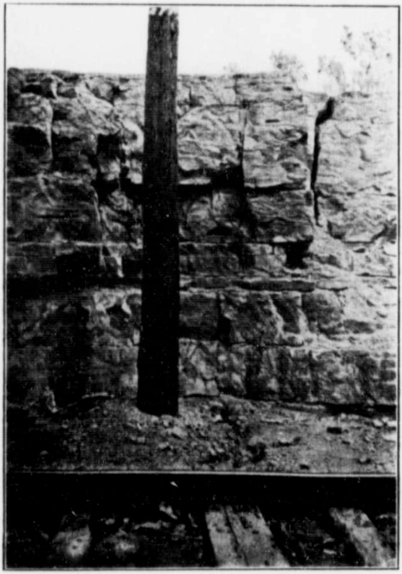
[1]Parks, W. A., The Palæozoic Section at Hamilton, Ontario, Guide Book No. 4. Excursions in Southwestern Ontario, 1913, p. 136.

PLATE X.



Niagara limestone, shale, and Clinton dolomite,
Hamilton mountain, Wentworth county, Ont.

Plate XI.



Clinton dolomite in railway cut near Hamilton, Hamilton mountain, Wentworth county, Ont.

PLATE XII.

Clinton dolomite on Hamilton mountain, Wentworth county, Ont.

(Top of Clinton is just below trolley wires.)

About the same time two other wells were also drilled in Hamilton, the depths being similar. Only small showings of gas were found.

The city of Hamilton is trying at the present time to decide whether it will be worth while to give a franchise to the Natural Gas Co., which has holdings in Seneca township and which, it is claimed, owns wells which produce 15,000,000 feet per day. More wells are contemplated and R. F. Miller, General Manager of the Company, declares there will be sufficient produced to meet all needs of Hamilton if the franchise is granted—when they promise to pipe it to that city in two months' time. On the other hand, the Ontario Pipe Line Co. declares the supply is limited and that they are ready to meet Hamilton's needs in the coke plant they are erecting for the manufacture of artificial gas. The wells of the Natural Gas Company are only drilled to 600 feet and it is said that their nearness to the surface causes more leakage, and it will not be possible to keep up to their promises.

Possibilities of Wentworth county.—Judging by the testing which has been done and by the fact that the Clinton and Medina sands have become very thin in Wentworth county, there is little prospect for obtaining any oil or gas of value in this county. Another unfavourable fact is that the three sands mentioned outcrop in the cliff of Hamilton mountain and along the entire length of the Niagara escarpment; consequently, whatever oil or gas may have been held in the sands within a few miles of this outcrop must have escaped into the atmosphere thousands of years ago.

The question arises whether there is any prospect for obtaining oil or gas in underlying formations. To this it may be said that below the White Medina sand there is a depth of at least 1,400 feet in Wentworth county, composed entirely of the Medina, Lorraine and Utica shales, which are unfavourable for the existence of oil or gas. Below the depth mentioned, or approximately 1,250 feet below the city of Hamilton, is the top of the Trenton limestone, which is the formation producing oil or gas so abundantly in Ohio, but which has thus far never been proved commercially productive in Ontario. There is no geological structure in Wentworth county which would justify the expectation of finding a large quantity of gas in this formation.

Deep drilling.—Although a number of tests have been drilled at various times for oil and gas in this county, the majority of them have been comparatively shallow, and it is unfortunate that few records are available of the deep wells which were drilled. One good log, which shows the formations underlying the city of Hamilton, is of a well which was drilled below the railway station at Dundas to a depth of 1,650 feet. The record furnished by Mr. James Kerr is as follows:—

Log of well near Dundas, Flamboro West.

Material	*Formation*	*Top Feet*	*Bottom Feet*
Surface	Pleistocene	0	80
Red shale	Medina	80	480
Blue shale	Partly Medina and partly Lorraine	480	1030
Black shale	Lorraine and Utica	1030	1430
Limestone	Trenton	1430	1650
	Total depth		1650

Several small shows of gas were found.

Several deep wells also have been drilled in the city of Hamilton going deep into the Trenton limestone. The latter is reported 700 feet in thickness, below which is the Potsdam sandstone, resting on granite.

Mr. Carmody reports that in one well they drilled half a day in the granite. The three wells in question were the same depth, all being completed at 1,950 feet, and there is very little difference in the records. About 3,000 cubic feet per day of gas was obtained about 100 feet from the top of the Trenton. There was a slight showing of oil in the well at Copp Block. The majority of well records are of little importance, since they show few details below the Clinton dolomite.

York County.

General statement.—No oil or gas fields of commercial size exist in York county, and conditions are such that it is useless to hunt for them. Small showings of gas have been reported at various localities, but these are not sufficient, when viewed in the light of geological conditions, to warrant any development.

History of drilling.—Considerable drilling has been done, notwithstanding the unfavourable conditions. Testing began as far back as 1866 or 1867, when a well was sunk at Highland creek in Scarboro township to a depth of 434 feet, but without success. In 1882, a well was sunk for water to a depth of 1,200 feet, in the yard of Coplin's brewery on Parliament street, Toronto, likewise without success. In 1888 to 1891 an attempt was made by the Ontario Bolt Company to obtain gas by drilling to a total depth of 1,261 feet. In 1889 a well was sunk by the government at Mimico in Etobicoke township in search of water, reaching a depth of 1,060 feet, and finding a showing of gas, but without other success.

About 25 years ago a well at the Massey-Harris works, corner of King street and Strachan avenue, was drilled by what was then the Massey Manufacturing Company. The reported depth was about 1,200 feet, and showings of gas were found. A number of other wells with showings have been reported at various times in Toronto and vicinity.

In the early part of 1913 a well was reported to have produced gas on the Van Sickler property at 252 Dupont street, Toronto. The total depth of the well was 1,107 feet, and the flame is reported to have been 12 feet in height before the gas suddenly disappeared, proving that only a pocket had been struck.

Rosebank, a suburb a few miles east of Toronto, has become suddenly active in the gas world. Three high flowing gas wells are reported to have been discovered. The owner of them is a Mr. William Cowan who owns most of the cottages in the suburb.

Formations penetrated.—The geological formations underlying the glacial drift in York county consist at the extreme north end of Trenton limestone. Farther south and occupying a belt one-third of the distance from the north end of the county, is the Utica shale, south of which the Lorraine outcrops over more than half the county, extending to its southeastern corner. The general dip of the formations is from northeast to southwest.

The rocks penetrated in drilling are principally those from the Lorraine shale downward, including the Utica, Trenton and associated limestones. It is unfortunate that few good well records exist, but we have several which are worth mentioning. The best available log appears to be that of the Ontario Bolt Company, drilled between 1888 and 1891 in York township on the east side of the Humber river, three-fourths of a mile from Lake Ontario, penetrating 16 feet into the crystalline rocks. The log of this well is as follows:—

Log of well in York township[1].

Material	Formation	Top Feet	Bottom Feet
Sand	Pleistocene	0	65
Quicksand	Pleistocene	65	80
Hardpan	Pleistocene	80	107
Grey shale	Lorraine and Utica	107	547
Black shale	Lorraine and Utica	547	587
Grey shale	Lorraine and Utica	587	643
Limestone	Trenton	643	750
Soapstone	Trenton	750	755
Limestone	Trenton	755	1235
Fossil rock	Trenton	1235	1245
Crystalline rocks		1245	1261
	Total depth		1261

Another fair well record, not so deep, was sunk in 1889 at Mimico in Etobicoke township by the Ontario government, and reached to the total depth of 1,060 feet. The log is as follows:—

Log of well in Etobicoke township[2].

Material	Formation	Top Feet	Bottom Feet
Surface	Pleistocene	0	7
Blue shale	Lorraine and Utica	7	500
Brown shale	Lorraine and Utica	500	723
Limestone	Trenton	723	1060
	Total depth		1060
Shows of gas		425, 575 and	1052
Water			25
Casing			100

Granite is reported in the well of the Massey-Harris Company at a depth of about 1,200 feet.

Statistics of Petroleum and Natural Gas Production in Ontario.

The following table gives the production of crude petroleum of Ontario by districts, for the last five years, as reported by the Deputy Minister of Mines[3].

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[1] Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 25.
[2] Brumell, H. P. H., Geol. Survey Canada, Vol. V, Pt. Q, 1889-91, p. 24.
[3] Twenty-second Annual Report, Bureau of Mines, Vol. XXII, Part I, 1913.

Field.	1908.	1909.	1910.	1911.	1912.
	$	$	$	$	$
Lambton	265,368	243,123	205,456	184,450	150,272
Tilbury and Romney	201,283	124,003	63,058	48,707	44,727
Bothwell	39,228	38,092	33,999	35,244	34,486
Leamington	9,334	5,929	141	....	....
Dutton	13,734	9,513	7,752	6,732	4,335
Onondaga (Brant co.)	....	....	1,005	13,501	7,115
	528,959	420,660	314,410	288,634	240,935

In the following table, furnished by the Imperial Oil Company, Limited, is given the production of petroleum in Ontario, Canada, during the years 1898–1912, by districts.

Production of Petroleum in Ontario, Canada, 1898-1912, by districts, in barrels of 35 imperial gallons.[a]

District.	1898.	1899.	1900.	1901.	1902.	1903	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.
Bothwell	66,404	65,044	47,405	52,873	50,141	48,880	47,654	47,959	43,836	40,556	39,820	38,707	36,615	35,094	33,257
Coatesworth (Romney)	....	....	....	....	....	....	....	....	....	49,784	11,165	1,082	....	....	....
Dutton	901	3,622	4,791	10,588	8,867	21,483	14,217	20,976	18,597	14,698	12,268	10,052	7,860	3,598	2,455
Leamington	....	....	....	....	....	1,190	25,241	113,806	....	....	....	....	....	....	....
Blytheswood	....	....	....	....	....	....	669	....	35,958	16,210	18,117	9,367	248	13,501	....
Comber	....	....	....	....	....	....	97	....	....	....	....	....	....	....	....
Staples	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
East Tilbury	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Raleigh including Pardo's Siding and Sandison	....	....	....	....	2,462	1,161	3,274	....	115,400	344,358	170,589	115,862	60,416	49,027	43,376
Onondaga	....	....	....	....	....	....	....	....	....	....	....	....	1,070	12,602	....
Pelee Id.	....	....	....	....	....	....	1,023	....	....	....	....	....	....	....	....
Richardson Station (Chatham) including Blakely	....	....	....	....	....	....	....	1,249	1,376	940	2,883	2,923	1,689	1,776	711
Thamesville	....	....	....	....	....	....	....	5,037	2,463	1,585	1,139	853	710	141	....
Wheatley	....	....	....	....	....	1,995	4,490	1,750	....	....	....	....	....	....	....
Petrolia and all other districts	b513,179	528,641	541,435	432,906	397,628	350,390	278,299	250,701	247,446	206,285	171,019	156,581	129,372	126,089	95,968
Oil Springs	c133,366	107,487	99,019	76,059	60,747	56,405	75,530	78,125	68,100	55,813	61,252	60,868	55,508	56,248	41,532
Plympton	25,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Moore township	....	....	....	....	....	....	36,971	93,815	53,030	32,720	25,667	18,033	14,614	....	....
Dawn	5,923	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Euphemia	5,227	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Zone	901	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	750,901	704,794	692,650	572,426	519,845	481,504	492,502	610,844	585,328	762,503	513,633	414,185	307,533	297,935	217,299

a Min. Res. U. S. 1910, pp. 109–11; 1900, p. 587.
b Includes production from Plympton.
c Includes production from Dawn, Euphemia and Zone.

The following table gives the statistics of natural gas production in the Province of Ontario, Canada, since 1892[1]:—

Statistics of Natural Gas production in the Province of Ontario, Canada, 1892–1912[2].

Year.	Wells Bored in the Year.		Producing wells.	Miles of gas pipe.	Workmen employed.	Gas Production.		Wages for labour.
	Productive.	Non-productive.				Quantity. (Cubic feet.)	Value.	
1892	....	....	....	....	....	....	$150,000	....
1893	....	....	107	117	59	....	238,200	$24,592
1894	....	....	110	183	99	....	204,179	53,130
1895	....	....	123	248	92	....	282,986	73,328
1896	....	....	141	287	87	....	276,710	47,527
1897	....	....	140	297	84	....	308,448	42,338
1898	....	....	142	315	85	....	301,599	31,457
1899	....	....	150	341	95	....	440,904	40,149
1900	....	....	175	306	161	....	392,823	43,636
1901	....	....	158	368	129	....	342,183	59,140
1902	....	....	169	369	107	....	195,992	55,618
1903	....	....	210	312	138	....	196,535	79,945
1904	....	....	176	231	....	....	253,524	53,674
1905	....	....	273	462½	130	....	316,476	88,865
1906	....	....	332	550	108	2,534,200,000	533,446	64,968
1907	....	....	582	810	191	4,155,900,000	746,499	110,832
1908	....	....	656	850	152	4,483,000,000	988,616	106,786
1909	....	....	744	987	171	5,388,000,000	1,145,307	103,672
1910	145	30	828	982	186	7,263,427,000	1,271,303	118,786
1911	268	38	1,179	1,296	287	10,863,871,000	1,807,513	183,663
1912	178	41	1,247	1,448	277	12,529,463,000	2,036,245	184,351

[1] The first year in which records of natural gas production were kept was in 1892.
In part from—
Min. Resources, U.S., 1910, pp. 324-5; 1912, pp. 341-342.
Geol. Survey of Canada, Vol. 8, 1893, Pt. S. 1899.

PART 2

CANADIAN FIELDS IN DETAIL
WESTERN

CONTENTS.

PART 2.

CANADIAN FIELDS IN DETAIL: WESTERN

CHAPTER IX.

ILLUSTRATIONS.

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PETROLEUM AND NATURAL GAS RESOURCES OF CANADA

VOL. II

DESCRIPTION OF OCCURRENCES

PART 2

Canadian Fields in Detail

WESTERN CANADA

CHAPTER VI

MANITOBA

GEOLOGY[1]

Stratigraphy

GENERAL STATEMENT

The sedimentary formations of Manitoba are limited to two areas; one underlain by Ordovician and Silurian strata lies along the lower courses of the Churchill and the Nelson rivers and extends along Hudson bay from the mouth of the former river to the southeastern border of the Province; and the other occupies the southwest quarter of the Province, and includes formations from the Ordovician to the Devonian and also Cretaceous and Tertiary strata. These formations outcrop in wide bands parallel to the southwest edge of the Pre-Cambrian, and extend from the United States border to the boundary between Manitoba and Saskatchewan. In the intervening region between these two areas, the rocks are all crystalline and metamorphic Pre-Cambrian deposits. The rocks of the Province, if grouped together, would form the geological section given below. The data for this section and for the descriptions of the geological formations, and the logs of the bore-holes, have been taken from McConnell, Tyrrell, and Dowling as summarized by Wyatt Malcolm in Geological Survey of Canada Memoir 29 E[2].

[1]Chiefly by F. G. Clapp.
[2]Oil and gas prospects of the Northwest Provinces of Canada.

Generalized Geological Section of Manitoba.

System.	*Period.*	*Formation.*	*Thickness.* (*Feet*)	*Material.*
Tertiary.....	Laramie.......	Laramie (Fort Union)		
Cretaceous..	Foxhill........	Odanah........	400	Light grey hard fissile shales.
	Pierre.........	Millwood......	664	Soft dark grey clay shales.
	Niobrara......		130–540	Calcareous shales and chalky limestones.
	Benton........		160	Soft dark grey fissile shale.
	Dakota........		13–200	Coarse light grey sandstone.
Devonian....	Upper.........	Manitoban	210	Light grey brittle limestone with red and grey shales.
	Middle........	Winnipegosan..	200	Hard white to spongy yellow dolomites.
	Lower.........	LowerDevonian	100	Red and other shales.
Silurian......	Niagara.......		200	Compact light dolomites and argillaceous limestones.
Ordovician..	Utica (?)......	StonyMountain	190	Limestones and shales.
	Trenton.......	Upper mottled limestone....	130	Limestone.
		Cat Head limestone........	70	Dolomite with chert.
		Lower mottled limestone....	70	Limestone.
	Black River (?)	Winnipeg sandstone........	10–100	Sandstone and shales.
Pre-Cambrian	Huronian......			Quartzites, conglomerates, limestones and schists.
	Laurentian....			Granite and granite gneiss.

DESCRIPTION OF GEOLOGICAL FORMATIONS.

Pre-Cambrian:—The Pre-Cambrian rocks of Manitoba are part of the great Pre-Cambrian shield of North America stretching from the Great Lakes region to Labrador and the Arctic Ocean. The Laurentian, a granite-gneiss complex, occupies most of the territory. In this area, there are smaller belts and areas of Huronian and Keewatin, consisting of much altered sedimentaries such as quartzite, conglomerates, limestone, and crystalline micaceous and chloritic schists.

Ordovician-Winnipeg sandstone.—The Winnipeg formation consists of shales and sandstones of varying thickness, ranging from 10 feet in the northern part of the province to 100 feet in the southern part. These sandstones are friable and generally light coloured, though at places they are deeply stained with iron. In the southern part of the province, the upper part of the formation is made up mostly of shale. The age of the formation is Black River, or a transition from Black River to Trenton.

Trenton Group.—The Trenton group is made up of three formations of which the *Lower mottled limestone* is the basal one. This limestone consists of dark-yellowish to greyish white mottled limestone, some beds of which are quite fossiliferous, and the total thickness of which is about 70 feet. *The Cathead limestone* comes next in ascending order. It also has a thickness of about 70 feet, and is made up of fine grained, evenly coloured, yellow dolomitic limestone with numerous concretions of dark coloured chert. The lower beds resemble lithographic limestone, and are very rich in fossils. The uppermost member of the Trenton is the *Upper mottled limestone* which has a thickness of 130 feet. It consists of light, yellowish, and at a few places reddish, mottled dolomitic limestone. In places it is quite porous and contains impressions of salt crystals. It is quarried at East Selkirk, and is used as a building stone in Winnipeg. The rocks of the Trenton group thin out towards the north so that at Reed lake in northern Manitoba only the Upper mottled limestone is present resting on the Winnipeg sandstone.

Stony Mountain formation.—This formation is exposed only at Stony mountain and Little Stony mountain, but has been shown by drilling to extend from Stonewall southeastward to the vicinity of Winnipeg. Towards the north it thins out. The complete thickness as shown in well borings is 190 feet. It consists of shales in the lower part and grey thick bedded argillaceous limestones above. The lower shales are thought to be Utica in age and the limestones with the upper part of the shales is to be correlated with the Richmond group.

SILURIAN ROCKS.

Niagara limestone.—This formation has a thickness of 200 feet and consists largely of dolomites. On the west side of Lake Winnipegosis, it is made up of compact, thin bedded dolomites and at Cross lake of compact and porous dolomites with numerous fossils, while at Grand Rapids on the Saskatchewan river the dolomites are hard, tough, and light-yellowish in colour. The formation has not been recognized in the southern part of the province, although rocks resembling the Niagara are found at Stonewall, 20 miles northwest of Winnipeg. Gypsum has been found in the vicinity of Lake St. Martin. It has also been found by boring about 325 feet beneath the surface, southeast of Winnipeg. It is probable that the gypsum beds and associated shales belong to a higher formation of the Silurian

DEVONIAN ROCKS.

Lower Devonian formations.—These rocks are softer than the underlying and overlying beds, and do not form cliffs, hence the nature and extent of the formations are not well known. They appear to consist of red and other coloured shales with a thickness of about 100 feet. It is suggested that the softness of these rocks resulted in their erosion and the development of the depressions now largely occupied by Lakes Winnipegosis and Manitoba.

Winnipegosan or Middle Devonian formation.—These rocks form a belt running from the west boundary of the province through Dawson bay of Lake Winnipegosis, to Point Richard on Lake Manitoba, their farther southern extension being concealed by glacial drift. The formation consists of two members; a lower one, 100 feet in thickness, of porous spongy yellow dolomite; and an upper one, likewise 100 feet in thickness, of whitish or light yellow, hard, tough, compact dolomite with many fossils.

Manitoban or Upper Devonian formation.—This formation outcrops in a belt to the west of the preceding. It consists of three members. The lower one is made up of red and grey shale, with a thickness of 70 feet, and is exposed along the west shore of Lake Winnipegosis and elsewhere. The middle member consists of light grey hard limestone, having a thickness of 40 feet. The upper member consists of light grey hard brittle limestone, fossiliferous, underlain by red argillites, with a total thickness of 100 feet. The whole thickness of the Manitoban formation is therefore 210 feet.

CRETACEOUS ROCKS.

Dakota formation.—The Dakota formation is of the greatest importance as it is the chief bitumen bearing formation in the Northwest. It is in these rocks that the tar sands of the Athabaska occur, and that the chief gas reservoirs of southern Alberta are located. The formation is exposed at several points along the northern portion of the Manitoba escarpment. On account of the irregularity of the floor on which it was deposited, it varies in thickness from 13 to 200 feet. It is composed of white or reddish sandstones, either cemented by a calcareous matrix, or often quite incoherent, being then an even-grained white quartzose sand. It grades up into a light green and rather hard sandstone commonly interstratified with thin bands of green shale. These upper greenish beds have yielded a few fossils, mainly coniferous leaves and fragments of wood.

Benton formation.—This formation consists of dark grey, almost black shale, holding a considerable quantity of carbonaceous material. This shale is evenly bedded, breaks down readily into flakes, and is easily eroded. It is associated with thin bands of white, soft, sweet-tasting magnesian clay (bentonite). It is generally destitute of fossils. The thickness of the formation in Manitoba is about 160 feet.

Niobrara formation:—The Niobrara consists of grey calcareous shale or marl, sometimes varying to a band of moderately hard limestone and weathering into steep or vertical bluffs. At the top there is usually greyish chalky limestone, often highly pyritiferous. The more calcareous layers of the formation yield cement rock in certain localities. The thickness varies from 130 to 200 feet, and it is possibly 540 feet in thickness in the Swan River valley.

Millwood formation.—These rocks are well exposed at Millwood on the Assiniboine river. They consist of dark grey soft shales containing crystals of selenite and ironstone septaria with a few fossils. The thickness in southwestern Manitoba is over 650 feet but farther north it ranges from 450 to 500 feet.

Odanah formation.—The Odanah formation conformably follows the Millwood and has a thickness of 400 feet. A good exposure of these rocks is seen in the upper part of Edwards Creek valley and at Odanah. They are made up of light grey, hard, clay shales. They contain a meagre marine fauna.

TERTIARY ROCKS.

Laramie formation.—In the southwestern part of Manitoba, extending for 40 miles along the boundary line of the United States, occurs an outlier of the Laramie, consisting of clays and sands, and known in the United States as the Fort Union formation.

Structural Geology.

As has already been indicated, the sedimentary rocks of the southwest third of Manitoba outcrop in northwest-southwest bands parallel to the border of the Pre-Cambrian and have a general dip of a few feet to the mile to the southwest. Over much of this country the rocks are concealed by glacial drift, and much of it has not yet been thoroughly examined, so that the details of the geological structure are unknown except here and there. Some light anticlines have been detected in the Niagara rocks on the east shore of Lake Winnipegosis. In the same region, the Devonian strata are found to be folded into low anticlines and in places are faulted. At the south end of the lake the disturbance becomes rather pronounced and there are dips up to 20 and 30 degrees.

OIL AND GAS DEVELOPMENTS.

A few scattering holes, some of them reaching considerable depth, have been drilled in Manitoba in the search for oil and gas, but as yet no deposits of importance have been located. Gas is reported to have been struck in August, 1912, at a depth of 120 feet in a well being drilled for water, 3 miles west of Miami. As shown by the following log of a borehole at Morden, 12 miles east of south of the foregoing, the Dakota would not be likely found at less depth than 300 feet, so that the supply of gas probably did not come from that formation.

Log of bore-hole at Morden.

Boring about 150 yards northwest of the railway station.
Altitude, 978 feet above sea-level.

			Thickness (Feet)	Depth (Feet)
Alluvium, 15 feet	1.	Light sandy soil	8	8
	2.	Quicksand	3	11
	3.	Quicksand, red	1	12
	4.	Fine gravel, red	3	15
Till, 16 feet	5.	Lead coloured clay with pebbles	10	25
	6.	Limestone boulder, with fine scratches	2·5	27·5
	7.	Small boulders and shale	3·5	31
Pierre (Millwood series) 24 ft	8.	Dark grey shale	24	55
Niobrara, 160 feet	9.	Hard streak	0·5	55·5
	10.	Dark grey shale	4·5	60
	11.	Hard streak	3	62
	12.	Dark grey shale	6	68
	13.	Hard streak	1	69
	14.	Dark grey shale	11	80
	15.	Hard streak, mixture of stones and shale	1	81
	16.	Dark grey shale	4	85
	17.	Black shale, very gritty	1	86
	18.	Dark grey shale	7	93
	19.	Black shale, hard and gritty	1	94
	20.	Grey calcareous shale	121	215
Benton, 105 feet	21.	Dark grey shale	35	250
	22.	Soapstone	3	253
	23.	Dark grey shale	67	320
Dakota, 92 feet	24.	White sand, with water	4	324
	25.	White sand with particles of coal	54	378

			Thickness (Feet)	Depth (Feet)
Dakota, 92 feet	26.	White shale	2	380
	27.	White sand		
	28.	Soft grey shale	10	390
	29.	Slack shale	10	400
	30.	Grey shale with sandstone	12	412
Devonian, 188 feet	31.	Red and grey shale	88	500
	32.	Porous limestone at		500
	33.	Red and grey shale	100	600

Water at depth of 324 feet strongly charged with sodium chloride.

Other wells have been drilled, of which the logs of four are available and they are given on the following pages:—

Log of bore-hole at Rosenfield.

Altitude 770 feet above sea-level.

			Thickness (Feet)
Magnoketa shale	1.	Black soil	4
	2.	Fine silt or clay	111
	3.	Sand and gravel	10
	4.	Boulder clay (hard pan)	12
	5.	Boulders	6
	6.	Grey shale	62
	7.	Limestone	15
	8.	Red shale	5
	9.	Grey shale	10
	10.	Limestone	30
	11.	Fine, grey sandstone	40
	12.	Chalky limestone	30
	13.	Red shale	160
Galena limestone passing below into the Trenton	14.	Cream-coloured limestone	305
	15.	Red shale	75
St. Peter	16.	Soft sandstone	50
Lower Magnesian	17.	Dark red shale	50
	18.	Reddish and greenish shale	25
	19.	Bluish and grey shale	20
	20.	Red shale	15
Laurentian	21.	Granite	2
		Total	1037

Small flows of brine were struck below Nos. 10 and 14, and from No. 16 the brine produced a flowing well.

Log of bore-hole at Deloraine.

About 100 yards north of the railway station.
Altitude 1,644 feet above sea-level.

			Thickness (Feet)	Depth (Feet)
Pleistocene, 91 feet	1.	Black soil	3	3
	2.	Clay, with some small pebbles	30·5	33·5
	3.	Hard blue clay, with pebbles	56·5	90
	4.	Fine black sand and gravel	4	94
Pierre—Odanah, 292 ft.	5.	Light blue-grey shale	56	150
	6.	Black sand, with water	0·5	150·5
	7.	Blue shale	235·5	386
Pierre Millwood, 664 feet	8.	Soapstone, with thin layers of lime rock	401	787
	9.	Blue clay, with round boulders	188	975
	10.	Dark blue-grey shale	75	1050
Niobrara, 545 feet	11.	Grey shale	25	1075
	12.	Mottled grey calcareous shale	200	1275
	13.	Dark non-calcareous, or but very slightly calcareous shale	135	1410
	14.	Grey calcareous shale	185	1595
Benton	15.	Dark non-calcareous shale	205	1800

In 1892 this hole was deepened to 1943 feet, of which the lower 121 feet were in the Dakota sandstone. In this formation saline water was struck.

Log of bore-hole at Solsgirth[1].

North half of section 30, township 17, range 25 west of 1st principal meridian. Altitude above sea 1,757.

	Thickness (Feet)	Depth (Feet)
Loam	2	2
Hard blue clay and gravel	42	44
Hard blue clay and stones	10	54
Hard yellow hardpan	12	66
Softer bluish clay	90	156
Blue clay with stones	136	292
Grey clay (shale?)	68	360

Log of bore-hole on Vermilion River.

Township 23, section 22, range 20 west of the principal meridian. Altitude above sea, 1,300.

			Thickness (Feet)	Depth (Feet)
Pierre-Millwood series	1.	Soft dark grey clay shale	95	95
Niobrara	2.	Fragmental limestone	4	99
	3.	Grey calcareous shale	124	223
Benton	4.	Dark grey fissile shale	178	401
Dakota	5.	Coarse sandstone, with pyrites	19	420
Devonian	6.	Compact white limestone	120	540
	7.	Blue-grey clay shale	10	550
	8.	White gypsum	15	565
	9.	Red shale	110	675
	10.	Shale and limestone	68	743
	11.	Red shale at bottom		

During 1913 prospecting was active a few miles south of Manitou, in the Pembina River valley. While no oil is yet reported, considerable gas was developed. In 1907 oil indications were found in this section and a couple of wells were drilled, each with a showing of gas, but accidents prevented the completion of the wells.

Natural gas strikes have been made at Treherne and Melita. That at Treherne has been used for the past three years for the heating and lighting of a farm house, while the local mill at Melita has been supplied by gas discovered fifteen years ago.

[1]Dawson, G. M.

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CHAPTER VII

SASKATCHEWAN

GEOLOGY[1]

Stratigraphy

GENERAL STATEMENT

Information relating to the geology of Saskatchewan is obtainable chiefly from the reports of the Geological Survey of Canada and is contained in reports by Dawson, McConnell, Tyrrell, and others. The results of the work of the geological work in this province have been summarized by Wyatt Malcolm in Memoir No. 29E, of the Survey, already quoted in reference to Manitoba[2]. From this memoir are taken the data used in the following pages in summarizing the stratigraphy and geology of this province. The relations between the sedimentary formations and the Pre-Cambrian crystallines in Saskatchewan are similar to those which prevail in Manitoba. The northern half of the province is underlain by the crystalline and metamorphic rocks, and south of this area the sedimentary formations outcrop in successive bands which dip to the west of south. In the following table of geological divisions, there is summarized the succession, thickness, and character of the different formations which go to make up the geological sections of the province. As is the case in Manitoba the Cambrian is not represented, and strata belonging to the Carboniferous, Triassic, Jurassic, and the earlier part of the Cretaceous do not occur.

[1]By F. G. Clapp.
[2]Oil and gas prospects of the Northwest Provinces.

Table of Geologic Divisions and Formations of Saskatchewan.

System.	*Period.*	*Formation.*	*Thickness. (Feet)*	*Materials.*
Tertiary.....	Pliocene.......		2–50	
	Oligocene......		50–500	
	Laramie.......	Upper.........	750	
		Lower.........	150	
Cretaceous...	Montana......	Bearspaw......	900	
		Belly River....	894	
		Claggett (Millwood).......	250	
	Niobrara......		200–500	Soft grey shales.
	Benton........		175–266	Dark shales.
	Dakota........		200 ?	Soft white to buff sandstone.
Devonian....			500 ?	Heavy buff dolomite.
Silurian.....	Niagara.......		200 ?	Heavy white to spongy and cherty dolomitic limestone.
Ordovician..	Trenton.......	Upper mottled limestone....		Thick yellowish dolomitic limestone.
	Black River....	Winnipeg sandstone........	10–20	Coarse, soft sandstone.
Pre-Cambrian	Keweenawan..	Athabaska sandstone....	400	Coarse white and red sandstone.
	Huronian......			Quartzites, conglomerates, schists, and limestones.
	Laurentian....			Granites and gneisses.

DESCRIPTION OF GEOLOGICAL FORMATIONS.

Pre-Cambrian.

Pre-Cambrian crystallines occupy the northern third of the province of Saskatchewan. The rocks are mapped chiefly as Laurentian and undivided Pre-Cambrian and consist of granites and gneisses. There are also a few small known areas in which Lower Huronian or Keewatin rocks occur. These rocks are usually micaceous and chloritic schists or conglomerates, quartzites and limestones.

The territory south of Athabaska lake as far as Cree lake and east as far as Wollaston lake is underlain by the *Athabaska* sandstones, which are mapped as probably Keeweenawan or Animikie, but which may possibly be Cambrian. These sandstones vary in colour from white to dull red and are coarsely granular to conglomeritic in texture. Near the east end of Lake Athabaska they attain a thickness of 400 feet.

Ordovician.

Winnipeg sandstone.—This formation, consisting of light coloured, coarse, friable sandstones outcropping around Lake Winnipeg in Manitoba, extends westward into Saskatchewan, though soon overlapped by the Cretaceous. The thickness is probably about the same as that in the northern part of Manitoba, where it is 10 to 20 feet, thickening greatly to the south.

Trenton group.—The rocks of the Trenton group in Manitoba thin out towards the north so that only the Upper mottled limestone persists as far as the Saskatchewan border and the overlapping edge of the Cretaceous 75 miles west. It consists of thick bedded yellowish-grey dolomitic limestone with the thickness not stated.

Silurian.

Niagara limestone.—In Manitoba, this formation has its greatest development in the northern part of the province in the vicinity of Winnipegosis, Cedar, and Cross lakes. From here it continues westward, fully developed, past Cumberland lake to where it passes beneath the Cretaceous overlap, doubtless extending far to the west and south beneath the overlying formations. In the vicinity of Cumberland House, it consists of thick-bedded white dolomitic limestone—at some places cherty—at others spongy and vesicular. The thickness is estimated at not over 200 feet.

Devonian.

Rocks of Devonian age are widely distributed about Lake Winnipegosis, Dawson bay, and Red Deer lake in Manitoba where they develop the three divisions—Lower Devonian, Winnepegosan, and Manitoban. Toward the west, however, the superficial area occupied by these rocks is more and more restricted by the overlapping Cretaceous formations until in the region southwest of Cumberland lake it is entirely covered by them. In the vicinity of Lake La Ronge, the Devonian is again exposed and probably extends northwest beyond the limits of Saskatchewan to a point west of Lake Athabaska, where it widens out and extends in a broad zone down the valley of the Mackenzie river. From the great development of the Devonian in northern Manitoba, it must exhibit much the same features in Saskatchewan. On the shore of Lake La Ronge, large angular blocks of buff coloured dolomite are so numerous as to indicate strata of the same sort immediately below. The fossils contained belong to about the *Stringocephalus* zone which is Middle Devonian.

Cretaceous.

Dakota sandstone.—The Dakota sandstone is well exposed at several places along the northern portion of the Manitoba escarpment with a thickness up to 200 feet, and extends westward into Saskatchewan. On Carrot river, 4 miles above the Indian Reserve, a soft sandstone containing some carbonaceous material outcrops and is apparently overlain by a hard, purplish sandstone. Though no fossils were found, these rocks are probably

Dakota. East of Lake La Ronge, along the south shore of Wopamekka lake, are bluffs of a white quartz sandstone, containing a lignite bed, and these are probable Dakota. On Beaver river, just above the mouth of Dore river, are 90 foot bluffs of soft white or light yellow sandstone. On the south shore of Ile à la Crosse lake is a light yellow sandstone with thin beds of calcareous ironstone and carbonized plant remains. Both the latter occurrences are probably Dakota.

Benton group.—The Benton shale in Porcupine mountain on the boundary between Saskatchewan and Manitoba has a thickness of about 175 feet. This is a soft, easily eroded, fissile shale soon weathering into soft clay. The formation probably outcrops westward across the whole province of Saskatchewan, and it doubtless extends southward and westward beneath the overlying formations throughout the south half of the province. Wells in this part of Alberta give it a thickness of 266 feet.

Niobrara formation.—Some exposures of the Niobrara have been recognized in Saskatchewan on Carrot river, 40 miles above the Redearth Indian Reserve. A soft grey shale dipping southwest at a low angle is thought to belong to the Niobrara, as also the similar shales of the Pasquia hills. Some of the latter are almost black and rich enough in volatile matter to burn with a bluish flame and a strong odour of petroleum. Typical Niobrara shales outcrop near the south end of Green lake. The formation doubtless extends southward beneath the overlying Cretaceous beds to beyond the United States border, since in the borings at Bow island, Alberta, not far from the southwest corner of Saskatchewan, it has a thickness of 500 feet.

Claggett formation.—This formation does not outcrop so far as known in this province, but it does outcrop in Alberta on Milk river not far from the southwest corner of Saskatchewan, and it doubtless extends northwestward beneath the overlying Cretaceous formation of the plains. It has a thickness of about 250 feet, and consists of dark marine shales very similar to the Benton. Their equivalence to the Millwood formation of Manitoba has been suggested.

Belly River formation.—This formation, which is a continuation of the Judith River beds of Montana, extends northward, in a belt more than a hundred miles wide, into Alberta, and down the valley of the south Saskatchewan river into Manitoba, swinging northward and finally veering back again into Alberta. It must extend far eastward beneath the overlying formations in southern Saskatchewan. It consists of characteristic white cross-bedded sandstone, with yellowish, grey, blue, and greenish shales and clays. Darker sandstones, weathering brown, grey and yellow also occur. The thickness is about 900 feet.

Bearpaw formation.—This formation consists of grey, brownish to nearly black shales with interbedded light grey to yellow soft sandstone. It outcrops in a belt around the area underlain by the Belly River formation in the southwestern part of Saskatchewan and extends eastward across the plains to the Manitoba escarpment, and northwards to an east-west outcrop in central Saskatchewan. The formation is equivalent to the Fox mill sandstone and the upper part of the Pierre shales. Its thickness is about 900 feet in the southwest part of the Province.

Tertiary Laramie group.—The rocks assigned to the Laramie group are a continuation of the Fort Union beds of North Dakota, and are divisible into two divisions. The lower one consists of 150 feet of grey and white clays, sandy clays, and sand with carbonaceous shales and lignites. It is correlated with the Edmonton series of Alberta, and is believed to be Cretaceous in age. The upper division consists of soft silts, clays, and sands, the latter passing into sandstones. It has a maximum thickness of 750 feet. It corresponds to the Paskapoo series of Alberta and is Tertiary in age. The Laramie group occurs in the Cypress hills, in various buttes between the Cypress hills and Wood mountain, in the Coteau, and stretches away eastward from Wood mountain along the United States boundary as far as the east boundary of the province.

Oligocene.—Beds of this age cap the more elevated parts of the upland of the Cypress hills and the Swift Current Creek plateau. They consist of conglomerates with waterworn pebbles of quartzite from the Rocky mountains, and the pebbles are also distributed in lenticular beds and layers in sands and sandstones. They vary in thickness from 50 to 500 feet.

Pliocene.—Gravels of this age, known as the Saskatchewan gravels, are found in pre-glacial depressions in southern Saskatchewan. There is generally a single bed of conglomerate from 2 to 50 feet in thickness composed of quartzite pebbles, with a calcareous or ferruginous cement. They always lie at a lower level than the Oligocene from which they were derived—in great part at least.

Structural Geology.

Cretaceous formations of the plains of Saskatchewan show local irregularities and undulations and in places the dips amount to 20 or 30 degrees. Nothing is known in detail of these folds although they would naturally have an important bearing in any search for oil and gas. A wide low anticline crosses the boundary line of Alberta and Saskatchewan about the 52nd degree of north latitude, in the neighbourhood of the Ear hills and trends northwest into Alberta. The extension of this anticline northwest and southeast brings the Belly River beds to the surface, and is partly responsible for the large area of that formation exposed in southwestern Saskatchewan and southeastern Alberta. As pointed out, the bituminous Dakota sandstone is nearer to the surface in this area than anywhere else in southern Saskatchewan.

OIL AND GAS DEVELOPMENT.

Considerable drilling has been done in Saskatchewan, and at several places small pockets of natural gas have been penetrated, but so far no petroleum has been encountered, and nc commercial quantity of gas has been obtained.

PENSE.

The Western Gas and Fuel Company drilling in August, 1912, at Pense, 18 miles west of Regina, struck gas and artesian water at a depth of 1,500 feet. The water itself is a valuable desideratum, as the town had been without adequate water supply for 20 years. The quantity of gas available was not known at the time of writing, but as no later reports are at hand, it is to be presumed that the gas supply was but a limited one. The log of a deep well at Belle Plaine, 8 miles west of Pense, is given on a later page.

ESTEVAN.

In June, 1912, on the Wilson farm, 4 miles northeast of Estevan, gas and water were struck at 450 feet in drilling a well for domestic water supply. The flow of gas is reported to be stronger than in the well in section 1, township 4, range 7, west of the 2nd meridian, and 5 miles north of the Wilson well, from which gas had been burning for half a year. The quantity of gas available in the Wilson well has not been reported. According to reports in the early part of 1913, oil was discovered at Estevan at a depth of 2,000 feet. The discovery was said to be made in a well bored on the property of the Empress hotel in that town, the well being sunk as a water well, which was abandoned at a depth of 1,800 feet on account of a stronger flow of salt water. More recently a considerable flow of gas and indications of oil are said to have been discovered in the well. The Estevan Oil Company, Ltd., was organized for the purpose of further operations.

HANLEY.

On the Andrews farm in section 28, township 50, range 5, west of the 3rd meridian, 10 miles southwest of Hanley and 40 miles due north of Saskatoon, a small quantity of gas burning with a flame about a foot high flows from a well 116 feet deep. No log of this well is available, but it seems likely that the gas is derived from a bed in the glacial drift. The gas has been flowing for 3 years.

SASKATOON.

In May, 1912, a drill hole at Saskatoon had reached a depth of 1,115 feet and the last cuttings were reported to smell strongly of gas and oil. In October, preparations were being made by the Saskatoon Gas and Oil Company to shoot the well, which had then reached a depth of 1,800 feet. No later information is at hand.

NORTH BATTLEFORD.

Drilling was in progress in February, 1913, and near the close of that month had reached a depth of 940 feet. Three small pockets of gas had been struck. The hole was expected to go to 2,000 feet if oil or gas was not found before that depth had been reached.

Oil Shales.

In the Pasquia hills of east central Saskatchewan, there is an occurrence of bituminous shales which may eventually serve as a source of oil and ammonium sulphatum by distillation. The best exposures are found in the valley of Nabi river. The lower part of the section consists of 35 to 40 feet of thick-bedded soft grey bituminous shales and thin-bedded sandstones with fish remains, bivalves, and foramenifera. These are overlain by a half foot of compact, impure limestone with abundant fossil shells. The upper part of the section consists of 120 feet or more of soft, fissile, light grey (almost black when wet) bituminous shales with fish remains and foramenifera. The fossils show these strata to be Cretaceous and probably Niobrara in age.

These shales on ignition leave 70·17 per cent of ash. A sample of this shale taken at random was analyzed by the Mines Branch with the following result:—

Sulphate of ammonia	33·5 pounds per ton.
Crude oil	40·05 imperial gallons per ton.

Well Logs.

The following are all the logs of deep holes drilled in Saskatchewan that are on record:—

Log of bore-hole at Kamsack.

Township 29, range 32, west of 1st meridian.

	Thickness (Feet)	Depth (Feet)
Blue clay	50	50
Shale	721	771
Very hard rock	2	773

It is reported that at 618 feet a coal seam about 8 feet thick was struck.

Log of bore-hole at McLean Station[1].

Canadian Pacific Railway, 24 miles east of Regina.
Altitude 2,248 above sea-level.

	Thickness (Feet)	Depth (Feet)
Black loam	1	1
Yellow clay	25	26
Blue clay	65	91
Gravel and sand	12	103
Blue clay and sand	85	188
Gravel and sand	10	198
Blue clay and gravel	98	296
Sand and gravel	52	348
Boulders	6	354
Blue clay and gravel	96	450
Gravel and sand	35	485
Boulders	5	490
Clay and sand	5	495

Log of bore-hole at Wilcox.

Well 4 miles east of Wilcox, Saskatchewan, on N.E. ¼ sec. 24, tp. 13, range 20, west of 2nd meridian.

	Thickness (Feet)	Depth (Feet)
Clay	45	45
Boulder clay	52	97
Blue shale	213	310
Grey shale	420	730
Black sand	4	734
Grey shale	30	764
Black sand	86	850
Shale	36	886
Sandy shale	5	891
Grey shale	169	1,060
Dark shale	224	1,284
Grey shale	67	1,351
Sand	9	1,360
Shale	25	1,385
Rock and shale alternately	22	1,407
Hard rock	19	1,426
Shale	4	1,430
Hard rock and shale alternately	20	1,450

Log of bore-hole at Belle Plaine.

Station on Canadian Pacific Railway, 18 miles east of Moosejaw.
Altitude 1,877 feet above sea-level.

	Thickness (Feet)	Depth (Feet)
Dark clay loam	3	
Yellow clay	11	
Blue clay	80	
Blue shale	150	
Black shale	75	
Grey shale	125	

[1]Dawson, G. M., Trans. Roy. Soc. Can. vol. IV, 1886, p. 92.

	Thickness (Feet)
Brown limestone	6
Grey shale	444
Reddish sand rock	20
Grey shale	190
Hard white sand rock	2
Grey shale, with thin layers of sand rock	200
Grey, soft shale	175
Black shale	70
Total	1,551

Log of bore-hole at Moosejaw.

Well sunk by the Corporation.

		Thickness (Feet)	Depth (Feet)
Clay	Pierre	5	5
Gravel		14	19
Hard grey clay		396	415
Hard clay, mouse grey		10	425
Hard clay		35	460
Sandy clay		20	480
Hard grey clay		75	555
Sandy clay, grey		45	600
Hard grey clay		177	777
Hard, grey sandy clay		13	790
Hard grey clay		100	890
Grey sand	Probably Belly River	20	910
Sandrock, shale		10	920
Shale and clay		10	930
Sand and hard grey clay		30	960
Sand		8	968
Sand, pepper and salt		42	1,010
Grey sand and clay		10	1,020
Grey clay and shale	Niobrara-Benton	10	1,030
Hard grey clay		30	1,060

Struck water, which is somewhat sulphury, and some gas.

Bore-hole of Keithville.

One mile east of Keithville in S.W. ¼ of N.W. ¼ of sec. 35, tp. 18, range 16, west 3rd meridian.

Owner—Benjamin F. Emerick.

Drilled in 1910.

	Thickness (Feet)	Depth (Feet)
Top soil	10	10
Yellow clay	90	100
Blue clay	56	156
Coarse yellow sand	4	160
Quicksand	20	180
Sand and gravel	13	193
Clay, sand and gravel	10	203
Yellow sand and clay	2	205
Clay	5	210
Sand and clay	25	235
Blue clay	65	300
Yellow sand	13	313
Sand and clay	20	333
Sand	4	337
Blue clay	77	414

Dry Holes.

The following is a tabular list of the deep drill holes of the Province which have yielded neither oil nor gas.

List of Dry Holes in Saskatchewan.

Well.	Depth.	Year Drilled.	Owner.	Notes.
Fort Pelly	501	1874-5	Dominion Gov't.	At 259 feet, a 9-foot calcareous stratum.
Kamsack	773	....	....	See log.
Yorkton	1,000	....	Drilled by city	....
Edwin, Sec. 13, Tp. 15, R 19 W 2nd Mer.	2,410	1909-10	Abray and Patterson.	Grey shale from top to bottom.
Wilcox	1,450	....	....	See log.
Belle Plaine	1,551	....	....	See log.
Moosejaw	1,060	....	Drilled by city	See log.
Keithville	414	1910	B. F. Emerick	See log.
Maple Creek, Sec. 15, Tp. 11, R 26 W 3rd Mer.	1,860	1909	Maple Creek Gas, Oil and Coal Co., Ltd.	Coal at 196 feet and 7 foot seam at 292 feet. Gas at 1,121 feet and at two other points between 1,120 and 1,500 feet.
Langham, Tp. 39, R7, W 3rd Mer.	1,358	1905	Mackenzie, Mann and Co.	In soft shale from top to bottom. Salt water at 1,340 feet

CHAPTER VIII

YUKON AND NORTHWEST TERRITORIES

GEOLOGY[1]

Stratigraphy

Under the above caption is included Yukon and all the unorganized territory in Canada north and west of Hudson bay, including the Arctic islands, and north of the boundaries of the western provinces. Our present knowledge of this vast area is very meagre, but the geological horizons are known to range from the Archæan to the Tertiary, the whole area being also more or less covered with Quaternary deposits.

Archæan.—The greater portion of the area west of Hudson bay as far as a line drawn between the west end of Lake Athabaska, the middle of Great Slave lake, and the eastern third of Great Bear lake is underlain by Archæan, including probably some undivided Pre-Cambrian; the northern boundary is approximately the Arctic ocean. To the south these crystalline rocks pass beneath the Palæozoic strata of Manitoba, or are united with the Laurentian areas of Ontario. Archæan rocks also occur on Baffin island and on some of the adjacent islands.

Within the limits of this territory are a number of small areas of Keewatin and Lower Huronian rocks consisting of metamorphosed sediments and volcanics. There are also several areas of later Pre-Cambrian, probably Keweenawan or Animikie. An area of considerable size lies along the Thelon river to Aberdeen and Schultz lakes, and south of this, also occupying a strip of territory between Baker and Dubawnt lakes. Small areas occur around the east end of Great Slave lake and near Beechey lake on Backs river. A still larger area, that promises to become of commercial importance because of its copper deposits, occurs in the territory between Great Bear

[1]By Alfred W. G. Wilson.

lake and Coronation gulf, and about Bathurst inlet. The rocks are chiefly sandstones and lava flows.

Pre-Cambrian gneisses and schists also occur along the southern side of Baffin island.

Palæozoic deposits.—Palæozoic deposits are found on many of the Arctic islands from Baffin island west to Victoria island. They also occur on the southern side of Southampton island, and on Coats and Mansel islands at the north of Hudson bay, and near Franklin bay on the Arctic coast.

A large area of Palæozoic strata occupies the western part of the Northwest Territories and Yukon. A portion of this has been definitely assigned to the Devonian, the balance is mapped as unclassified, chiefly Palæozoic, and constitutes the northern extension of the Rocky Mountain belt.

Silurian.—Silurian strata have been recognized on Baffin and Southampton islands, and in the basin of the Mackenzie river.

Devonian.—Small areas of Devonian strata are reported from Devon, Ellesmere, and other smaller Arctic islands.

Devonian rocks outcrop along the Mackenzie river from Lake Athabaska to within about 200 miles of the Arctic ocean, and also underlie a broad strip of territory on either side of the river. A narrow band of Devonian strata extends southeast from Lake Athabaska to Lake La Ronge, bordering the main Laurentian areas to the east.

McConnell describes the Devonian of the Mackenzie basin as follows[1]:—

Throughout the Mackenzie district the Devonian is generally divisible lithologically into an upper and lower limestone, separated by a varying thickness of shales and shaly limestones, but in some cases limestones occur throughout. The upper division has an approximate thickness of 300 feet and consists of a compact yellowish weathering limestone occasionally almost wholly composed of corals, interstratified with some dolomitic beds. This limestone is well exposed at the falls on Hay river and also at the Ramparts on the Mackenzie. In both of these places it is underlain by several hundred feet of greenish and bluish shales alternating with thin limestone beds. At the Grand View on the Mackenzie the shales are hard and fissile, and are blackened and in places saturated with petroleum. At the Rock by the River Side, and at other places where the beds are tilted and older rocks exposed, the middle

[1]R. G. McConnell, Yukon and Mackenzie Basins, Report Geol. Survey, Vol. IV, Part D, p. 15, 1888-89.

division is underlain by 2,000 feet or more of greyish limestones and dolomites interbedded occasionally with some quartzites. No fossils were collected from the lower part of this series, and rocks older than the Devonian may possibly be represented in it.

Carboniferous.—Carboniferous rocks have been reported from Melville, Prince Patric, Banks, and some smaller Arctic islands. Low[1] states that:—

The southern boundary of the Carboniferous sandstones, with their included coal seams, crosses the southern part of Banks island in a north-northeast direction, and they consequently cover the northern two-thirds of that island, while the extreme northwest portion of Victoria island is also occupied by these rocks. The western Parry islands on the north side of Melville sound are almost wholly formed of these rocks, whose southern boundary strikes northeast across the northern half of Cornwallis island. They are found again in Grinnell peninsula, the northwest portion of North Devon, and again on the western side of Ellesmere, in the vicinity of Store Bjornekap, being probably largely developed in the northeast part of that great island.

The rocks consist of close-grained sandstones, containing numerous beds of highly bituminous coal and but few marine fossils, and limestones, more or less fossiliferous.

Carboniferous strata have been noted in Yukon but the boundaries have not been determined. McConnell mentions the discovery of Carboniferous fossils in the Kluane district. He describes the associated rocks as bands of limestone, green schists, and dark slaty rocks, passing in places into a hard cherty variety[2].

Mesozoic.—Rocks of this age occur in Yukon chiefly north of the Arctic circle, though some small areas of Cretaceous strata have been mapped between Atlin lake and the Lewis river, and one on the Pelly river. A large area of Mesozoic strata occupies the basin of the Peel river and extends to the mouth of the Mackenzie river. A considerable area is found along the Arctic coast east of the Mackenzie delta as far as Franklin bay, and two smaller areas occur in the basin of the Mackenzie above Fort Good Hope and south of Fort Norman. The north and west shores of Great Bear lake are also bordered by strata of this age. In the southwest corner of the Northwest Territory in the vicin-

[1] A. P. Low, Cruise of the Nepture, p. 222.
[2] R. G. McConnell, Geol. Surv. Summary Report, 1904, p. 6.

ity of Fort Liard we find the northern extension of the great Mesozoic area of northern Alberta. Mesozoic rocks also occur in the Arctic basin, outcropping on the Sverdrup islands. Low maps these as mostly Triassic and states that they consist largely of sandstones with shales, schists and limestones. They also occur on the northern shores of the Parry islands; at Point Wilkie in Prince Patric island; Rendezvous hill, near the northwestern extreme of Bathurst island, and at Exmouth island and places in the vicinity, near the northwest part of North Devon[1].

McConnell describes the Cretaceous along the Liard river as follows[2]:—

Fossiliferous Cretaceous beds were not recognized in descending the Liard until the Plateau belt which borders the eastern foothills was reached. Below Fort Halkett, west of the mountains, a band of soft dark shales crosses the river, which may be in part Cretaceous, but no fossils were found in it. The eastern foothills are built of a great series of alternating shales and sandstones, with some limestones, all folded closely together, which resemble those found in the foothills farther south, and, like them, probably consist largely of Cretaceous rocks, but it was found impossible on a hasty trip along one line to separate these from the Triassic, or from the shales which cap the Palæozoic system, owing to the lithological similarity which prevails throughout. East of the foothills the convolutions gradually cease and the section becomes more legible. The beds here consist of soft, finely laminated shales, interstratified with a few beds of sandstone and ironstone. They have a minimum thickness of 1,500 feet. The shales yielded some fossils among which were several specimens of *Placenticeras Perezianum*, one of the characteristic fossils of series C of the Queen Charlotte islands. With this were species of *Camptonectes* and *Inocerami*. Near the eastern edge of the plateau belt the shales are overlain by massive beds of rather soft sandstones and conglomerates, the thickness of which was not ascertained. The conglomerates are affected by a gentle easterly dip, and descend to the level of the river in the course of a few miles. From the point at which they disappear to the eastern edge of the Cretaceous basin, the rocks consist of dark fissile shales, crumbly sandy shales and sandstones, but the exposures along the valley are infrequent, and the succession soon becomes obscure.

The Cretaceous section along the Liard thus shows two great shale and sandstone series separated by a heavy band of sandstones and conglomerates. The lower shales, from the imperfect fossil evidence at hand, and also from their lithological character, may be referred tentatively to the horizon of the Queen Charlotte islands or Kootanie formation, the upper shales to that of the Benton, while the intervening conglomeritic band probably represents the Dakota. The lithological succession of the Cretaceous

[1] A. P. Low, The Cruise of the Neptune, 1906, p. 226.
[2] R. G. McConnell, An Exploration in the Yukon and Mackenzie Basins, N.W.T., Geol. Survey Report, New Series, Vol. IV, part D, pp. 19-20.

beds here is almost identical with that which obtains in other parts of the Cordilleran belt north of the International Boundary and on the Queen Charlotte islands, and shows that similar conditions of deposition prevailed at the same time over this whole area.

The Cretaceous rocks cross the Liard with a width of over a hundred miles, and north of the river enter a bay in the mountains, the extent of which to the northwestward is not known; southwards they are connected with the great Cretaceous basin of the plains.

Cretaceous rocks on the lower Mackenzie were first encountered by McConnell near the Dahadinni river in latitude 64°N. They consisted of about 200 feet of dark grey shales and sandstones. They continue along the river for 10 or 12 miles and then disappear beneath boulder clay, but probably continue under this as far as the Tertiary basin at the mouth of the Bear river, a distance of 50 miles. Here the Cretaceous beds occupy a depression between two high ranges of limestone mountains and cannot have a greater width than 10 or 15 miles. They are separated from the Cretaceous beds on the western shores of Great Bear lake by the Mount Clark range. The Cretaceous beds again reappear on the banks of the Mackenzie 40 miles below Bear river, and underlie the valley all the way to the Ramparts a distance of 90 miles, with the exception of one break of a couple of miles where they have been removed by denudation.[1]

A third Cretaceous area occurs on the Mackenzie 120 miles below the Ramparts. This is the largest on the river and extends from a short distance below old Fort Good Hope to the head of the Mackenzie delta, and westwards across the Rocky mountains and down the Porcupine river to about longitude 139°W. The rocks on the Mackenzie are coarse shales interstratified with some sandstones and fine grained conglomerates. In the mountains several thousand feet of barren sandstones and quartzites underlain by dark shales constitute the formation. On the Porcupine the same two series, sandstones and quartzites, occur underlain by a great thickness of alternating shales, sandstones and conglomerates. The intermediate dark shales are regarded by McConnell as probably of Benton age, while the lower division so far as fossil evidence goes is regarded as representing the Queen Charlotte Island formation and the Dakota[1].

[1]R. G. McConnell, An Exploration in the Yukon and Mackenzie Basins, N.W.T., Geol. Survey Report, New Series, vol. IV., part D, p. 21.

Cretaceous shales, passing upwards into fine grained conglomerates, occur on the Yukon for many miles above and below the mouth of the Tatonduc. They have been greatly disturbed and are folded up in broad bands with the underlying Palæozoic[1].

Tertiary.—Small areas of Tertiary strata occur on some of the Arctic islands. The deposits consist of slaty clays, shales and sandstones with which are associated lignites and some soft coals[2].

Small areas of Tertiary strata are also shown on the geological map occurring in Yukon about the Frances river which joins the Dease river at Lower Post; north of the Yukon river west of Dawson; and along the upper Porcupine river. A small area is also developed in the basin of the Mackenzie at Fort Norman.

McConnell states that the Tertiary beds in the Mackenzie valley and about Bear river:—

Occupy a basin of about thirty to forty miles in length and twenty to thirty in breadth. They rest unconformably upon Cretaceous shales and Devonian limestones. They are lacustral in origin and consist largely of discordantly bedded sand, sandy clays, clays and gravels. Beds of purely argillaceous material usually somewhat plastic in character are also present, and seams of lignite and carbonaceous shales not infrequently constitute a considerable portion of the section. The beds on the Porcupine river are somewhat similar. They extend along the river for about 42 miles and consist essentially of light coloured sands, sandy clays, clays and conglomerates, with occasional nodular beds of ironstone, and in one section held a small lignite seam. No fossils of any kind were obtained from them. They are horizontal, or nearly so, and have a minimum thickness of 300 feet[3].

Quaternary.—Quaternary deposits occur in the basin of the Mackenzie often in sufficient quantity to completely cover the underlying formations. They also occupy the delta of the Mackenzie river and probably of the Anderson river, and occur widely distributed in the basin of the Yukon and its tributaries. There are numerous smaller areas of less importance underlain by sands, gravels, clays, and tills, widely distributed over northern Canada.

[1]R. G. McConnell, An Exploration in the Yukon and Mackenzie Basins, N.W.T., Geol. Surv. Report, New Series, vol IV., part D., p. 21.
[2]Refer to Low, Voyage of the Neptune, pp. 226-229.
[3]R. G. McConnell, *op. cit.*, pp. 22-23 and pp. 99-100.

Geologic Structure[1]

In the Mackenzie valley, according to McConnell[2]:—

The beds, (speaking especially of the Devonian) are practically undisturbed and are seldom affected by dips exceeding a few feet to the mile.

But he states further in this connexion that,—

For some miles above Bear river the Devonian, which forms the top of the Palæozoic system in the district, is overlain unconformably by the Cretaceous, and Cretaceous anticlines of limited extent recur at intervals all the way to the Upper Ramparts.

OCCURRENCE OF OIL[3]

According to McConnell[4]:—

The Devonian rocks throughout the Mackenzie valley are nearly everywhere more or less petroliferous, and over large areas afford promising indications of the presence of oil in workable quantities. The rock is in several places around the western arm of Great Slave lake highly charged with bituminous matter and on the north shore tar exudes from the surface and forms springs and pools at several points.

McConnell[5] says further:—

That the springs are situated a couple of hundred yards from the shore, at the base of a low limestone cliff, which runs inland from the lake, and are three in number, each of them being surrounded with a small basin, three to four feet in diameter, filled with inspissated bitumen, while the soil and moss for some distance away is impregnated with the same material. A small quantity of pitch is annually taken from these springs and used for boat building purposes, while a much larger supply could be obtained if needed. A sulphur spring resembling those at Sulphur point on the south shore of the lake, but much more copious, issues from the foot of the cliff in close proximity to the bituminous springs, and feeds a considerable stream.

The rock through which the petroleum ascends here is a heavily bedded greyish, rather coarsely crystalline cavernous dolomite, and is entirely unlike the bituminous beds south of the lake and down the Mackenzie, which in most cases consist of calcareous shales. The dolomite is everywhere permeated with bituminous matter, which collects in the numerous cavities, and oozing up through cracks, often forms small pools on the surface of the rock.

The age of the bituminous beds here could not be clearly ascertained as they are entirely unfossiliferous, but it is altogether likely that they are older than the Devonian shales and limestone which outcrop along the southern

[1]Written by F. G. Clapp.
[2]R. G. McConnell, Ann. Rept. Geol. Surv., Canada, vol. IV, part D, p.15, 1888-89.
[3]Written by F. G. Clapp.
[4]R. G. McConnell, *loc. cit.* p. 31.
[5]R. G. McConnell, *loc. cit.* pp. 75-76.

shore, and are more nearly related to the dolomites which underlie the fossiliferous Devonian beds at the Nahanni river, and other places. The presence of bitumen in such abundance here also suggests an anticlinal which would bring up lower beds.

Sulphur and tar springs are reported to occur at a point about half way between this and Fort Rae, but as I did not hear of them until I had left the lake, I was unable to visit them. A tar spring is also known to exist under the surface of the water in the deep bay immediately east of the Big Island fishery, as many of the boulders and rocks along the shore in this neighbourhood are coated with bitumen which has been washed ashore, and hummocks of ice stained with the same material are often observed. On the south shore bituminous shales and limestones outcrop at several points, and it would thus appear that the oil-bearing beds underlie the whole western part of the lake.

McConnell says there are also several tar springs near Fort Good Hope, and still farther down in the vicinity of old Fort Good Hope, the river is bordered for several miles by evenly bedded dark shales of Devonian age which are completely saturated with oil. These shales are in places so highly charged with bituminous matter that, according to McConnell, combustion has taken place. At one place along the Mackenzie (15 miles below Grand View) McConnell describes reddened shales, which he states are undoubtedly due to the burning of the bitumen.

Fifteen miles farther down, according to McConnell:—

The Devonian shales are again found. The shales are black in colour, evenly bedded, and highly bituminous. The laminæ, when freshly separated, are moistened on the surface with an oily liquid, and burn when thrown into the fire, and patches of red shales, marking the sites of former fires, alternate with the dark varieties. The shales are exposed in the right bank for some miles, or almost as far as old Fort Good Hope. They dip down the river at a low angle, and are overlain by the Saskatchewan gravels and boulder-clay.

Recently, August, 1912, according to a report published in the "Bulletin" of Edmonton, Alberta, samples of oil have been brought from the Mackenzie about 25 miles below Fort Norman where it seeps from the bed of the river, at low water, and in winter rises through the ice. According to the report, this oil is reddish-black in colour and flows as freely as engine oil, and burns freely, with a strong petroleum smell.

Possible Oil Fields.

From the data at hand, the most promising region in the Northwest Territories for the development of a producing oil field appears to be along the Mackenzie although the evidence is by no means conclusive. The presence of great quantities of oil bearing beds with a formation unconformably overlapping it suggests favourable conditions for the accumulation of oil into pools. In the Coalinga district, California, according to Arnold and Anderson[1] the productiveness of some of the Miocene sediments is greatest where the overlying formation "occupies a position of angular unconformity with the Miocene sands."

At some time in the future, it may be found profitable to open up an oil shale industry on the Mackenzie similar to the oil shale industry of Scotland at the present time.

[1]Arnold, Ralph, and Anderson, Robert, Geology and Oil Resources of the Coalinga district, Cal., U.S. Geol. Surv., Bull. 398, p. 186, 1910.

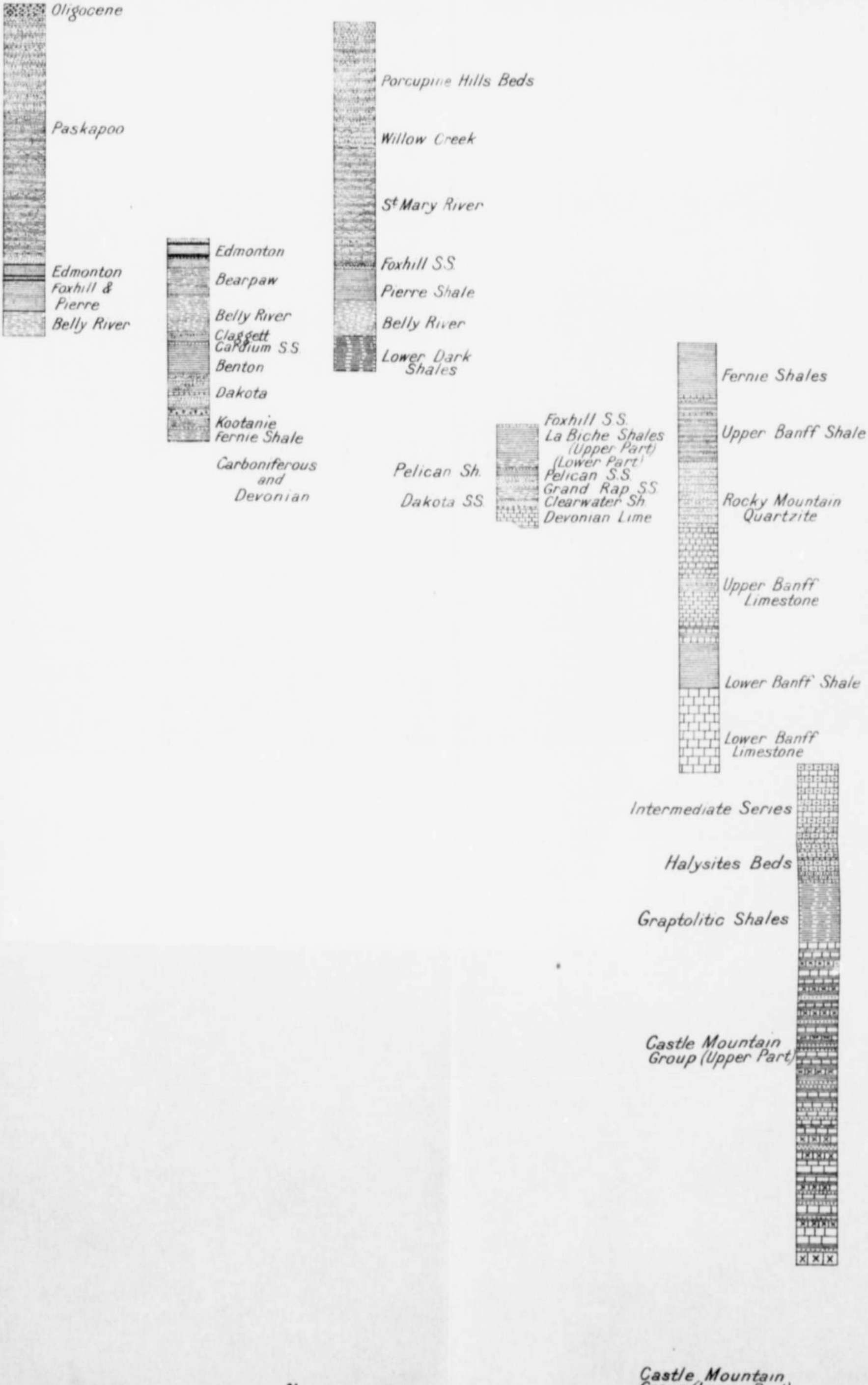

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Fig. [redacted]. Sections showing the geological column in Alberta.
(By F. G. Clapp and L. G. Huntley)

Comparative Table of Formations in Western Canada.

	Group	Alberta	Saskatchewan	Manitoba	Montana	Dakota	Kind of Rocks	Character of Fossils
Tertiary	Oligocene Eocene	Oligocene Paskapoo	Oligocene		Fort Union	Fort Union	Conglomerates and sandy clays	Land and freshwater
			Laramie	Laramie	Lance	Lance		
	Montana	Edmonton Bearpaw Belly River Claggett Eagle	Bearpaw Belly River	Odanah Millwood	Lennep Bearpaw Judith R. Claggett Eagle		Sandstones and clays Sandstones and clays Sandstones Shales Sandstones	Freshwater Land plants. Brackish and marine Brackish and fresh Marine Marine
Cretaceous	Colorado	Niobrara Cardium		Niobrara	Niobrara	Niobrara	Calcareous shales	Marine
		Benton		Benton	Benton	Carlile Greenhorn Graneros	Shales	Marine
	Dakota	Dakota		Dakota	Dakota	Dakota	Sandstones	Freshwater, land plants.
	Kootanie	Kootanie			Kootanie Morrison	Fuson Minnewaste Dakota Morrison	Sandstones and shales	Land plants, brackish and fresh water
Jurassic		Fernie			Ellis	Unkpapa Sundance	Shales and sandstones	Marine
Triassic						Spearfish		
		Upper Banff shale						
Carboniferous	Permo-Carboniferous	Upper Banff limestone				Minnekahta Opeche Minnelusa	Sandstones and shales	Land plants
	Pennsylvanian Mississippian	Lower Banff shale			Quadrant Madison	Pahasapa Englewood	Limestones	Marine
		Lower Banff limestone						
Devonian	Upper Middle Lower	Intermediate series	Winnipegosan	Manitoban Winnipegosan Lower Devonian	Threeforks Jefferson		Limestones	Marine
Silurian		Halysites beds	Niagara	Niagara	Maywood		Limestones	Marine
	Utica (?)	Graptolitic shales		Stony Mountain				
Ordovician	Trenton			Upper mottled limestone	Upper mottled limestone Cathead limestone Lower mottled limestone	Whitewood	Limestones, shales and sandstone	Marine
	Black River (?)		Winnipeg sandstone	Winnipeg sandstone				
		Castle Mountain						
	Upper				Barker Flathead		Shales, sandstones and limestones	Marine
Cambrian	Middle							
	Lower					Deadwood		
		Bow River						

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[1]By

CHAPTER IX

ALBERTA

GEOLOGY[1]

Stratigraphy

From Lake Athabaska south to the International Boundary all Alberta is underlain by sedimentary beds of Cretaceous age, which rest unconformably upon the Devonian limestone beds that outcrop in northern and eastern Alberta, and are underlain by intervening Carboniferous rocks along the west side of the province, adjacent to the Rocky mountains. These Devonian limestone beds are in turn underlain by sands and shales probably of Cambrian age. The latter vary in thickness because of the uneven character of the crystalline floor upon which they were deposited.

The entire body of sedimentary rocks thickens westward toward the Rockies where almost the entire geological series is represented in the exposed sections. All these beds thin out to the north and east, and the Carboniferous rocks disappear entirely at some point between their exposures in the vicinity of the Rocky mountains and the outcrops of the lower formations in Manitoba and at Lake Athabaska. Towards the southeast the nearest exposures of Carboniferous strata are found in the Black hills of the Dakotas; where they have a thickness much less than in the Canadian Rockies. It is impossible to conjecture whether or not these Carboniferous rocks are continuous between the localities named.

Geological columns, as observed by different Canadian geologists, at various localities in Alberta, are indicated on pp. 266—270. The same columns are shown graphically in Fig. 24. In the folder table facing p. 265, the correlations

[1]By F. G. Clapp, with additions by Alfred W. G. Wilson.

between the formations in Alberta and those in the other districts in Canada and in the United States are indicated[1].

SOUTHERN ALBERTA (DAWSON).

System.	*Formation.*	*Approximate thickness in feet.*
	Porcupine Hill beds	2500
Laramie	Willow creek	450
	St. Mary river	2800
	Foxhill sandstones	80
Cretaceous	Pierre shales	750
	Belly River series	910
	Lower dark shales	800

CENTRAL ALBERTA (TYRRELL).

System.	*Formation.*	*Approximate thickness in feet.*
Oligocene		270
Laramie	Paskapoo	5700
	Edmonton	
Montana	Foxhill and Pierre	600
	Belly River	600+

ATHABASKA RIVER (MCCONNELL).

System.	*Formation.*	*Approximate thickness in feet.*
Laramie		
Montana	Foxhill sandstone	
	LaBiche shales[2] (upper part)	700
Colorado	LaBiche shales (lower part)	225
	Pelican sandstone	40
	Pelican shales	90
	Grand Rapids sandstone	300
	Clearwater shales	275
Dakota	Tar sands	140–220
Devonian		

[1]Dowling, Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, p. 20. See also Geological Notes to Accompany Map of Sheep River Gas and Oil Fields, Alberta.

[2]See Log No. 1.

PEACE RIVER (MCCONNELL).

System.	*Formation.*	*Approximate thickness in feet.*
Laramie	Wapiti River sandstone	
Montana	Foxhill sandstone	
	Smoky River shales	
	Dunvegan sandstone	600+
	Fort St. John shales	700
Colorado	Peace River sandstones	400
	Loon River shales	400
Devonian		

YELLOWHEAD PASS (MCEVOY).

System.	*Formation.*
Laramie	Paskapoo (49)
	Edmonton (49)
Cretaceous	Pierre and Foxhill (42)
Devono-Carboniferous	
Cambrian	Castle Mountain group (14)
	Bow River series (13)
Pre-Cambrian	Shuswap

CASCADE COAL BASIN (DOWLING).

System.	*Formation.*	*Approximate thickness in feet.*
Cretaceous		
Jurassic	Fernie shales (28)	1600
Permo-Triassic	Upper Banff shale (25)	1200–1300
	Rocky Mountain quartzite (25)	1600
Carboniferous	Upper Banff limestone (25)	2500–3000
	Lower Banff shale (25)	1000–1500
	Lower Banff limestone (25)	2000
Devonian	Intermediate series (21)	

ROCKY MOUNTAINS ALONG MAIN LINE OF CANADIAN PACIFIC RAILWAY. (MCCONNELL).

System.	*Formation.*	*Approximate thickness in feet.*
Cretaceous	Kootanie to Benton	
Carboniferous passing into Devonian	Upper Banff shale (25)	
	Upper Banff limestone (25)	
	Lower Banff shale (25)	
	Lower Banff limestone (25)	
Devonian	Intermediate series (21)	1500
Silurian	Halysites beds (20)	1300
Ordovician	Graptolitic shales (16)	1500
	Castle Mountain group (upper part) (14).	
		7700+
Cambrian	Castle Mountain group (lower part) (14)	
	Bow River group (13)	10,000

ALBERTA PORTION OF CORDILLERAN SECTION (C.P.R. MAIN LINE. DALY).

System.	*Formation.*	*Approximate thickness in feet.*	*Materials.*
Recent and Pleistocene	Fluviatile		Gravel, sand.
	Lacustrine		Gravel, sand, clay, silt and conglomerate.
	Glacial		Till.
	Erosion surface.		
Post-Cretaceous?	Igneous rock		Nephelite syenite, ijolite, urite, jacupirangite, etc., with dikes.
Cretaceous	Upper Ribboned sandstone	550+	Thin-bedded sandstone and shale with hard bands of sandstone.
	Kootenay Coal measures	2800+	Sandstone and shale with coal seams.
	Lower Ribboned sandstone	1000+	Thin-bedded brown sandstone and shale.

System.	*Formation.*	*Approximate thickness in feet.*	*Materials.*
Jurassic	Fernie shale	1500+	Dark brown to black arenaceous shale; weathers into lens-like fragments.
Permian	Upper Banff shale	1400+	Dark brown arenaceous shale; weathering reddish and yellowish.
	Rocky Mountain quartzite	800	White to grey quartzite and arenaceous siliceous limestone.
Mississippian	Upper Banff limestone	2300+	Thick-bedded dark grey limestones with numerous thin cherty layers underlain by thin-bedded limestone and shale; weathering grey.
Pennsylvanian	Lower Banff shale	1200	Black to dark grey shale, argillaceous and calcareous; weathering light brown.
	Lower Banff limestone	1500+	Thick-bedded grey limestones with numerous dolomitic segrations.
Devonian	Intermediate limestone	1,800+	Thin-bedded limestones, with alternating more massive layers of grey dolomitic and siliceous limestone.
	Sawback limestone (age ?)	3,700+	Thin-bedded limestone interbedded with less resistant layers and brownish and yellowish shale.
	Contact relations not known.		
Silurian	Halysites beds	1,850+	Dolomites and quartzites weathering light grey to white, with shale interbedded.

MOOSE MOUNTAIN DISTRICT (CAIRNES).

System.		*Formation.*	*Approximate thickness in feet.*
Cretaceous	Montana	Edmonton (49)	
		Bearpaw (42)	650
		Belly River (40)	850
		Claggett (39)	250
	Colorado	Cardium sandstone (38)	50
		Benton (37)	725
	Dakota	(33)	950
	Kootanie (33)		375
Jurassic	Fernie shales (28)		225
Carboniferous and Devonian.			

ALBERTA AREAS (CROW'S NEST SECTION BY LEACH).

System.	*Formation.*	*Approximate thickness in feet.*	*Materials.*
Cretaceous	Allison Creek (Belly River ?)	1,900	Soft, light-coloured sandstones, with small coal seams near top.
	Benton	2,750	Chiefly dark shales with a few hard, siliceous sandstone beds.
	Crowsnest Volcanics	1,150	Trachytic tuffs and breccias.
	Dakota	2,750	Chiefly shaly sandstone with plant impressions, usually green in colour.
	Kootenay	600	Sandstones, shales and coal seams.
Jurassic	Fernie	750	Dark shales with a few thin sandstone beds.
Devono-Carboniferous	Limestone Series	4,000	Massive light-grey limestone.

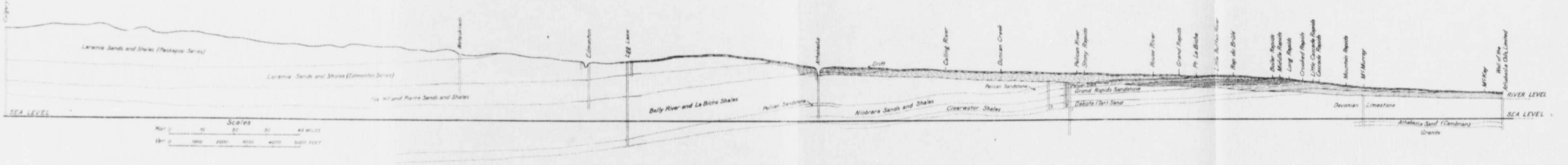

Fig. 25. Generalized geological section from Grand Rapids to Calgary, showing the "lay" of the strata and also wells drilled at Pelican, Athabaska, Morinville, Edmonton, Wetaskiwin, and Calgary. (By F. G. Clapp and L. G. Huntley)

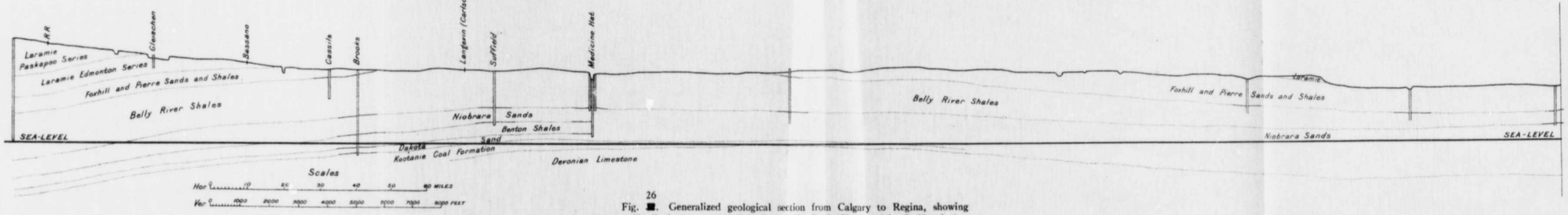

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Fig. [illegible]. Generalized geological section from Calgary to Regina, showing "lay" of strata and well borings. (By F. G. Clapp and L. G. Huntley)

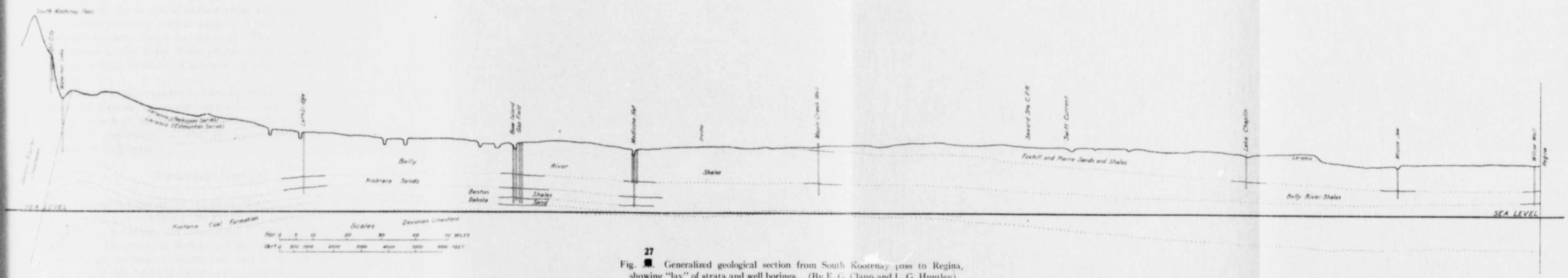

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Fig. Generalized geological section from South Kootenay pass to Regina, showing "lay" of strata and well borings. (By F. G. Clapp and L. G. Huntley)

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The great tar seepages of the Athabaska river in northern Alberta exude from the outcrop of the Dakota sandstone, from which sandstone the gas in the Bow island is also derived. However, gas has been found in the sands of the Niobrara formation underlying Medicine Hat, Dunmore Junction, Suffield, and Vegreville; and from the nature and persistence of the sands of this series, it is believed that they will prove of importance in the results of future drilling, as has the Dakota sand heretofore. No gas supply of importance has been developed in the strata lying above the Niobrara beds, although the overlying shales very generally contain pockets of gas, which soon exhaust themselves when struck by the drill. This is particularly true of the gas in the Belly River shales, in which gas is found in Medicine Hat, Suffield, Carlstadt, Topfield, Bruce and elsewhere.

While a few oil seepages are known to exude from older rocks than the Cretaceous in the vicinity of South Kootenay pass, yet the sands of the Cretaceous formations are the only strata in which presumably oil and gas will be developed in large quantities in Alberta.

Structural Geology.

Throughout the entire extent of Alberta, with the exception of a narrow belt bordering the Rocky mountains in the western part of the province, the formations lie in a nearly horizontal attitude. However, as shown in Figs. 25, 26, and 27, a broad syncline or depression occurs just east of the disturbed belt. The axis of this basin is followed in a general way by the Macleod and Edmonton branches of the Canadian Pacific railway. East of this great basin there is evidence of three widely diffused anticlines. The first of these crosses the International Boundary in the vicinity of the Sweet Grass hills in Montana, extending in a northwesterly direction, but probably dying out after reaching the Bow river (Fig. 27). The axis of this anticline will probably be found west of the Bow Island gas field.

The second of these wide arches enters Alberta from Saskatchewan in the vicinity of the fifty-second parallel, and extends in a northwesterly direction almost to Vegreville (Fig. 26). The gas possibilities of this anticline have never been tested by drilling.

The third of these structural arches has been found to cross the Athabaska river in the vicinity of Crooked rapid (Fig. 26). However, owing to the impossibility of obtaining geological data on this northern region, it has not been possible to trace this anticline definitely for a great distance, it being known merely to extend in a northwesterly by southeasterly direction, more or less parallel with the two similar arches to the south.

Of the three structural arches mentioned above, only that of the Bow river and that of the Athabaska river have been tested as to their natural gas possibilities. A large supply of gas has been developed at Bow island in southern Alberta, near the crest of the first mentioned anticline. A smaller supply has been encountered in the vicinity of the Pelican rapids, some miles south of the axis of the Athabaska River anticline. (See Fig. 28.) A well drilled at Vegreville at the extreme limit of the Battle River anticline in central Alberta has given evidence of being located upon the edge of good gas territory.

Owing to the great depth at which the principal oil and gas bearing sands lie in western Alberta, the oil possibilities of this great structural depression have not been tested at all thoroughly, all wells having as yet failed to reach the principal oil and gas bearing horizons; viz., the Niobrara and Dakota sands.

Wells have been drilled in the disturbed belt lying within the foothills of the Rockies at several places, notably at Waterton lake and at the MacDougal ranch west of Okotoks. However, owing to the greatly disturbed and faulted nature of the formations at these points, it is not presumed that the relatively small showings of both oil and gas which were encountered in these wells offer sufficient indication for the development of a larger supply.

PLATE XIII.

Foreground—blocks of red burnt shale from outcrop of La Biche shale at Red Mud, Athabaska river, Alberta.

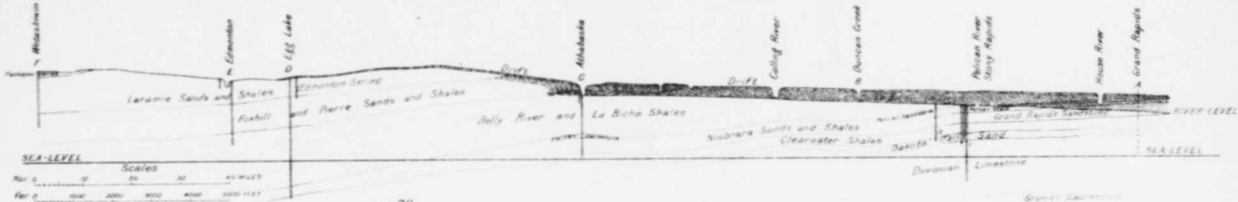

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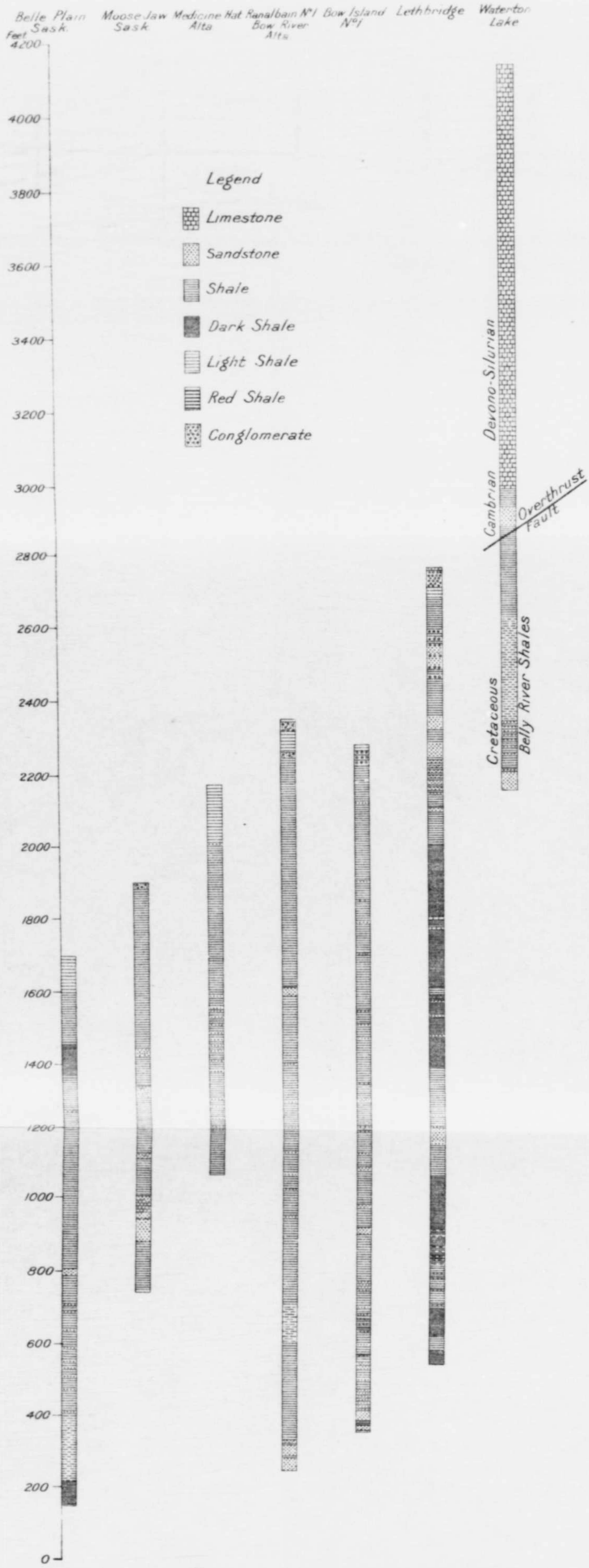
Fig. [redacted]. Generalized geological section, from Grand Rapids to Wetaskiwin, showing the "lay" of the strata, and also wells drilled at Pelican, Athabaska, Morinville, Edmonton and Wetaskiwin.



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Fig[redacted]. Sections across Southern Alberta.
(By F. G. Clapp and L. G. Huntley)

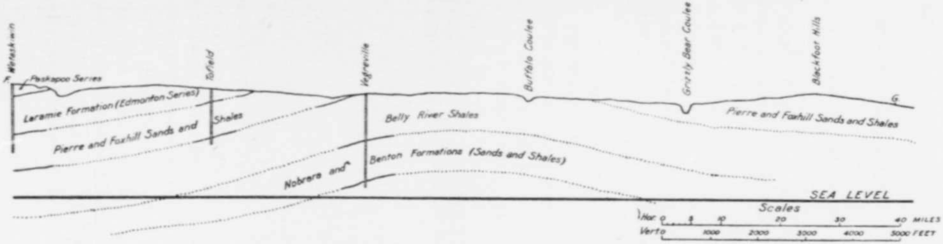
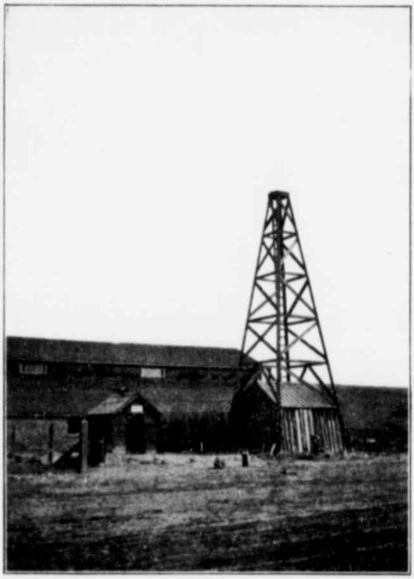


Fig. 29. Geological section showing the lay of the strata across the Battle River anticline from Wetaskiwin to Lloydminster, Alberta, also showing wells drilled at Wetaskiwin, Tofield, and Vegreville (by F. G. Clapp and L. G. Huntley.)

History of Drilling Operations.

MEDICINE HAT FIELD.

Natural gas in the vicinity of the Medicine Hat field was encountered in a well drilled for water at Carlstadt by the Canadian Pacific railway in 1885. In 1890 a well drilled at Medicine Hat in search of coal encountered a considerable supply of natural gas, the flow being so strong as to lead the town officials to take the matter up with the Canadian Pacific railway, with the view to drilling a deeper well for gas. Sir Willian Van Horne offered to lend the town a drilling machine, the town to stand the expense of the drilling. A considerable flow of gas was encountered at about 650 feet in depth, with a closed pressure of 250 pounds, but was accompanied by a large amount of moisture. In the hope of obtaining a larger supply free from moisture, deeper wells were drilled and the present gas pay was developed in a well drilled by the city in 1905 at a depth of 1,010 feet showing a closed pressure of 550 pounds. The flow was quite dry, being probably near the top of the Niobrara formation. The 600 foot vein is the principal gas horizon before reaching the 1,000 foot horizon, the other being only pockets, according to Mr. Winter. In the summer of 1912 the Medicine Hat field had been extended, and the wells had a capacity of approximately 25,000,000 cubic feet per day. In 1913 the city contracted with Messrs. Martin and Fish to drill nine new wells for gas, two of which had been completed in August of that year. The best well at Medicine Hat is the Tuno well, the production of which is reported to be 6,000,000 cubic feet per day. It is situated two miles west of the city hall and is a ten-inch hole. The completion of the wells recently contracted for will make a total of twenty wells in the field, tapping the Medicine Hat sand, one of which was continued to the Dakota. In addition about thirteen shallow wells have been drilled. At the end of 1912 the gas department of the municipality was drawing from six wells owned by the city, and supplied



One of the earliest Alberta wells, Medicine Hat, Alberta.

PLATE XV.

The Toronto street well, Medicine Hat, Alberta.

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1,900 domestic consumers and sixteen factories with natural gas, valued at $70,000 per year. The department operates 56½ miles of pipe line. A number of shallow wells were shut in and not used.

During the latter part of 1913, in order to show exactly what has been done in Medicine Hat in the way of drilling gas wells, the city engineer's office furnished a statement of the number of wells operated or in construction in Medicine Hat, with the depth, name, open flow in cubic feet per 24 hours, one year drilled. The information is the first of the kind issued and was prepared at the request of the Board of Trade, the data being as follows:—

Name.	Depth.	Open flow cu. ft. 24 hours.	Year drilled.
Main street	1,000	2,225,000	1904
Park	1,000	3,000,000	1906
Altawana	1,000	2,500,000	1909
Maple street	1,000	2,500,000	1911
Electric	1,200	4,000,000	1911
Rosery	1,000	2,500,000	1911
Balmoral street	1,200	2,500,000	1911
Central Park	1,300	3,000,000	1913
Stella	1,002	2,200,000	1913
Big Chief	1,100	2,800,000	1909
Rolling Mills	1,050	2,900,000	1910
W. Industrial site	1,202	2,300,000	1913
S. Industrial site	1,202	2,100,000	1913
Craft	1,075	3,300,000	1913
Cousins and Sissons	1,075	2,900,000	1913
Ogilvie	1,033	2,500,000	1912

In addition drilling has been started on Well No. 17, near the Maple Leaf mills site, and the Medicine Hat Brick Company has a well 1,050 feet deep. For some years the Canadian Pacific railway has had a gas well on its right of way near the station, and work has been completed on a second well for the Canadian Pacific railway, the depth, open flow and rock pressure averaging with the other natural gas wells in this city.

The above wells are all within the city limits, and it is notable that there has been no appreciable diminution in the pressure or flow from the same notwithstanding the increased consumption due to the rapid industrial expansion of Medicine Hat.

This list does not take into account the string of wells being drilled by the Hunt Engineering Company for the $2,500,000 plant of the Canada Cement Company.

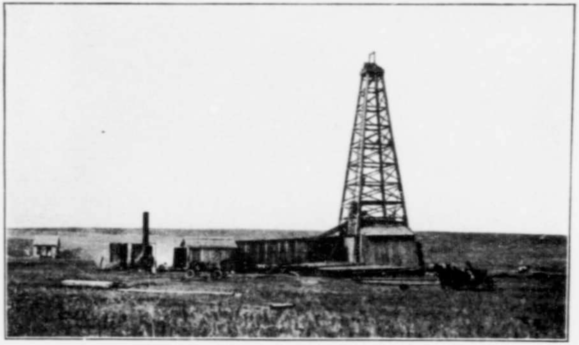
The officials of the city of Medicine Hat defend their action in giving away gas and selling it at such a low rate upon the basis that if this were not done, the gas companies would drain the underground supply for piping to other districts, and as a matter of self defense they must make use of it for home developments while they may; in the earlier history of this development, large flambeaux were burnt, and even more recently one or two wells were allowed to blow wide open. At present these are all closed in and the gas is being used to advantage by the city of Medicine Hat which controls the gas rights in two townships.

BOW ISLAND FIELD.

The discovery of gas in the Bow Island field was brought about in 1908 by the drilling of a well about 1900 feet deep by the Canadian Pacific railway at their pumping station ten miles south of Suffield, and twelve miles east of the present centre of production. It had a reported volume of 8,000,000 cubic feet of gas per day and 800 pounds per square inch rock pressure. Up to the summer of 1913 sixteen wells had been drilled, producing about 75,000,000 cubic feet per day. The field has been developed by the Canadian Western Natural Gas, Light, Heat and Power Company, Limited, for the purpose of supplying the city of Calgary and fourteen other towns en route, including Lethbridge, Grannum, Okotoks, Claresholm, Nanton, MacLeod, Sandstone and Tregillus, and for which purpose a 16-inch pipe line 160 miles in length has been laid. The first well was drilled in the main field in 1909, the famous "Old Glory Well." Its pressure was 810 pounds and the flow 7,000,000 cubic feet per day. It caught fire and burned for fifteen days before it was finally put out by two boilers of steam. The above company is reported to be backed by stockholders of the Canadian Pacific railway and has taken over all the drilling business of the latter company, including several small gas wells at Carlstadt, Brooks, Cassils, Dunmore, etc.

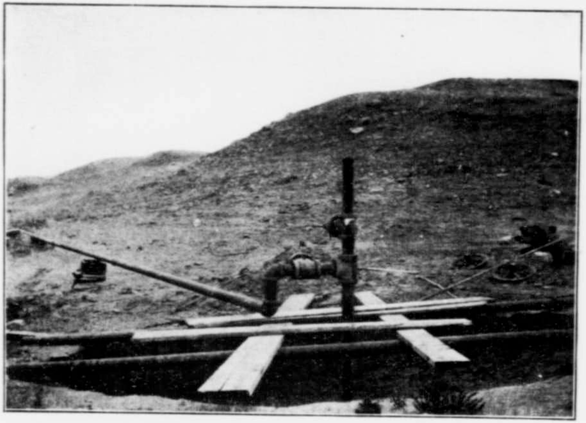
Shallow gas in Bow Island wells, Numbers 1, 2, and 3, is found at from 800 to 1000, which is cased off and escapes around the casing. Considerable water escapes around the casing of all these wells, but it is artesian water, good for drinking but hard on boilers.

PLATE XVI.



Well No. 12, Bow Island field, Alberta

PLATE XVII.



Well No. 3, Bow Island field, Alberta.

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The following yields of gas have been authenticated by Eugene Coste, President of the Canadian Western Natural Gas, Light, Heat and Power Co., for the first eight wells in this field:—

No. 1	—10,000,000	cubic feet
2	7,000,000	" "
3	15,000,000	" "
4	29,000,000	" "
5	1,250,000	" "
6	4,200,000	" "
7	7,000,000	" "
8	12,500,000	" "

REDCLIFFE.

Four wells have been drilled at Redcliffe for supplying that town with natural gas. Gas was encountered at a depth of approximately 1200 feet in the same producing stratum as at Medicine Hat. The capacities and pressures of these wells are very similar to those in the latter field.

At Redcliffe, at the end of 1912, there were three wells being drawn upon to supply the town, furnishing gas valued at $7000 per year. Gas is sold to 150 domestic consumers and eight factories of various sorts. The price for domestic consumption varies from $2 to $3.50 per month, although the Redcliffe Realty Company was preparing to put in the meter system, to be started in the summer of 1913. The price to industrial plants varied from $10 to $100 per month.

PINCHER CREEK AND SOUTH KOOTENAY PASS DISTRICTS.

Oil seepages have been known for years in the Cretaceous rocks on the Alberta side of South Kootenay pass; and from the Cambrian or Pre-Cambrian formations on Kishinena creek small seepages of light oil have been utilized in the past as a source of cattle remedies and for lighting purposes. The oil in this district was first used by a farmer named Aldrich, who obtained it by means of a blanket from the top of a spring of cold water in the valley of Akamina creek.

History of Developments.—The drilling in the Pincher Creek district appears to have been caused by a report of the Geological Survey for 1898, in which Dr. G. M. Dawson described the various seepages on both sides of the divide and expressed an opinion that boring operations were warranted to prospect for oil.

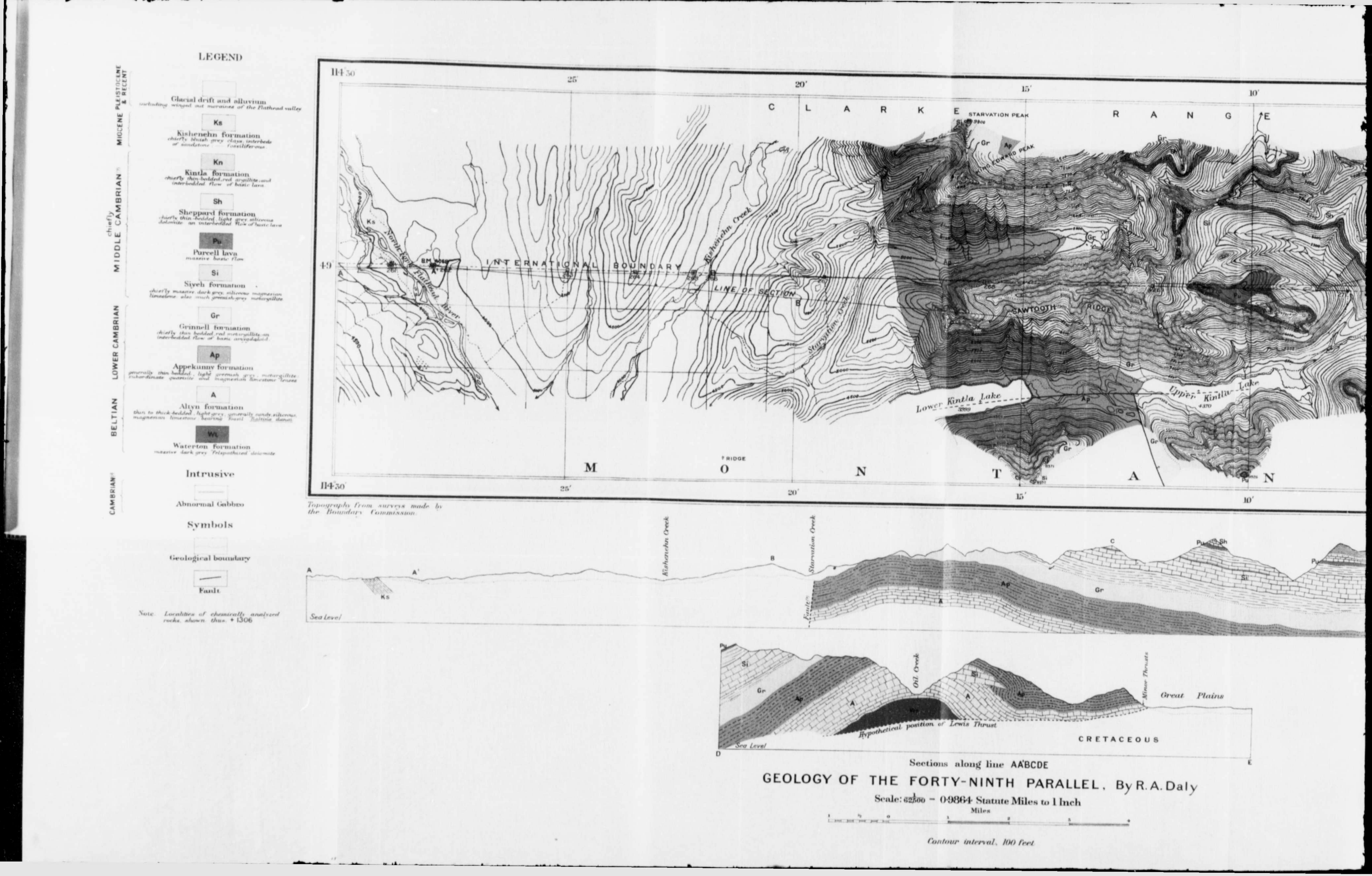
As stated by Dr. Selwyn[1]:—

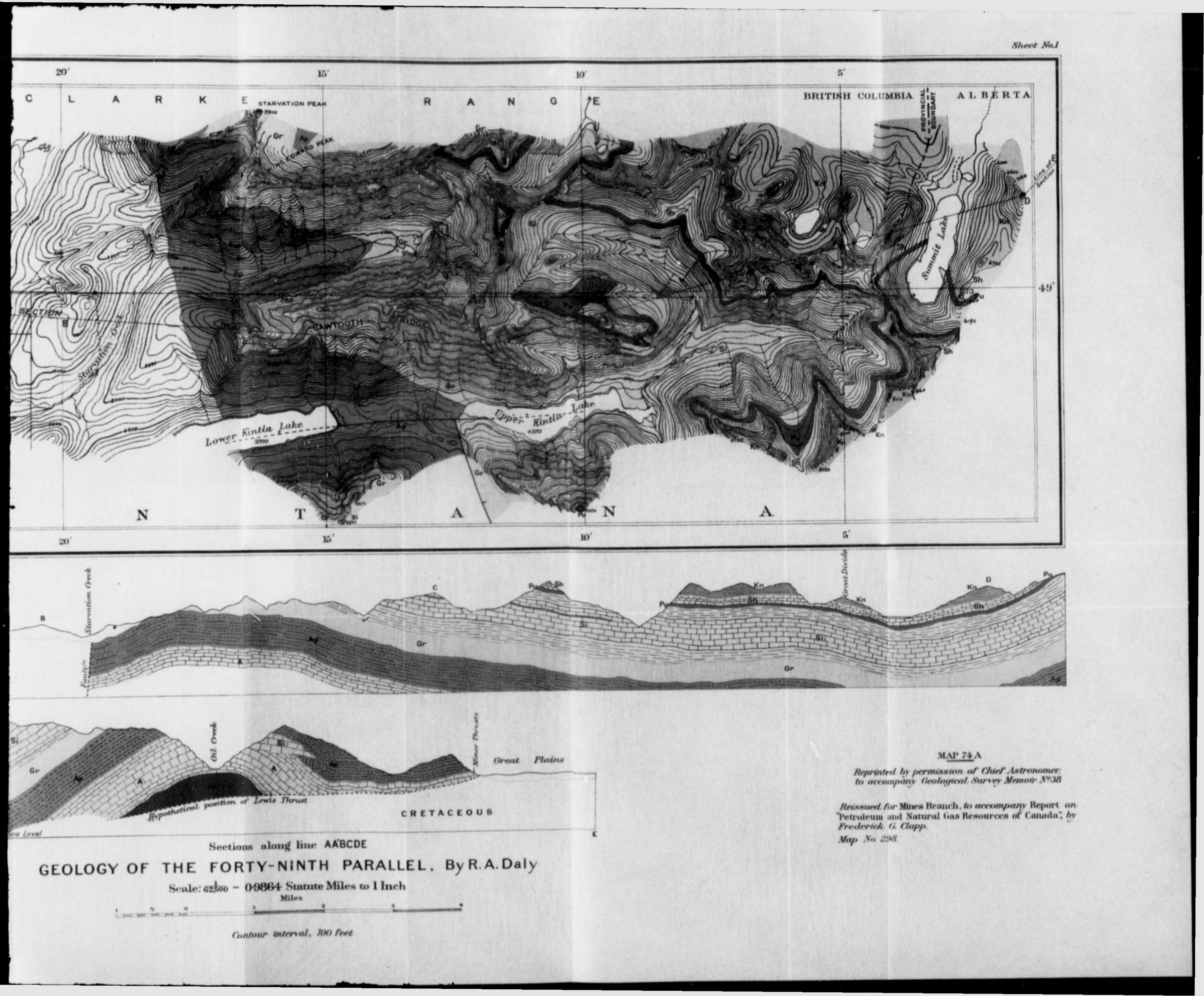
Oil has never been produced in a formation as old as the Cambrian, nor do the rocks here exposed admit of the probability of their being the source of the oil under anything but very extraordinary conditions. These surface geological conditions would seem to render it impossible for oil to occur in this section; but the fact remains that it is found there. It is, as Dr. Dawson very appropriately calls it, 'a somewhat anomalous occurrence of petroleum.' In accounting for the fact, Dr. Dawson says 'the overthrust fault must have been great, as Cambrian rocks extend eastward for over 12 or 15 miles over the summit into Alberta. The oil may have travelled westward underground, but the existence of pronounced faults intervening make this improbable.'

This fact did not deter the wild-catter, and in 1900 and 1901 oil claims were staked and recorded on both sides of the boundary by both American and Canadian companies. The first drilling commenced in 1903, and by 1912 there were twelve wells drilled in the district, varying in depth from 200 to 1900 feet. The principal drilling was done at Waterton lake and at Oil City, the latter located about five miles up Oil creek, a tributary of this lake. Of three oil holes put down at Waterton lake, one was drilled to a depth of 1900 feet, encountering oil in a soft caving formation at that depth. Accounts varied as to the amount of this oil, which was never produced commercially. From the amount bailed out of the well, Mr. Stafford, a driller residing at Pincher, states that the well would have produced 18 to 20 barrels per day. However, the tools were lost, and after a dilatory attempt at fishing lasting for almost six months, the well was plugged and abandoned; and the Western Oil Company, after having spent some $200,000 in this district, quit the oil business and started to invest in coal lands.

The other two wells at Waterton lake produced nothing. At Oil City about ten wells were drilled. One of the first of these, drilled by the late Mr. Lineham to a depth of about 1400 feet, struck a quantity of high gravity oil at 1080 feet. The well flowed naturally for a short time, and probably produced

[1]Summary Rept. Geol. Survey Can., 1891, pp. 9-10, and Rept. of Minister of Mines of British Columbia 1896, p. 529.


LEGEND
PLEISTOCENE & RECENT
Glacial drift and alluvium
including winged out moraines of the Flathead valley
MIOCENE
Ks
Kishenehn formation
chiefly bluish grey clays, interbeds of sandstone — fossiliferous
chiefly MIDDLE CAMBRIAN
Kn
Kintla formation
chiefly thin-bedded red argillite and interbedded flow of basic lava
Sh
Sheppard formation
chiefly thin-bedded, light grey siliceous dolomite an interbedded flow of basic lava
Pu
Purcell lava
massive basic flow
Si
Siyeh formation
chiefly massive dark grey, siliceous magnesian limestone also much greenish-grey metargillite
LOWER CAMBRIAN
Gr
Grinnell formation
chiefly thin bedded red metargillite an interbedded flow of basic amygdaloid
Ap
Appekunny formation
generally thin bedded, light greenish grey, metargillite subordinate quartzite and magnesian limestone lenses
BELTIAN
A
Altyn formation
thin to thick-bedded, light grey, generally sandy siliceous magnesian limestone bearing fossil Beltina danai
Wt
Waterton formation
massive dark grey 'Felspathized' dolomite
CAMBRIAN
Intrusive
Abnormal Gabbro
Symbols
Geological boundary
Fault
Note. Localities of chemically analyzed rocks, shown thus + 1306
C L A R K E R A N G E
STARVATION PEAK
LONG KNIFE PEAK
INTERNATIONAL BOUNDARY
LINE OF SECTION
SAWTOOTH RIDGE
Lower Kintla Lake
Upper Kintla Lake
Kishenehn Creek
Starvation Creek
North Fork of Flathead River
M O N T A N
49°
114°30'
25'
20'
15'
10'
Topography from surveys made by the Boundary Commission
Sea Level
Kishenehn Creek
Starvation Creek
Fault
Oil Creek
Minor Thrust
Great Plains
Hypothetical position of Lewis Thrust
CRETACEOUS
Sections along line AA'BCDE
GEOLOGY OF THE FORTY-NINTH PARALLEL, By R.A. Daly
Scale: 1/62500 — 0·9864 Statute Miles to 1 Inch
Miles
Contour interval, 100 feet


Sheet No.1
C L A R K E R A N G E
BRITISH COLUMBIA
ALBERTA
STARVATION PEAK
SAWTOOTH RIDGE
Lower Kintla Lake
Upper Kintla Lake
Summit Lake
N T A N A
49°
20'
15'
10'
5'
Starvation Creek
Great Divide
Fault
Oil Creek
Minor Thrust
Great Plains
Hypothetical position of Lewis Thrust
CRETACEOUS
Sea Level
Sections along line AA'BCDE
GEOLOGY OF THE FORTY-NINTH PARALLEL, By R.A. Daly
Scale: 1/62500 — 0·9864 Statute Miles to 1 Inch
Miles
Contour interval, 100 feet
MAP 74 A
Reprinted by permission of Chief Astronomer; to accompany Geological Survey Memoir No. 38
Reissued for Mines Branch, to accompany Report on "Petroleum and Natural Gas Resources of Canada", by Frederick G. Clapp.
Map No. 298.

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about twenty barrels per day. A small refinery was erected on the ground and the oil refined there. However, the well was poorly packed and was flooded. Nothing was being done on the property in the summer of 1912 due to litigation. Of all the other wells in the vicinity of Oil City, none produced more than two barrels of oil per day, and may be rated as failures. The Pincher Creek Oil Company has drilled several wells. The most recent one, in Pincher Creek, had been drilled to a depth of 700 feet, which they expected to deepen to 1200 feet during next summer. Several small shows of oil were encountered at from 230 to 350 feet.

The Western Oil Company drilled an 1,800 ft. hole between the town of Pincher and the Canadian Pacific railway, the entire distance being in the Cretaceous formations. A small show of gas was encountered at 700 feet in a fine grained sand, and a small show of oil is claimed to have been encountered at a depth of 1,600 feet. This well was drilled on the Mortimer farm. Owing to differences arising between the company and the contractors, the work had stopped, and nothing was being done with the hole in the early part of the summer of 1912. At a depth of 1,500 (?) feet Dowling reports this well to have been in reddish Laramie shale.

On the western side of South Kootenay pass, in British Columbia, two wells have been drilled by the Gloin Oil Company, which recently sold its property to the Royal Canadian Northwest Oil Company. In one of these Mr. Gloin made affidavit that oil to the extent of approximately twenty barrels per day was struck and cased off at a depth of approximately 1,200 feet, the hole being 1,600 feet deep. In May, 1912, the present owners were preparing to pull the casing, to ascertain the exact quantity of oil which existed at this depth. There were no shows of oil around the derrick at this time, although there was a pronounced odour of petroleum from the hole. The oil is said to have been encountered in a coarse red sandstone.

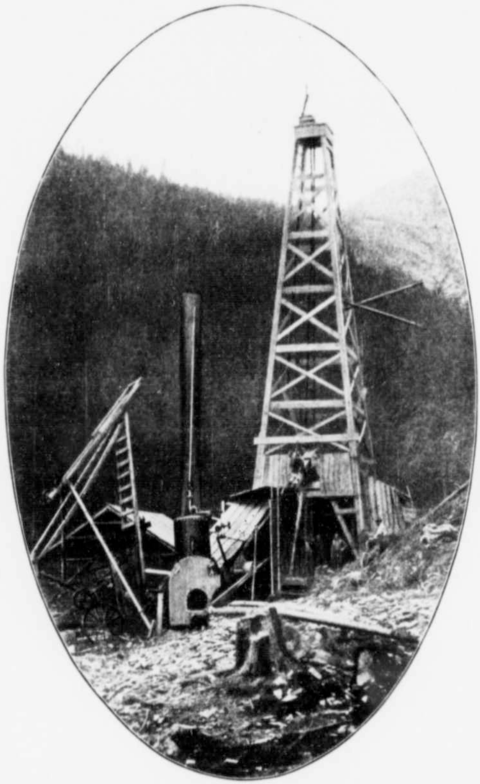
In this entire district, lying inside the first range of foothills, and extending over the first range of the Rockies, the formations are very much tilted and broken, with little opportunity for the existence of a reservoir of oil of any extent. This, combined with the fact that oil has never been found to exist in any quantity in rocks of the Cambrian age, makes the prospects of development of an oil field here seem very slight. Extensive stock selling and booming of the meagre shows already obtained has caused much money to be wasted, with not even a good gambling chance of success. The oil springs and seepages remain of scientific interest only, occurring as they do among formations of such great geologic age; and the two or three wells which alone among the nineteen or twenty drilled might have produced oil in commercial quantities have never been utilized.

The following is a record of wells drilled in the South Kootenay Pass district up to May, 1912.

Record of well-drilling in South Kootenay Pass District.

	Wells	*Section*	*Township*	*Range*	*Drilled by*
Waterton Lake	2	23	1	30	Western Coal and Coke Company.
	1	26	1	30	Western Coal and Coke Company.
	1	4	2	30	
	1	29	1	30	Pincher Creek Oil and Refining Company.
	2	30	1	30	Lineham Oil Company.
	1	28 (or 33)	1	30	" " "
	1	24	1	1 w. of 5th.	Pincher Creek Oil and Refining Company.
	1	25	1	1 w. of 5th.	Pincher Creek Oil and Refining Company.
	1				(Jack Drader, driller. Do not know company).
	1	32	1	30 w. of 4th.	Western Coal and Coke Company.
	2	Flathead Valley	B.C. side		
	3	Montana and Kintla lake, by Butte Company.			
	3	" or Flathead river, 2½ miles southwest of Kintla lake.			

PLATE XVIII.



Pincher Creek Oil and Refining Co's well, Oil City district, South Kootenay Pass, Alberta.

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BOW RIVER.

Five dry holes were drilled to the Dakota sandstone along the Bow river, from fifteen to twenty-five miles northeast of the Bow Island field. This drilling was undertaken by the Southern Alberta Land Company near where their irrigation ditch crosses the Bow river. Later this company drilled a producing well in the Bow Island field.

SUFFIELD.

In 1911 a well was drilled by the Southern Alberta Land Company to supply gas for their townsite at Suffield. This well encountered more or less gas in the Niobrara sands and shales, but owing to a crooked hole and to an accident to the casing, the well was almost entirely ruined. However, a considerable flow came up through 1,200 feet of water which stood in the casing, and was used by the town. A second well is reported to have been drilled in the early part of 1913, and to be a fair gas well. Another well was also drilled ten miles south of Suffield, near the pumping station for field purposes. This was drilled close to the former well put down in 1907–8.

BROOKS.

The Canadian Pacific railway drilled a well at Brooks station to a depth of 2,795 feet, passing entirely through the Dakota sand without encountering either oil or gas in paying quantities. A small show of gas was encountered in the Dakota sand, amounting to approximately 300,000 cubic feet per day, and a flow of salt water in the salt sand. This was plugged off, and the gas used by the town.

CARLSTADT AND CASSILLS.

Small flows of gas have been encountered in four wells drilled by the Canadian Pacific railway at Carlstadt (Langevin) and Cassills[1], the gas originating in pockets in the Belly

[1]Dawson, Geol. Survey Canada, Vol. IV, p. 745. Roy. Soc. Can. Vol. IV, Sec. 4, p. 96.

River shales. The gas was used by the railway for steam, and for lighting and heating the station houses.

The well reported by Dawson to have been drilled at Cassills, 38 miles west of Carlstadt, reached a depth of 997 feet, passed the bottom of the Pierre shales at a depth of 294 feet, at which horizon the Lethbridge coal seam has a thickness of 6 feet.

GLEICHEN.

Dawson also reports a well[1] which was drilled at Gleichen station, 55 miles east of Calgary, in 1885 or thereabouts, which reached a depth of 502 feet.

BASSANO.

Two wells were also drilled at Bassano by the Canadian Pacific railway, but did not tap either the Niobrara or the Dakota sands. The casing was pulled and the wells abandoned, although one is reported to have had an initial capacity of 200,000, and the other 700,000 cubic feet per day.

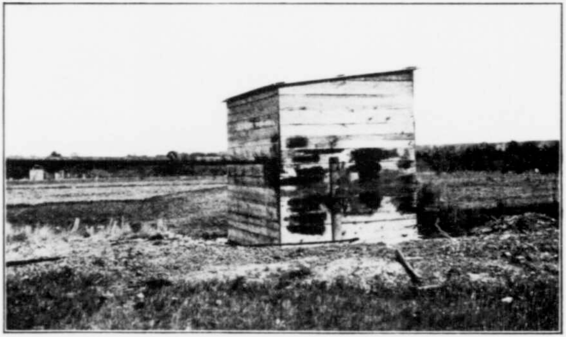
CALGARY.

Two wells have been drilled within the city limits of Calgary, one of which was discontinued at a depth of 3414 feet. A small show of gas was encountered at a depth of 2772 feet, ut it proved of no importance. Otherwise, the well was a failure. This well was drilled in East Calgary near the place where the Canadian Pacific railway crosses the Bow river in section 12 of Southeastern Calgary, township 24, range 1. It was drilled in 1909, and in 1912 produced 80,000 (?) cubic feet of gas per day, with a closed pressure of 285 pounds, according to Mr. Eugene Coste. The other well was drilled within the city limits about twenty years ago, and only reached a depth of 1426 feet. The deep well mentioned ended near the bottom of the Belly River shales.

The other well drilled in the Sarcee Indian Reserve, twelve

[1]Roy. Soc. Can., IV, 1886, p. 99.

PLATE XIX.



Small gas well, Calgary, Alberta.

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miles southwest of Calgary, reached a depth of 3,365 feet. Neither of these wells reached either the Niobrara or the Dakota sands, and hence cannot be considered fair tests of the oil or gas possibilities of this locality. The driller of this well had much trouble owing to inclined, greatly folded and crushed rock.

OKOTOKS.

During the summer of 1913 a well was being drilled on the MacDougal ranch west of Okotoks, section 6, township 20, range 2 west of the fifth meridian. Messrs. Dingman, Segur, MacDougal and others are operating in this district in which the formations are greatly disturbed and faulted. A flow of gas was encountered amounting to 2,000,000 cubic feet per day, which soon decreased to less than a million, and was apparently declining rapidly. This gas is reported to contain about 1 gallon of gasoline per 1,000 cubic feet.

About June, 1913, oil was discovered 16 miles west of Okotoks, in the Black Diamond district, Alberta, at a depth of 1,560 feet. It was what is technically known as white oil, being transparent and of an amber colour and having a specific gravity of about 62° Baumé, and consisting largely of gasoline. As a matter of fact, it was used with satisfactory results in the tank of an automobile. The light oil appears to be the result of filtration through clay of the lighter portions of ordinary petroleum, and then too at a higher horizon in this well a flow of gas of 2,000,000 cubic feet a day was struck. Whether it is present in commercial quantities or not, the strike is of importance, as white oils are sometimes found in the vicinity of larger bodies of ordinary petroleums.

By December, a number of companies and individuals had filed on oil lands in this vicinity and announced their intention of sinking wells. If all their plans are carried out, a fair test of the field will be the result because their operations will cover a large area. The company[1] at about this time issued a statement that oil of a very high specific gravity had been encountered in a stratified limestone, through which the oil percolated—about

[1]Calgary Petroleum Products Co.

10 to 15 barrels a day. A test of the oil indicates a light, high grade oil of paraffin base. Gasoline to the extent of 90 per cent was distilled from the oil at 50° to 150°, centigrade. Specific gravity of oil tested was 67·5° Baumé—early sample was 62·5° Baumé.

Dr. H. E. Elliott of California, among the number of those who have secured leases in the vicinity, is of the opinion—in view of developments in other parts of Alberta—that crude oil close to 37° Baumé and containing 30 per cent of gasoline of approximately 76 degrees Baumé, will be found.

There is oil of commercial quality, but how much or how little no one can yet say. The Great Northern railway announces an early extension of that system into and passing through the Black Diamond district.

The prairie provinces of western Canada, where farming is carried on on a large scale, and in the development of which tractive implements are used necessitating huge annual importations of liquid fuel, will offer a ready market for the oil should a field develop.

WETASKIWIN.

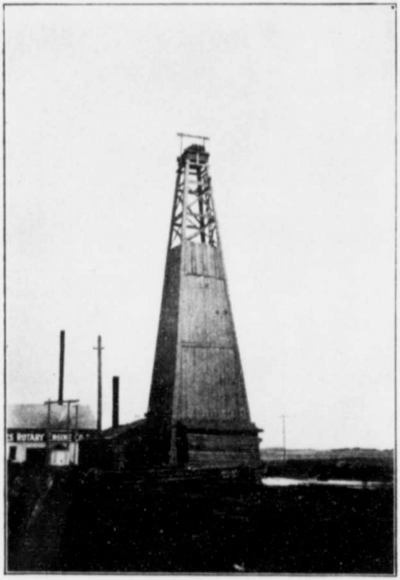
Two wells were started at Wetaskiwin previous to 1912, but owing to frequent caves and trouble with casing, they did not reach the supposed gas horizons, and Mr. Grant, the contractor, lost considerable money trying to complete the second well.

The drilling contracts for the second well at Wetaskiwin called for a 2,000 foot well at $7.50 per foot, unless gas should be struck at a less depth, the city to pay for fuel and for all casing which may be left in the hole. The hole reached a depth of 1,150 feet before it was found impossible to proceed on account of dropping a piece of casing into the hole, which could not be dislodged. However, until 1912 all attempts had been unsuccessful due to accidents and delays in drillings. In the early part of 1913 the drilling contract was taken up by the Northwest Drilling Company of Calgary, who, in June of that year, brought in a small gas well. Gas was encountered in the Pierre

PLATE XX.

Scene at Okotoks, Alberta, showing pipe for main line of Coronation Western Natural Gas, Light, Heat, and Power Co., Ltd.

PLATE XXI.



Original well at Wetaskiwin, Alberta, which has only a showing of gas.

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sands and shales at from 1,187 to 1,443. The principal pay was at the depth of 1,347. The hole reached a depth of 1,511 feet, ending near the top of the Belly River shales, which it did not penetrate. The initial flow of this well was estimated to have been 2,000,000 cubic feet per day, but it declined rapidly, and in August, 1913, showed an open flow of only 350,000 cubic feet per day. However, it is expected a still greater flow will be secured. The strike is valuable to the city of Wetaskiwin since it will eliminate the large coal account at the power plant as well as some hundreds of dollars in wages.

TOFIELD.

In June, 1912, the well being drilled by the town of Tofield struck a small flow of gas at a depth of 1,051 feet. The well was flooded by water from an overlying formation, due to an accident to the casing and was abandoned. Later in the year another well was drilled about one-half mile southeast of the first, but failed to develop a gas supply. In the summer of 1913, the third well was drilled close to the location of Well No. 1. The gas in the first well was encountered near the top of the Belly River shales.

VEGREVILLE.

The well drilled by the Northwest Drilling Company for the town of Vegreville in April, 1913, encountered a considerable flow of gas in a sand stratum of the Niobrara formation at a depth of 1,360 feet. The hole was continued to a depth of 2,000 feet, without developing any further gas in large quantities. The pressure and volume of this well showed a gradual increase during the spring and summer of 1913, and gave evidence of its being located upon the edge of good gas territory. In August, 1913, the well showed a closed pressure of 280 pounds, with an open flow of 220,000 cubic feet per day.

EDMONTON.

Two wells have been drilled within the city limits of Edmonton by the Northwest Gas and Oil Company. Well No. 1

was located at the south end of First street and reached a depth of 1,150 feet. Well No. 2 was located upon the north side of Jasper avenue and reached a depth of about 1,800 feet. Both were dry holes and were abandoned.

In a recent report on the strip of country including Edmonton, Dr. D. B. Dowling, of the Dominion Geological Survey, says, " I should hesitate to advise any deep boring and would suggest if any wells in the vicinity show small flows of gas to trust rather to a number of shallow ones than to an expensive deep well." A test well at Nakamun has been started.

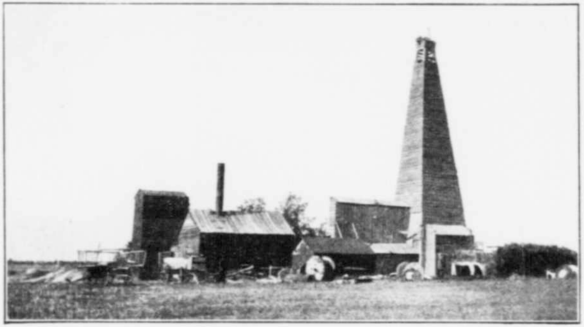
MORINVILLE.

Eighteen miles north of Edmonton near Egg lake, the California-Alberta Oil Company drilled a shallow well to a depth of 490 feet. Small flows of gas were discovered at various points but soon exhausted themselves, and the well was abandoned. Another well was drilled by Edmonton people, the company being managed by H. L. Williams of that city. Drilling was pursued intermittently for five years prior to 1913, and the well reached a total depth of 3,340 feet. More or less gas was encountered in the upper part of the hole, and from 3,040 feet to the bottom of the hole, Mr. Williams reports small oil shows. This well probably reached the top of the Devonian limestone, having passed through the Dakota formation which was very hard and shaly at this point, and contained considerable calcareous water.

VICTORIA.

A well was drilled in 1899 by the Canadian Geological Survey at Victoria on the North Saskatchewan river, about 40 miles northeast of Edmonton. Drilling ceased near the bottom of the Niobrara formation at a depth of 1,840 feet. Small flows of gas were encountered in the shales in the upper part of the hole, but as the well did not reach the Dakota sand, it cannot be considered a fair test of the district. It is believed that the Dakota (tar) sand would be encountered at about 2,100 feet below the river level in this vicinity.

PLATE XXII.



Dry hole at Morinville, Alberta.

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ATHABASKA.

In 1894 the Canadian Geological Survey drilled a well at this point to a depth of 1,771 feet, failing to reach the Dakota sand by probably less than 100 feet. Owing to the small diameter of the hole at this depth, it was found impossible to continue. Several pockets of gas were encountered near the top of the LaBiche shales, but they were not considered of importance. During the fall of 1912, several shallow wells from 250 to 400 feet in depth were drilled by local people of Athabaska. These encountered the same shale gas found in the government well, and, as was to be expected, they soon declined and proved of no importance.

PELICAN.

In the year 1897, the Canadian Geological Survey drilled a well on the banks of the Athabaska river two miles above the mouth of the Pelican river. This well encountered a large flow of gas in the Dakota sand at a depth of 800 feet. The flow was so strong as to prevent further drilling and to prevent capping the well, which was allowed to blow wide open for fifteen years. In 1911 the Calhoun Oil Company, of which Mr. H. L. Williams of Edmonton was the manager, obtained a lease of this well from the government and commenced drilling a second well a few hundred feet away. This second well encountered a considerable flow of gas at a depth of 625 feet, which was apparently coming from the Dakota sand and the old government well, being fed through this upper, 625-foot porous stratum. This condition is shown by Plate XXIII. In the summer of 1913 a third well was being drilled by the Pelican Oil and Gas Company, which company superseded the Calhoun Oil Company. These three wells are all located within a radius of less than 200 feet. Well No. 1, started by the Calhoun Oil Company, reached a depth of 2,069 feet, being still in the Devonian limestone.

In July, 1913, a fourth well was being drilled by the Pelican Oil and Gas Company at a point six miles south of the old government well, but had shown no result at that time. Boring operations have demonstrated beyond a doubt the existence of large reservoirs of natural gas, and it seems probable that further exploratory work throughout the wide area underlain by the Cretaceous rocks should lead to the discovery of other reservoirs.

FORT MCMURRAY.

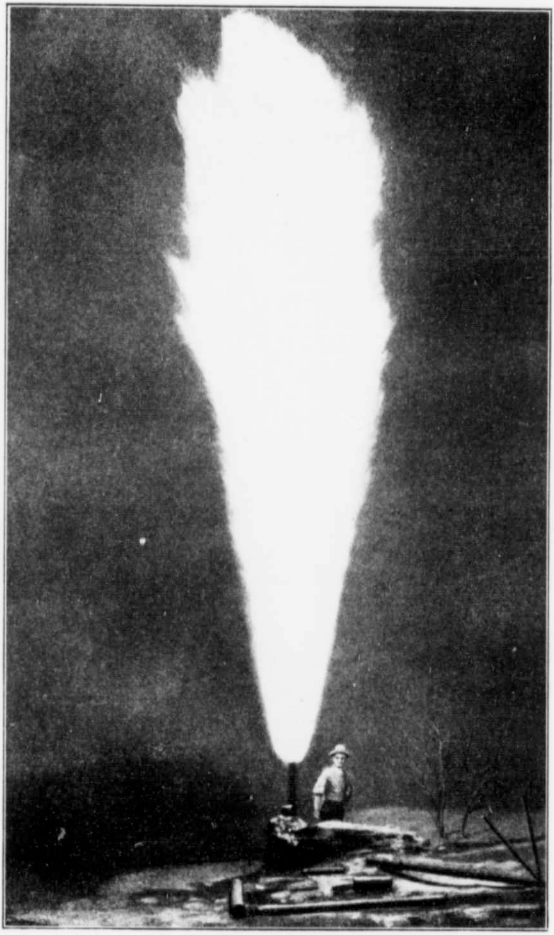
Two wells have been drilled on the banks of the Athabaska river at the mouth of Horse creek one-half mile south of Fort McMurray. The first well met with an accident; and the second, located about 100 feet east, reached a depth of 1,405 feet in August, 1912. This well was drilled 266 feet in granite. A show of black oil was encountered in the well but not in commercial quantity, and the well was abandoned.

FORT MCKAY.

Several shallow wells have been drilled by Alfred von Hamerstein and associates in the district between Fort McMurray and Lake Athabaska. One of these on Tar island is said to have encountered a considerable quantity of heavy oil, none of which has ever been taken out of the country, however.

The Fort McMurray Oil and Asphalt Company has also drilled three shallow wells along the river between Fort McMurray and Fort McKay, with no particular results.

The Athabaska Oils, Limited, a Vancouver syndicate, has drilled several shallow wells on the banks of the Athabaska river nine miles below Fort McKay. The deepest of these reached a depth between 1,100 and 1,200 feet, having penetrated the granite at that depth. Two oil impregnated sands were encountered near the top of the first well, corresponding to the Dakota sand, which outcrops along the banks of the river, and which probably has dipped below the surface in the bottom of a low syncline which crosses the river at this point.



Natural gas bursting from oil well drilled by the Dominion Government at Pelican portage, Athabaska river, Alberta. Burning since 1897.

Plate XXIV.

Derrick at No. 2 well in course of erection, Athabaska Oils, Ltd., 9 miles below Fort McKay, Alberta.

No. 1 rig, Athabaska Oils, Ltd., 9 miles north of Fort McKay, Alberta.

PLATE XXVI.

Well No. 2, Athabaska Oils, Ltd., 9 miles below Fort McKay, Athabaska river, Alberta.

Dry hole at Taber, Alberta, showing traction engine used in drilling.

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CASTOR.

During the summer of 1913 the Northwest Drilling Company of Calgary was engaged in drilling a well for gas at the town of Castor. On August 1, 1913, the well was at a depth of 1,350 feet, and had encountered a small flow of gas at that depth, according to Mr. Triplett of the above company.

CAMROSE.

In August, 1913, the town officials of Camrose contracted with Messrs. Martin and Fish of Medicine Hat to drill a well for gas near the power house. Gas was struck at a depth of 1,235 feet.

TABER.

A boring was made in 1902 at Taber to a depth of 1,200 feet, and while the well was dry, a showing of oil was encountered at 1,020 feet in the lower part of the Belly River series.

DRUMHELLER.

Natural gas has just been struck at Drumheller in the coal mines of the Drumheller Coal Company. This gas is now issuing from the mines in such quantities that the proprietors, ot necessity, have had to close down all the mining operations.

Mr. Drumheller, after whom the town is named, is one of the pioneer coal operators, and while the discovery of natural gas in his mine is causing some hardship in handicapping work, this, in his opinion, is offset by the importance of having gas in the town.

Present Producing Gas Fields.

As described in the preceding section, the only two producing gas fields in southern Alberta are those at Medicine

Hat and the vicinity, and at Bow island, about forty miles northwest of Medicine Hat.

In central Alberta the Vegreville well is being used for power purposes by the town and shows an open flow capacity of from 200,000 to 300,000 cubic feet per day. The gas well at Wetaskiwin, while declining in volume, is being used for fuel at the municipal power house and shows an open flow capacity of from 300,000 to 350,000 cubic feet per day. On the MacDougal ranch, west of Okotoks and south of Calgary, the well being drilled by Mr. Dingman and his associates, while at present showing considerable flow of gas, does not give promise of long life or great vitality. The gas from this well is reported to contain one gallon of gasoline per 1000 cubic feet of gas. In northern Alberta the wells at Pelican on the Athabaska river had a combined capacity of less than 1,000,000 cubic feet per day.

Production of gas in Alberta.—In 1905 the gas from 12 wells at Medicine Hat was valued at $33,000. The value of natural gas produced in Alberta in 1910[1] is reported as $68,568, and its volume was over 450,000,000 cubic feet.

In 1912[2] the production was reported as 780,000,000 cubic feet, valued at $110,165, the value representing as closely as can be ascertained the value received by the owners or operators of the wells for gas produced and sold or used.

Location of Dry Holes.

Dry holes have been drilled at various points in Alberta, at most of which geological conditions indicate the uselessness of future prospecting. Among these may be mentioned the wells at Fort McMurray, Morinville, Edmonton, Victoria, Bassano, Cassills, Brook, and Pincher creek. There is also little apparent prospect of natural gas in large quantities at any of the undeveloped localities described, with the exception of the field southeast of Vegreville.

[1]John McLeish, Summary Rept. Mines Branch, Dept. of Mines for 1910, pp. 177-8.
[2]John McLeish, Summary Rept. Mines Branch, Dept. of Mines for 1912, pp. 159-160.

Oil Wells.

No oil in commercial quantities has been encountered in Alberta up to the present time. Several wells drilled along the Athabaska river south of Fort McMurray have developed small quantities of heavy black oil in the lower part of the tar sand, at points where it lies below the surface. One company in particular is making arrangements to develop this source of oil by drilling numerous shallow wells on its property, hoping to recover the oil by bailing or by some similar means. However, owing to the difficulty of transportation and travelling, no oil has ever been shipped out of this northern county.

The deep well drilled by Mr. Williams, of Pelican, encountered numerous small shows of heavy oil in the Devonian limestone. However, none of these were of enough importance to warrant further prospecting in that vicinity.

A small oil production was developed in the vicinity of Oil City and Waterton lake, on the eastern slope of South Kootenay pass in southwestern Alberta. However, these wells failed to produce in quantities sufficient to warrant further drilling, especially in view of the badly faulted nature of the rocks in this district.

Present Drilling Operations.

NORTHERN ALBERTA.

While several oil drilling outfits were preparing to begin work along the Athabaska river during the summer of 1913, yet the only drilling operations at that time were those of the Pelican Oil and Gas Company in the vicinity of Pelican rapids. This company was working intermittently in deepening several wells which had already been drilled.

The syndicate of local people of Athabaska which held the gas franchise of that town expected to begin the drilling of a deep well to test the Dakota sand at that point.

Operations at Morinville had ceased and one drilling rig from that point had been moved to Nakamun, forty miles northwest of Edmonton, where the formations were being tested for oil.

Mr. Chamberlain and associates are drilling a well a few miles south of the city of Edmonton, on Mr. Chamberlain's farm in section 30, with the object of developing a natural gas supply. A light rotary drilling outfit is being used for this work and the prospects are that the Dakota sand will not be reached, owing to the great depth at which it lies under Edmonton.

A third well was being drilled at Tofield, in August, 1913, by Mr. George Peat, of Petrolia, Ontario. The town of Wainwright was endeavouring to obtain funds to drill a well to test the Battle River anticline in that vicinity. The Northwest Drilling Company of Calgary was drilling a well for gas at Castor, and in August had reached a depth of 1,350 feet. Mr. Dingman and associates of Calgary were drilling a test for oil on the MacDougal farm west of Okotoks, and Mr. Dingman stated that they expected to go through to the Dakota sand. On November 8, 1913, the well was approximately 1,570 feet deep, and drilling in the lower part of the Belly River or upper Claggett formation.

The city of Medicine Hat contracted during the latter part of 1912 for the drilling of nine additional wells to furnish fuel for manufacturing purposes to the plants located near that city. Two of these had been completed in August, 1913.

Well No. 16 in the Bow Island field was being completed in August, 1913, and Mr. Eugene Coste, the president of the Canadian Western Natural Gas, Light, Heat and Power Company, stated that no wells would be drilled during that year.

Oil Seepages.

NORTHERN ALBERTA.

The great tar seepages which exude from the Dakota sand along the Athabaska river in northern Alberta, and which have been described by McConnell and others, represent in their explored portion a body of solid bitumen having a volume of six cubic miles. This body of bitumen is believed to be the residue from an enormous quantity of petroleum from which the lighter constituents have volatilized, leaving only the comparatively solid residue.[1]

Similar seepages of less extent are found on the Clear Water river, on the Loon river, and in the vicinity of Tar island on the Peace river.

These seepages follow a northwest by southeast line, and the oil from which they originated may have been governed in its accumulation by the great arch which crosses the Athabaska river in the vicinity of Crooked rapids. All these seepages apparently lie on the northeast side of the crest of this arch or series of arches.

CENTRAL ALBERTA.

South of Athabaska and between that point and the Red Deer river, numerous occurrences of tar impregnated sand have been reported. The best known of these is found in the vicinity of Egg lake near Morinville and has been described by Dawson. Another occurs in the vicinity of Legal between Morinville and Athabaska, on section 33, township 57, range 20.

The well being drilled at Nakamun, west of Edmonton, was located near a similar deposit of tar sand.

South of Edmonton near LeDuc a tar sand deposit of considerable size is reported to have existed and to have been used by Indians in curing hides. Various other small seepages of tar or heavy oil are reported to exist south of Camrose and to exude from the banks of the Red Deer river.

SOUTHERN ALBERTA.

A small seepage of reddish oil is reported to exude from a creek bottom in the vicinity of MacLeod in southern Alberta.

In the valley of Oil creek, a tributary of Waterton lake, in the extreme southeastern corner of Alberta, numerous oil seepages occur, exuding both from the limestone cliffs of Devono-

[1]A report by S. C. Ells on the Athabaska Tar Sands has been published by the Mines Branch, 1914. Field work is still in progress and a more complete report will probably be issued in 1915.

Silurian age and from the sand and shales of the Cambrian age. On the British Columbia side of South Kootenay pass, in the valley of the Akamina and Kishinena rivers, several seepages of light oil have been reported by Selwyn and others. These seepages have led to the drilling of from eighteen to twenty wells—with no results of importance. No drilling is going on at the present time, and the geological indications do not warrant further prospecting.

Oil seepages are reported in northern Montana near the international border, in the vicinity of Kevin, Montana, and shallow wells drilled in the vicinity encountered a dark oil of good quality at a depth of approximately 100 feet from the surface.

Gas Springs and Water Wells with Showings of Gas.

NORTHERN ALBERTA.

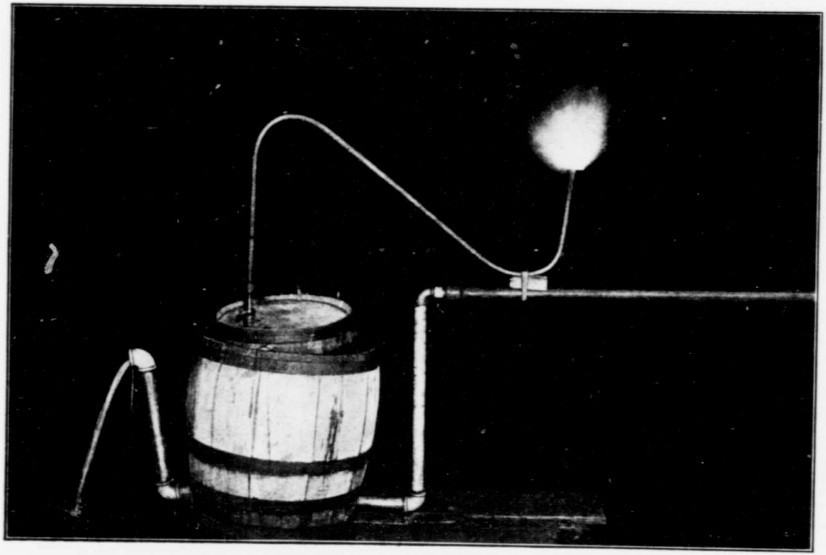
Gas springs are reported by McConnell at the mouth of the Little Buffalo river on the Athabaska, and at a point on the Athabaska river thirteen miles north of Pelican. He suggests the possibility that this gas may have worked its way up from the tar sand through the overlying clear water shale. The gas first mentioned covers an area of approximately 50 feet in diameter, and is reported to have been of sufficient volume to cook a camp meal. At the time the writer visited this locality the volume was considerably less than described by McConnell and it is believed to be decreasing. The gas spring last mentioned is only noticeable at very low water and during the winter time, when it prevents the ice from freezing solid. McConnell also reports gas springs as occurring at Tar island on the Peace river.

Water wells drilled at Athabaska have encountered more or less shale gas.

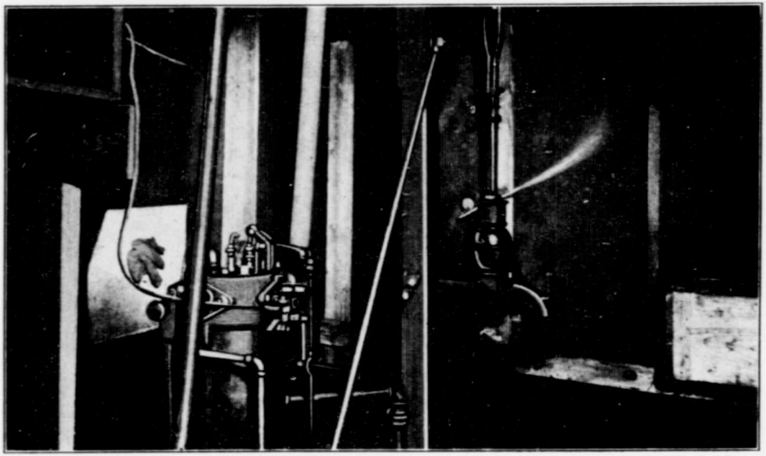
CENTRAL ALBERTA.

Water wells drilled at Vegreville some years ago, encountered more or less natural gas at a shallow depth, which fact led

PLATE XXVIII.



Contrivance for catching gas from water wells at Bruce, Alberta.



Gas from water well, Bruce, Alberta.

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to the drilling of the present gas well by the town. Nine or ten water wells in the vicinity of Bruce, southwest of Tofield, show considerable gas derived from the Belly River shales, which underlie this district.

A gas spring is also reported to exude from the bottom of the valley of the Battle river near Wainwright, also having its source in the Belly River shale.

The fact that gas is found so generally at a shallow depth along the axis of the Battle River anticline between Vegreville and Wainwright, while not proof of its existence in large volumes at a great depth, yet is in line with similar occurrences in the Medicine Hat field, which led to the development of natural gas at that point and at Bow island, along the crest of a similar arch.

Gas was encountered in a water well drilled on Bernard de Nobblens' property at Aldersyde, south of Calgary, at a shallow depth, 300 feet.

SOUTHERN ALBERTA.

As stated above, the development of the gas field at Medicine Hat and Bow island was brought about by the finding of natural gas in shallow water wells at Langevin, Carlstadt, Medicine Hat, and at other points in the vicinity.

Salt Water Conditions.

NORTHERN ALBERTA.

In the wells drilled at Fort McKay, Fort McMurray and Pelican, a large body of salt and gypsum was shown to exist in the Devonian limestone. Several strong flows of brine were also encountered in these wells, occurring in rocks of Devonian age. No salt water was encountered in the Cretaceous sands and shales at Pelican, Athabaska, or Victoria. Several comparatively small flows of salt water were encountered in the Morinville and Edmonton wells.

While it is presumed that the trough of the great basin lying in western Alberta parallel to the Rockies will contain considerable salt water throughout the belt in which the formations reach their greatest depression, yet it is not known how far up the sides of the basin this body of salt water will extend. No wells have been drilled to sufficient depth to tap the principal porous sand beds; namely, the Niobrara and Cretaceous sands.

The Dakota and Niobrara sands at Moosejaw and Regina are apparently saturated with salt water, but owing to lack of drill tests, it is not known how far west in Alberta this body of salt water extends; nor is it known whether an intervening oil belt exists between Moosejaw and the Medicine Hat gas field.

No tests west of the Bow Island field have penetrated to a sufficient depth to determine the extent of the salt water saturation in the Dakota sand, with the exception of the well at Brooks station on the Canadian Pacific railway. This well encountered a large flow of salt water, in the salt sand below the Dakota, which was cased off. The well drilled at Taber struck a large flow of water, which flowed on the surface.

Presence of Known Oil and Gas Sands Underlying Alberta.

Throughout Alberta more or less gas is found in pockets in the shales and sands overlying the Niobrara formation. This is particularly true of the Belly River shales, which outcrop at the surface throughout a wide belt from the International Boundary along the Milk river, to Vegreville in eastern Alberta. Gas has also been found in the Pierre shales in small quantities by wells drilled at Morinville, Edmonton, Wetaskiwin and elsewhere. However, no oil and gas have been encountered in commercial quantities in sands lying above those of the Niobrara series. In view of the fact that the sand beds found in the upper Cretaceous measures are of a lenticular nature—not being continuous for great distances—it is not believed that they are of a nature to act as a reservoir for the accumulation of large quantities of either gas or oil. No continuous porous strata are found in the Belly River shale or in the Claggett formation lying above the Niobrara sands.

In view of the persistence of the sands of the Niobrara series and of the Dakota or tar sand which underly the greater part of Alberta, it is in these sands that the greatest probability exists for finding oil or gas in large quantities.

The upper part of the Niobrara formation has been found to consist of porous sand beds at Pelican, Athabaska, Victoria, Morinville, Vegreville, Medicine Hat and elsewhere. Considerable gas in commercial quantities has been encountered in this sand at Medicine Hat and Vegreville, and it is believed that it will prove of importance in the results of future drilling.

The Dakota or tar sand is the source from which exude the tar seepages along the Athabaska river, and in which the gas production in southern Alberta has been developed at Bow island. The Dakota sand has also been encountered in the gas well at Vegreville and that at Brooks station; and, in view of its great continuity, it is the horizon in which it is believed the greatest possibilities exist for the development of both oil and gas production in the province of Alberta.

Depths to Which Wells should be Carried in the Different Fields.

In the following table are shown the depths at which the Niobrara formation and also the Dakota sand have been encountered in wells already drilled, as well as the estimated depth at other localities where wells have not as yet been drilled, or where they were not continued to a sufficient depth to strike either one or both of these formations:—

Depths necessary to reach the Niobrara and Dakota Formations.

	Niobrara. Top (Feet)	*Dakota.* Top (Feet)
Pelican	00	750
Athabaska	985	1800
Morinville	2900(?)	3250
Nakamun (approx.)	3000	3300 (approx.)
Edmonton	3000	3300 "
Tofield	2100	3000
Vegreville	1000	1900
Phillips	900	1800
Wainwright	800	1700
Innisfree	900	1800
Camrose (approx.)	3000	3700 (approx.)
Wetaskiwin "	3600	4200 "
Castor	2100	3000
Calgary	5000	5900–6000
West of Okotoks (Dingman's well)	1600	2500
Macleod	2700	3600
Lethbridge	1600	2800
Bow island	1450	2200
Suffield	1260	2000
Brooks	1720	2600
Medicine Hat	1000	1850

Conditions Favourable for Gas Accumulation.

In order that natural gas may exist in any locality three conditions are necessary:—

1. A porous formation to hold the gas.

2. An impervious overlying formation to prevent it from escaping.

3. Suitable geological structures to form an accumulative reservoir for it.

GEOLOGICAL STRUCTURE.

When oil, gas and water exist in any porous stratum which is not perfectly flat, these substances separate according to their specific gravities. That is, water, being heaviest, settles into the syncline or basin where the sand is lowest; oil, being lighter, rests above the water; while gas, being volatile, occupies the upper portions of the stratum, including anticlines, domes and the upper edges of sandy lenses, unless under the pressure present it remains dissolved in the oil.

Longitudinal sections of these several structures are somewhat as shown in Figs. 31, 32, 33, 34, and 35. The question arises, do any of those geological structures exist in Alberta?

This may be answered in the affirmative. As has been stated on page 271 of this report, there exist three main anticlines or arches of the formations underlying Alberta. The first crosses the Athabaska river in the vicinity of Crooked rapids.

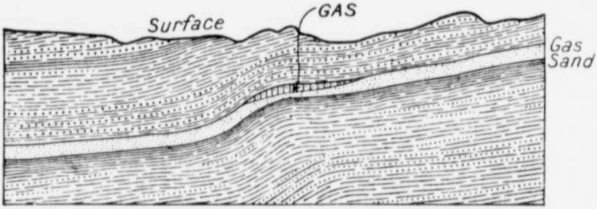


Fig. 31. Section through strata, showing example of gas accumulation on a structural terrace.

The second extends from Vegreville southeast to the intersection of the fourth meridian with the fifty-second parallel; and the third, in southern Alberta, extends from the Sweet Grass hills in Montana to the Bow river. (See Figs. 25, 26, and 30.) The most northerly and the most southerly of these arches have been tested successfully for gas. However, the anticline southeast of Vegreville has not as yet been drilled.

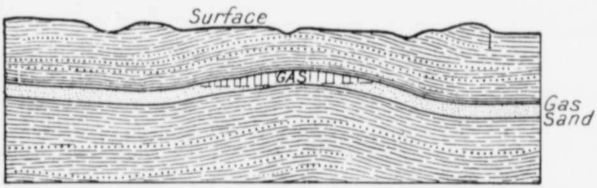


Fig. 32. Section through strata, showing example of gas accumulation on the crest of a structural dome.

Owing to the more complicated structure and the steeper dips which exist along the first range of foothills of the Rockies, it is believed that gas pools of relatively small extent will be developed in this region. The well being drilled by Mr. Dingman and associates, west of Okotoks, has already given evidence of the existence of gas in this vicinity. However, in view of the prevalence of faults and inclined structures along the

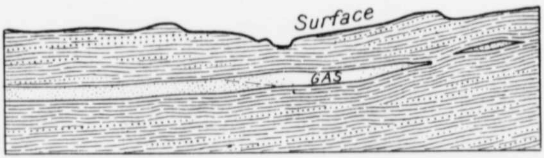


Fig. 33. Section through strata, showing example of gas accumulation in the upper portion of a sand stratum which plays out.

foothills, in general, the territory may be considered unfavourable for the existence of a large supply of natural gas.

Natural gas occurring along the upper edges of sandy lenses of which the gas at Wetaskiwin is probably an example, has not been found to be the source of long-lived pools. While

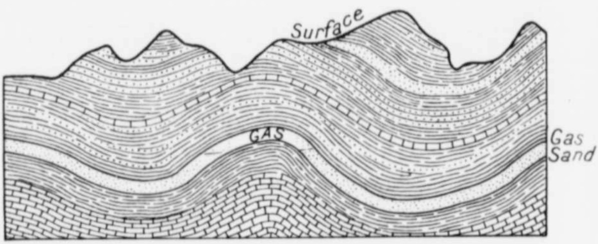


Fig. 34. Section through strata, showing example of gas accumulation on the crest of a structural anticline.

more or less gas will no doubt be found in different parts of Alberta having its source in such type of structure (see Fig. 33), yet, in general, such wells will be short-lived and have no great vitality. The principal gas fields of Central Alberta will be found to lie chiefly along the axis of the Battle river anticline, in the Niobrara and Dakota formations.

The crest of the northern arch, which crosses the Athabaska river at Crooked rapids, throughout the greater part

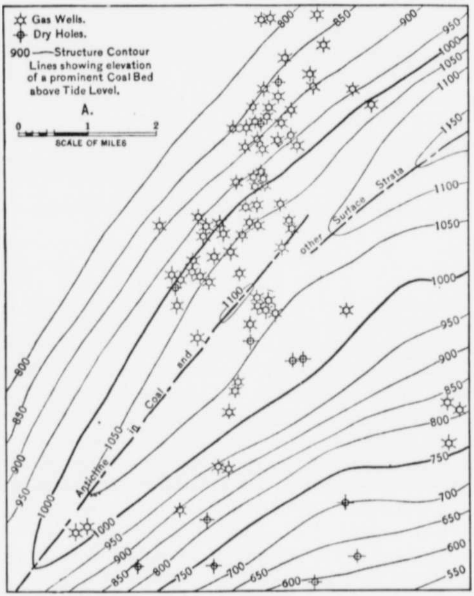


Fig. 35. Illustration of anticlinal gas field in Pennsylvania in which several sands are productive, showing lay and dip of surface strata, with position of all wells.

of its extent is not overlain by a sufficient thickness of impervious shale as to form a reservoir for large quantities of gas under great pressure; and, in view of the great distance from a market for any gas production which might be developed along this anticline, it can be disregarded as a source of a natural gas supply.

GEOLOGICAL CONDITIONS LACKING FOR GAS ACCUMULATION.

In general it may be said that no gas supply of importance can be developed within the great syncline of west central Alberta. However, in the intermediate zone between the three main anticlines described in the preceding paragraphs, and the sycline or depression above mentioned, minor structures favourable for gas accumulation undoubtedly exist, in which small gas pools will probably be developed from time to time.

Conditions Favourable for Oil Accumulation.

GEOLOGICAL STRUCTURE.

As stated in the preceding paragraph, when oil, gas and water exist in any porous strata which is not perfectly flat, these substances separate according to their specific gravity, except where the gas remains dissolved in the oil under pressure. The great trough or syncline, the axis of which extends in a general north-south direction through the western part of Alberta, forms a structural depression which has been found to be favourable for the accumulation of great quantities of oil and salt water in other fields throughout the world. Water, being heavier than oil, will settle into that syncline or basin where the sand is the lowest, while oil being lighter, will be found up the dip above the water. The quantity of water existing in the porous sands of the Niobrara and Dakota formations in this central Alberta basin cannot be conjectured, as no wells have ever been drilled to a sufficient depth to tap these sands, within the limits of this basin. In general, however, it may be said that the lower sands in the central part of this basin will probably be found saturated with water, while along the flanks of this water-saturated zone, oil pools will probably be found to exist.

Oil pools of lesser extent will also no doubt be developed in the disturbed region along the foothills of the Rockies, as is evidenced by seepages which occur in southeastern Alberta near South Kootenay Pass and elsewhere.

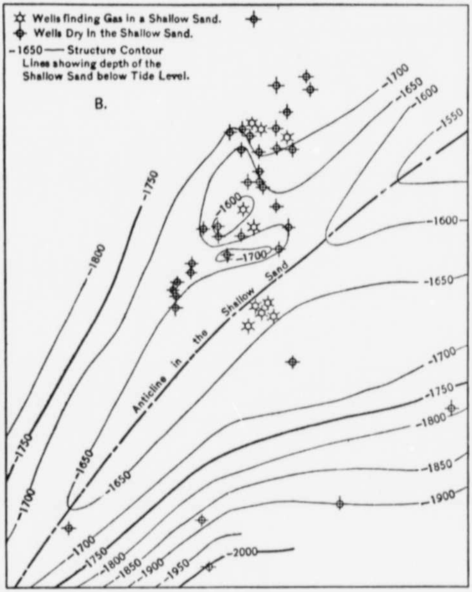


Fig. 36. Illustration of an anticlinal gas field in Pennsylvania in which several sands are productive, showing lay and dip of a shallow sand, with positions of wells drilled to it.

GEOLOGICAL CONDITIONS LACKING FOR OIL ACCUMULATION.

A number of wells have been drilled for oil throughout Alberta, many of which were located upon the evidence of pockets of tar sand, occurring at or near the surface. Others have been located apparently with no reason to justify them except the necessity of drilling a well somewhere as a basis for stock selling. In the first instance it may be said that most of these

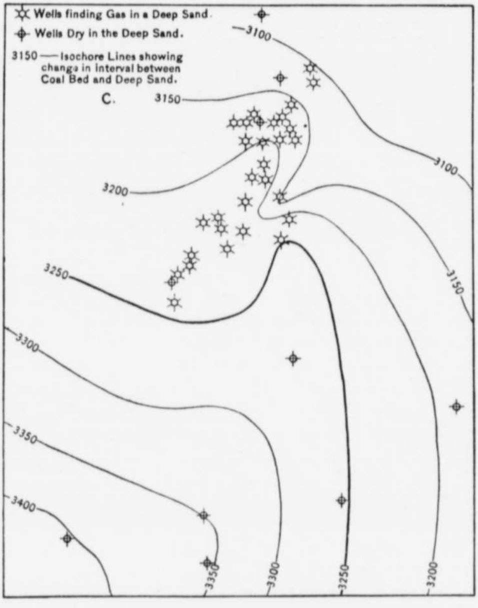


Fig. 37. Illustration of an anticlinal gas field in Pennsylvania in which several sands are productive. This is a convergence map used in calculating the lay of the deep sand for Figure 38, which follows.

small tar seepages or pockets of tar sand, are not, in any manner, proof of the existence of oil at a greater depth underlying the locality in which they occur. Various theories have been given to account for the existence of these isolated deposits of tar sand, but they have not as yet been studied or mapped in sufficient detail to warrant the acceptance of any of these theories. In the case of the occurrences of tar sand in the vicinity of Egg lake near Morinville, which Dawson accounted for as a dike

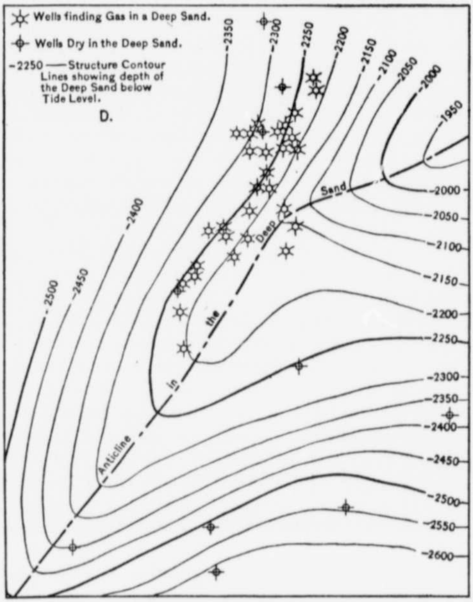


Fig. 38. Illustration of an anticlinal gas field in Pennsylvania, in which several sands are productive, showing lay and dip of a deep sand, with positions of wells drilled to it.

or seepage from an oil reservoir at a great depth, it may be said that this theory has been proved untenable by the drilling of two wells in the vicinity of this deposit, and by the lack of evidence of sufficient geological disturbance to make the fissure theory at all probable.

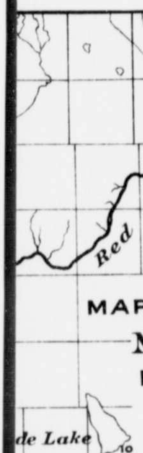
Existing Pipe Lines.

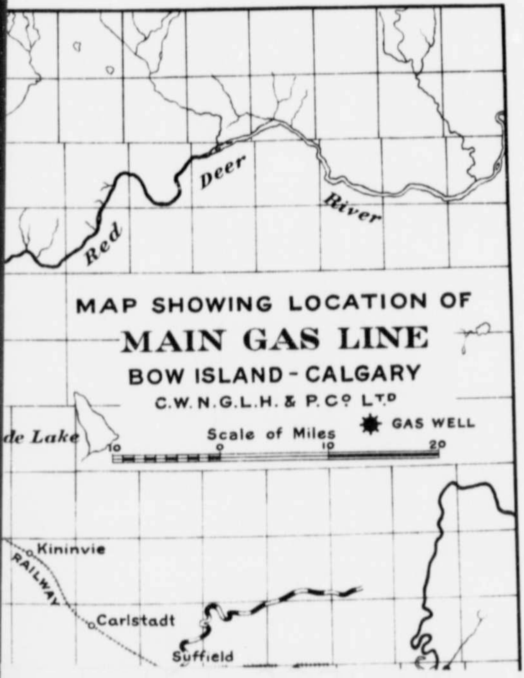
The Canadian Western Natural Gas, Light, Heat and Power Company during the year 1912 completed a 16″ pipe line for the transmission of gas from their wells in the Bow Island field to Calgary and fourteen towns en route.[1] This is the only pipe line at the present time in Alberta, and has a capacity of approximately 40,000,000 cubic feet per twenty-four hours, on the assumption that only 500 pounds pressure is utilized for transmission purposes, a pressure of 800 pounds being reported in the wells. The line was contracted for at the rate of $1.35 per foot for hauling, ditching, laying the line and refilling. It was laid by two crews working from opposite ends with traction diggers and an average of 4000 feet of completed line per day per crew is reported have been accomplished. It is reported to have cost approximately $3,000,000 completed exclusive of branch distribution lines to towns en route. The main line is 160 miles in length. The company is controlled by the British Empire Trust Company, Limited, of London, England. The report of that company for 1912 shows that in that year the company drilled 17 wells, giving a daily production of 174,300,000 cubic feet. Pipe lines aggregating 200 miles in length had been built and 5,000 consumers had been secured and supplied. The company had drilled up to that time 61 gas wells, only two of which had been non-productive. In the spring of 1913 thirteen wells were drawn from, and three were drilling.

Projected Pipe Line.

The city of Edmonton is contemplating securing a natural gas supply either as a municipal enterprise, or by contracting with a private company or individuals to bring gas from the Pelican gas field or from the field southeast of Vegreville. In the following tables are shown the comparative estimated cost of the pipe lines from each of these fields for the transmission of the gas supply for Edmonton.

[1] See Map No. 302.




MAP SHOWING LOCATION OF
MAIN GAS LINE
BOW ISLAND - CALGARY
C.W. N.G.L.H. & P. C° LTD
GAS WELL
Scale of Miles
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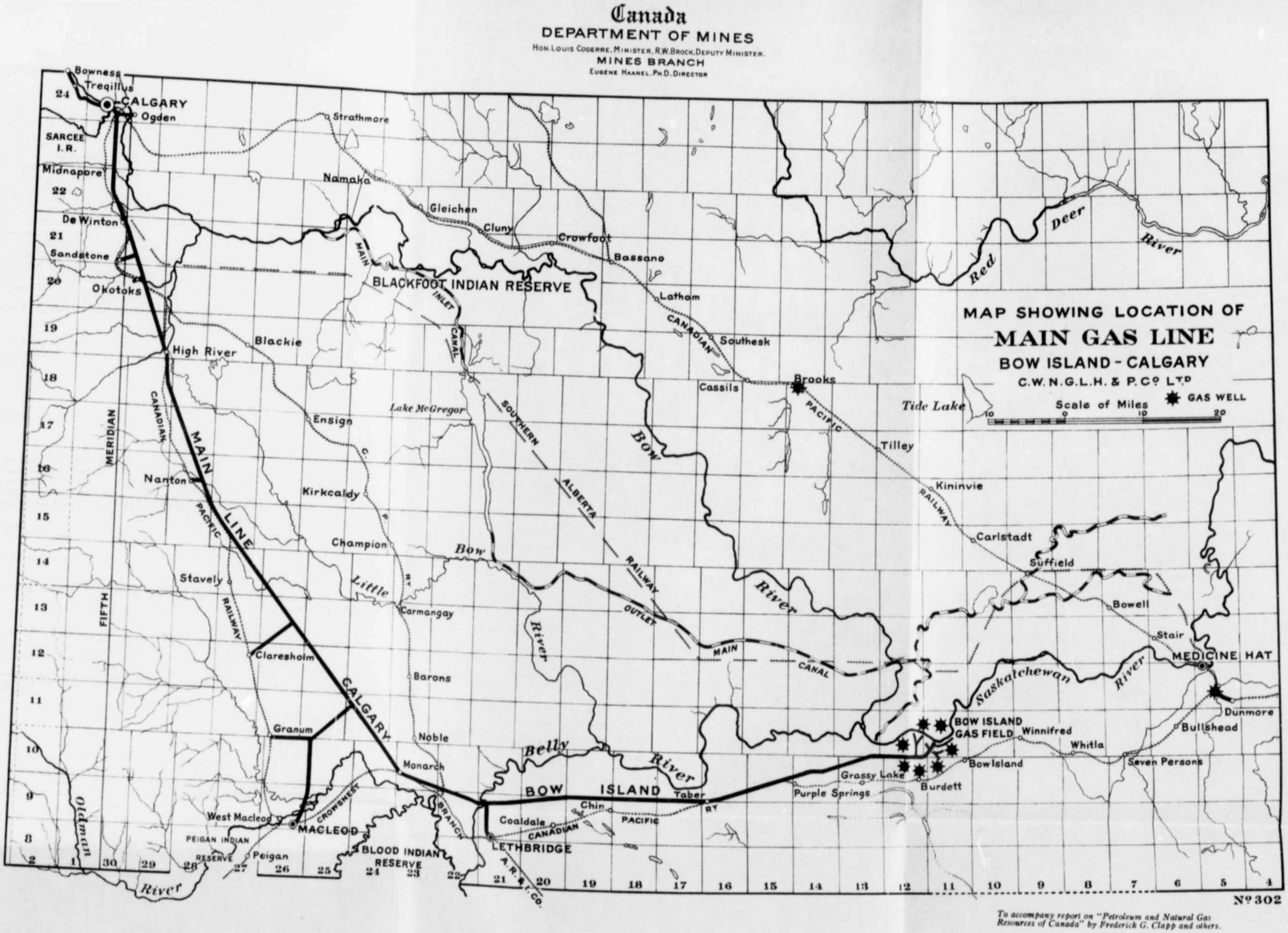
10
20
Red Deer River
de Lake
Kininvie
RAILWAY
Carlstadt
Suffield


Canada
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER, R.W. BROCK, DEPUTY MINISTER.
MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR
MAP SHOWING LOCATION OF
MAIN GAS LINE
BOW ISLAND - CALGARY
C.W.N.G.L.H. & P. Co LTD
GAS WELL
Scale of Miles
CALGARY
MEDICINE HAT
LETHBRIDGE
MACLEOD
BOW ISLAND GAS FIELD
BLACKFOOT INDIAN RESERVE
BLOOD INDIAN RESERVE
MAIN LINE
CALGARY
BOW ISLAND
No 302
To accompany report on "Petroleum and Natural Gas Resources of Canada" by Frederick G. Clapp and others.

ESTIMATED COS

60 miles of 12″ 45-lb
and Athabaska.....
60 miles of 14″ 56-lb.
and Athabaska.....
60 miles of 16″ 64-lb
and Athabaska....
The average length of
of each size will be
12,672 12″ Dresser co
12,672 14″ Dresser co
12,672 16″ Dresser co
Freight on couplings
Duty on importing pi
Labour, ditching, etc.
$3,225.00 per mile,
Hauling: 90 miles @
Right-of-way, 180 mil
Use of tools, 180 mile
Cement and cribbing

Overhead charge and
and material).....
Telephone line.......

ANNUAL OUTL

Interest on pipe line i
Depreciation on line
Drilling, average of 1
Connecting with pipe
Offices, equipment, m

Total.........
Interest for 12 month

Total annual

ESTIMATED COS

30 miles 8″ 20 lb. li
30 miles 10″ 28-lb. l
30 miles 12″ 36-lb. li

[1]The author, Mr. Cl
cases appear to be excess
field. A.W.G.W.

ESTIMATED COST OF PIPE LINE TO EDMONTON FROM THE PELICAN FIELD.[1]

60 miles of 12" 45-lb. pipe @ $1.59 per ft., f.o.b. Edmonton and Athabaska	$503,712.00
60 miles of 14" 56-lb. pipe @ $2.62 per ft., f.o.b. Edmonton and Athabaska	830,016.00
60 miles of 16" 64-lb. pipe @ $3.01 per ft., f.o.b. Edmonton and Athabaska	963,568.00
The average length of pipe is 25 feet; hence 12,672 couplings of each size will be necessary. Therefore—	
12,672 12" Dresser couplings, 50 lb. @ $2.20, f.o.b. Bradford	27,878.40
12,672 14" Dresser couplings, 63 lb. @ $3.02, f.o.b. Bradford	38,269.44
12,672 16" Dresser couplings, 72 lb. @ $3.32, f.o.b. Bradford	42,071.04
Freight on couplings from Bradford, U. S. A. to Athabaska	70,297.90
Duty on importing pipe and couplings @ 7½%	102,445.00
Labour, ditching, etc. (50% added to figures in other fields):	
$3,225.00 per mile, 180 miles @ $3,225.00 per mile	580,500.00
Hauling: 90 miles @ $400.00 per mile; 90 miles @ $6,000.00	576,000.00
Right-of-way, 180 miles @ $300.00 per mile	54,000.00
Use of tools, 180 miles @ $100.00 per mile	18,000.00
Cement and cribbing (in swamps and river crossing)	65,000.00
	$3,871,767.78
Overhead charge and contractor's profit (10% of cost of labour and material)	387,176.78
Telephone line	20,000.00
	$4,279,944.56

ANNUAL OUTLAY ON ACCOUNT OF PIPE LINE FROM THE PELICAN FIELD.

Interest on pipe line investment at 5½%	$235,396.95
Depreciation on line (estimating life at 15 yrs.) 7%	298,896.12
Drilling, average of 10 wells per year, @ $25,000	250,000.00
Connecting with pipe line 10 wells @ $1,000.00	10,000.00
Offices, equipment, maintenance, salaries and repairs	30,000.00
Total	$814,293.07
Interest for 12 months @ 5½% on annual outlay	44,786.12
Total annual outlay	$859,079.19

ESTIMATED COST OF PIPE LINE TO EDMONTON FROM FIELD SOUTHEAST OF VEGREVILLE.

30 miles 8" 20 lb. line pipe @ 55c. per foot, f.o.b. Pittsburgh	$87,120.00
30 miles 10" 28-lb. line pipe @ 77c. per ft., f.o.b. Pittsburgh.	124,298.00
30 miles 12" 36-lb. line pipe @ 90.75 per ft., f.o.b. Pittsburgh.	144,251.00

[1]The author, Mr. Clapp, is responsible for these estimates. The figures given in certain cases appear to be excessive under present conditions, especially with respect to the Pelican field. A.W.G.W.

6,336 8" Dresser couplings @ $1.40, f.o.b. Bradford, Pa. ..	$ 8,870.40
6,336 10" Dresser couplings, @ $1.80, f.o.b. Bradford, Pa. .	11,404.80
6,336 12" Dresser couplings, @ $2.20, f.o.b. Bradford, Pa..	12,939.20
Freight @ $1.25 per cwt. on 12,686,000 pounds............	208,575.00
Duty at 7½% on pipe and couplings......................	44,884.38
Labour, ditching, etc., at $1,800.00 per mile................	162,000.00
Right-of-way @ $200.00 per mile........................	27,000.00
Use of tools @ $100.00 per mile..........................	9,000.00
Cement and cribbing in crossing swamps, streams, etc.......	10,000.00
Total..	$851,342.78
Overhead charge and contractor's profit (10% of the cost of of labour and material................................	85,134.28
Telephone line..	10,000.00
Total..	$946,476.06

ANNUAL OUTLAY ON ACCOUNT OF THE PIPE LINE FROM THE FIELD SOUTHEAST OF VEGREVILLE.

Interest on pipe line investment @ 5½%...................	$52,056.18
Depreciation of line (estimating life at 15 years) 7%.........	66,253.32
Drilling an average of 10 wells per year @ $16,000 each.....	160,000.00
Connecting with pipe line 10 wells @ $1,000 each...........	10,000.00
Offices, equipment, maintenance, salaries and repairs........	20,000.00
Total..	$398,309.50
Interest for 12 months @ 5½% on annual outlay............	16,957.02
Total annual outlay................................	$325,266.52
Daily outlay..	888.40

In the following table, the comparative advantages of the two fields as a source of a natural supply for the city of Edmonton are summarized:—

Field.	Present pressure of gas in the field. Pounds per sq. inch.	Present volume of gas per well.	Probable life of the field.	Miles of pipe-line necessary.	Cost of pipe-line.	Necessary daily outlay account of pipe-line.	Price at which 10 million cu.ft of gas per day must be sold for 15 years to pay for pipe-line outlay.
Pelican	225	840,000 cu. ft.	4 years.	180	$4,280,000	$2,356.10	24c—45c
Vegreville and Southeast.	350	No wells in main field.	15 years.	90	946,500	888.40	9c

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PRICES AND AMOUNTS OF GAS NECESSARY FROM EACH FIELD TO COVER DAILY OUTLAY ON ACCOUNT OF BRINGING GAS FROM IT.

Commenting upon the estimated price at which gas from the Pelican field must be sold in Edmonton to pay for the daily outlay on account of this pipe-line, as shown in the preceding table, it many be said in view of the probable short life of the Pelican field, the higher rate of 45 cents per thousand will probably apply. Adding to this the additional amount on account of an intra-urban distribution system, it is estimated that 10,000,000 cubic feet of gas have to be sold at 50 cents per thousand to cover this daily outlay. This 10,000,000 cubic feet per day is the estimated consumption of gas in Edmonton. As the consumption of gas per capita is largely determined by the price at which it is sold, the price of 50 cents per thousand cubic feet would limit the domestic consumption of the city to nearer 5,000,000 instead of 7,000,000 cubic feet per day; or a total consumption for city and domestic uses of 8,000,000 instead of 10,000,000 cubic feet. This proportion is determined by comparison with towns in Ontario where gas is sold at 45 cents and 25 cents per thousand in the same vicinity. In the first case, the consumption is 45 cubic feet per day per capita, and in the case of the 25 cent gas, it is 60 cubic feet per day. In the case of Edmonton, this decreased consumption in the city would necessitate a still higher price for the gas in order to pay expenses, because gas at this price is entirely out of the question for industrial purposes.

As a proposition has been made to the city of Edmonton to supply gas at the city limits at 15 cents per thousand cubic feet, it is appropriate to make an estimate on the basis of the foregoing figures as to the number of cubic feet of gas which must be sold at 15 cents per thousand to cover the daily outlay on account of piping gas from the different fields.

In the case of the Pelican field (Fig. 39) with an estimated daily outlay of $2,356.10 on account of pipe-line, there must be sold..............15,707,000 to 28,273,000 cu. ft. per day at 15c per 1000

The large quantity is contingent upon the probable life of the Pelican field being only four years, and assuming the necessity of installing compressor stations. Thus it will be nearer correct to consider that 28,273,000 cubic feet must be sold at 15 cents per thousand, to pay the expenses of a pipe-line.

In the case of the Southeastern field (Fig. 40), with a daily necessary outlay of $888.40 on account of pipe-line, there must be sold..............5,936,000 cu. ft. per day at 15c per 1000.

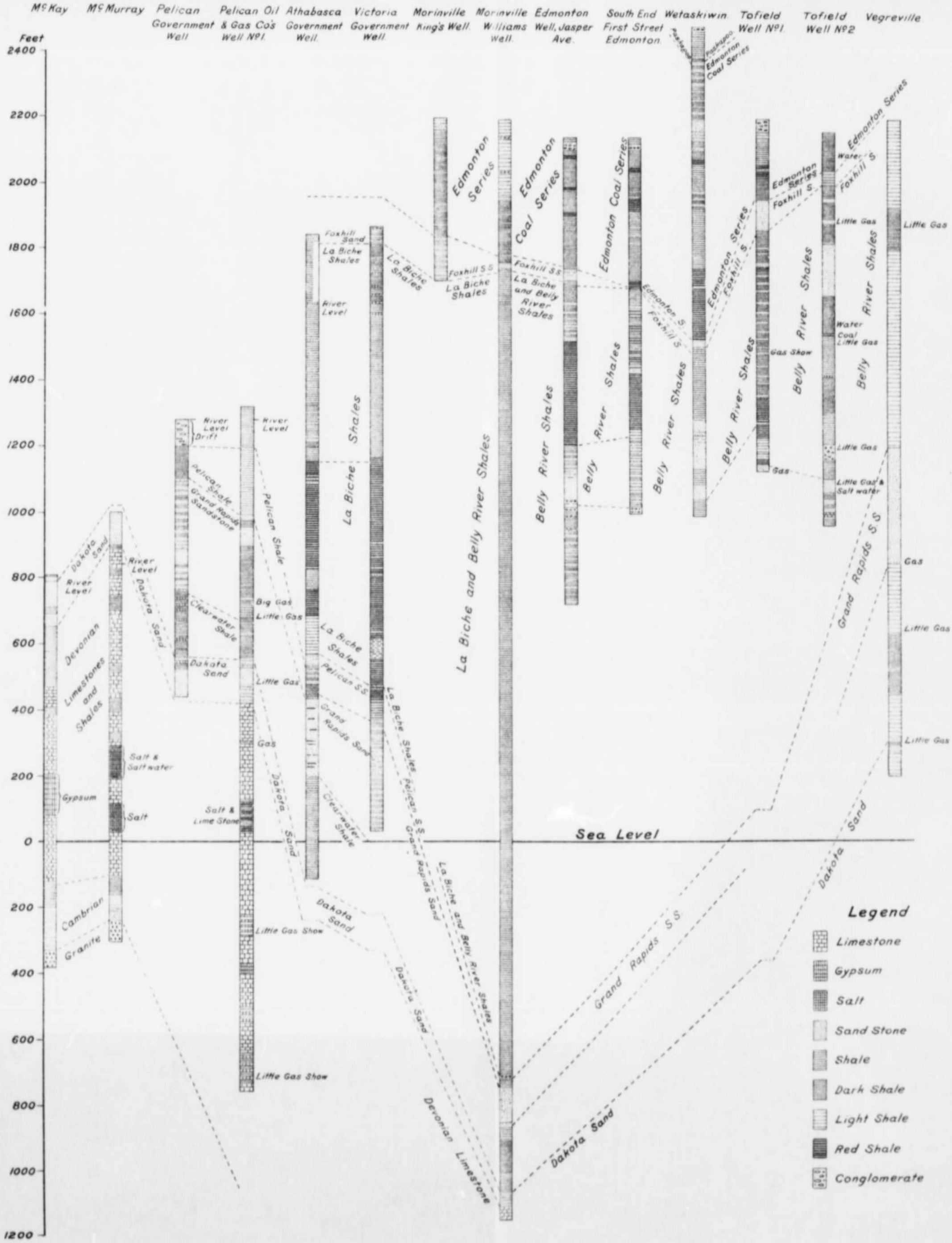

Fig. 39. Graphic section, well logs of Northern Alberta, showing strata passed through and their correlations. (By L. G. Huntley)

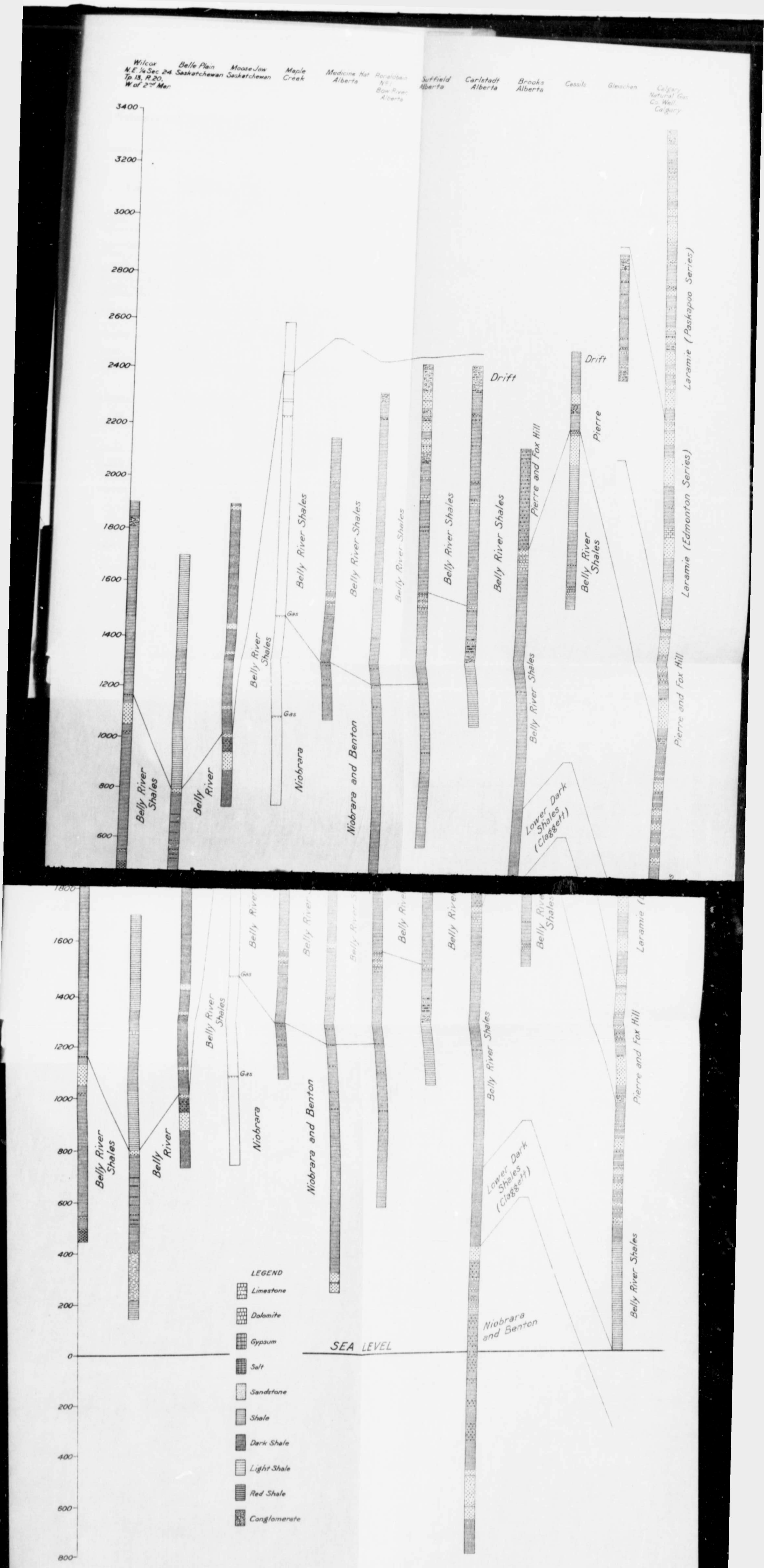

Fig. 40. Sections across Southern Alberta.
(By F. G. Clapp and L. G. Huntley)

Volumes a

FIELD.
Pelican.........
Athabaska......
Vegreville.......
Bruce...........
Wetaskiwin.....
Camrose, Aug., '1
Castor, Aug., '13.
Medicine Hat....
Bow Island......
Okotoks........
Irvine..........
Dunmore.......
Suffield........
Redcliffe........
Carlstadt.......
Brooks.........
Cassills.........
Bassano.........
Calgary.........
Taber..........

Volumes and Pressures in the Different Gas Fields in Alberta.

FIELD.	Productive Formation.	Total Production (Nominal) Cubic Feet per Day.	Volume per well (Open Flow) Cubic Feet per Day (Initial Flow).	(Pounds) Closed Pressure per Square Inch.
Pelican	Dakota sand	860,000	840,000	225
Athabaska	Shale gas	....	....	Declining rapidly.
Vegreville	Niobrara	220,000	220,000	280
Bruce	Shale gas	In shallow	water wells	Gradually increasing.
Wetaskiwin	Pierre sands	350,000	350,000	....
Camrose, Aug., '13	Drilling	....	....	....
Castor, Aug., '13	Drilling	....	....	....
Medicine Hat	Niobrara	25,000,000	500,000 to 4,000,000	550 to 600
Bow Island	Dakota sand	50,000,000 to 60,000,000	1,500,000 to 28,000,000	700 to 800
Okotoks	Belly River shale.	900,000	900,000	Declining rapidly.
Irvine	Shale gas	Small show	....	....
Dunmore	Niobrara	....	2,000,000	590
Suffield	Niobrara	Small flow; well almost ruined	Reported 700,000	500
Redcliffe	Niobrara	Same as Medicine Hat wells.		
Carlstadt	Shale gas	Small flow used by railway.	....	....
Brooks	Dakota	350,000	Reported 500,000	590
Cassills	Shale gas	Small flow used by railway.	....	....
Bassano	Shale gas	Wells abandoned.	200,000 to 700,000 cu. ft. per day reported initially	....
Calgary	Small flow gas.	80,000	80,000	285
Taber	....	Small show gas.	....	96

Methods and Costs of Drilling in the Different Fields.

NORTHERN ALBERTA.

In that part of Alberta north of Athabaska, the great difficulty in drilling for oil and gas is found to be the cost and difficulty of transportation. Men and supplies are transported to the north from the end of the railway at Athabaska by means of scows in the summer time, and by wagon and dog sled over the ice in the winter. Several trips are made during the summer months from Athabaska to Grand Rapids by a Hudson Bay Company steamer, but beyond Grand Rapids all transportation is by the primitive means mentioned.

The cost of hauling supplies to Pelican rapids is $2.25 per one hundred pounds. All supplies and drilling outfits which are sent to any point farther north than Pelican are sent by the operating companies for their own account.

In the vicinity of Fort McKay one standard California rig was in use, together with a standard Canadian rig, and another make-shift three-pole derrick. The holes drilled are located near Fort McKay, Fort McMurray and vicinity, and required approximately one season to complete. The hole drilled by the Northern Explorations Company at Fort McMurray was put down by means of a Canadian standard rig with a 56 foot derrick, using Canadian drillers from Ontario.

At Pelican it is reported that in the summer of 1912, the hole being drilled by the Calhoun Oil Company had cost approximately $25,000, at a depth of 1,400 feet. During the summer of 1913, the hole had reached the depth of approximately 2,100 feet, having a 6 inch hole at that point. A California standard cable rig was being used with a 72 foot derrick. The drillers employed by the Calhoun Oil Company, and later by its successor, the Pelican Oil and Gas Company, were brought from the California oil field.

The wells drilled by the Geological Survey for the government at Pelican, Athabaska and Victoria were drilled by the old spring pole method, and the casing used was of such small diameter that great difficulty was experienced in continu-

Hauling boiler from Edmonton to Athabaska, Alberta, 1911.

Hauling casing from Edmonton to Athabaska, Alberta, 1911.

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ing the holes to sufficient depths. All wells drilled in northern Alberta have been on oil claims denounced upon government land. No contract drilling has been done in that part of Alberta, although one of the leading contracting companies in Alberta has quoted a tentative price of $12 per foot for drilling north of Athabaska.

Past experience has indicated that it will take the entire season to drill one well along the Athabaska river.

CENTRAL ALBERTA.

In general all the wells drilled throughout central Alberta have been by means of standard California cable rigs using American drillers and methods. An 84 foot derrick is used, reinforced by having an extra 8 × 8 piece bolted up the inside of each leg, the derrick having a 24 foot base.

It is frequently found necessary to brace the derricks with guy lines, in order to guard against the high winds which frequently prevail on the prairie.

American casing is used throughout central Alberta, although it has given some trouble by parting, due to the long heavy strings which it is necessary to use. A great deal of under-reaming is necessary at some places, due to the caving character of the formations, especially in the Claggett and Benton formations. However, in the well drilled at Wetaskiwin by the Northwest Drilling Company, it was found possible to keep from 200 to 250 feet ahead of the pipe at all times with the drill.

No. 1 well at Tofield was drilled by the day, work commencing during the summer of 1911, the well being completed on June 20, 1913. The record of the casing used is as follows:—

1048 feet 8″ × 6¼″ 17 lb. Inserted Pipe.
331 feet 11⅝″ Collar Pipe.
631 feet 9⅝″ Collar Pipe.
940 feet 7⅝″ Collar Pipe.

A standard American rig was used with Manila cable to 240 feet, and a wire line for the balance. The under-reamer split the 6¼″ casing, allowing gas to escape through the 7⅝″

casing, and probably admitting water to the gas formation, which was flooded.

Well No. 2 at Tofield was drilled by contract to a depth of approximately 1,200 feet for a price of $9.50 per foot. This well was started during the fall of 1911, and was completed in the spring of 1912, being drilled by the Northwest Drilling Company.

Well No. 3 at Tofield, which commenced drilling in April 1912, was being drilled by Mr. Geo. Peat, of Petrolia, Ontario, for a price of $7.50 per foot.

The gas well at Vegreville was drilled by the Northwest Drilling Company of Calgary, to a depth of 2,000 feet at $9 per foot.

The gas well at Wetaskiwin was taken over by the Northwest Drilling Company from Mr. Grant at a depth of approximately 700 feet, and it is reported that the contract price for drilling was $10 per foot. A liner was used in this well, perforated at all gas pays. This extended from a depth of 1,100 feet to the bottom of the hole, being 398 feet long.

A well was being drilled during the summer of 1912 on the farm of Mr. Chamberlain, two miles southeast of Edmonton. It is stated that the intention is to drill through the Dakota sand, and a light weight rotary rig is being used for drilling purposes by a contractor from the Texas oil fields in the United States. At a depth of 150 feet, 8 inch casing was being used, making it extremely improbable that this hole will ever reach a sufficient depth to test the Dakota sand.

A well was being drilled for the town of Castor by the Northwest Drilling Company during the summer of 1913. The contract price is reported to be $10 per foot. This well was started in the fall of 1912, and had reached a depth of 1,400 feet in August, 1913. Trouble was encountered in a black sand at a depth of 700 feet, and later the casing parted causing more trouble, which accounts for the delay in drilling this hole.

SOUTHERN ALBERTA.

Wells in the Bow Island field are reported to cost about an average of $16,000 each when completed. The cost is in excess of this for wells drilled on the prairie, above the river level, which means an additional 250 feet or 300 feet in depth. The wells are drilled for the Western Canadian Natural Gas, Light, Heat and Power Company by the Northwest Drilling Company of Calgary, reported to be a subsidiary of the first-named company. Owing to the great weight of the long strings of casing used in this hole, trouble was experienced with American casing, which frequently stripped the threads or buckled. German inserted weldless casing was next tried, and after becoming accustomed to its use, it was found to be much superior for the necessities of the Bow Island field, and, according to Mr. Coste, is being used exclusively at the present time. California rigs with 84 foot derricks are used, with reinforced corners, and all derricks guyed against the wind pressure. The casing is cemented on top of the gas sand, while all intermediate flows of gas or water are allowed to escape at the surface around the outside of the casing. Most of the land in the Bow Island district is leased by the above named company, although a few leases are held by other parties. The average haul from the railway to wells in the Bow Island field is approximately six miles. Hauling is all done by the company's teams. Owing to the difficulty and delay in obtaining spare parts for replacing broken tools, a large stock of such extra parts and tools is kept on hand in the Bow Island field. Wells are spaced approximately one mile apart. In the Bow Island field drilling twenty feet per day is considered good work. Medicine Hat wells are said to cost from $4,700 to $8,000 completed, ready to use, depending upon the diameter, and delays of various sorts. Wells drilled off the railway are said to average $25,000 apiece to drill to the Dakota sand. The well drilled by the railway at Brooks station to a depth of about 2,700 feet cost in the neighbourhood of $40,000. However, the wells in the Bow Island field are said to have averaged $16,000 apiece to put to producing. This represents the cost to the company, including derrick, which costs $2,000 in that district.

The well drilled by the Southern Alberta Land Company at 14 miles northwest of Bow island at their town site, was started in June, 1911, and finished in March, 1912.

A driller unaccustomed to the field can safely calculate upon a year's time to complete his first well, provided he is drilling a wildcat. It costs $1,000 per month to drill, while tools and rig alone cost $6,000. Drillers get $150 and tool dressers $100 per month to drill, with board. Two bull wheels are used, the second one being for pipe.

Natural gas is used as fuel for drilling, and is pumped from the river in some instances for two or three miles. Five strings of casing are used, namely 20″, 13″, 10″, 8″ and 6″. The 6″ casing goes to the top of the gas sand. One well had 1,640 feet of 8″ casing, representing a weight of 22 tons, and was still going.

The first wells in that field were started with fifty feet or so of 18″ casing; about 600 feet of 13″ casing, 1,100 feet of 10″; 1,600 feet of 8″ and 1,900 feet of 6″ seventeen pound casing. Considerable difficulty is experienced in drilling through the lower dark shales of the Claggett formation, which cave badly. The contractor supplies the derrick and rig, while the company supplies the pipe and water. The caprock above the gas sand in the Bow Island field is from 15 to 20 feet thick, a grey pebbly material which is believed to correspond with the Dakota limestone.

In the Medicine Hat field all wells are drilled by contract, one contractor quoting the following prices for drilling:—

$7.25 for 10″ hole from 1,000 to 3,100 feet deep.
$6.50 for 6″ hole from 1,000 to 1,300 feet deep.

The principal size of casing used in the Medicine Hat field are 20″, 16″, 12½″ 59 pound; and 10″ 35 pound. Most of the wells are finished with a 10″ hole at from 900 to 1000 feet in depth. The gas rock is twenty feet thick and the casing is set in an 18″ caprock of lime shell.

American rigs are used with methods similar to those at Bow island. However, owing to the lesser depth of the wells in the Medicine Hat field, derricks are not reinforced for handling the heavy strings of pipe necessary in the former field. Several steel derricks are being used by contractors in the vicinity of Medicine Hat, and are reported to give satisfaction.

The Canadian Pacific railway uses natural gas for lighting its passenger trains between Medicine Hat and Kootenay Landing. The gas is bottled in steel flasks 8″ in diameter and 30 feet in length, under a pressure of 170 pounds. Pintsch gas is used on all the divisions but in Medicine Hat they are restocked with natural gas from the gas well in the railway yard. The same apparatus is used, the cars being charged by a Chapman Fuller regulator from 600 pound well pressure, to 150 pounds. The Pintsch incandescent mantle and equipment is used, no change being found necessary, the only appliances required in charging being a pipe line from the well to the coach yard, and a connecting hose to the gas tanks on the cars. One man is said to be able to charge a train to its full capacity in twenty minutes. The first test was made in 1908, at which time a car ran lighted continuously for thirty-nine hours on one charge.

An especially constructed drilling machine has been built for prospecting purposes in southern Alberta by the Northwest Drilling Company. A well was drilled with this machine at the old pumping station of the railway, ten miles south of Suffield, during the early part of 1913. The machine is built to go a depth of 2,000 feet.

The wells are not shot in either the Bow Island or the Medicine Hat gas field. No dry holes had been drilled in the Bow Island field up to the fall of 1913. One well encountered a small flow of water in the first sand which was cased off, and Mr. Coste reports that the well obtained from 4½ to 5 million cubic feet of gas in the second sand. Most of the other wells are entirely dry in this field, and about fifteen square miles are reported to have been tested.

A well drilled at Lethbridge by the Light and Heat Company during 1907-8 is reported to have cost $10,000 including everything for the first 1,500 feet. This well was taken over by the city when the money of the company ran out.

A well was drilled a few years ago at Dunmore Junction, three miles west of Medicine Hat, by the Canadian Pacific railway, under the direction of Mr. Eugene Coste. A light rotary rig was used, probably not being sufficiently heavy for the formations in this district. Considerable delay was experienced and it was decided that the rotary was unsuitable for drilling in the formations in Alberta. However, the rig used at Dunmore was entirely too light for the purpose, and the crew was apparently unaccustomed to its use in the formations encountered.

Several borings were made two years ago at Kipp station a few hundred feet deep. A rotary core drill was used in a hole drilled during 1910-11-12. The hole was finally abandoned, due to an accident to the casing, which tipped sideways and was lost. No. 1 well was drilled by the city of Taber, while No. 2 was drilled by the Sullivan Drilling Company, of Chicago. A crooked hole was drilled at Suffield, and in an endeavor to straighten it, the casing dropped and buckled, and it was found impossible to cement the water off.

A diamond drill hole was put down within the city limits of Calgary about twenty years ago, to a depth of 1,426 feet. The recent holes drilled at Calgary, and in the Sarcee Indian Reserve, were drilled by means of American cable rigs. In the latter hole, the rocks were found greatly inclined, folded and crushed, and much trouble was experienced with a crooked hole. It was, however, continued to a depth of 3,365 feet.

In the vicinity of Waterton lake and South Kootenay pass, in southwestern Alberta, practically all the different methods of drilling have been tested. A number of standard American rigs with 72 foot derricks have been used. Canadian standard cable rig and Canadian pole-tool system have also been used. Several steel derricks have also been used in the drilling of wells in this district. The deepest well in the district, that of the Western Oil, Coal and Coke Company at Waterton lake, was drilled to a depth of approximately 1,900 feet, by means of a pole-tool rig. Several other deep wells in the district have also been drilled by pole-tools, which is claimed to be the preferable system, on account of the highly inclined dolomites which are drilled through. It is claimed that the pole-tool system gives a more positive rotation of the drilling bit than the cable system, and insures a straighter hole than can be obtained by cable tools in the Pincher Creek district. Most of the wells were drilled by contract at an average price of $7.50 per foot in depth. It is estimated that the wells in this district cost approximately $10 per foot completed, including everything. The company furnishes pipe and fuel, while the contractor furnished derrick, tools and labour.

The Lineham well at Oil City, 1,020 feet deep, was drilled in less time than two months. Pole-tools were used in drilling this well, and also in drilling the 1,400 foot well one mile below Oil City on the Lineham lease. However, the 1,900 foot well drilled at Waterton lake required several years, on account of the trouble with caving formations and a prolonged fishing job.

Prices and Markets for Natural Gas.

The Canadian Western Natural Gas, Light, Heat and Power Company has contracts with Calgary and other towns along the route of their pipe line from the Bow Island field, to sell gas at 35 cents per thousand cubic feet for domestic use, and 20 cents per thousand for industrial purposes.

The town of Medicine Hat has drilled a number of wells for gas, turning them over to industrial plants free of charge, for fuel purposes. The city has also drilled, and is operating a number of gas wells, selling gas for industrial purposes at a rate of 5 cents per thousand cubic feet, and for domestic purposes for 15 cents per thousand. Prior to 1912 a number of contracts had been made with factories to furnish gas free of cost for a five-year period, in order to induce such companies to locate in the city. While this was apparently a short sighted policy on the part of the city, yet they claim that it was only by this means that they could secure for the city the benefits of the natural gas supply from the underlying formations, asserting that if they did not sell gas at a very low rate, gas companies would drain the natural gas away and it would be lost to the city. However, it is understood that the city has taken means to prevent waste, and is making no more contracts for giving away gas. Other wells drilled in southern Alberta have all been drilled either by the Canadian Pacific railway at their town sites, by the Southern Alberta Land Company on their town site, or by municipalities endeavouring to secure a gas supply for local use.

In central Alberta, several companies have made proposals to the city of Edmonton for supplying natural gas, either from the Pelican field 180 miles north, or from the probable field southeast of Vegreville. The proposed prices range from 15 cents to 27, but as the city is still debating the advisability of taking up the production and the distribution of natural gas as a municipal enterprise, nothing has yet been done in the way of drilling wells.

The wells at Vegreville and Wetaskiwin are used for fuel purposes at the municipal power plants. The gas from the old govermnent well at Pelican, which has been leased by the Pelican Oil and Gas Company from the government, is being used for fuel for drilling purposes by the above company.

Quality of Gas and Oil in Alberta.

The gas which has been found in northern and southern Alberta would not yield gasoline by the usual process of compression. However, the gas encountered in the Dingman well on the MacDougal ranch west of Okotoks is reported* to contain one gallon of gasoline per one thousand cubic feet of gas.

The following is an analysis made by the Pittsburgh Testing Laboratory of a sample of gas taken by the writer early in August, 1913:—

Analysis of Natural Gas from Alberta.

	Per Cent.
Carbon dioxide	None
Oxygen	·14
Methane	98·55
Nitrogen	1·41
Total	100·10

The following is also given by the California-Alberta Oil Company of gas taken from a small flow encountered in their well at Morinville:—

Analysis of Natural Gas from Morinville, Alberta.

	Per Cent.
Sulphuretted hydrogen	0·0
Carbonic acid	0·0
Illuminants	0·1
Oxygen	0·5
Carbon monoxide (?)	0·3
Hydrogen (?)	8·7
Methane	90·2
Nitrogen	0·2
Total	100·0

The foregoing analyses show that the central Alberta gas is somewhat superior in heating value to gas from the Bow Island field in southern Alberta, as given below:—

Analysis of Natural Gas from Central Alberta.

	Per Cent.
Carbon dioxide CO_2	0·00
Carbon monoxide CO	0·00
Oxygen	0·10
Heavy hydrocarbons	1·80
Methane	86·70
Hydrogen (?)	5·40
Nitrogen	6·00
Total	100·00

The gas in central Alberta resembles that encountered in the Caddo field in northern Louisiana. Its composition is also very similar to that found in the Ontario peninsula. Analyses of these gases are given below:—

Comparative Analyses of Natural Gas from Louisiana and Ontario.

	Caddo-Louisiana Per cent.	Pt. Albino, Ontario Per cent.
Methane (CH_4)	95·00	96·57
Nitrogen	2·56	2·69
Carbon dioxide (CO_2)	2·43	None
Sulphur	0·01	0·74
	100·00 (980 B.T.U's per cubic foot)	100·00 (974 B.T.U's per cubic foot).

Analysis of the gas at Medicine Hat shows it to be composed almost entirely of methane (CH_4), and the following table shows its relative heating power:—

Comparative heating power of Medicine Hat and other gases.

	B.T.U.
Medicine Hat gas	1100
West Virginia	1145
Ohio and Indiana	1095
Kansas	1100
Coal gas	755
Water gas	350
Producer gas	155

Given below are copies of various analyses of samples of heavy oil taken from the wells of the Athabaska Oils, Limited, nine miles north of Fort McKay in northern Alberta. These analyses are furnished by Mr. James D. Tait of the above company.

Analysis of oil from Well No. 1 of the Athabaska Oils, Limited, nine miles north of Fort McKay.

	Per cent.
Water approximately	5
Light oil distilling over up to 150° Centigrade	None
Illuminating oils from 150° to 300° Centigrade	15
Residue	70

F. G. Wait, Chemist, Mines Branch, Department of Mines, Ottawa.

Analysis of oil from No. 2 well at Athabaska Oils, Limited.

Analysis made by Falkenberg at Laucks, Vancouver.

	Per cent.
Specific gravity	1·02
Distillation made from the water—free sample	
Gasoline and naphtha to 150° Centigrade	7·1
Kerosene 150° to 300° Centigrade	60·1
Base fixed at 300° (asphaltum)	32·8

Analysis by the Government Laboratory at Victoria, Dec. 20, 1912.

	Per cent.
Gravity 14·5° Baumé equal to specific gravity	0·970
Specific gravity of oil between 150° to 300° C	·892
Distillates below 150° C	2·00
Distillates between 150° and 300° C	70·00
Distillates between 300° and 350° C	5·00
Residue	23·00

Herbert Carmichael, Government Analyst.

Analysis of oil from No. 1 well.

Analysis made by Price and Sons of San Francisco.
11·20 per cent 48° Baumé.
6·60 per cent 42° Baumé.
11·20 per cent lubricating oil.
72 per cent asphaltum.

An analysis by Dr. Hoffman of a sample of the tar impregnated sand along the Athabaska river is given below. These sands were being investigated by an expedition headed by Mr. Sydney Ells, of the Mines Branch, Department of Mines, during the summer of 1913.[1]

[1]The analyses of samples collected by Mr. Ells in 1913 appear in his report on the Tar Sands of the Athabaska river, published by the Mines Branch in 1914.

Analysis by Dr. Hoffman of sample collected by Dr. Bell.

	Per cent.
Bitumen	12·42
Water (mechanically mixed)	5·85
Siliceous sands	81·73
Total	100·00

The following analyses are reported of samples of oil from the Lineham wells at the Oil creek, in the South Kootenay Pass district:—

Analysis by Arthur D. Little, Inc. Boston, Mass.

	Per cent.
Below 150°C. Light oils	5·1
150–300°C. Illuminating oils	41·0
300–340°C. Lubricating oils	41·1
Paraffine, residue and loss	9·7
Total	96·9

Analysis by Dr. Ellis, Toronto University.

	Per cent.
Light at 150°C. naptha, etc., sp. g. 0·77–52°B	5·7
Illuminating oils 150–300°C. sp. g. 0·82–41°B	56·3
Lubricating oils over 300° sp. g. 0·86	35·6
Residue, tar and coke	2·16
Total	99·76

Logs of wells in Alberta.

Product—Gas.
Authority—Geol. Survey Canada, Memoir 29–E, p. 90.
Province—Alberta, Canada.
Date—1912.
Location—1912.

Gas is reported to have been struck in 1912, at a depth of 1,050 feet about the top of the Belly River formation. The bottom of the Edmonton formation lies at a depth of about 260 feet, at which point some coal was struck.

Authority—Geol. Survey Canada, Memoir 29–E, pp. 89–90.
Drillers—Sullivan Machine Co.
Location—Taber, Alberta, Canada.
Date—1912.

	Top Feet	*Bottom Feet*
Sandy clay and small boulders		41
Gravel and small boulders	41	51
Shale and sandstone	51	71
Shale and bands limestone	71	93
Taber coal seam at 90 feet		
Dark shale	95	104
Sandstone	104	106
Shale	106	109
Shaly sandstone	109	111
Shale	111	125
Sandstone	125	130
Mixed limestone and sandstone	130	135
Dark shale	135	145
Sandstone	145	149
Shale	149	160

	Top Feet	Bottom Feet
Mixed sandstone and shale	160	184
Shale	184	190
Sandstone	190	195
Shale	195	214
Sandstone	214	271
Shale	271	273
Dark shale	273	276
Sandy shale	276	308
Mixed shale and sandstone	308	320
Black shale	320	330
Mixed shale and sandstone	330	337
Shale	337	373, 6"
Shaly coal	373, 6"	374
Shale	374	376, 4"
Coal	376, 4"	377
Dark shale	377	378
Mixed sandstone and shale	378	395
Mixed black slate and coal	395	396, 10"
Shale	398, 10"	405
Limestone	405	405, 6"
Sandstone	405, 6"	411
Shale	411	591
Sandy shale	591	602
Conglomerate	602	604
Sandy shale	604	608
Sandstone	608	627, 2"
Fireclay	627, 2"	627, 3"
Dark shale	627, 3"	635
Sandstone	635	642
Shale	642	646
Sandy shale	646	658
Sandstone	658	670
Fireclay	670	673
Coal	673	673, 3"
Sandstone	673, 3"	744
Light shale	744	744, 6"
Sandstone	744, 6"	810
Mixed sandstone and shale	810	838
Shale	838	905
Shale with sandstone partings	905	930

The above is the depth reached in July, 1912, and operations were being continued.

Product—Gas.
Owner—Canadian Pacific Railway Company.
Location—Medicine Hat, Alberta, Canada.
Authority—Geol. Survey Canada, Memoir 29-E, p. 82.

	Top Feet	Bottom Feet
Gravel and sand		37
Shale	37	166
Sandstone	166	183
Sand shale	183	200
Sandstone and shale mixed	200	243
Shale	243	290
Sandstone	290	318
Sand shale	318	660
Struck gas and salt water		177

Struck gas 558, 642, 651.

Product—Gas.
Location—Cassills, Alberta, Canada.
Authority—Geol. Survey Canada, Memoir 29-E, p. 74.
Elevation—2493.

Dark clay loam	2	Drift—52
Yellow clay	10	
Blue clay	40	
Blue shale	110	52 (Pierre) 242
Grey shale	38	
Drab sand rock	3	
Blue shale	85	
Brown shale	6	

Coal	2		
Grey shale	134		
Brown sand rock	3		
Black shale	257	(Belly River)	
Grey shale	135	706	
Brown sand rock	5	(gas)	
Blue shale	85		
Grey sandy shale	40		
Grey shale	45		
Total		1000	

Product—Gas.
Owner—Canadian Pacific Railway Co.
Sec. SE¼ 33-18-14 West 4th Meridian.
Authority—Geol. Survey Canada, Memoir 29-E, p. 71.
Location—Brooks, Alberta, Canada.

	Top Feet	Bottom Feet	
Sandy clay with sandstone		386	Pierre-Foxhill.
Sandstone and two coal seams (494 and 540)			
Shale, grey	386	1420	Belly River
Dark shale	1420	1725	Lower dark shales (Claggett)
Sandstone, fine	1725	1775	Eagle.
Sandy shale and dark grey shale	1775	2590	Niobrara-Benton.
Sandstone	2590	2795	Dakota.

(Flow of about 20,000 cubic feet of gas per day).

Authority—Geol. Survey Canada, Memoir 29-E, p. 77.
Location—Gleichen, Alberta, Canada.
Elevation—2926.

	Top Feet	Bottom Feet
Sand and clay		8
Quicksand	8	28
Blue clay, with gravel and boulders	28	67
Black sand	67	78
Blue clay	78	100
Cement gravel	100	115
Soapstone	115	155
White sand, small flow water	155	160
Soapstone	160	254
Black sand	254	261
Loose soapstone	261	335
White lime	335	338
Black shale	338	378
Putty rock	378	390
Lime and loose shale	390	400
Soapstone	400	435
Sand rock	435	444
Black shale	444	464
Gravel soapstone with sand and water	464	502

Owner—W. Can. Coal Mng. Co.
Sec. 34-9-23, West 4th Meridian.
Authority—Geol. Survey Canada, Memoir 29-E, p. 78.
Completed June, 1910.
Location—Kipp Sta., Alberta, Canada.

Started 10 feet above water level and 50 feet below sandstone overlying the Bearpaw.

	Top Feet	Bottom Feet	
River silt		20	
Clay	20	32	
Shale	32	96	
Sandstone	96	115	
Shale	115	129	
Sandy shale	129	143	Bearpaw
Ironstone	143	144	
Shale	144	166	
Ironstone	166	167	
Shale	167	260	
Sandy shale	260	565	
Sandstone	565	592	
Coal	592	595	Belly
Shale	595	600	River
Sandy shale	600	615	
Shale and sandstone	615	658	

Authority—Geol. Survey Canada, Memoir-29-E, p. 79.
Location—Langevin, Alberta, Canada.
Elevation—2471.

The log here given is taken from the results of two borings, the first 1,155 feet being from one and the remaining 271 feet from the other. The terms employed are chiefly those of the borers' log.

	Top Feet	Bottom Feet
Clay loam		30
Quicksand	30	37
Clay	37	49
Quicksand	49	59
Clay and sand	59	68
Quicksand	68	75
Clays	75	83
Quicksand	83	88
(The following general grey and pale tints according to W. A. Simpson). Probably lower part Belly River shales.		
Sandstone	88	104
Soapstone (grey, fine-grained clay)	104	113
Lime rock (fine calcareous sandstone) (Small supply of water)	113	118
Hardpan (dark shale)	118	126
Coarse sand	126	133
Soapstone (greyish clay)	133	193
Lime rock (fine calcareous sandstone)	193	200
Sandstone	200	209
Small coal seam		227
Soapstone	209	227
Sandstone	227	232
White clay	232	271
Soapstone	271	322
Lime rock	322	327
(Beds generally shales of dark to black tints):		
Loose shaly soapstone	327	464
Brown ferruginous clay	464	469
Dark lime rock	469	474
Small coal seam		463
Soapstone	474	524
Gravel (supply water)	524	531
Sandstone	531	537
Lime rock	537	541
Sandstone	541	548
Hardpan (dark shale)	548	558
Clays	558	593
Loose shaly soapstone (fine grey clay)	593	943
(Following generally grey tints; one bed of very black shale about 30 feet thick at 1,000. Fragment of Baculite from about here.)		
Lime rock (fine calcareous sandstone)	943	951
Hard soapstone	951	1041
Sand and soapstone with beds of hard pan and supply of gas	1041	1061
Sandstone with streaks of hard gravel	1061	1111
(Following generally dark to black tints):		
Gravel and clay	1111	1151
Hard lime (great flow gas)	1151	1155
Shales and lime rock (probably Calcareous limestone) with layers of very dark, soft shale in 2" hole, to bottom	1155	1426
Total		1426

Calgary Nat. Gas Co. No. 1.
Authority—Geol. Survey Canada, Memoir 29-E, pp. 88-90.
Location—Sarcee Indian Reserve, 12 miles S.W. of Calgary, Alberta, Can.

	Top Feet	Bottom Feet
Drift		64
Sandstone and shale alternating	64	152
Blue shale and grey sandstone	152	205
Blue clay shale	205	246
Sandstone with pebble	246	256
Shale with thin sandstone shells	256	301

	Top Feet	Bottom Feet
Sandstone and shale	301	322
Blue clay shale	322	401
Grey to blue shales and sandstones alternating	401	474
Grey sandstone and shale alternating	474	872
Sand lime	872	894
White to grey sandstone and shale	894	978
Shell "red lime"	978	983
White shale and sandstone in alternating layers 3 to 30 feet thick	983	1143
Sandstone, white and black in alternating layers	1143	1244
Black shale with sandstone shells	1244	1471
Sandstone, hard and soft, grey and black with few bed shales	1471	2036
Black coarse sandstone with pebble	2036	2057
Hard shale with pebble	2057	2121
Sandstone, dark and light grey, coarse and fine	2121	2221
Shale and sandstone alternating	2221	2297
Hard, grey sandstone	2297	2371
Sandstone and shale	2371	2425
Black and grey sandstone alternating	2425	2676
Soft, blue sandy shale	2676	2691
Sandstone, dark grey, hard and soft alternating	2691	2756
Light and dark grey sandstones, alternating with pebble	2756	2961
Top of Belly river		2969
Dark grey sandstone and shales intermixed with coal, 1st coal horizon	2969	2996
Sandstone with pebble	2996	3001
Sandstone, grey, coarse and fine	3001	3050
Sandstone, shale and coal	3050	3071
Black sandstone	3071	3135
Black, sandy shale	3135	3160
Grey sandstone	3160	3185
Black, sandy shale	3185	3202
Hard, light grey sandstone, with pebble	3202	3262

Wister Oil Co. No. 23.
Location—So. Kootenay Pass Dist., Alberta, Canada.
Old Section 23, now in park.
Authority—G. F. Stafford, Pincher Creek.

Surface 4140′
Depth 1984′
1150′ of hard lime.
Red sand at 1200′ (Show of oil eased off.)
Casing to 1400′.
1250 or 1260 to bottom Red sand; then 200 to 300′ Blue marl.
Soft to about 1800′.
Hard streaks from 1800 on.
About 1900′ became soft brown shale, and a big cave occurred. Show of oil.
Baled from 6.00 until 12.00 o'clock, about 5 bbls. of oil. Was not pumped and no tubing was put down.
Drilling finished in March, 1907.

Stafford says well would have been an 18 or 20 bbl. producer, but lost tools, and caved, fished for a year until Company became disgusted.

Says this the only well he saw which looked like a producer.

Dark brown shale	3262	3266
Hard brown to white sandstone with pebble	3262	3306
Black shale	3306	3325
Light grey sandstone	3325	3355
Dark shale	3355	3365

James Miller farm.
Owner—Montana Oil and Development Co.
Sec. T. 34 N. R. 4 E. Meridian 6.
Authority—Howard Price.
Date—Started 7-16-12.
Location—6 mi. westerly from Kevin, Montana.

	Top Feet	Bottom Feet
Black shale	40	160
Lime shell	160	162
Black shale	162	315
Water gas sand	315	320
Hard shell	320	
Shale	320	420

	Top Feet	Bottom Feet
Gas sand	420	430
Sandy shale	430	460
Hard shale	460	470
Black shale	470	650
Grey sandy shale	650	720
Black sand	720	730
Sandy shale	730	770
Light shale	770	850
Sandy shale	850	950
Black shale	950	1045
Grey sand	1045	1065
Gas sand (some gas)	1065	1070
Black shale	1070	1100
Light shale	1100	1115
Red rock	1115	1150
Light shale	1150	1195
Hard shell	1195	1200
Hard sand	1200	1223
Shell	1223	1230
Sand	1230	1300
Light shale	1300	1360
Sand	1360	1390
Hard shell	1390	1400
Light shale	1400	1460
Hard sand	1460	1500
Hard shell	1500	1510
Hard sand	1510	1550
Yellow shale	1550	1560
Gritty sand	1600	1650
Hard shell	1650	1655
Black shale	1655	1675
Hard shell	1675	1680
Lime rock	1680	1730
Black shale	1730	1755
Well abandoned at depth		1755
Casing 13" 40′ 10" 320′ 8" 770′ 6" 1500′ 6" 1500′		

Product—Gas.
Owner—Town of Wetaskiwin.
Location—Wetaskiwin.
Authority—W. L. Crane, City Engineer.
Drillers—Northwest Drilling Co.
Date—June, 1913.

	Top Feet	Bottom Feet
Two good seams coal about		400
Blue clay	710	855
Grey sand	855	878
Coal	878	880
Black shale	880	950
Soft grey sand	950	1002
Shaly mud	1002	1115
" "	1115	1187
" "	1187	1216
Little gas		1187
Gas		1216
Sand	1216	1255
Gas		1248
Broken shale and sand	1255	1290
Sand	1290	1372
Gas		1347
White slate	1372	1420
Sand	1420	1465
Gas		1443
White slate (bottom of hole)	1465	1511

Government well.
Sec. T. 66, R22.
1898.
Location—Athabaska, Alberta, Canada.
Authority—Geol. Sur. Can. Memoir 29-E, p. 68.

	Top Feet	*Bottom Feet*
Drift		14
Grey shale, soft and caving badly	14	245
(At 23 ft., 136 ft. and 245 ft., hard streaks were met. Below the hard streak at 245 a strong flow of gas)		
Soft shale	245	400
Shale, slightly harder	400	425
(At 425 a hard stratum about 1 ft. thick)		
Grey shale	425	500
Darker shale, soft, caving badly	500	550
Shale with streaks of sand 1 to 2 ft. thick	550	580
Dark shale, very soft	580	825
(At 780 ft. salt water was struck and a strong flow of gas)		
Shale, harder and bluer	825	900
Soft, dark shale	900	1015
Hard, light shale	1015	1037
Dark shale	1037	1090
Sandstone, carrying water	1090	1130
Dark shale, caving badly	1130	1170
Dark shale, layers sandstone	1170	1207
Dull reddish shale and sandstone	1207	1233
Dark soft shale	1233	1237
Light grey shale, very hard	1237	1242
Light grey shale (soft)	1242	1247
Dark shale, soft	1247	1255
Sandstone, very hard	1255	1260
Soft, dark shale	1260	1285
Hard sandstone	1285	1310
Dull reddish shale and sandstone, soft	1310	1323
Reddish shale	1323	1338
Sandstone and dark shale	1338	1350
Dull reddish shale and a little sandstone	1350	1391
Sandstone with layers of dark shale	1391	1435
Hard sandstone with soft streaks	1435	1448
Sandstone and dark shale	1448	1461
Dark shale (thin streaks of lignite)	1461	1491
Light, hard shale	1491	1531
Shale, not so hard	1531	1540
	1540	1566
Hard sandstone	1566	1576
Hard shale	1576	1601
Hard shale with soft streaks	1601	1613
Hard shale	1613	1626
Very hard ironstone boulder	1626	1633
Hard shale (little gas 1650)	1633	1682
Hard and soft shale alternating	1682	1689
Shale and sandstone	1689	1722
Shale with little sandstone	1722	1731
Shale soft and dark	1731	1736
Hard sand rock	1736	1747
Shale	1747	1752
Shale and sandstone	1752	1759
Shale	1759	1763
Hard, supposed sandstone	1763	1767
Soft shale	1767	1770

Pelican Well No. 1.
Owner—Pelican Oil and Gas Co.
Authority—H. L. Williams.
Elevation—1280.
Dec. 3, 1912.
Location—Alberta, Canada.

	Top Feet	*Bottom Feet*
Blue and yellow shale	1	66
White and grey shale, water	66	82
Blue shale	82	200
Blue and brown shale	200	235
Brown	235	285
Grey, brown shale	285	331

	Top Feet	Bottom Feet
Sand rock 21', very hard	331	352
Shale	352	365
Sand rock	365	425
Shale	425	507
Brown shell, very hard	507	509½
Grey shale	509½	538
Shell	538	540
Sandstone	540	546
Shale	546	575
Hard shell	575	581
Gray shale, with streaks sandstone	581	644
Struck Pelican flow		625
Grey shale (gas)	644	653
Grey shale (very soft cement like)	653	666
Sand rock	666	671
Grey shale	671	688
Hard brown shell	688	689
Dark grey shell	689	740
Hard shale	740	741
Dark grey shale	741	766
Hard shell	766	767
Dark grey shale, sandy (Bradley verifies this)	767	843½
Sandy shale	843½	872
Sandy shale	872	882
Coarse rock, mixed with oil	882	887
Shale and sand	887	898
Hard rock	898	903
Lime carrying oil	903	997
Limestone	997	1051
Hard flinty shell (strong flow of gas under shell)	1051	1053½
Limestone	1053½	1158
Hard limestone shell	1158	1159
Limestone	1159	1192
Hard shell—gypsum	1192	1197
Blue shale and gypsum	1197	1293
Very hard lime shell	1293	1296
Lime rock	1296	1538
Lime, shale and lime rock	1538	1560
Grey shale and lime (gas)	1560	1700
Limestone	1700	1784
Hard shell	1784	1790
Lime rock—shale streaks	1790	1875
Hard shell	1875	1879
Layer of limestone and shale	1879	2040
Strong flow gas		2040
Limestone and shale interstratified	2040	2069

No. 1 well.
Owner—H. L. Williams.
Authority—Mr. Tait.
Contractor—H. L. Williams, Mgr.
Location—Morinville, Alberta, Canada.

	Top Feet	Bottom Feet
Surface to 280', clay boulders		
Sand rock	250	260
Blue and brown shale interstratified with thin layers of sandstone	260	440
Sand rock with flow gas	440	465
Blue and brown shale, with one or two thin layers of sandstone	465	1410
Dark blue shale with heavy oil seepages	1410	1415
Blue shale, varying in colour from dark blue to light blue and greenish	1415	2450
Hard ironstone shell	2050	2456
Blue and grey shale with gas	2456	2900
Gravel in which saline water was struck	2900	2902
Greenish shale (like Dobe shale)	2902	2940
Sand rock (oil)—flow gas underneath	2940	3052
Very hard shell with iron	3052	3064
Greenish shale (like Dobe shale in Cal.)	3064	3100
Blue shale, interstratified with thin layers of sandstone	3100	3200
Greenish shale, very sticky (Dobe)	3200	3260
Hard ironstone shell	3260	3262
Blue sandy shale with oil seepages	3262	3310
Blue shale, interstratified with hard lime shells	3310	3350

From 3040 to present depth, more or less oil, increasing shale from 3040, very hard with pyrites, but slacked on exposure.

Product—Oil.
Authority—Geol. Survey Canada, Memoir 29-E, p. 86.
Location—Pelican river, Alberta, Canada.

	Top *Feet*	*Bottom* *Feet*
Sand and gravel	1	86
Very soft, dark-bluish shale	86	101
Soft sandstone	101	105
Very soft, dark-bluish shale. At 185 ft. slightly saline water	105	185
Rather hard, reddish-brown shale	185	225
Sandstone (water 225')	225	234
Sandstone and brown shale	234	245
Hard grey shale (at 253' more water and gas)	245	253
Light greenish-grey shale	253	280
Soft, greenish-grey shale, cement-like	280	290
Brown shale with strata of grey shale	290	308
Brown shale	308	310
Hard sandstone (More gas and water)	310	311
Brown shale and sandstone in alternate strata	311	328
Sandstone	328	340
Brown shale	340	353
Hard sand rock with layers of soft rock (*At 355' struck maltha and gas*)	353	365
Sandstone, rather hard	365	410
Brown shale	410	427
Brown shale, hard	427	450
Sandstone (more gas and water)	450	465
Grey shale	465	526
Ironstone	526	532
Grey shale	532	553
Sandstone	553	556
Very hard, probably ironstone	556	558
Very hard sandstone	558	563
Brown shale	563	573
Grey shale, streaks of sandstone	573	590
Grey shale, brown shale and sandstone in alternating strata; the cuttings show traces of maltha	590	620
Grey shale (strong flow gas at 625'; considerable maltha coming away with the water	620	625
Very hard sandstone	625	643
Soft grey shale	643	648
Hard sandstone	648	652
Soft grey sandy shale	652	665
Ironstone	665	675
Soft, grey shale	765	684
Hard sandstone	684	685
Soft, dark-grey shale	685	703
Hard sandstone	718	723
Sandstone	723	733
Soft, grey shale	733	743
Soft, grey shale, streaks soft sandstone, strong flow gas		750
Heavy oil mixed all through sandstone and shale	743	758
Soft, dark grey shale and soft sandstone, heavy oil throughout. At 773 heavy gas	758	781
Alternate strata soft grey shale and soft sandstone. Increased quantities of heavy petroleum. Gas increasing in volume	781	800
Same as foregoing. At 820 tremendous flow gas of which roar could be heard 3 miles or more	800	820
Soft sandstone. Hard stream and light flow gas	820	830
Soft sandstone	830	836
Iron pyrites nodules embedded in cement like sandstone. Very strong flow gas	836	837

Mr. Dawson gives the following section from this well:

Sand and gravel (surface deposits)		86
Dark bluish-black soft shales, with some sandstone in upper part (Pelican shales)	86	185
Greyish sands and sandstones and brownish and greyish shales. Grand Rapids sandstones	185	465
Greyish and brownish shales alternating with thin beds of hard sandstone and ironstone. Clearwater shales	465	750
Sands and clays often saturated with heavy oils and tar. Tar sands	750	837

Vegreville No. 1.
Owner—Town of Vegreville.
Finished Apr. 8, 1913.
Drillers—N. W. Drilling Co., J. P. Kelly and L. J. McNallum.
Location—near power house, ½ mile N. of R.R. Sta.

	Top Feet	Bottom Feet
Surface	0	15
Blue mud (13" casing carried 272')	15	272
Brown shale	272	325
Gas		328
Shell 2' thick	330	386
Water		386
Sand	386	410
Bottom of sand		410
Blue mud	410	515
Gas		520
Blue mud	502	1000·3
Sand	1000·3	1356
Gas		1360
Bottom sand		1362
Brown shale	1362	1440
Blue mud	1440	1558
(8" casing to 1558).		
Little gas		1563
Brown shale	1563	1740
Blue mud	1740	1868
Top of sand	1868	
Small flow gas		1870
Bottom of sand		1872
Blue mud	1872	1880
Brown sand	1890	1920
Blue mud	1920	2000
Bottom of hole		2000

No. 2 well.
Owner—Tofield.
Product—Show of gas.
Authority—Geo. Peat.
Elevation—R. R. Sta.
Drillers—Northwest Drilling Co.
Location—Tofield, near tracks east of town.

	Top Feet	Bottom Feet
Clay		20
Shell	20	25
Grey shale	25	60
Grey shale	60	75
Water		70
Cased 13" at 62'		
Brown shale	75	120
Shells and sand	120	173
Broken shale	173	200
Grey sand	200	212
Brown shale	212	270
Grey sand	270	280
Little gas		273
Brown shale	280	340
Grey sand	340	500
Brown shale	500	610
Water		590
Cased 10" at 515'		
Grey sand	610	615
Coal	615	618
Blue clay	618	750
Little gas		625
Blue shale	750	850
Lime shell	850	860
Blue clay	860	935
Blue slate	935	950
Sand and little gas	950	960
Gravel	960	1000
Brown shale	1000	1020
Black slate	1020	1057
Salt and water	1057	1103
Little gas		1063

	Top Feet	Bottom Feet
Blue slate	1103	1125
Dark sand	1125	1135
Blue clay	1135	1147
Dark sand	1147	1153
Dark sand	1153	1158
Lime	1158	1170
Blue clay	1170	1200

No. 2 well.
Owner—Great Northern Exploration Co.
Finished Aug., 1912.
Driller—Neil Cameron.
Location—Ft. McMurray, Alberta, Canada.

	Top Feet	Bottom Feet
Surface—soil		17
Limestone	17	77
Shale	77	92
Lime	92	152
Shale	152	192
Soft shale	192	197
Lime	197	237
Shale	237	242
Lime	242	362
Shale	362	382
Lime	382	462
Shale	462	502
Lime	502	562
Shale	562	592
Lime	592	604
Salt—saltwater	604	704
Limestone	704	779
Salt	779	869
Lime	869	999
Shale	999	1059
Brown sandstone	1059	1119
Brown Medina rock	1119	1139
Red rock—streaked—hard	1139	1405

Owner—California-Alberta Oil Co.
Authority—(Owner) and Geol. Sur. Canada, Memoir 29-E, p. 85, 1910.
Location—Egg Lake, Morinville, Alberta, Canada.

	Top Feet	Bottom Feet
Surface deposits	50	
Chocolate coloured shale, hard to drill	50	70
Gravel, very coarse (flow of water)	70	75
Water and 18-22" seam of lignite	75	80
Brown shale, black slate, pyrite and dark sandstone	80	160
Shale, slate and coal in thin seams	160	260
Sandstone, with water	265	270
Brown shale and dark grey sandstone	270	300
First gas with pungent odor (cased off)		300
Blue and green soapstone shale (still gas and little oil)	300	320
Green soapstone, shale	340	360
Sandstone with gas of petroleum odor	360	360
Gas and light oil (cased off)		375
Very hard shell		380
Pungent gas, pressure for 1 month averaged 70 pounds, yield 370,000 cu. ft. per day		387
Light grey sandstone (gas still flowing)	387	400
14 inch pipe driven to		421
In same sand, with gas and oil		423
This saturated sand is probably 6 ft. thick.		
Brown shale and hard shells	430	435
Salt water		435
Sandstone, shale, slate and few hard shells	435	490
At 423, the tools came up covered with oil, and every bailer brought up from one to two pints		

The following analysis of gas was also furnished by the Company:—

Sulphuretted hydrogen	0·0
Carbonic acid	0·0
Illuminates	0·1
Oxygen	0·5
Carbon monoxide	0·3
Hydrogen	8·7
Methane (marsh gas)	90·2
Nitrogen	0·2

Owner—Town of Wetaskiwin.
Authority—Geol. Survey Canada, Memoir 29-E. pp. 92-3.
Contractor—Geant.
Elevation—R.R. Station.
Location—Wetaskiwin, Alberta, Canada.

	Top *Feet*	*Bottom* *Feet*
Soil and sand		10
Blue clay	10	92
Sandstone	92	93
Blue shale	93	120
Sandstone	120	122
Blue shale	122	135
Sandstone	135	135½
Blue shale	135½	140
Sandstone	140	140½
Blue shale	140½	163½
Sandstone	163½	165
Shale with small sandstone strata	165	276
Sandstone	276	320
Sandstone and shale strata	320	340
Shale	340	348
Sandstone	348	363
Brown shale	363	403
Sandstone	403	405
Coal	405	413
Brown shale	413	508
Sandstone	508	516
Shale and sandstone strata	516	558
Grey shale (gas)	558	585
Sandstone	585	590
Grey shale	590	740
Coal	740	744
Dark shale	744	788
Sandstone	788	794
Dark shale	794	825
Coal	825	828
Light shale	828	838
Dark shale	838	888
Very light shale	888	894
Dark shale	894	900
Light shale	900	905
Dark shale	905	937
Coal and shale strata	937	944

No. 1 well.
Owner—N. W. Gas and Oil Co., Ltd.
Authority—Geol. Sur. Can. Memoir E-29, p. 76.
Location—South end of First St., Edmonton, Alberta, Canada.

	Top *Feet*	*Bottom* *Feet*
Alluvial soil, sand and gravel		20
Sand and gravel	20	30
Through the gravel into tenacious mud and clay	30	40
Through the gravel into tenacious mud and clay	40	55
Thin film of culm	55	75
Mud (considerable gas)	75	85
3-ft. seam of lignite	85	100
Mud	100	120
Hardpan clay, slate wall	120	150
Tenacious dark grey clay	150	175

	Top Feet	Bottom Feet
Hard clay and sharp sand (6′ coal)	175	200
Thin seam of coal	200	210
Dark grey slate	210	250
From 250 to 300 ft. soft blue shale with thin layers of sandstone	250	300
8-ft. of hard coal. Black slate rock and shale to 450	300	350
Black shale with sand rock to 600 ft	350	500
Formation same as above	500	675
Twenty feet of sandstone	675	720
Slate	720	730
Slight flow of brackish water	730	750
Hard slate	750	790
Flow of dry gas	790	800
Slate continues through gas area	800	840
Dark grey slate, with sharp grey sand shale	840	887
Dark shale	887	900
Slate and soft clay to bottom of well at 1,150 feet	900	1000
Boulder bed from 1,125 to 1,150 feet.		

Product—Gas.
No. 2 well.
Owner—N. W. Gas and Oil Co., Ltd.
Authority—Geol. Survey Canada, Memoir E-29, p. 76.
Location—North side of Jasper Avenue, Edmonton, Alberta, Canada.

	Top Feet	Bottom Feet
Through alluvial soil for 16 ft., then sand and gravel to 35 ft. and soft clay to a depth of 50 feet.		
Soft clay and shale continue		50
12-inch seam coal, slate formation, 5′ gravel	50	90
Slate and shale	90	125
Slate and shale continue to 215 feet	125	150
Coal, 8-feet thick	150	215
Black slate and shale from 223 to 260 ft	215	230
9-foot seam hard coal		
Black rock 10 feet thick	230	260
Grey sand and shale continuing for 30 feet	260	270
Black slate rock and clay in alternate layers to 400′	270	300
Black grey shale and sand	300	400
Brown sand with layers of black slate for 30 feet	400	435
Black slate and shale continue	435	465
Black slate and shale of varying degrees of hardness from 470 to 560 feet	465	500
Formation changed for soft grey sand followed by seam of grey slate 10 ft. thick. Grey sand and slate alternating to 610 feet	500	560
Small flow gas struck in dark, soft slate formation which continued to 700 feet	560	630
Dark shale to 790 feet	630	750
Formation continues the same	750	810
Formation continues dark slate and shale. Small flow brackish water	810	850
Small flow gas from 910 to 940 feet	850	910
Very soft, dark shale to 1000 feet	910	940
Soft clay, or shale alternating with thin layers of rock	940	1020
Hard rock to 1,118 feet	1020	1080
Soft, dark rock and shale to 1,160 feet	1080	1118
Dark grey sand rock reached, of the nature of a boulder bed	1118	1160
Boulder bed apparently ended and a soft, blue shale was entered	1160	1189
Second boulder bed of 5 feet followed by hard, blue sand rock for about 12 feet	1189	1196
Soft shale from 1208 to 1243 feet	1196	1213
Five feet of dark grey sand yielding a small quantity of oil, salt water and gas. Soft grey shale, with layers of dark grey sand continued to 1,306 feet	1213	1243
From 1,306 to 1,358 very little change in formation	1243	1306
Dark shale with frequent layers of coal and sand down to 1,412 feet	1306	1358

This well was continued to a depth of about 1,800 feet but the log is not available.

Product—Water.
No. 2 well.
Owner—Town of Camrose.
Elevation—2400.
June, 1911.
Drillers—Maxwell and Mackenzie.
Location—Camrose.

	Top Feet	*Bottom Feet*
Clay		12
Quicksand	12	39
Shale	39	69
Sandstone	69	99
Black shale	99	111
Sandstone	111	121
Water		121
Coal	121	125
Water		125
Shale	125	130

Product—Water.
Authority—Maxwell.
June, 1911.
Elevation—2400.
Drillers—Maxwell and Mackenzie.
Location—Camrose.

	Top Feet	*Bottom Feet*
Clay		60
Shale	60	70
Sandstone	70	100
Coal	104	104
Little water		104
Black shale	104	154
Sandstone	154	164
Water		164
Shale	164	195
Sand	195	205
Shale	205	245
Sandstone	245	255
Shale	255	265
Coal with black shale	265	275
Water		275
Shale	275	278

Product—Water.
Owner—Camrose city.
Authority—Maxwell.
Contractors—Maxwell and Mackenzie.
July, 1912.
Elevation—2400.
Location—At power house east of Camrose, Alberta, Canada.

	Top Feet	*Bottom Feet*
Clay	12	
Sand	27	
Clay	30	
Sandstone	30	
Little water		
Sand	8	
Blue shale	12	
Coal	10	
Clay with water to the bottom of the hole	129	

Owner—California-Alberta Oil Co. (King).
Sec. Morinville.
Authority—Mr. Tait.
July 5, 1910.
Location—Alberta, Canada.
Outfit bought by Nakanum outfit.

	Top Feet	Bottom Feet
First 50' loam and sand with pyrites		
Brown shale and slate	50	70
Gravel, coarse—water	70	75
Water and 18" to 22" coal	75	80
Brown shale, black slate, pyrites and dark sandstone	80	160
Shale, slate, thin veins coal	160	260
Sandstone and water	260	270
Brown shale and dark grey sandstone	270	300
First gas, pungent (sulphur)	300	320
Shale, little gas and oil		
Green soapstone shale	340	360
Second sandstone in gas of petroleum odor		360
Still gas, little oil in bailer, gathered 3 bottles		375
Two days' drilling through hard slate shell		380
(Oct. 5, 1910) pungent gas, heavy flow 70, 370,624 cu. ft day		387
Light green sandstone, gas still flowing, having burned from top derrick and under boiler	387	400
14-inch pipe to this point		421
Sand with gas, oil on tools and one or two pints in bailer. Sand saturated about 6' thick		
Brown shale and hard shells at 435, big salt water 1¼% solid salt. Filled up 200-250' in hole	430	435
Sandstone shale and slate and few hard shells to 490'	435	463
421' casing in hole	435	490
Pulled up casing to 480' to light gas		
Casing collapsed. Hole caved and abandoned.		

Authority—Geol. Sur. Canada, Memoir 29-E, p. 69.
Elevation—1660.
Location—Athabaska, Alberta, Canada.

	Top Feet	Bottom Feet
Yellowish sandstones, thin beds, with some ironstone, Foxhill or Laramie	0	15
Grey and blackish shales, often very soft, with occasional thin, hard layers of sandstone or ironstone. Much gas at different levels between 245 feet and 780 feet, LaBiche shales	15	1270
Grey sandstone, with a flow of soft water; Pelican sandstone	1270	1310
Dark shales, often soft, a little sandstone; Pelican shales	1310	1413
Grey sandstones and grey reddish and blackish shales, the sandstone sometimes very hard and probably nodular, as in outcrop at Grand Rapids. Grand Rapids sandstone	1413	1641
Dark and light-grey shales, generally hard, with some sandstone layers, particularly towards the base. Clear-water shales	1641	1950

Owner—Western Oil and Coal Company.
Sec. SE ¼ 27-6-30 West 4th Meridian.
Authority—Geol. Sur. Canada, Memoir 29-E, p. 88, 1907.
Location—Pincher Creek, Alberta, Canada.
No record given.

Product—Gas.
Col. Jas. Walker farm, No. 2 Well.
Owner—Calgary Natural Gas Co.
Authority—Geol. Sur. Canada, Memoir 29-E, p. 74-4.
Location—East Calgary near the Bow river, Alberta, Canada.

	Top Feet	Bottom Feet
Surface deposits, gravel and boulders		54
Sandstone	54	74
Soft shale, blue	74	111
Sandstone, hard and fine	111	119
Soft shale, white	119	126
Lime crystal, quartzite	126	137
Soft shale	137	143
Slate, white	143	145
Shell, sand, hard	145	147

	Top *Feet*	*Bottom* *Feet*
Shale, white	147	151
Shell, sand	151	152
Slate, white, hard	152	158
Shell, lime, hard	158	160
Slate, white, soft	160	178
Shell, sand	178	180
Shale, blue, soft	180	215
Sand	215	228
Slate, soft	228	252
Sand, grey, hard and soft alternating	252	268
Slate, white	268	275
Sand	275	280
Slate, soft	280	290
Slate, grained	290	300
Sand, grey, hard	300	335
Slate, soft	335	340
Sand, hard	340	352
Slate, dark grained lignite	352	360
Sand, grey, hard, with pebble culm	360	430
Slate, soft	430	432
Sand, grey	432	450
Slate, grey and black carrying traces of coal	450	507
Sand, medium, hard	507	512
Slate, black	512	515
Sand, black	515	530
Slate, hard, brown	530	550
Slate, white	550	575
Sand, grey, fine	575	585
Slate, white	585	590
Sand, grey	590	596
Slate, soft	596	597
Sand, hard	597	610
Sand, grey, soft	610	637
Sand, grey, sharp	637	648
Slate	648	660
Sand and slate in alternating layers 10-12′	660	738
Slate	738	773
Sand, grey, soft	773	792
Slate, dark, soft	792	801
Sand, dark, grey	801	838
Slate	838	843
Shale, sand with pebble conglomerate	843	858
Slate	858	862
Sand	862	875
Sand, blue, hard	875	918
Slate	918	928
Sand	928	954
Slate	954	956
Sand	956	963
Slate, black, grained	963	993
Sand, blue, hard	993	1013
Slate	1013	1025
Sand, blue, hard	1025	1088
Slate	1088	1130
Sand, grey, dark	1130	1144
Slate	1144	1147
Sand, grey	1147	1181
Slate	1181	1183
Sand, dark grey, sharp	1183	1232
Slate	1232	1236
Sand, grey, fine, hard	1236	1243
Shale	1243	1285
Sand, fine, dark blue turning grey	1285	1388
Shale, hard, grey turning to soft and black, then brown	1388	1468
Sand	1468	1473
Shale, brown	1473	1488
Slate, white	1488	1562
Limestone	1562	1598
Sand, grey, sharp	1598	1673
Slate, white turning brown	1673	1766
Sand, dark, grey, fine	1766	1821
Slate, grey	1821	1873
Shale, brown	1873	1898
Coal	1898	1911
Sand, dark grey	1911	1953

	Top Feet	Bottom Feet
Shale, black, grained	1953	1970
Sand, hard, fine	1970	1985
Shale, brown	1985	1991
Sand, black, hard	1991	2065
Shale, brown	2065	2075
Shell, sand	2075	2078
Shale, brown	2078	2086
Shell, sand	2086	2090
Shale, brown	2090	2122
Sand, dark grey	2122	2142
Shale, brown	2142	2155
Shell, very hard and flinty	2155	2157
Shale, brown	2157	2167
Sand, grey	2167	2172
Shale, brown	2172	2179
Shell, sand	2179	2181
Shale, brown	2181	2192
Shell, hard	2192	2197
Sand, brown	2197	2202
Shale, sandy brown with culm or bitumen	2202	2242
Slate, white and sand shells with pebble	2242	2252
Sand, light grey, then dark grey, hard and soft with pebble at bottom	2252	2362
Shale, brown	2362	2374
Shell, hard, brown	2374	2378
Coal—semi-bituminous	2378	2379
Shale, sandy	2379	2388
Shale, brown	2388	2394
Sand slate, black and shaly, calcareous matter with sand and dark brown pebble	2394	2410
Sand with white quartz crystals	2410	2418
Sand, grey, hard pebble, trace of culm	2418	2421
Shale, sandy, with shells of bitumen	2421	2452
Gypsum, calcareous	2452	2454
Shale, sandy	2454	2458
Shale, dark and soapy	2458	2483
Slate, black with sand shells	2483	2488
Slate, black, flaky with bituminous coal seams	2488	2502
Shale, hard and flint like	2502	2508
Shell, black and flaky	2508	2512
Slate, shaly	2512	2524
Shell, flinty, hard	2524	2528
Slate, shaly	2528	2533
Shell, sandy	2533	2535
Slate, shaly	2535	2544
Shell, hard and gritty	2544	2547
Slate, shale	2547	2554
Shell, sandy	2554	2558
Slate, shaly	2558	2560
Coal	2560	2565
Shale, sandy culm	2565	2569
Shell, sandy	2569	2572
Shell, sandy, pebbled	2572	2578
Sand, with streaks of shale and little gas	2578	2610
Shale, black and sandy	2610	2623
Shell, sand	2623	2636
Shale, black with some coal	2626	2636
Sand, shale, coal showing	2636	2644
Sand, black and white with pebble	2644	2656
Coal shale or culm	2656	2658
Coal seam	2658	2665
Shale, sandy	2665	2666
Sand, coarse then fine	2666	2682
Slate	2682	2683
Sand, grey, then darker	2683	2702
Shale, black and sandy	2702	2719
Shell, sand	2719	2721
Shale, black, sandy	2721	2739
Sand, black and hard	2739	2742
Sand, with shale	2742	2752
Sand, fine, black, very hard	2752	2761
Sand, coarse, gas sand	2761	2772
Coal, with tarry-like sand just above it	2772	2776
Shell sand, blue, hard	2776	2779
Slate, black	2779	2794
Soapstone	2794	2795

	Top Feet	Bottom Feet
Sand, coarse, grey	2795	2800
Coal, bituminous	2800	2801
Slate, sandy	2801	2810
Shale, brown	2810	2819
Sand, coarse, grey	2819	2834
Coal, bituminous	2834	2837
Slate, dark brown	2837	2845
Shell, sand	2845	2848
Shale, dark brown, soft	2848	2868
Coal, bituminous	2868	2872
Slate, shale with soapstone	2872	2878
Sand, coarse and grey	2878	2897
Slate, black	2897	2898
Sand, hard, black	2898	2904
Coal, bituminous	2904	2907
Slate, shale, hard	2907	2949
Coal, bituminous	2949	2952
Shale, slate and coal	2952	2967
Total depth of well		3414
Bottom of Edmonton series about		1953
Top of Belly River series about		2454

Analysis of gas.

	Per Cent.
Carbon dioxide	0-0
Oxygen	0-1
Heavy hydrocarbons	1-80
Hydrocarbons of marsh gas series	86-70
Hydrogen	5-40
Nitrogen	6-00
	100-00

CHAPTER X

BRITISH COLUMBIA

GEOLOGY[1]

Stratigraphy

The North American Cordillera, otherwise known as the Pacific Mountain system of North America, borders the whole western side of the continent. This mountain belt, where it traverses Canada, occupies nearly the whole of British Columbia and of Yukon in western Canada. Where it crosses the International Boundary the belt has a width of about 435 miles. While the general geology of this belt, within the boundaries of this province, is well known, much detailed work yet remains to be done. The southern portion of the province, within the railway belt and along the International Boundary, has been studied in greater detail than has been possible elsewhere.

The geological history of the North American Cordillera can be clearly expressed with reference to two large geosynclinals; the eastern or Rocky Mountain geosynclinal and a western or Pacific geosynclinal. It can also be shown that previous to the Mesozoic these two geosynclinals, as regards their relative periods of deposition and erosion, bore reciprocal relations to each other.

The Rocky Mountain geosynclinal lies between the Great Plains and the Purcell trench. It embraces sediments from the base of the Belt (pre-Olenellus) terrane up to and including the Mississippian and is composed of a single group of conformable strata varying in composition and texture according to relative proximity to the ancient shore lines which border such basins of sedimentation. The four type sections which illustrate this principle from east to west are the Lewis, Galtin, Purcell, and Summit series which have an average thickness of about 20,000 feet.

[1]This sketch of the Geology of British Columbia is based on the articles in Guide Books No. 8, Part II, No. 8, Part III, and No. 9, International Geological Congress, 1913. The authors quoted are Daly, Allan, Clapp, Schofield, Leach, LeRoy, Camsell, and Drysdale. In some cases extracts from these guide books have been used without further acknowledgment. The description of the areal distribution of the formations is based on the Geological Map of Canada, issued by the Geological Survey, 1913 edition. For a more complete discussion of the Geology of Southern British Columbia the reader is referred to Geological Survey Memoir No. 38, North American Cordillera, Forty-Ninth Parallel, by Dr. R A. Daly. *Compilation by A. W. G. Wilson.*

During the Triassic, Jurassic and Cretaceous, sedimentation was continuous in the middle and eastern part of the Rocky Mountain geosyncline with a probable increase in the area of sedimentation of at least the Cretaceous beyond the Rocky Mountain geosyncline proper. This period of sedimentation was brought to a close by the Laramide Revolution (Eocene), whose effects are seen in the folding and overthrust faulting so characteristic of the structure of the Rocky Mountain system. Since that time, this belt has been subject to denudation, the detritus of which is seen in the Tertiary and superficial deposits of the piedmont belt of the Great Plains.

Passing to the western or Pacific geosynclinal, which lies between the Purcell trench and the Pacific ocean, the earliest record is the important Pre-Cambrian (Archæan) sedimentation leading to the formation of the Shuswap limestones, schists and gneisses, the latter at least partly of igneous origin. From this time until the Mississippian period, the western geosyncline was an area of erosion which supplied the material for the formation of the Rocky Mountain geosynclinal. At or near the close of the Mississippian, the western geosyncline area was submerged and received a great load of Pennsylvanian sediments and accompanying lava floods. The record for the Jurassic is meagre, indicating that an upheaval of the Triassic sea bottom had begun as an early preparation for the Jurassic revolution. This was closely followed by the intrusion of many large batholiths of granodiorite and related rocks. Erosion of these Jurassic mountains produced the material for the smaller Cretaceous geosynclinals at various points in the Main Pacific geosynclinal. Orogenic movements, called the Laramide revolution, and batholithic intrusion followed.

During the Tertiary, erosion was dominant in this belt with accompanying deposition in isolated basins. Sedimentation was interrupted by local folding in late Miocene and Oligocene. Vulcanism was prevalent throughout the Tertiary while batholithic was confined to the Miocene[1].

The following section across the Cordillera has been prepared by R. A. Daly:—

[1]S. J. Schofield, in Guide Book No. 9, pp. 19-20.

Table of Cordilleran Formations.

System.	*Formation.*	*Thickness.*	
		Feet.	*Metres.*
Recent and Pleistocene	Fluviatile, lacustrine, glacial...		
	Unconformity.		
Oligocene (?)	Kamloops volcanic group.....	3,000+	914+
	Tranquille beds (largely tuffs).	1,000	305
	Unconformity.		
Eocene..............	Coldwater group (conglomerate, sandstone, etc.) of interior....................	5,000	1,524
	Puget group of coast		
	Rhyolite porphyry at Ashcroft		
	Unconformity.		
Lower Cretaceous.... (Comanchean)	Jackass Mountain group and Queen Charlotte Islands group (sandstones, shales, conglomerates) of the west		
	Upper Ribboned sandstone....	550	168
	Kootenay Coal Measures of Rocky Mts...............	2,800	853
	Lower Ribboned sandstone...	1,000	305
	Spence's Bridge volcanic group		
Jurassic..............	Fernie shale of Rocky Mts.....	1,500	457
	Upper part of Nicola group (interior)................		
Triassic..............	Lower part of Nicola group (basic volcanics with limestone.....................	10,000 ∓	3,048 ∓
	Boston Bar group of coast range (Triassic ?)...........		
	Unconformity with Pennsylvanian.		
Permian............	Upper Banff shale............	1,400	427

System.	Formation.	Thickness Feet.	Thickness Metres.
Pennsylvanian...	Rocky Mountain quartzite (thickness, 244m.)..... Rocky Mts.		
	Upper Banff limestone (thickness, 701m.)........................		
	Cache Creek group of the Western Belt (quartzite, limestone, basic volcanics).....................	9,500	2,896
Mississippian....	Lower Banff shale................	1,200	366
	Lower Banff limestone (partly Devonian........................	1,500	457
Devonian.......	Intermediate limestone............	1,800	548
	Sawback limestone (Devonian) (thickness, 1,128m.).............		
Silurian.........	Halysites beds....................	1,850	563
Ordovician.....	Graptolite shale..................	1,700	518
	Goodsir shale.....................	6,040	1,841
Upper Cambrian	Ottertail limestone...............	1,725	526
	Chancellor shales.................	4,500	1,372
	Sherbrooke limestones.............	1,375	419
	Paget limestones..................	360	110
	Bosworth limestones...............	1,855	565
MiddleCambrian	Eldon limestones..................	2,728	831
	Stephen limestone-shale...........	640	196
	Cathedral limestones..............	1,595	486
Lower Cambrian	Mt. White sandstone shale.. (Rocky Mts.)		
	St. Piran quartzite......... (Rocky Mts.)		
	Lake Louise shale.......... (Rocky Mts.)		
	Fairview sandstone......... (Selkirk Mts.)		
	Sir Donald quartzite........ (Selkirk Mts.)	5,000	1,524
	Ross quartzite, upper part, (Selkirk Mts.)	2,750	838
	Conformity in Selkirk Mts.; local unconformity in Rocky Mts.		

System.	Formation.	Thickness	
		Feet.	Metres.
Beltian	Ross quartzite (lower part)	2,500	762
	Nakimu limestone	350	107
	Cougar quartzites	10,800	3,292
	Laurie metargillites	15,000	4,572
	Illecillewaet quartzite	1,500	457
	Moose metargillite	2,150	655
	Limestone	170	52
	Basal quartzite	280	85
	Unconformity.		
Pre-Beltian (Shuswap series)	Adams Lake greenstones	10,000	3,048
	Tshinakin limestone-metargillite	3,900	1,188
	Bastion schists (phyllites, etc.)	6,500	1,981
	Sicamous limestone	3,200	975
	Salmon Arm mica schists	1,800	548
	Chase quartzite	3,000	914
	Tonkawatla para-gneiss(?)	1,500	457
	Base concealed.		
	Total thickness (minimum)	135,018	41,150

With this section by Daly may be compared the sections that have been measured across portions of southern British Columbia in the vicinity of the Crow's Nest Pass line of the Canadian Pacific railway.

The following section is given by Leach for southern British Columbia, west of the Crowsnest Pass[1]:—

Name of Formation.	*Age.*	*Description.*
Flathead beds............	Cretaceous......	Sandy shales and shaly sandstones.
Elk Conglomerates, including Flathead beds, 6,500 ft. (1981 m.)............	Cretaceous......	Conglomerates, sandstones and some semi-cannel coal seams.
Kootenay, 1,847 ft. (562·9 m.)..................	Cretaceous......	Sandstones, shales and coal seams.
Fernie, 3,000 ft. (914·3 m.)..	Jurassic.........	Shales, calcareous towards base.
Limestone series, 4,000 ft. (1,219 m.)................	Devono-Carboniferous.........	Massive, light grey limestone.
	Cambrian........	Siliceous argillites.

Proceeding farther west, the following section is given by Schofield for the Purcell range, between Elko and Kootenay lake[2]:—

Pleistocene and Recent..............................		Unconsolidated gravels and sands.
	Unconformity.	
Jurassic?..............................		Dike intrusion: aplites, lamprophyrs and porphyritic granite.
	Kootenay granite.......	Granite and porphyritic granite
Mississippian ..	Wardner limestone......	Grey limestone. Thickness 1,000 +ft. (305+m.)
Devonian..............................		Limestone and shale. Thickness 500+ft. (150+m.).

[1]Guide Book No. 9, p. 24.
[2]Guide Book No. 9, p. 47.

Cambrian ?	Roosville formation	Green siliceous argillites. Thickness 600 ft. (183 m.) (Daly).
	Phillips formation	Purplish-red and green siliceous argillites and sandstones. Thickness 550 ft. (167 m.) (Daly).
	Gateway formation	Light grey quartzites, siliceous dolomites and limestone. Thickness 2,025 ft. (617 m.) (Daly).
	Purcell lava	Amygdaloidal basalt. Thickness 300 ft. (91m.).
	Siyeh formation	Thin-bedded green and purple mud cracked shales; some limestone. Thickness 4,000 ft. (1,220 m.). (Daly).
	Kitchener formation	Thin-bedded dark grey argillaceous quartzites and limestones. Thickness 4,500 ft. (1,372 m.).
Pre-Cambrian.	Creston formation	Light grey argillaceous quartzite and purer quartzites. Thickness 5,000 ft. (1,525 m.).
	Aldridge formation	Rusty weathering heavy and thin-bedded argillaceous quartzites and slates. Numerous sills of gabbro at various horizons. Thickness 6,000+ft. (1,830+ m.)[1]

For West Kootenay LeRoy gives the section as follows:—

Quaternary	Glacial and recent.	
Tertiary	Miocene	Midway volcanic group.
	Oligocene	Kettle river formation, Rossland alkali granite and syenite, Valhalla granite.
Mesozoic	Jurassic ?	Nelson batholith. (Rocks range from granite to gabbro). Monzonite.

[1]Guide Book No. 9, p. 62.

Palæozoic	Carboniferous and Post-Carboniferous	Rossland group. Rocks largely of igneous origin. It includes the Brooklyn and Rawhide formations and the Knob Hill group at Phoenix; the Mount Roberts formation and the augite porphyrite series at Rossland.
	Carboniferous(?)	Pend d'Oreille group. (Metamorphosed sediments in great part). Slocan series. (Slates, argillaceous limestones and quartzites).
	Cambrian (?)	Selkirk series.
Pre-Cambrian		Shuswap series. (Schists, orthogneisses, etc.).

The preceding sections will serve to give the reader a general idea of the geological horizons that are known to occur in British Columbia. In the following notes some further details with respect to individual horizons are added and these are supplemented by a general description of the areal distribution of the formations named.

Archæan.—The crystalline basement in British Columbia as elsewhere is a complex series of metamorphic rocks. In the southern part of the province it consists of a very thick conformable bedded group, called the *Shuswap* series, and a younger group of granite intrusives. These occur in the Selkirk mountains in the central part of the province. The better known section is crossed by the Canadian Pacific railway between Bear Creek station and Stormont siding, having a lineal width of about 85 miles. The Archæan area extends south almost to the International Boundary and north to the vicinity of Quesnel Forks and Mount Robson, where it passes beneath undifferentiated Palæozoic strata. Northwest of this a somewhat smaller area outcrops along the Finlay river in the vicinity of Fort Graham.

Unconformably overlying the Shuswap terrane in the Selkirk mountains is a vast thickness of conformable unfossiliferous sediments, for which, as a whole, the name *Selkirk series* has been adopted. The lower and greater portion of these beds is of Pre-Cambrian age; the uppermost beds, as exposed in the railway section, are referred, on stratigraphic evidence, to the Lower Cambrian. The group is clearly the northern continuation of the Belt series of Montana and Idaho. Walcott has applied the name *Beltian* as a systematic designation for this series. The rocks of the series include quartzites, limestones and metargillites. The Geological Survey map shows these rocks lying in two bands, one on either side of the area of Archæan rocks in the southern part of the province. The eastern belt is much the larger, extending from the International Boundary to north of Mount Robson, and having a width of over 100 miles at the boundary, but narrowing northward.

Palæozoic formations.—The Geological Survey maps as unclassified Palæozoic a large belt of country, traversing eastern British Columbia and Yukon, and including the Rocky Mountain region. This area at its southern end occupies only a narrow portion of the province, being about 70 miles in width where crossed by the main line of the Canadian Pacific railway. Farther north at the Yukon boundary, latitude 60°N., it extends nearly across the province, having a width of approximately 250 miles. In north-central British Columbia, between latitudes 54° 30′ N. and 58° N., a considerable area of Mesozoic rocks, chiefly Cretaceous, intervenes in such a way as to separate a narrow western belt of Palæozoic rocks from the main area on the east. The eastern portion here flanks the Archæan areas about the Finlay river on both sides, and has a total width of about 110 miles. The intervening strip of Mesozoic strata varies in width from 50 to 90 miles, and the Palæozoic spur varies in width from 20 to 50 miles. This western limb lies only a short distance from the Pacific coast, and extends from the Stikine to the Skeena river.

This large area is known to contain Palæozoic formations ranging in age from the Cambrian to the Upper Carboniferous, but only in a few localities, especially in the vicinity of the transcontinental railways, have they been studied in sufficient detail to be differentiated locally into the various Palæozoic horizons. Daly's section, given on a previous page, indicates the horizons that have been identified along the Canadian Pacific railway belt, and gives estimates of the thickness of the different formations.

The Survey also maps as Palæozoic a belt of highly metamorphic rocks which occur along the Pacific Coast, and which underlies the greater portion of Vancouver island and the Queen Charlotte islands and some of the smaller islands adjacent. Clapp[1] describes Vancouver island as being composed of deep formed metamorphic volcanic and sedimentary rock, intruded and replaced by numerous irregular bodies of granitic rocks and fringed along both coasts with fragmental sediments, which rest unconformably upon the metamorphic and granitic rocks. He states further that these metamorphic rocks are largely of lower Mesozoic age, presumably Upper Triassic and Lower Jurassic, but they may include some Palæozoic members. Apparently the oldest rocks, considered provisionally as of late Palæozoic (Carboniferous) age, are a series of slates and quartzose schists, with some fragmental volcanic members. This series extends across the southern end of the island and is called the Leech River formation.

In the railway section we find the following formations:—

Lower Cambrian.—Represented by thick quartzites, quartzitic sandstones, and some shales.

Middle Cambrian.—Represented by certain limestone beds.

Upper Cambrian.—Represented by limestones and including a thick deposit of shales. Dr. J. A. Allan[2] states that there is a total thickness of over 18,578 feet, which represents one of the thickest Cambrian sections yet measured in the world. It essentially consists of 3,800 feet of siliceous beds, principally quartzitic sandstone, 10,275 feet of calcareous and dolomitic limestone, and 4,500 feet of shale much of which is calcareous.

Ordovician.—Dr. Allan[3] estimates the thickness of this formation at over 6,040 feet. The basal portion of the formation consists of alternating hard and soft bands of argillaceous, calcareous, and siliceous shale, which weather light yellowish,

[1]Chas. H. Clapp, Guide Book No. 8, Pt. III, p. 281.
[2]International Congress Guide Book 1913, No. 8, Part II, p. 174.
[3]*Op. cit.* p. 179.

grey and buff. The upper part of the formation consists of banded cherts, cherty limestone and dolomites, thin bedded and very dense, so that they weather into compact angular fragments.

Silurian.—This formation conformably overlies the highest beds assigned to the Ordovician. It consists chiefly of dolomitic (Halysites beds) and white quartzite. The total thickness where measured is 1,850 feet, the white quartzite being 900 feet in thickness.

Devonian.—A formation, consisting of thin-bedded limestones, alternating with harder layers of grey dolomitic and siliceous limestones, has been identified as of Devonian age. This limestone formation is known as the *Intermediate limestone* and has an estimated thickness of 1,800 feet. Some of the beds are highly fossiliferous.

Conformably underlying the Intermediate limestone is a series of massive and thin-bedded dolomitic limestones and shales. It has been possible to measure and estimate a thickness of about 3,700 feet, but the actual thickness is believed to be much greater. McConnell placed this limestone series provisionally in the Cambrian. Fossils have not yet been found in the series. Since it differs lithologically from the recognized Cambrian beds in adjacent localities the age of the formation is still in doubt, but it is older than the Intermediate limestone which is definitely known to be Devonian. This series is named the *Sawback* formation. The beds are lithologically closely related to some of the Silurian beds in the Beaverfoot range to the west.

Recent investigations by Dr. Shimer show that at least the lower part of the Banff limestone, to which reference is made below, are also to be assigned to the Devonian.

Carboniferous—Mississippian formations.—The formations formerly mapped as Carboniferous in the Canadian Rocky Mountain section have recently been shown by Shimer to be partly Mississippian and partly Pennsylvanian[1]. The Mississippian is represented in part by the *Lower Banff limestone,* having a total thickness of 1,500 feet, and the

[1]H. W. Shimer, Summary Report, Geol. Surv., Can., 1910, p. 147.

overlying *Lower Banff shale*, having a total thickness of 1,200 feet. The *Lower Banff limestone* grades into the Devonian limestone below so that it is not possible always to draw a sharp dividing line between these two formations. As noted above, Dr. Shimer, on the basis of fossils recently collected from this limestone, has concluded that the lower part, and possibly the whole, is to be classed as Devonian rather than Mississippian. The *Lower Banff shales* are black to dark grey in colour, and weather brown. They are usually calcareous in composition, but certain layers are argillaceous and arenaceous.

Carboniferous—Pennsylvanian formations.—The Pennsylvanian, as represented in the Rocky Mountain section, consists of two formations, the *Upper Banff limestone* (about 2,300 feet) and the *Rocky Mountain quartzite* (varies in thickness from 800 to 1,600 feet). The limestone series is shaly at the bottom, but more massive towards the top. Cherty lenses and cherty shale interbedded with the lower shaly limestone help to distinguish this formation from the shales below. The quartzite formation lies directly on the Upper Banff limestone.

Permian formations.—Conformably overlying the *Rocky Mountain quartzite* is a formation classed as Permian and named the *Upper Banff shale*. This formation consists of a series of brown, calcareous and arenaceous, often sun-cracked shales, interbedded with thin layers of sandstone. More than 1,400 feet are represented in the section.

Mesozoic formations.—The geological map of Canada shows the Mesozoic of Western Canada distributed in three distinct areas. The character of the mid-continental area, which finds its greatest development in Alberta, has already been discussed. This area crosses the British Columbia boundary near the southwest corner of the province where both Jurassic and Cretaceous strata have been recognized. There is also a very considerable development of this series in the northeastern part of the province, north of latitude 54° 30′ N., and west of the 120th meridian. The territory about the headwaters of the Peace and Fort Nelson rivers, and bordering a portion of the Liard river is known to be underlain by the Mesozoic sediments, which, however, have only partially been differentiated into their respective horizons.

A long narrow belt of Mesozoic sediments occupies the central portion of British Columbia, extending northward from the International Boundary with slight interruptions to about latitude 58° N. It appears to reach its greatest development north of latitude 54° N. South of this it is more or less interrupted by Tertiary effusives which cover a very considerable area in the central part of the province. The horizons represented are either Jurassic or Lower Cretaceous.

A third belt of Mesozoic strata has been developed along the Pacific coast, and underlies Vancouver island and the Queen Charlotte islands. "Lower Mesozoic rocks comprise the larger part of Vancouver Island, and constitute the Vancouver group. They consist chiefly of metamorphosed basic volcanics, principally meta-andesites, the Vancouver volcanics. Certain schistose and more salic volcanic rocks are apparently interbedded with Leech River formation, but the typical meta-andesites, although separated from the Leech River formation largely by faults, are apparently younger and unconformable. Associated with the Vancouver meta-andesite and occurring chiefly in small intercalated lentils, is a formation of limestones called the *Sutton* formation. Besides the limestones, there is associated with the meta-volcanics a series of stratified slaty and cherty rocks, the *Sicker* series, composed partly of volcanic material. These rocks and their associated volcanics have been greatly metamorphosed and converted into schists."

"All of the above mentioned rocks are included and partly replaced by batholithic and dike rocks. The batholithic rocks are chiefly granodiorite with marginal facies of diorite, but in the southeastern part of the island there is a large batholith of gabbro-diorite and quartz-diorite gneisses. All of the batholithic rocks are closely related and appear to have been irrupted during the same period of intrusion."

Triassic-Jurassic.—In southeastern British Columbia, underlying the productive coal measures, is a series of black and dark brown, siliceous, very thinly laminated shales which break up into small fragments on the weathered surfaces. These shales, which are well developed in the Crowsnest Pass area, are of Jurassic age and are called the *Fernie* shales. They have a thickness of about 3,000 feet. Similar shales occur west of Banff, lying above the *Upper Banff* shale, and no sharp line can be drawn between the two formations except where fossils are found. It is altogether probable that similar deposits occur farther northwest along the line of the Rocky mountains. McConnell has reported Triassic rocks from Peace River pass, and similar rocks occur at the great bend of the Dease river in northern British Columbia, and at the Rapids of the Drowned at Hell Gate on the Liard river.

In central British Columbia along the Thompson river valley Drysdale places the Triassic-Jurassic section at 10,000 feet[1]. The rocks consist of various greenstones intercalated with beds of argillite and limestone, some of which contain fossils which place the series in the Triassic, grading up into Lower Jurassic. These rocks constitute the *Nicola* formation.

In the same district there are a number of granitic intrusives, occurring as batholiths, stocks and tongues, which are referred to the Upper Jurassic.

Still farther southwest along the Thompson valley are a group of about 5,000 feet of acidic and intermediate lavas and tuffs called the *Spence's Bridge Volcanic* group. Recently obtained evidence places this group in the late Jurassic or Lower Cretaceous.

Similar Triassic-Jurassic rocks probably occur both southeast and northwest of the Thompson river section along a line approximately parallel to the Coast Range. Gwillim[2] mentions the occurrence of sandstones and conglomerates in the vicinity of Atlin lake, some of the beds of which contained Jurassic fossils.

Cretaceous.—Along the main line of the Canadian Pacific railway the Cretaceous is represented by three formations as follows: *the Lower Ribbon sandstone*, consisting of alternating bands of brown weathering sandstone and shale, having a thickness of about 1000 feet; the *Kootenay Coal Measures*, consisting

[1]Guide Book No. 8, Part II, pp. 239-240.
[2]J. C. Gwillim, The Atlin Mining District, British Columbia, Geol. Survey, New Series, Vol. XII, part B, 1899, pp. 24-26.

of over 2,800 feet of sandstone and shale, enclosing several workable seams of coal. There are fourteen seams exposed at Bankhead, where mining operations are now in progress, and nearly twice as many are reported in the vicinity of Canmore. The coal measures are well defined between two massive sandstone bands. The coal measures are followed by the *Upper Ribbon sandstone*. It comprises thin-bedded sandstone and shales. Near Cascade mountain this formation has a thickness of about 550 feet but exposures both northwest and southeast of this section show greater thickness. The railway section does not give the full thickness of the formation, which Dawson places at about 11,000 feet.

In the Crowsnest Pass area the Cretaceous section is as follows: *Kootenay sandstones* including some shales and coal measures, 1,847 feet; *Elk conglomerate* including conglomerate, sandstone and some semi-cannel coal seams; and the *Flathead beds* consisting of sandy shale and shaly sandstone[1]. The Elk conglomerate and the Flathead beds have a total thickness of about 6,500 feet.

Cretaceous shales and sandstones have been reported from the Liard river valley by McConnell. Similar rocks have been found at a number of other localities along the line of the Rocky mountains between this area and the International Boundary. The Cretaceous rocks throughout this mountain belt have been more or less folded and faulted in common with the other formations which occur in this region.

Small inliers of *Lower Cretaceous* strata have been recognized in the Cordilleran section along the railway belt in the vicinity of Ashcroft and near the Fraser valley north and south of Lytton. Dr. Drysdale estimates the minimum thickness of the Ashcroft remnant at 5,000 feet, while Dawson places the Fraser valley Cretaceous between 7,000 and 10,000 feet. A still greater remnant of Lower Cretaceous strata has been mapped by Daly at the 49th parallel section under the name *Pasayten series*, the Cretaceous members of which have a thickness of about 22,500 feet. The deposits in the Fraser valley near Ashcroft and Lytton consist of carbonaceous shales, sandstones

[1]W. W. Leach, in Guide Book No. 9, International Geological Congress, p. 24.

and conglomerates, occupying local synclinoria striking north and south. They are correlated on lithological grounds with the Queen Charlotte Islands formation of the Pacific coast.

Farther north in the vicinity of Francois lake and in the country southwest of the Bulkley river a great series of volcanics occurs. The series is composed of tuffs, andesites, agglomerates and similar rocks, often occurring in sheets as volcanic flows but frequently showing evidences of deposition under water. Dawson estimates their thickness at over 10,000 feet and has classed them as Lower Cretaceous on the basis of fossils found near Francois lake[1]. Similar strata are reported by Leach from the Telkwa valley, but no fossils were discovered. Immediately overlying them, however, possibly unconformably, is a series of beds composed chiefly of clay shales and containing a number of important coal seams. In no place in the Telkwa district was this formation found to have a thickness of over 300 feet. Fossil plant remains found in the coal-bearing beds indicate that the horizon is Lower Cretaceous[2].

Still farther north about the headwaters of the Skeena, Naas, and Stikine rivers well developed coal measures covering an area over 2,000 square miles in extent are known. In one locality near the southern end of this basin, known as the Groundhog basin, 3,650 feet of strata are exposed in one section, the most important coal seams appearing near the upper and lower limits of the section. The rocks of this coal-bearing group are conformable with the underlying rocks, and both have been thrown into folds and faulted by pressure from the southwest. This group has been named the *Skeena series* and Malloch regards them as probably of Lower Cretaceous age[3].

It is interesting to note that Dr. R. A. Daly discovered fossil plant remains on the Skagit river near the International Boundary line which are similar to those found by Leach on the Telkwa. It is probable that Cretaceous strata similar to those reported from the various areas mentioned above occur at a number of localities not yet studied in detail along a belt running approximately parallel to the coast range northwest

[1]Geol. Survey Report of Progress, 1876-77, pp. 58-64.
[2]W. W. Leach, The Telkwa River and Vicinity, Geol. Survey, 1907, pp. 11-12.
[3]G. S. Malloch, Summary Report Geological Survey, 1911, pp. 72-90.

from the International Boundary and including the localities mentioned above, and other smaller areas which are now known but which have not been included in the descriptions given here.

On the Queen Charlotte islands the Lower Cretaceous is represented by two formations. The lower consists of greenish ashy sandstones, more or less arenaceous shales, and a great thickness of massive or thin-bedded sandstones with occasional layers of well rounded conglomerate and frequent zones characterized by large calcareous nodules. Overlying this is a series of agglomerates and tufaceous sandstones almost exclusively of volcanic origin. To the former Dawson assigns a thickness of about 1,000 feet and to the latter 3,500 feet[1]. These formations do not appear to be represented on Vancouver island.

In the Queen Charlotte islands the Upper Cretaceous is represented by three formations. The lower division consists of blackish and grey shales interbedded with grey and yellowish-grey sandstones and numerous layers composed of sandy argillaceous material, intermediate in character between shale and sandstone; these beds are associated with coal seams. Dawson assigns a thickness of 5,000 feet to this formation. Overlying it is a series of well rounded conglomerates interbedded with grey and yellowish sandstones, having a thickness which varies from 1,900 to over 3,000 feet. The highest beds consist of shales interstratified with sandstones, the whole formation having a thickness of not less than 1,500 feet. The total thickness assigned to the Queen Charlotte Island group is therefore about 13,000 feet.

The Upper Cretaceous is represented on Vancouver island by three somewhat similar series of rocks constituting the *Nanaimo* series. These rest unconformably upon an erosion surface of metamorphic and granitic rocks of Mesozoic age and are confined, for the greater part, to the east coast of the island. They consist of conglomerates, sandstones and shales with some coal. In general the series has been deformed into broad open folds with a northwest-southeast strike and a general northeast dip, but in places it has been closely folded, overturned

[1]Geological Survey Report of Progress, 1878-79, report B, pp. 63-71. Compare also, Report of James Richardson in Annual Report of the Geological Survey for 1872-73.

to the southwest and broken by reversed and overthrust faults. There are a number of coal mines in the vicinity of Ladysmith and Nanaimo which have been opened upon coal seams of this series[1].

The Cretaceous strata on Vancouver island are found along the east side of the island bordering the Strait of Georgia and extending north nearly to Seymour narrows. A smaller area is also preserved near the northern end of the island in the vicinity of Quatsino sound.

Tertiary formations.—Tertiary sediments do not occur to any great extent in British Columbia. Small areas are found in the southern part of the province in the vicinity of Princeton, near Nicola, near Walhachin on the main line of the Canadian Pacific railway, and on the lower Fraser river below Agassiz. Slightly larger areas occur in the vicinity of Fort George and on the Nechako river west of this. A small area has been reported in the valley of the Finlay river above Fort Graham, and another small area occurs near the Lower Post on Dease river near its junction with the Liard. They also occur on Graham island in the Queen Charlotte group.

The Tertiary sediments include the *Coldwater group* of Dawson and the *Puget group*, both developed in the valley of the Fraser river. Both formations are local and their mutual relations have not been determined. The Coldwater group is probably the younger and includes conglomerate, sandstone, shale and some coal beds. Dawson estimated the local maximum thickness of the Coldwater beds to be about 5,000 feet. The Puget beds, developed on the lower Fraser, below Agassiz, consist of sandstones, conglomerates and shales with thin coal beds. They have an observed thickness of about 3,000 feet.

A large area in central British Columbia between latitudes 50° N. and 54° N., and lying east of the Coast Range of mountains is underlain by Tertiary effusives. Several smaller areas are shown on the geological map as occurring in the northern part of the province about the headwaters of the Stikine river, north of Telegraph creek, and south of Atlin lake. The northern part of Graham island, in the Queen Charlotte group, is

[1]C. H. Clapp, Summary Report Geological Survey, 1911, p. 91.

also underlain by members of this series. The rocks consist of basalts, agglomerates, breccias, some trachytes, and tuffs. Dawson mapped them as the "Upper Volcanic group" and referred them to the Miocene. They have more recently been designated the *Kamloops Volcanic* group, and have been referred to the Oligocene on the basis of fossils found in one member of the group, the *Tranquille beds*, a series of local, tufaceous, and partly fresh-water sediments intercalated near the base of the Kamloops volcanics. The Kamloops lavas have a maximum thickness of at least 3,000 feet, and had originally a probable average thickness greater than 2,000 feet. The Tranquille beds are estimated to have a thickness of 1,000 feet.[1]

Batholithic intrusions.—Granitic batholithic intrusives occupy a considerable area in southern British Columbia west of Kootenay lake. They also cut the Palæozoic strata of the Western Belt on a scale unmatched elsewhere in the world, except perhaps in the Pre-Cambrian terrane of eastern Canada. The composite coast range batholith of British Columbia and Alaska is about 1,200 miles in length with an average width of nearly 90 miles. It is composed of granodiorite, and quartz-diorite, with diorite, biotite granite, syenite, and allied types. There is clear evidence of successive intrusion but it is agreed that the general date of irruption, for the greater part, falls in the period from latest Jurassic to the early Cretaceous.

Quaternary deposits.—Quaternary deposits of sand, gravels, clays, and till are found scattered over the province in numerous localities but no special descriptions are essential to the present report.

Geologic Structure.

The geologic structure of British Columbia is perhaps more complex than any other similar area on the continent.

The main structural features, according to Dawson[2], are that of a central Archæan axis or geanticline with a geosyncline on the east and a wider geosyncline on the west. The eastern geosyncline is occupied by the Rocky mountains, whereas the Coast Range is included in the western geosyncline.

[1]Based on notes by Daly and Drysdale in Guide Book No. 8, part II, International Geological Congress, 1913.
[2]Dawson, G. M., Geologic record of the Rocky Mountain region in Canada; Geol. Soc Am. Bulletin, vol. 12, 1901, pp. 58-92.

More or less connected with these major features are numerous minor folds and flexures including many faults. Time and space will not permit here a detailed discussion of the structure, but that great disturbances of the beds exist in many parts of the country is evinced by the fact that in writing of the geology of British Columbia, Dawson[1] speaks of the "extremely broken and disturbed character of the rocks." In this connexion he says in speaking of the Cache Creek formation of the Kamloops map-sheet that

In attempting a brief general description of this formation, it must in the first place be observed that the extremely broken and disturbed character of the rocks, almost everywhere renders it next to impossible to learn much about their attitude or sequence in any one locality. It is very generally impossible to determine whether the dip of the beds is normal or has been overturned.

Speaking further of the Kamloops map-sheet, Dawson[2] says:—

The limestone belt above described, has, within the limits of the map, a length of above sixty miles. There can now be no doubt that this represents a great syncline, upon both sides of which the older members of the Câche Creek formation are displayed; but superimposed upon this general structure are very numerous smaller folds, which generally run in more or less exact parallelism with it, but often in varied directions. The limestone has thus been, as it were, heaped together by repeated folding, in such a manner that it occupies a width much greater than that which can possibly be due to its thickness, with the high dips which are usually found. Similar complex folding affects the underlying rocks of the formation, and it is due to this fact that it is almost impossible to obtain any good estimate of its total thickness or of that of its parts. This folding is not generally of the tightly compressed and linearly direct kind met with in, and near, the mountains of the coast ranges, but is just sufficiently irregular to make it very difficult to follow. Occasional instances are also found—as for example on the upper part of Jack's creek, between the Thompson and Hat creek and in Glen Hart—where the rocks rest at very low angles; but these are in immediate contact with others in which the same beds are found to be nearly vertical.

In another case Dawson[3] says that:—

The mountainous axis of the Queen Charlotte islands from Cape St. James to Skidegate channel, and probably still farther northward as far as Hippa island, is composed of a mass of much disturbed, and in some places highly altered rocks, which have at first sight an appearance of great antiquity, but are found on close inspection to owe this appearance to the inclusion of

[1]Dawson, Geo. M., Ann. Rep. Geol. Surv. Canada, n.s., vol. VII., 1896, section B.
[2]Dawson, Geo. M., Ann. Rep. Geol. Survey Canada, vol. VII, p. 40B.
[3]Dawson, Geo. M., Report on the Queen Charlotte islands, Geol. Surv. Canada, Reports for 1878-79; 1880, p. 45B.

great masses of easily altered contemporaneous volcanic materials, and to the fact that they have been subjected to an extreme of flexure and disturbance which very frequently takes the character of actual fracture and displacement, as has been observed elsewhere on the Pacific coast. To work out the intricacies of these older rocks, which may be looked on as the nucleus of the islands, would be a work of time, and would involve much patient labour.

Other instances might be cited relating to the generally disturbed character of the rocks of the mountainous portion of

Lines 22 and 25. "Victoria, B.C.," should read "Victoria, Alberta." This well record should have followed the last paragraph on page 286. The well is located near the post-office of Pakan, Alberta, on the North Saskatchewan river, in the Electoral District of Victoria.

Softer, dark grey shale	310	340
Harder, dark grey shale	340	350
Hard brownish-grey shale	350	390
Hard, light grey shale with 2 ft. ironstone	390	410
Brown shale	410	420
Brownish grey shale	420	470
Very hard, grey shale	470	480
Light brownish-grey shale	480	500
At 485 ft. water, slightly saline and gas		
Ironstone stratum	500	508
Light brownish-grey shale	508	520
Grey shale, losing brown tone	520	530

More or less connected with these major features are numerous minor folds and flexures including many faults. Time and space will not permit here a detailed discussion of the structure, but that great disturbances of the beds exist in many parts of the country is evinced by the fact that in writing of the geology of British Columbia, Dawson[1] speaks of the "extremely broken and disturbed character of the rocks." In this connexion he says in speaking of the Cache Creek formation of the Kamloops map-sheet that

[illegible]

Speaking further of the Kamloops map-sheet, Dawson[2] says:—

[illegible]

In another case Dawson[3] says that:—

[illegible] Hippa island, is composed of a mass of much disturbed, and in some places highly altered rocks, which have at first sight an appearance of great antiquity, but are found on close inspection to owe this appearance to the inclusion of

[1]Dawson, Geo. M., Ann. Rep. Geol. Surv. Canada, n.s., vol. VII., 1896, section B.
[2]Dawson, Geo. M., Ann. Rep. Geol. Survey Canada, vol. VII, p. 40B.
[3]Dawson, Geo. M., Report on the Queen Charlotte islands, Geol. Surv. Canada, Reports for 1878-79; 1880, p. 45B.

great masses of easily altered contemporaneous volcanic materials, and to the fact that they have been subjected to an extreme of flexure and disturbance which very frequently takes the character of actual fracture and displacement, as has been observed elsewhere on the Pacific coast. To work out the intricacies of these older rocks, which may be looked on as the nucleus of the islands, would be a work of time, and would involve much patient labour.

Other instances might be cited relating to the generally disturbed character of the rocks of the mountainous portion of British Columbia, but time and space will not permit.

HISTORY OF DRILLING OPERATIONS AND PROSPECTS OF OIL IN BRITISH COLUMBIA.

For several years past prospect drilling for oil in various parts of British Columbia has been going on more or less intermittently, but oil exploration is still entirely speculative.

A well put down to a depth of 1,840 feet by the Canadian Government near Victoria, B.C., shows small quantities of gas at several horizons, but no oil indications. The records of this well follows:—

Victoria, B.C., Canada.
Geol. Sur. Can., 29-E, pp. 91-2.

	Top Feet.	*Bottom Feet.*
Sand		10
Light grey shale, traces sand	10	20
Grey sandy shale	20	30
Light grey sandy shale	30	50
Light grey shale, no sand	50	100
Grey shale, darker in colour	100	110
Grey shale, lighter	110	120
Grey shale, brownish	120	130
Ironstone layer	130	131
Light grey shale	131	140
Light brownish-grey shale, quite hard	140	180
(At 156 struck small vein of gas)		
Dark-brownish shale streaks of ironstone	180	260
Dark brown shale (strata of sandstone)	260	270
Grey shale (ironstone stratum)	270	280
Grey shale with 3 ft. ironstone stratum	280	290
Hard brown-grey shale	290	300
Hard, grey shale	300	310
Softer, dark grey shale	310	340
Harder, dark grey shale	340	350
Hard brownish-grey shale	350	390
Hard, light grey shale with 2 ft. ironstone	390	410
Brown shale	410	420
Brownish grey shale	420	470
Very hard, grey shale	470	480
Light brownish-grey shale	480	500
At 485 ft. water, slightly saline and gas		
Ironstone stratum	500	508
Light brownish-grey shale	508	520
Grey shale, losing brown tone	520	530

	Top Feet.	Bottom Feet.
Ironstone stratum	530	535
Hard, light grey shale	535	540
Grey shale, with stratum ironstone	540	550
Bluish-grey shale	550	554
Dark bluish-grey shale	554	560
Dark bluish-grey shale with ironstone stratum and fragments pyrite	560	570
Very soft grey shale	570	620
Very soft grey shale with 3 ft. sandstone and ironstone	620	630
Bluish-grey shale, very soft	630	705
Soft, dark shale	705	960
Soft, dark shale with layers sand and gas	960	970
Soft, dark shale	970	1000
Soft, dark shale, streaks sandstone	1000	1020
Dark shale, gas	1020	1030
Dark shale, increased gas	1030	1090
Soft, black shale	1090	1230
Soft, black shale, streaks sandstone	1230	1250
Soft black shale	1250	1320
Brown shale, with sandstone layers	1320	1340
Soft, dark shale	1340	1390
Bluish shale, with thin streaks sandstone	1390	1410
Black shale	1410	1428
Hard sandstone	1428	1430
Black shale	1430	1460
Bluish shale	1460	1500
Bluish shale streaks sandstone with gas	1500	1565
Hard sandstone	1565	1575
Dark shale, mixed with sandstone	1575	1585
Hard sandstone	1585	1600
Shale and sandstone strata mixed	1600	1645
Hard sandstone	1645	1650
Sandstone	1650	1665
Dark shale	1665	1669
Very hard sandstone	1669	1680
Dark blue shale with strata hard sandstone 1 to 4 feet thick	1680	1840

William E. Park published in October, 1913, a rather exhaustive discussion of the outlook for commercial oil in British Columbia, and this discussion is quoted here:—

Though the Pacific province of Canada is more than usually stirred by oil excitement, the oil industry west of the Rockies and north of the International Boundary is still in the purely wild-cat stage. There has been no discovery of commercial importance made in the province up to the moment of writing; though in many quarters drillers are at work, and as is always possible with the driller, a new day may change the entire aspect of affairs.

The possible oil and gas resources of the province are a matter of opinion; and this opinion is in some instances extremely optimistic, and in others just the contrary. The story of what has already been done or is now under way in the course of developing these possible resources, reveals the fact that tests have been made in several sections of the province So far, neither oil nor gas has been found in anything approaching commercial quantities; though indications have frequently been met with.

The borings already attempted naturally indicate the locations considered by operators as the most likely to give profitable results. These borings are about as follows:—

On Vancouver island, on the southwest coast, a couple of holes were put down to a depth approximating 1,000 feet, without success. Bore-holes on the east coast of the island put down for coal have produced neither gas nor oil.

On the Queen Charlotte islands, farther north, boring for oil has been in progress for a year or more. The location is on the northwest end of Graham island. So far as is known, no success has been met with. Other holes on the east coast and in the centre of the island, put down for coal, showed no gas or oil.

On the islands between Vancouver island and the mainland, one or more holes have been put down. One hole on Pender island was put down for coal to a depth of 1,200 feet, but not reaching any, was abandoned. This bore now gives off gas, but it is nitrogen gas, of no commercial value.

These lesser islands were reported on last summer for a gas and oil boring syndicate by a responsible geologist, whose report indicates very considerable possibilities for oil and gas. The company which secured the survey is now about to test the matter by drilling in the vicinity of the 1,200-foot bore-hole previously referred to; knowing in advance that the hole will have to be sunk to a greater depth than 1,200 feet before the possibilities are within reach of the drill. The operators are very sanguine of success, their optimism being largely due to the presence of seepages of oil, found floating on the adjacent waters, and supposed to emanate from submarine fissures.

In recent years, several holes have been drilled near New Westminster, in the delta of the Fraser river. Regarding these, little reliable data as to the depth can be obtained, but it is known that they did not find oil or gas, at least in any quantity.

On Pitt Meadows, the Coast Development Syndicate, of Vancouver, of which enterprise W. Innes Patterson is manager, has been engaged in drilling. The syndicate has a hole down 1,200 feet, and claims to have met with indications of oil, but drilling has been stopped, as a result of an accident somewhat similar to that which occurred with the Oil Springs, Ontario, deep well, and the hole cannot be sunk any deeper. It is understood that the syndicate intends starting a new well.

Near Horsefly, in the Cariboo district, there are shales carrying several per cent of oil. A half-hearted attempt at drilling was made in this vicinity, but the drillers did not find any fluid oil nor any flowing gas. Similar oil-bearing shales occur on the North Thompson river.

Promoters have claimed to find oil indications in the Kettle River valley, on the north fork, but no serious attempt has ever been made to test this district.

WHERE SEEPAGES OCCUR.

In the southeastern corner of the province, in the valley of the Flathead river, there are undoubtedly small seepages of crude oil. Among others, the Provincial Mineralogist, W. Fleet Robinson, has inspected them and obtained samples of the product. The oil secured is of good quality, but, so far, it has been met with only in the form of seepages, coming up with water in a spring. Similar seepages occur just over the summit to the eastward, in the Province of Alberta, where two or three holes have been drilled to a depth of from 1,200 to 1,500 feet. On the British Columbia side of the mountain range, the British Columbia Oil and Development Co., of Victoria, has taken in a drilling plant, and is now engaged in putting down a hole. This hole is reported to show a little oil, whether from seepages or not is not known, but the hole, in any event, is not down far enough to give conclusive results. This district has, in the opinion of reliable men, distinct possibilities, which thorough drilling tests alone can determine.

Unlike the oil and gas fields of New Brunswick, Ontario and Alberta, the greater part of British Columbia is very mountainous and much disturbed geologically, so that in most parts of the province oil or gas could scarcely exist. The limited areas where these products might exist within reach of transportation and settlement are pretty well represented by the drillings referred to.

Among the pronounced surface indications are those in the Flathead district of East Kootenay, in the southeastern corner of the Province, close to the Washington state line. Some test drilling is now going on in this section.

The operations of the drilling plant on Pitt lake, where Innes Patterson and associates have been drilling, have been suspended for a time. Reports were at one time current of a big strike in this section, but they were without foundation. Some float sandstone showing oil impregnation was found in the vicinity of this well.

The oil occurrences on the coast, some 300 miles north of Vancouver city, are to be developed by Vancouver capitalists, with a view to determining their commercial value, if any. Henry Lye of Vancouver has secured licenses covering an oil seepage at Evans Arm, on King island, and Merton Smith, also of Vancouver, has had a number of locations recorded in the vicinity of Seymour inlet.

Oil shale deposits of a considerable extent exist in the vicinity of Ashcroft, and efforts are being made to organize a company to develop these shales. The shales are similar to those of Albert county, New Brunswick, which have shown a production of 63 gallons of oil from a ton of shale.

The utilization of slack and waste coal from the British Columbia coal mines for the production of petrol is also being urged. This method is being used to a considerable extent in Great Britain, and though the process requires an expensive plant, a number of other by-products are secured. The manager of one coal company has had in contemplation for a considerable time the establishment of a by-product of this nature at Vancouver. The benzol value of coal averages, according to expert estimate, $5 a ton. The amount of waste available for this purpose is quite large, one of the leading collieries having reported a loss last year of 164,854 tons, or nearly one-third of its total output.

APPENDICES

I. "THE PETROLEUM BOUNTY ACT, 1909".

II. "REGULATIONS FOR THE DISPOSAL OF PETROLEUM AND NATURAL GAS RIGHTS, THE PROPERTY OF THE CROWN . . . . . REFERRED TO IN SUBSECTION (B) OF SECTION 3 OF THE DOMINION LANDS ACT." APPROVED BY ORDER-IN-COUNCIL. DATED THE 19TH DAY OF JANUARY, 1914.

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APPENDIX I.

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9-10 EDWARD VII.

CHAP. 46.

An Act to provide for the payment of Bounties on Crude Petroleum.

[*Assented to 4th May, 1910.*]

His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. This Act may be cited as *The Petroleum Bounty Act, 1909*. Short title.

2. The Governor in Council may authorize the payment out of the Consolidated Revenue Fund of a bounty of one and one-half cent per imperial gallon on all crude petroleum, having a specific gravity not less than ·8235 at 60 degrees by Fahrenheit's thermometer produced from wells in Canada or from shales or other substances mined in Canada on and after the day on which this Act comes into force,—the said bounty to be paid to or divided amongst the producers of the petroleum, the owner or occupier of the soil through which it is mined or won, or such other person interested, or injuriously affected by the mining operations or works, as the Governor in Council by regulation approves. **Bounty on petroleum.**

3. The Minister of Trade and Commerce shall be charged with the administration of this Act, and may, subject to the approval of the Governor in Council, make such regulations as he deems necessary respecting the payment of the said bounties. **Administration and regulations.**

4. Chapter 33 of the statutes of 1907, and *The Petroleum Bounty Act, 1908*, chapter 52 of the statutes of 1908, are repealed. **Repeal.**

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APPENDIX II.

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REGULATIONS

FOR THE

DISPOSAL OF PETROLEUM AND NATURAL GAS RIGHTS, THE PROPERTY OF THE CROWN IN MANITOBA, SASKATCHEWAN, ALBERTA, THE NORTHWEST TERRITORIES, THE YUKON TERRITORY, THE RAILWAY BELT IN THE PROVINCE OF BRITISH COLUMBIA, AND WITHIN THE TRACT CONTAINING THREE AND ONE-HALF (3½) MILLION ACRES OF LAND ACQUIRED BY THE DOMINION GOVERNMENT FROM THE PROVINCE OF BRITISH COLUMBIA, AND REFERRED TO IN SUB-SECTION (b) OF SECTION 3 OF THE DOMINION LANDS ACT.

Approved by Order in Council, dated the 19th day of January, 1914.

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Regulations for the disposal of Petroleum and Natural Gas rights, the property of the Crown, in Manitoba, Saskatchewan, Alberta, the Northwest Territories, the Yukon Territory, the Railway Belt in the Province of British Columbia, and within the tract containing three and one-half ($3\frac{1}{2}$) million acres of land acquired by the Dominion Government from the Province of British Columbia, and referred to in subsection (b) of section 3 of the Dominion Lands Act.

Approved by Order in Council dated the 19th of January, 1914.

INTERPRETATION.

"Minister" shall mean the Minister of the Interior of Canada.

"Adjoining" lands shall be those which are not separated by a section, or by any of the regular subdivisions into which a section may be divided.

"Location" shall mean the tract described in a petroleum and natural gas lease.

"Group" shall mean two or more of the locations described in petroleum and natural gas leases, consolidated for purposes of operation.

"Lessee" means any individual, company, corporation or municipality the holder of a petroleum and natural gas lease in good standing.

"River" shall mean a stream of water the bed of which is of an average width of 150 feet throughout the portion thereof on which the tract applied for fronts.

1. The petroleum and natural gas rights which are the property of the Crown, in Manitoba, Saskatchewan, Alberta, the Northwest Territories, the Yukon Territory, the Railway Belt in the Province of British Columbia, and within the tract containing three and one-half ($3\frac{1}{2}$) million acres of land acquired

by the Dominion Government from the Province of British Columbia, and referred to in subsection (*b*) of section 3 of the Dominion Lands Act, may be leased to applicants at a rental of twenty-five (25) cents an acre for the first year, and for each subsequent year a rental at the rate of fifty (50) cents an acre, payable yearly in advance. The term of the lease shall be twenty-one years, renewable for a further term of twenty-one years, provided the lessee can furnish evidence satisfactory to the Minister to show that during the term of the lease he has complied fully with the conditions of such lease and with the provisions of the regulations in force from time to time during the currency of the lease.

2. The maximum area of a petroleum and natural gas location shall be 1,920 acres, and no person shall be permitted to acquire a greater area except by assignment:

Provided that a person who has been granted a lease for a location, and who subsequently abandons or assigns the same, may, after the expiration of twelve months from the date of the said lease, apply for an area not greater than that abandoned or assigned:

Provided further, however, that such right shall not be granted unless all payments on account of rent or other liability to the Crown, due by such person, have been fully made, up to the date of the registration by the Department of the assignment of his right to such lease, or up to the date upon which the notice of his abandonment of the same was received by the Department.

3. If the tract applied for is situated in surveyed territory, it shall consist of sections, or legal subdivisions of sections, but the several parcels comprising the tract shall be adjoining, the length of the tract not to exceed three times its breadth. In unsurveyed territory, if at least one of the lines bounding the tract applied for has been surveyed, and the returns of such survey have been duly received in the office of the Surveyor General, an application for a lease of the petroleum and natural gas rights under such tract may be considered under the provisions of this section of the regulations.

4. Application for a lease of the petroleum and natural gas rights on surveyed lands shall be filed by the applicant in

person with the Agent of Dominion Lands for the district in which the rights applied for are situated, or with a sub-agent for such district for transmission to the agent; but priority of application shall be based upon the date of the receipt of such application in the office of the Agent of Dominion Lands for the district.

5. If the rights applied for are situated in unsurveyed territory, application for a lease shall be made by the applicant in person to the Agent of Dominion Lands for the district in which the rights applied for are situated, or to a sub-agent for such district, for transmission to the agent.

6. Application for a location situated in unsurveyed territory shall contain a description by metes and bounds of the location applied for, and shall be accompanied by a plan showing the position of such location in its relation to some prominent topographical feature or other known point. The plan shall contain sufficient data to admit of the position of the location applied for being definitely shown in the records of the Department. The location must be rectangular in form, except where a boundary of a previously located tract is adopted as common to both locations, the length not to exceed three times the breadth.

The application shall be accompanied by evidence, supported by affidavit of the locator, to show that the following requirements have been fully complied with:—

(*a*) That the location applied for has been defined on the ground by the locator in person by planting two wooden posts, at least four inches square and standing not less than four feet above the ground—such posts being numbered "1" and "2" respectively. The distance between post No. "1" and post No. "2" shall not exceed 15,840 feet, and upon each post shall be inscribed the name of the locator and the date of the location. Upon post No. "1" there shall be written, in addition to the foregoing, the words "initial post," the approximate compass bearing of post No. "2" and a statement of the number of feet lying to the right and to the left of the line between post No. "1" and post No. "2." Thus—(initial post, direction of post No. "2" is................feet lie to the right and................feet to the left of the line between post No. "1" and post No. "2".

When the tract which an applicant desires to lease has been located, he shall immediately mark the line between post No. "1" and post No. "2" so that it can be distinctly seen in a timbered locality, by blazing trees and cutting underbrush, and in a locality where there is neither timber nor underbrush he shall set posts of the above dimensions or erect mounds of earth or rock not less than two feet high and two feet in diameter at the base in such a manner that the line may be distinctly seen.

(*b*) All the particulars required to be inscribed on posts No. "1" and No. "2" shall be set out in the application and shall be accompanied by a plan showing the position of the tract in its relation to some prominent topographical feature or other known point, such plan to contain sufficient data to admit of the location being shown definitely on the records of the Department.

(*c*) The locator shall post a written or printed notice on a conspicuous part of the location applied for, setting out his intention to apply within thirty days from the date of such notice for a lease of the petroleum and natural gas rights under the said location.

(*d*) The application shall be accompanied by evidence, supported by the affidavit of the locator, in due form, to show that the above requirements of the regulations have been fully complied with.

7. In case, the tract applied for is located in unsurveyed territory on the margin of a river or lake, it shall not include more than one mile in direct distance along such water frontage, and shall extend back therefrom as far as may be necessary to include a total area of not more than 1,920 acres, the length of the location, however, not to exceed three miles. The tract shall be marked on the ground by two posts firmly fixed in the ground, one at each end of such front boundary. The posts shall be numbered "1" and "2" respectively. It shall not be lawful to move post No. "1", but post No. "2" may be moved by a Dominion Land Surveyor if the distance between the posts exceeds the length prescribed by these regulations, but not otherwise. The side boundaries shall be parallel lines drawn from each end of the front boundary at right angles to the base line of such river or lake, established or to be established by the Department. In

the event of the base line not being established, the side boundaries of the location shall be drawn at right angles to the general direction of the valley of the r ver, or the margin of the lake. The required notice of application shall be posted conspicuously on the location near the margin of the lake or river on which it fronts.

The boundaries of claims situated on the margin of a lake or river, and any disputes which may arise in connection therewith, shall be subject to final adjustment by the Minister.

8. Application for a lease of the petroleum and natural gas rights under lands situated in unsurveyed territory shall be made by the locator in person to the Agent of Dominion Lands for the District in which the tract applied for is situated, or to a sub-agent for such district within thirty days from the date upon which the tract applied for was staked as above provided, if it is situated within one hundred miles of the office of the Agent or Sub-Agent, otherwise it will not be considered. One extra day, however, shall be allowed for every additional ten miles or fraction thereof that the location is distant more than one hundred miles from the office of the Agent or Sub-Agent.

9. Where two or more persons lay claim to the same location, or to portions of the same locations, situated in unsurveyed territory, the right to the lease shall be in him who can prove to the satisfaction of the Minister that he was the first to take possession of the tract in dispute by staking in the manner prescribed in these regulations, and that he made application for a lease within the specified time.

10. As soon as the survey of a township has been confirmed, all petroleum and natural gas leases embracing any portion of such township so surveyed and confirmed, shall be made to conform to the Dominion Lands System of Survey if the Minister so decides, by the substitution of a new lease describing by sections, legal subdivisions of sections, or regular portions of legal Subdivisions as nearly—as may be—the tract embraced in the leasehold in so far as the township so surveyed is concerned. If any part of the leasehold is in territory which remains unsurveyed it shall continue to be described as in the lease originally issued, until such portion is included in a confirmed survey.

11. As soon as the survey of a township has been confirmed, all petroleum and natural gas leaseholds embracing any portion of the township so surveyed and confirmed, shall be subject to the withdrawal forthwith from the lease, without compensation to the lessese, of any portions which, in accordance with such confirmed survey, are found to be the property of the Hudson's Bay Company.

Provided, however, that upon such withdrawal being made from any location in good standing, the rental paid on the land so withdrawn, in whole or in part, may, in the discretion of the Minister, be refunded to the lessee.

12. The rental for the first year of the location applied for at the rate of twenty-five (25) cents an acre per annum, shall accompany the application filed in the office of the Agent of Dominion Lands for the district in which the rights applied for are situated, and no application for a lease of petroleum and natural gas rights shall be accepted or recorded unless it is accompanied by the full amount of the rental for the first year at the above rate. The lease, when issued, shall bear date from the day upon which the application was filed in the office of the Agent of Dominion Lands. If, during the term of the lease, the lessee shall fail to pay rental in advance for each subsequent year at the rate of fifty (50) cents an acre per annum within thirty days after the date upon which the same became due, the lease shall be subject to cancellation in the discretion of the Minister and to the immediate forfeiture of the rights which the lessee had in the said lease.

13. Provided, that if the lessee, in consideration of the expenditure to be incurred by him in actual boring operations upon his leasehold, makes application, at or before the beginning of the second and third years, respectively, of the term of the lease, for an extension of time within which to pay the rental when due, or becoming due, the Minister may grant such extension of time in writing, and if the lessee, before the end of the year in respect of which application was made, submits evidence to the Land Agent of the district in which the leasehold is situated, supported by affidavit, that during such year actual boring operations have been prosecuted upon his lease-

hold, as required by section 15 of these regulations, the amount expended in such boring operations, exclusive of the cost of machinery and casing, may be deducted from the rental which became due at the beginning of the said year. The balance of rental due, if any, shall be paid at the same time as the evidence in regard to work done is submitted, as above required. Failure to submit such evidence, or to pay the balance or rental due, with interest, will render the lease liable to cancellation, as hereinbefore provided.

14. The lessee shall, within one year from the date of the lease, have upon the lands described therein such machinery and equipment suitable for carrying on prospecting operations as the Minister may consider necessary, and he shall within the same period furnish evidence, supported by affidavit, showing the character, quantity and value of the machinery so installed, the date of its installation and the particular parcel of land upon which it was installed. If the required machinery is not installed within the period specified, and if evidence of its installation is not furnished within the prescribed period, the lease shall be subject to cancellation in the discretion of the Minister. Provided, however, that the Minister shall not require that the value of the machinery so installed on a location shall exceed the sum of five thousand dollars ($5,000.00).

15. The lessee shall commence boring operations on his leasehold within fifteen months of the date of his lease, and he shall continue such boring operations with reasonable diligence, to the satisfaction of the Minister, with a view to the discovery of oil or natural gas. If the lessee does not commence boring operations within the time prescribed, or if having commenced such operations he does not prosecute the same with reasonable diligence, to the satisfaction of the Minister, or if he ceases to carry on the same for a period of more than three months, the lease shall be subject to cancellation in the discretion of the Minister, upon three months' notice to this effect being given to the lessee. Provided, however, that if satisfactory evidence is furnished to show that the sum of at least two thousand dollars ($2,000.00) has been expended in actual boring operations, by recognized methods, upon the leasehold in any year, such expen-

diture shall be accepted as compliance with this provision for the year during which such expenditure shall have been incurred.

16. The Minister may permit a lessee, who has acquired by assignment or otherwise, more than one petroleum and natural gas lease, to consolidate his operations and expenditure, and to install machinery and equipment on one or more of the locations described in the lease affected: Provided that such consolidation or grouping shall apply only to the second and third years of the term of the leases, and shall comprise only such leases as may at the time be included in such consolidation or grouping. Evidence of the installation of machinery on one or more of the locations included in a group shall be that prescribed by Section 14 of these regulations. If the required machinery is not installed on one or more of the locations included in a group within the period specified and evidence of its installation furnished within the prescribed period, and if boring operations are not commenced and continued on such location or locations in the manner set out in Section 15 of these regulations, the leases included in the group shall be subject to cancellation in the discretion of the Minister.

17. The Minister may, in consideration of the expenditure to be incurred by a lessee in boring operations upon one or more of the locations included in a group, grant an extension of time within which to pay the rental for the second and third years of the term of the several leases so included, and upon receipt of the evidence required by Section 13 of these regulations, he may deduct from the rental which became due at the beginning of the year in respect of the several locations grouped, the amount expended in actual boring operations on one or more of the locations, exclusive of the cost of machinery and casing. The balance of the rental due if any, shall be paid at the same time as the evidence in regard to work done is submitted, as above required. Failure to submit such evidence or to pay the balance or the rental due, with interest, will render the several leases included in the group liable to cancellation.

18. Provided, however, that the Minister shall not require that the value of the machinery to be installed on any group

of locations shall exceed the sum of ten thousand dollars ($10,-000.00), nor shall he require that the expenditure incurred in boring operations thereon in any one year shall exceed the sum of two thousand dollars ($2,000.00) for each location included in the group.

19. The maximum area of the locations which may be included in one consolidation or group shall not exceed twenty (20) square miles, nor shall the locations so included be separated one from the other by a greater distance than two miles.

20. The Minister may, upon application, grant a lessee during the second and third years of the term of the lease an extension of time within which to pay the rental and to install the prescribed machinery and equipment, and within which to commence actual boring operations upon the location, or upon a group of locations consolidated under the provisions of these regulations: Provided that evidence to the satisfaction of the Minister is furnished to show that an expenditure equal to that prescribed by these regulations in respect of boring operations, is to be incurred in some other acceptable and necessary form of preliminary development, having for its object the discovery of petroleum or natural gas, by which the interests of the district in which the locations are situated might be materially benefited. Upon receipt of evidence on or before the termination of the year, supported by affidavit and duly corroborated, that such expenditure has been incurred, and that the work done was of a character beneficial to the district, the Minister may deduct the amount of such expenditure from the amount due on account of the rental of the location or locations affected, in the manner prescribed in section 13 of these regulations. In case evidence is not furnished, or if furnished is not acceptable to the Minister, the leases shall be subject to immediate cancellation in the discretion of the Minister.

In case an extension of time is granted during the second and third years of the term of a lease within which to install machinery and commence boring operations on any location under the grouping provisions of these regulations, then the provisions of sections 14 and 15 of the regulations shall apply to the fourth year of the term of the lease of such location.

21. In case the surface rights of a petroleum and natural gas location are covered by a timber license, grazing or coal mining lease, mining claim or other form of terminable grant the lease shall not authorize entry thereon, without the permission of the Minister being first had and obtained, and such permission shall be given subject to such conditions for the protection of the rights of such lessee or licensee as it may be considered necessary to impose.

22. In case the surface rights of a petroleum and natural gas location have been patented, or have been disposed of by the Crown under any act or regulation which contemplates the earning of patent for such surface rights, and the lessee of the petroleum and natural gas rights cannot make an arrangement with the owner of such surface rights, or with his agent, or the occupant thereof, for entry upon the location, or for the acquisition of such interest in the surface rights as may be necessary for the efficient and economical operation of the rights acquired under his lease, he may, provided the mineral rights in the land affected with access thereto and the right to use and occupy such portion of the land as may be necessary for the effectual working of the minerals therein have been reserved to the Crown in the original grant of the surface rights, apply to the Minister for permission to submit the matter in dispute to arbitration. Upon receiving such permission in writing, it shall be lawful for the lessee to give notice to the owner, or his agent, or the occupant, to appoint an arbitrator within a period of sixty days from the date of such notice, to act with another arbitrator named by the lessee, in order to determine what portion of the surface rights the lessee may reasonably acquire:—

(*a*) For the efficient and economical operation of the rights and privileges granted him under his lease;

(*b*) The exact position thereof, and

(*c*) The amount of compensation to which the owner or occupant shall be entitled.

23. The notice mentioned in this section shall be according to a form to be obtained upon application to the Agent of Dominion Lands for the district in which the land in question is situated, and shall, when practicable, be personally served on the owner of

such land, or his agent, if known, or the occupant thereof, and after reasonable efforts have been made to effect personal service without success, then such notice shall be served by leaving it at or sending it by registered mail, to the last known place of abode or address of the owner, agent or occupant, and by posting a copy of the same in the office of the Agent of Dominion Lands for the district in which the land in question is situate. Such notice shall be ten days if the owner, or his agent, resides in the district in which the land is situate; if out of the district and if in the province or territory, twenty days, and if out of the province or territory, thirty days, before the expiration of the time limited in such notice. If the owner, or his agent, or the occupant of the land refuses or declines to appoint an arbitrator, or when, for any reason, no arbitrator is so appointed in the time limited therefor in the notice provided for by this section, the Agent of Dominion Lands for the district in which the land in question is situate shall forthwith, on being satisfied by affidavit that such notice has come to the knowledge of such owner, agent, or occupant, or that such owner, agent, or occupant, wilfully evades the service of such notice, or cannot be found, and that reasonable efforts have been made to effect such service, and that the notice was left at the last place of abode or known address of such owner, agent, or occupant as above provided, appoint an arbitrator on his behalf.

24. In case the two arbitrators cannot agree upon the award to be made, they may, within a period of ten days from the date of the appointment of the second arbitrator select a third arbitrator, and when such two arbitrators cannot agree upon a third arbitrator, the Agent of Dominion Lands for the district in which the land in question is situate, shall forthwith select such third arbitrator.

25. All the arbitrators appointed under the authority of these regulations shall be sworn before a justice of the peace to the impartial discharge of the duties assigned to them, and after due consideration of the rights of the owner and the needs of the lessee, they shall decide as to the particular portion of the surface rights which the latter may reasonably acquire for the efficient and economical operation of the rights and privileges granted him

under his lease, the area thereof, and the amount of compensation therefor to which the owner or occupant shall be entitled.

26. In making such valuation the arbitrator shall determine the value of the land irrespective of any enhancement thereof from the existence of minerals thereunder.

27. The award of any two such arbitrators made in writing shall be final, and shall be filed with the Agent of Dominion Lands for the district in which the land is situate, within twenty days from the date of the appointment of the last arbitrator. Upon the order of the Minister the award of the arbitrators shall immediately be carried into effect.

28. The arbitrators shall be entitled to be paid a per diem allowance of $5.00 together with their necessary travelling and living expenses, while engaged in the arbitration, and the costs of such arbitration shall be in the discretion of the arbitrators.

29. The lessee shall at all times take reasonable measures to prevent the injurious access of water to the oil bearing formation. Upon a well proving to be unproductive, or ceasing to yield oil in paying quantity, or being abandoned for any cause, the lessee shall be at liberty to withdraw the casing from the said well, but in order to prevent water gaining access to the oil-bearing formation, the lessee shall immediately close the well by filling it with sand, clay, or other material which may have the effect of preventing water from gaining access thereto.

In case natural gas is discovered through boring operations on a location, the lessee shall take all reasonable and proper precautions to prevent the waste of such natural gas, and his operations shall be so conducted as to enable him, immediately upon discovery, to control and prevent the escape of such gas.

Should salt water be encountered through operations upon the location, the lessee shall immediately and effectively, to the satisfaction of the Minister, close the well at such a depth as may prevent such water from gaining access to the oil-bearing formation.

The Minister may, from time to time, make such additional regulations as may appear to be necessary or expedient governing the manner in which boring operations shall be conducted, and the manner in which the wells shall be operated.

Failure on the part of the lessee to comply with the above requirements, or to comply with such other requirements as the Minister may consider it necessary to impose in respect of boring and operating, will render the lease subject to cancellation in the discretion of the Minister.

30. The lessee may be permitted to relinquish at any time the whole or any portion of the location described in his lease, provided he has complied in every respect with the provisions of the regulations, and that all payments on account of rental or other liability to the Crown, due in connection with the lease, have been fully made, and provided the portion of the location which may be retained shall be of the prescribed shape, and shall not be of a less area than forty acres.

31. The lease shall in all cases include only the oil and natural gas rights, which are the property of the Crown; but the lessee may, upon application, be granted a yearly lease at a rental of one dollar ($1.00) an acre per annum, payable yearly in advance, of whatever area of the available surface rights of the tract described in his petroleum and natural gas lease the Minister may consider necessary for the efficient and economical working of the rights granted him.

32. Should oil or natural gas in paying quantity be discovered on the leasehold, and should such discovery be established to the satisfaction of the Minister, the lessee will be permitted to purchase at the rate of ten dollars ($10.00) an acre whatever area of the available surface rights of the tract described in the lease the Minister may consider necessary for the efficient operation of the rights granted him.

33. If it is not established to the satisfaction of the Minister that oil or natural gas in paying quantity has been discovered on the leasehold, the lease shall be subject to termination upon two years' notice in writing being given to the lessee by the Minister.

34. The boundaries beneath the surface of a location shall be vertical planes or lines in which their surface boundaries lie.

35. A fee of five dollars ($5.00) shall accompany each application for a lease, which will be refunded if the rights applied for are not available, but not otherwise.

36. The lease shall be in such form as may be determined by the Minister of the Interior, in accordance with the provisions of these regulations.

37. The lessee shall not assign, transfer or sublet the rights described in his lease, or any part thereof, without the consent in writing of the Minister being first had and obtained.

38. No royalty shall be charged upon the sales of the petroleum acquired from the Crown under the provisions of the regulations up to the 1st day of January, 1930, but provision shall be made in the leases issued for such rights that after the above date the petroleum products of the location shall be subject to whatever regulations in respect of the payment of royalty may then or thereafter be made.

39. A royalty at such rate as may from time to time be specified by Order in Council may be levied and collected on the natural gas products of the leasehold.

40. Any company acquiring by assignment or otherwise a lease under the provisions of these regulations, shall at all times be and remain a British company, registered in Great Britain or Canada and having its principal place of business within His Majesty's Dominions, and the chairman of the said company and a majority of the directors shall at all times be British subjects, and the company shall not at any time be or become, directly or indirectly, controlled by foreigners or by a foreign corporation.

Any alteration in the memorandum of articles of association, or in the constitution of the company, or in the by-laws of the company, shall be reported to the Minister, provided that two months' previous notice of the intention to make any alteration which might conceivably affect the British character of the company shall be given in writing to the Minister, and if, in the opinion of the Minister, the said alteration shall be contrary to the cardinal principle that the lessee company shall be and remain a British company under British control, the Minister may refuse his consent to such alteration.

If the company which may acquire a location under these regulations shall at any time cease to be a British company, or shall become a corporation under foreign control, or shall assign any of the rights acquired under the lease without the consent in writing of the Minister being first had and obtained, the lease shall be subject to immediate cancellation in the discretion of the Minister.

41. The Minister may at any time assume absolute possession and control of any location acquired under the provisions of these regulations, if in the opinion of the Government of Canada such action is considered necessary or advisable, together with all buildings, works, machinery and plant, upon the location, or used in connection with the operation thereof, and he may cause the same to be operated and may retain the whole or any part of the output, in which event compensation shall be paid to the lessee for any loss or damage sustained by him by reason of the exercise of the powers conferred by this provision of the regulations, the amount of the compensation, in case of dispute, to be fixed by a Judge of the Exchequer Court of Canada, provided that the compensation in any such case shall not exceed the profit which the lessee would have earned in the working of the location and the disposal of the products thereof, had possession and control of the location and of the buildings, works, machinery and plant not been assumed.

42. If the location described in any lease issued under the provisions of these regulations, shall yield oil in paying quantity, the lessee shall pump and work the wells faithfully and uninterruptedly with due vigor and skill, with good and sufficient machinery and appliances in accordance with the provisions of the regulations and to the satisfaction of the Minister, so long as the said wells continue to yield oil in remunerative quantity.

43. At the end of each year of the term of the lease the lessee shall furnish a statement, supported by affidavit, showing the number of days during the year that operations were carried on upon the location; the number of men so employed; the character of the work done; the depth attained; the total expenditure incurred; a detailed statement setting out fully the purpose for which such expenditure was incurred; the quantity of crude oil or natural gas obtained; and the amount realized from the sale thereof. Failure to furnish such yearly return will render the lessee subject to a fine of ten dollars ($10.00) a day

for each day's delay in furnishing the sworn statement, and after three months' delay the lease shall be subject to cancellation.

44. These regulations shall apply to all applications submitted on and after the first day of August, 1913, in accordance with the provisions of the regulations which were for the time in force.

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DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR.

REPORTS AND MAPS

PUBLISHED BY THE

MINES BRANCH

REPORTS.

1. Mining conditions in the Klondike, Yukon. Report on—by Eugene Haanel, Ph.D., 1902.

†2. Great landslide at Frank, Alta. Report on—by R. G. McConnell, B.A., and R. W. Brock, M.A., 1903.

†3. Investigation of the different electro-thermic processes for the smelting of iron ores and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904.

5. On the location and examination of magnetic ore deposits by magnetometric measurements—by Eugene Haanel, Ph.D., 1904.

†7. Limestones, and the lime industry of Manitoba. Preliminary report on—by J. W. Wells, M.A., 1905.

†8. Clays and shales of Manitoba: their industrial value. Preliminary report on—by J. W. Wells, M.A., 1905.

†9. Hydraulic cements (raw materials) in Manitoba: manufacture and uses of. Preliminary report on—by J. W. Wells, M.A., 1905.

†10. Mica: its occurrence, exploitation, and uses—by Fritz Cirkel, M.E., 1905. (See No. 118.)

†11. Asbestos: its occurrence, exploitation, and uses—by Fritz Cirkel, M.E., 1905. (See No. 69.)

†12. Zinc resources of British Columbia and the conditions affecting their exploitation. Report of the Commission appointed to investigate—by W. R. Ingalls, M.E., 1905.

†16. *Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final report on—by Eugene Haanel, Ph.D., 1907.

†17. Mines of the silver-cobalt ores of the Cobalt district: their present and prospective output. Report on—by Eugene Haanel, Ph.D., 1907.

* A few copies of the Preliminary Report, 1906, are still available.
† Publications marked thus † are out of print.

†18. Graphite: its properties, occurrence, refining, and uses—by Fritz Cirkel, M.E., 1907.

†19. Peat and lignite: their manufacture and uses in Europe—by Erik Nystrom, M.E., 1908.

†20. Iron ore deposit of Nova Scotia. Report on (Part I)—by J. E. Woodman, D.Sc.

21. Summary report of Mines Branch, 1907–8.

22. Iron ore deposits of Thunder Bay and Rainy River districts. Report on—by F. Hille, M.E.

†23. Iron ore deposits along the Ottawa (Quebec side)and Gatineau rivers. Report on—by Fritz Cirkel, M.E.

24. General report on the mining and metallurgical industries of Canada, 1907–8.

†25. The tungsten ores of Canada. Report on—by T. L. Walker, Ph.D.

26. The mineral production of Canada, 1906. Annual report on—by John McLeish, B.A.

†27. The mineral production of Canada, 1907. Preliminary report on—by John McLeish, B.A.

†27a. The mineral production of Canada, 1908. Preliminary report on—by John McLeish, B.A.

†28. Summary report of Mines Branch, 1908.

29. Chrome iron ore deposits of the Eastern Townships. Monograph on—by Fritz Cirkel. (Supplementary section: Experiments with chromite at McGill University—by J. B. Porter, E.M., D.Sc.)

30. Investigation of the peat bogs and peat fuel industry of Canada, 1908 Bulletin No. 1—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.

32. Investigation of electric shaft furnace, Sweden. Report on—by Eugene Haanel, Ph.D.

47. Iron ore deposits of Vancouver and Texada islands. Report on—by Einar Lindeman, M.E.

†55. The bituminous, or oil-shales of New Brunswick and Nova Scotia, also on the oil-shale industry of Scotland. Report on—by R. W Ells, LL.D.

58. The mineral production of Canada, 1907 and 1908. Annual report on—by John McLeish, B.A.

† Publications marked thus † are out of print.

NOTE. — *The following parts were separately printed and issued in advance of the Annual Report for 1907-8.*

†31. Production of cement in Canada, 1908.

42. Production of iron and steel in Canada during the calendar years 1907 and 1908.

43. Production of chromite in Canada during the calendar years 1907 and 1908.

44. Production of asbestos in Canada during the calendar years 1907 and 1908.

†45. Production of coal, coke, and peat in Canada during the calendar years 1907 and 1908.

46. Production of natural gas and petroleum in Canada during the calendar years 1907 and 1908.

59. Chemical analyses of special economic importance made in the laboratories of the Department of Mines, 1906-7-8. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the commercial methods and apparatus for the analysis of oil-shales—by H. A. Leverin, Ch. E.)

Schedule of charges for chemical analyses and assays.

†62. Mineral production of Canada, 1909. Preliminary report on—by John McLeish, B.A.

63. Summary report of Mines Branch, 1909.

67. Iron ore deposits of the Bristol mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman, M.E., and Geo. C. Mackenzie, B.Sc.

†68. Recent advances in the construction of electric furnaces for the production of pig iron, steel, and zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.

69. Chrysotile-asbestos: its occurrence, exploitation, milling, and uses. Report on—by Fritz Cirkel, M.E. (Second edition, enlarged.)

†71. Investigation of the peat bogs, and peat industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenberg's wet-carbonizing process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. v. Anrep, Jr.; also a translation of Lieut. Ekelund's pamphlet entitled 'A solution of the peat problem,' 1909, describing the Ekelund process for the manufacture of peat powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. v. Anrep. (Second edition, enlarged.)

82. Magnetic concentration experiments. Bulletin No. 5—by Geo. C. Mackenzie, B.Sc.

† Publications marked thus † are out of print.

83. An investigation of the coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others.
    Vol. I—Coal washing and cooking tests.
    Vol. II—Boiler and gas producer tests.
    Vol. III—(Out of print.)
        Appendix I
            Coal washing tests and diagrams.
    Vol. IV—
        Appendix II
            Boiler tests and diagrams.
    Vol. V—(Out of print.)
        Appendix III
            Producer tests and diagrams.
    Vol. VI—
        Appendix IV
            Coking tests.
        Appendix V
            Chemical tests.

†84. Gypsum deposits of the Maritime provinces of Canada—including the Magalen islands. Report on—by W. F. Jennison, M.E. (See No. 245.)

88. The mineral production of Canada, 1909. Annual report on—by John McLeish, B.A.

    NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1909.*

    †79. Production of iron and steel in Canada during the calendar year 1909.
    †80. Production of coal and coke in Canada during the calendar year 1909.
    85. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1909.

89. Reprint of presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Eugene Haanel, Ph.D.

90. Proceedings of conference on explosives.

92. Investigation of the explosives industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Second edition.)

93. Molybdenum ores of Canada. Report on—by Professor T. L. Walker, Ph.D.

100. The building and ornamental stones of Canada: Building and orna, mental stones of Ontario. Report on—by Professor W. A. Parks-Ph.D.

102. Mineral production of Canada, 1910. Preliminary report on—by John McLeish, B.A.

† Publications marked thus † are out of print.

†103. Summary report of Mines Branch, 1910.

104. Catalogue of publications of Mines Branch, from 1902 to 1911; containing tables of contents and lists of maps, etc.

105. Austin Brook iron-bearing district. Report on—by E. Lindeman, M.E.

110. Western portion of Torbrook iron ore deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Fréchette, M.Sc.

111. Diamond drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with introductory by A. W. G. Wilson, Ph.D.

118. Mica: its occurrence, exploitation, and uses. Report on—by Hugh S. de Schmid, M.E.

142. Summary report of Mines Branch, 1911.

143. The mineral production of Canada, 1910. Annual report on—by John McLeish, B.A.

Note. *The following parts were separately printed and issued in advance of the Annual Report for 1910.*

†114. Production of cement, lime, clay products, stone, and other materials in Canada, 1910.
†115. Production of iron and steel in Canada during the calendar year 1910.
†116. Production of coal and coke in Canada during the calendar year 1910.
†117. General summary of the mineral production of Canada during the calendar year 1910.

145. Magnetic iron sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.

†150. The mineral production of Canada, 1911. Preliminary report on—by John McLeish, B.A.

151. Investigation of the peat bogs and peat industry ot Canada, 1910-11 Bulletin No. 8—by A. v. Anrep.

154. The utilization of peat fuel for the production of power, being a record of experiments conducted at the Fuel Testing Station, Ottawa 1910-11. Report on—by B. F. Haanel, B.Sc.

167. Pyrites in Canada: its occurrence, exploitation, dressing and uses. Report on—by A. W. G. Wilson, Ph.D.

170. The nickel industry: with special reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.

184. Magnetite occurrences along the Central Ontario railway. Report on—by E. Lindeman, M.E.

201. The mineral production of Canada during the calendar year 1911. —Annual report on—by John McLeish, B.A.

† Publications marked thus † are out of print.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1911.*

181. Production of cement, lime, clay products, stone, and other structural materials in Canada during the calendar year 1911. Bulletin on—by John McLeish, B.A.

†182. Production of iron and steel in Canada during the calendar year 1911. Bulletin on—by John McLeish, B.A.

183. General summary of the mineral production in Canada during, the calendar year 1911. Bulletin on—by John McLeish, B.A.

†199. Production of copper, gold, lead, nickel, silver, zinc, and other metals of Canada, during the calendar year 1911. Bulletin on—by C. T. Cartwright, B.Sc.

†200. The production of coal and coke in Canada during the calendar year 1911. Bulletin on—by John McLeish, B.A.

203. Building stones of Canada—Vol. II: Building and ornamental stones of the Maritime Provinces. Report on—by W. A. Parks, PhD.

209. The copper smelting industry of Canada. Report on—by A. W. G. Wilson, Ph.D.

216. Mineral production of Canada, 1912. Preliminary report on—by John McLeish, B.A.

222. Lode mining in Yukon: an investigation of the quartz deposits of the Klondike division. Report on—by T. A. MacLean, B.Sc.

224. Summary report of the Mines Branch, 1912.

227. Sections of the Sydney coal fields—by J. G. S. Hudson, M.E.

†229. Summary report of the petroleum and natural gas resources of Canada, 1912—by F. G. Clapp, A.M. (See No. 224.)

230. Ecomomic minerals and mining industries of Canada.

245. Gypsum in Canada: its occurrence, exploitation, and technology. Report on—by L. H. Cole, B.Sc.

254. Calabogie iron-bearing district. Report on—by E. Lindeman, M.E.

259. Preparation of metallic cobalt by reduction of the oxide. Report on—by H. T. Kalmus, B.Sc., Ph.D.

262. The mineral production of Canada during the calendar year 1912. Annual report on—by John McLeish, B.A.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1912.*

238. General summary of the mineral production of Canada, during the calendar year 1912. Bulletin on—by John McLeish, B.A.

† Publications marked thus † are out of print.

†247. Production of iron and steel in Canada during the calendar year 1912. Bulletin on—by John McLeish, B.A.

†256. Production of copper, gold, lead, nickel, silver, zinc, and other metals of Canada, during the calendar year 1912—by C. T. Cartwright, B.Sc.

257. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1912. Report on—by John McLeish, B.A.

†258. Production of coal and coke in Canada, during the calendar year 1912. Bulletin on—by John McLeish, B.A.

266. Investigation of the peat bogs and peat industry of Canada, 1911 and 1912. Bulletin No. 9—by A. v. Anrep.

279. Building and ornamental stones of Canada—Vol. III: Building and ornamental stones of Quebec. Report on—by W. A. Parks, Ph.D.

281. The bituminous sands of Northern Alberta. Report on—by S. C. Ells, M.E.

283. Mineral production of Canada, 1913. Preliminary report on—by John McLeish, B.A.

285. Summary report of the Mines Branch, 1913.

291. The petroleum and natural gas resources of Canada. Report on—by F. G. Clapp, A.M., and others:—
Vol. I.—Technology and Exploitation.
Vol. II.—Occurrence of petroleum and natural gas in Canada.
Also separates of Vol. II, as follows:—
Part 1. Eastern Canada.
Part 2, Western Canada.

299. Peat, lignite, and coal: their value as fuels for the production of gas and power in the by-product recovery producer. Report on—by B. F. Haanel, B.Sc.

303. Moose Mountain iron-bearing district. Report on—by E. Lindeman, M.E.

305. The non-metallic minerals used in the Canadian manufacturing industries. Report on—by Howells Fréchette, M.Sc.

309. The physical properties of cobalt, Part II. Report on—by H. T. Kalmus, B.Sc., Ph.D.

320. The mineral production of Canada during the calendar year 1913. Annual report on—by John McLeish, B.A.

NOTE.—*The following parts were separately printed and issued in advance of the Annual Report for 1913.*

315. The production of iron and steel during the calendar year 1913. Bulletin on—by John McLeish, B.A.

316. The production of coal and coke during the calendar year 1913. Bulletin on—by John McLeish, B.A.

† Publications marked thus † are out of print.

317. The production of copper, gold, lead, nickel, silver, zinc, and other metals, during the calendar year 1913. Bulletin on—by C. T. Cartwright, B.Sc.

318. The production of cement, lime, clay products, and other structural materials, during the calendar year 1913. Bulletin on—by John McLeish, B.A.

319. General summary of the mineral production of Canada during the calendar year 1913. Bulletin on—by John McLeish, B.A.

322. Economic minerals and mining industries of Canada. (Panama Edition).

323. The Products and by-products of coal. Report on—by Edgar Stansfield, M.Sc., and F. E. Carter, B.Sc., Dr. Ing.

325. The salt industry of Canada. Report on—by L. H. Cole, B.Sc.

331. The investigation of six samples of Alberta lignites. Report on—by B. F. Haanel, B.Sc., and John Blizard, B.Sc.

334. Electro-plating with cobalt and its alloys. Report on—by H. T. Kalmus, B.Sc., Ph.D.

336. Notes on clay deposits near McMurray, Alberta. Bulletin No. 10—by S. C. Ells, B.A., B.Sc.

The Division of Mineral Resources and Statistics has prepared the following lists of mine, smelter, and quarry operators: Metal mines and smelters, Coal mines, Stone quarry operators, Manufacturers of clay products, and Manufacturers of lime; copies of the lists may be obtained on application.

IN THE PRESS.

338. Coals of Canada: Vol. VII. Weathering of coal. Report on—by J. B. Porter, E.M., D.Sc., Ph.D.

344. Electrothermic smelting of iron ores in Sweden. Report on—by Alfred Stansfield, D.Sc., A.R.S.M., F.R.S.C.

346. Summary report of the Mines Branch for 1914.

348. Production of coal and coke in Canada during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

349. Production of iron and steel in Canada during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

350. Production of copper, gold, lead, nickel, silver, zinc, and other metals, during the calendar year, 1914. Bulletin on—by J. McLeish, B.A.

FRENCH TRANSLATIONS.

†4. Rapport de la Commission nommée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe—by Eugene Haanel, Ph.D. (French Edition), 1905.

26a. The mineral production of Canada, 1906. Annual report on—by John McLeish, B.A.

†28a. Summary report of Mines Branch, 1908.

56. Bituminous or oil-shales of New Brunswick and Nova Scotia; also on the oil-shale industry of Scotland. Report on—by R. W. Ells, LL.D.

81. Chrysotile-asbestos, its occurrence, exploitation, milling, and uses. Report on—by Fritz Cirkel, M.E.

100a. The building and ornamental stones of Canada: Building and ornamental stones of Ontario. Report on—by W. A. Parks, Ph.D.

149. Magnetic iron sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.

155. The utilization of peat fuel for the production of power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-11. Report on—by B. F. Haanel, B.Sc.

156. The tungsten ores of Canada. Report on—by T. L. Walker, Ph.D.

169. Pyrites in Canada: its occurrence, exploitation, dressing, and uses. Report on—by A. W. C. Wilson, Ph.D.

180. Investigation of the peat bogs, and peat industry of Canada, 1910-11. Bulletin No. 8—by A. v. Anrep.

195. Magnetite occurrences along the Central Ontario railway. Report on —by E. Lindeman, M.E.

196. Investigation of the peat bogs and peat industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenburg's wet-carbonizing process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. v. Anrep; also a translation of Lieut. Ekelund's pamphlet entitled "A solution of the peat problem," 1909, describing the Ekelund process for the manufacture of peat powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. v. Anrep. (Second Edition, enlarged.)

197. Molybdenum ores of Canada. Report on—by T. L. Walker, Ph.D.

198. Peat and lignite: their manufacture and uses in Europe. Report on—by Erik Nystrom, M.E., 1908.

202. Graphite: its properties, occurrences, refining, and uses. Report on—by Fritz Cirkel, M.E., 1907.

† Publications marked thus † are out of print.

219. Austin Brook iron-bearing district. Report on—by E. Lindeman, M.E.

224a. Mines Branch Summary report for 1912.

226. Chrome iron ore deposits of the Eastern Townships. Monograph on—by Fritz Cirkel, M.E. (Supplementary section: Experiments with chromite at McGill University—by J. B. Porter, E.M., D.Sc.)

231. Ecomomic minerals and mining industries of Canada.

233. Gypsum deposits of the Maritime Provinces of Canada—including the Magdalen islands. Report on—by W. F. Jennison, M.E.

263. Recent advances in the construction of electric furnaces for the production of pig iron, steel, and zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.

264. Mica: its occurrence, exploitation, and uses. Report on—by Hugh S. de Schmid, M.E.

265. Annual mineral production of Canada, 1911. Report on—by John McLeish, B.A.

287. Production of iron and steel in Canada during the calendar year 1912. Bulletin on—by John McLeish, B.A.

288. Production of coal and coke in Canada, during the calendar year 1912. Bulletin on—by John McLeish, B.A.

289. Production of cement, lime, clay products, stone, and other structural materials during the calendar year 1912. Bulletin on—by John McLeish, B.A.

290. Production of copper, gold, lead, nickel, silver, zinc, and other metals of Canada during the calendar year 1912. Bulletin on—by C. T. Cartwright, B.Sc.

307. Catalogue of French publications of the Mines Branch and of the Geological Survey, up to July, 1914.

308. An investigation of the coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma. E., and others—
    Vol. I—Coal washing and coking tests.
    Vol. II—Boiler and gas producer tests.

314. Iron ore deposits, Bristol mine, Pontiac county, Quebec, Report on—by E. Lindeman, M.E.

IN THE PRESS.

179. The nickel industry: with special reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.

204. Building stones of Canada—Vol. II: Building and ornamental stones of the Maritime Provinces. Report on—by W. A. Parks, Ph.D.

223. Lode Mining in the Yukon: an investigation of quartz deposits in the Klondike division. Report on—by T. A. MacLean, B.Sc.

246. Gypsum in Canada: its occurrence, exploitation, and technology. Report on—by L. H. Cole, B.Sc.

308. An investigation of the coals of Canada with reference to their economic qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durley, Ma.E., and others—
    Vol. III—
        Appendix I
            Coal washing tests and diagrams.
    Vol. IV—
        Appendix II
            Boiler tests and diagrams.

286. Summary Report of Mines Branch, 1913.

321. Annual mineral production of Canada, during the calendar year, 1913. Report on by J. McLeish, B.A.

MAPS.

†6. Magnetometric survey, vertical intensity: Calabogie mine, Bagot township, Renfrew county, Ontario—by E. Nystrom, 1904. Scale 60 feet to 1 inch. Summary report 1905. (See Map No. 249.)

†13. Magnetometric survey of the Belmont iron mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1906. (See Map No. 186.)

†14. Magnetometric survey of the Wilbur mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1906.

†33. Magnetometric survey, vertical intensity: lot 1, concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

†34. Magnetometric survey, vertical intensity: lots 2 and 3, concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

†35. Magnetometric survey, vertical intensity: lots 10, 11, and 12, concession IX, and lots 11 and 12, concession VIII, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch. (See Maps Nos. 191 and 191A.)

*36. Survey of Mer Bleue peat bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nystrom, and A. v. Anrep. (Accompanying report No. 30.)

*37. Survey of Alfred peat bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*38. Survey of Welland peat bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*39. Survey of Newington peat bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*40. Survey of Perth peat bog, Drummond township, Lanark county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

†41. Survey of Victoria Road peat bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)

*48. Magnetometric survey of Iron Crown claim at Nimpkish (Klaanch) river, Vancouver island, B.C.—by E. Lindeman. Scale 60 feet to 1 inch. (Accompanying report No. 47.)

Note.—1. Maps marked thus * are to be found only in reports.
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Note.—1. Maps marked thus * are to be found only in reports.
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†98. General map of coal fields in British Columbia. Accompanying report No. 83—by Dr. J. B. Porter.)

†99. General map of coal field in Yukon Territory. (Accompanying report No. 83—by Dr. J. B. Porter.)

†106. Geological map of Austin Brook iron bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)

†107. Magnetometric survey, vertical intensity: Austin Brook iron bearing district—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)

†108. Index map showing iron bearing area at Austin Brook—by E. Lindeman. (Accompanying report No. 105.)

*112. Sketch plan showing geology of Point Mamainse, Ont.—by Professor A. C. Lane. Scale 4,000 feet to 1 inch. (Accompanying report No. 111.)

†113. Holland peat bog Ontario—by A. v. Anrep. (Accompanying report No. 151.)

*119-137. Mica: township maps, Ontario and Quebec—by Hugh S. de Schmid. (Accompanying report No. 118.)

†138. Mica: showing location of principal mines and occurrences in the Quebec mica area—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†139. Mica: showing location of principal mines and occurrences in the Ontario mica area—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†140. Mica: showing distribution of the principal mica occurrences in the Dominion of Canada—by Hugh S. de Schmid. Scale 3·95 miles to 1 inch. (Accompanying report No. 118.)

†141. Torbrook iron bearing district, Annapolis county, N.S.—by Howells Fréchette. Scale 400 feet to 1 inch. (Accompanying report No. 110).

†146. Distribution of iron ore sands of the iron ore deposits on the north shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie. Scale 100 miles to 1 inch. (Accompanying report No. 145.)

†147. Magnetic iron sand deposits in relation to Natashkwan harbour and Great Natashkwan river, Que. (Index Map)—by Geo. C. Mackenzie. Scale 40 chains to 1 inch. (Accompanying report No. 145.)

†148. Natashkwan magnetic iron sand deposits, Saguenay county, Que.—by Geo. C. Mackenzie. Scale 1,000 feet to 1 inch. (Accompanying report No. 145.)

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†152. Map showing the location of peat bogs investigated in Ontario—by A. v. Anrep.

†153. Map showing the location of peat bog as investigated in Manitoba—by A. v. Anrep.

†157. Lac du Bonnet peat bog, Manitoba—by A. v. Anrep.

†158. Transmission peat bog, Manitoba—by A. v. Anrep.

†159. Corduroy peat bog, Manitoba—by A. v. Anrep.

†160. Boggy Creek peat bog, Manitoba—by A. v. Anrep.

†161. Rice Lake peat bog, Manitoba—by A. v. Anrep.

†162. Mud Lake peat bog, Manitoba—by A. v. Anrep.

†163. Litter peat bog, Manitoba—by A. v. Anrep.

†164. Julius peat litter bog, Manitoba—by A. v. Anrep.

†165. Fort Francis peat bog, Ontario—by A. v. Anrep.

(Accompanying report No. 151.)

†166. Magnetometric map of No. 3 mine, lot 7, concessions V and VI, McKim township, Sudbury district, Ont.—by E. Lindeman. (Accompanying Summary report, 1911.)

†168. Map showing pyrites mines and prospects in Eastern Canada, and their relation to the United States market—by A. W. G. Wilson. Scale 125 miles to 1 inch. (Accompanying report No. 167.)

†171. Geological map of Sudbury nickel region, Ont.—by Prof. A. P. Coleman. Scale 1 mine to 1 inch. (Accompanying report No. 170.)

†172. Geological map of Victoria mine—by Prof. A. P. Coleman.

†173. " Crean Hill mine—by Prof. A. P. Coleman

†174. " Creighton mine—by Prof. A. P. Coleman.

(Accompanying report No. 170.)

†175. " showing contact of norite and Laurentian in vicinity of Creighton mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†176. " Copper Cliff offset—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†177. " No. 3 mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)

†178. " showing vicinity of Stobie and No. 3 mines—by Prof. A. P. Coleman. (Accompanying report No. 170.)

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†185. Magnetometric survey, vertical intensity: Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†185a. Geological map, Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch (Accompanying report No. 184.)

†186. Magnetometric survey, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†186a. Geological map, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†187. Magnetometric survey, vertical intensity: St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†187a. Geological map, St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†188. Magnetometric survey, vertical intensity: Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†188a. Geological map, Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†189. Magnetometric survey, vertical intensity: Ridge iron ore deposits, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†190. Magnetometric survey, vertical intensity: Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†190a. Geological map, Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†191. Magnetometric survey, vertical intensity: Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†191a. Geological map, Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†192. Magnetometric survey, vertical intensity: Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 194.)

Note.—1. Maps marked thus * are to be found only in reports.
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†192a. Geological map, Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†193. Magnetometric survey vertical intensity: Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†193a. Geological map, Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†194. Magnetometric survey, vertical intensity: Bow Lake iron ore occurrences, Faraday township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

†204. Index map, magnetite occurrences along the Central Ontario railway—by E. Lindeman, 1911. (Accompanying report No. 184.)

†205. Magnetometric map, Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman, 1911. (Accompanying report No. 303.)

†205a. Geological map, Moose Mountain iron-bearing district, Sudbury district, Ontario, Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman. (Accompanying report No. 303.)

†206. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: northern part of deposit No. 2—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†207. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 8, 9, and 9A—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208. Magnetometric survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposit No. 10—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208a. Magnetometric survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: eastern portion of Deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208b. Magnetometric survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: western portion of deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)

†208c. General geological map, Moose Mountain iron-bearing district, Sudbury district, Ontario—by E. Lindeman, 1912. Scale 800 feet to 1 inch. (Accompanying report No. 303.)

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†210. Location of copper smelters in Canada—by A. W. G. Wilson. Scale 197·3 miles to 1 inch. (Accompanying report No. 209.)

†215. Province of Alberta: showing properties from which samples of coal were taken for gas producer tests, Fuel Testing Division, Ottawa. (Accompanying Summary report, 1912.)

†220. Mining districts, Yukon. Scale 35 miles to 1 inch—by T. A. MacLean (Accompanying report No. 222.)

†221. Dawson mining district, Yukon, Scale 2 miles to 1 inch—by T. A. MacLean. (Accompanying report No. 222.)

*228. Index map of the Sydney coal fields, Cape Breton, N.S. (Accompanying report No. 227.)

†232. Mineral map of Canada. Scale 100 miles to 1 inch. (Accompanying report No. 230.)

†239. Index map of Canada showing gypsum occurrences. (Accompanying report No. 245.)

†240. Map showing Lower Carboniferous formation in which gypsum occurs in the Maritime provinces. Scale 100 miles to 1 inch. (Accompanying report No. 245.)

†241. Map showing relation of gypsum deposits in Northern Ontario to railway lines. Scale 100 miles to 1 inch. (Accompanying report No. 245.)

†242. Map, Grand River gypsum deposits, Ontario. Scale 4 miles to 1 inch. (Accompanying report No. 245.)

†243. Plan of Manitoba Gypsum Co.'s properties. (Accompanying report No. 245.)

†244. Map showing relation of gypsum deposits in British Columbia to railway lines and market. Scale 35 miles to 1 inch. (Accompanying report No. 245.)

†249. Magnetometric survey, Caldwell and Campbell mines, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†250. Magnetometric survey, Black Bay or Williams mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†251. Magnetometric survey, Bluff Point iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†252. Magnetometric survey, Culhane mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

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†253. Magnetometric survey, Martel or Wilson iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

†261. Magnetometric survey, Northeast Arm iron range, lot 339 E.T.W. Lake Timagami, Nipissing district, Ontario—by E. Nystrom. 1903. Scale 200 feet to 1 inch.

†268. Map of peat bogs investigated in Quebec—by A.v. Anrep, 1912.

†269. Large Tea Field peat bog, Quebec " "

†270. Small Tea Field peat bog, Quebec " "

†271. Lanoraie peat bog, Quebec " "

†272. St. Hyacinthe peat bog, Quebec " "

†273. Rivière du Loup peat bog " "

†274. Cacouna peat bog " "

†275. Le Parc peat bog, Quebec " "

†276. St. Denis peat bog, Quebec " "

†277. Rivière Ouelle peat bog, Quebec " "

†278. Moose Mountain peat bog, Quebec " "

†284. Map of northern portion of Alberta, showing position of outcrops of bituminous sand. Scale 12½ miles to 1 inch. (Accompanying report No. 281.)

†293. Map of Dominion of Canada, showing the occurrences of oil, gas, and tar sands. Scale 197 miles to 1 inch. (Accompanying report No. 291.)

†294. Reconnaissance map of part of Albert and Westmorland counties New Brunswick. Scale 1 mile to 1 inch. (Accompanying report No. 291.)

†295. Sketch plan of Gaspé oil fields, Quebec, showing location of wells. Scale 2 miles to 1 inch. (Accompanying report No. 291.)

†296. Map showing gas and oil fields and pipe-lines in southwestern Ontario. Scale 4 miles to 1 inch. (Accompanying report No. 291.)

†297. Geological map of Alberta, Saskatchewan, and Manitoba. Scale 35 miles to 1 inch. (Accompanying report No. 291.)

†298. Map, geology of the forty-ninth parallel, 0·9864 miles to 1 inch. (Accompanying report No. 291.)

†302. Map showing location of main gas line, Bow Island, Calgary. Scale 12½ miles to 1 inch. (Accompanying report No. 291.)

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†311. Magnetometric map, McPherson mine, Barachois, Cape Breton county, Nova Scotia—by A. H. A. Robinson, 1913. Scale 200 feet to 1 inch.

†312. Magnetometric map, iron ore deposits at Upper Glencoe, Inverness county, Nova Scotia—by E. Lindeman, 1913. Scale 200 feet to 1 inch.

†313. Magnetometric map, iron ore deposits at Grand Mira, Cape Breton county, Nova Scotia—by A. H. A. Robinson, 1913. Scale 200 feet to 1 inch.

Address all communications to—

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