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PRELIMINARY REPORT

GENERAL GEOLOGY AND PETROLEUM RESOURCES OF MANITOULIN AND ADJACENT ISLANDS, ONTARIO

By

M.Y. Williams

OTTAWA

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DEPARTMENT OF MINES AND RESOURCES
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CHAPTER I

INTRODUCTION

Manitoulin island is one of the possible oil fields of Canada, but as yet the results of investigations have been inconclusive. The drilling during early boom days was interrupted by troubles with the Indians, and later drilling has been done quite regardless of geological structure, which in itself is difficult to determine. Sufficient oil was struck in at least three localities to arouse interest locally, but the testing practice was such as to leave some doubt as to the intrinsic value of at least one of these fields. The purpose of the work of 1935 was to make a careful investigation of the geology and structural conditions of the region, and of the past development and its results.

The first serious geological work on Manitoulin island was done by Alexander Murray in 1847 (See Bibliography). He laid a firm foundation for the stratigraphy and mapping of the island, and reported on the oil springs. In 1861 T. Sterry Hunt wrote his epoch-making papers on occurrence, origin, accumulation, and uses of petroleum, outlining the anticlinal theory of oil accumulation. In 1863-66 Hunt embodied information from Murray with information direct from the drillers in describing the Cape Smith oil wells and oil possibilities.

Robert Bell recorded his first work on Manitoulin island in the Geological Survey, Canada, Report of Progress for 1863-6, and completed his work on this region by his report on the geology of the French River sheet, published in 1898. The map (French River sheet) accompanying Bell's report, and the Manitoulin Island sheet, published in 1907 or

on the same scale (4 miles to 1 inch) supplied a complete map of the area. The Manitoulin Island sheet is the only reasonably large scale geological map of the region, and in a general way is an excellent map, although the terminology applied to the sedimentary formations is out of date, and the accuracy of some of the geological boundaries leaves much to be desired. On the Manitoulin sheet Dr. Bell has drawn twelve lines through the centres of straits and other water bodies, purporting to represent the axes of anticlines. These trend in a southwest direction, and are apparently placed on the map on the theory that the submerged valleys are anticlinal and the intervening hills synclinal. There is probably some structural control of the erosion of the region but the writer is unable to find field evidence to confirm the occurrence of these anticlines, although the theoretical basis for their existence is not unreasonable.

In 1912 Dr. A.F. Foerste of Dayton, Ohio, commenced field work on the Cincinnatian formations of the region, completing it the following year.

In 1912 the writer commenced a study of the Silurian formations of the eastern end of Manitoulin island, in preparation of the guide book of the Twelfth International Geological Congress, and so started his investigations of the Silurian of Ontario which continued without interruption for five years, culminating in the publication of Memoir III of the Geological Survey, Canada.

During the summer of 1915 the writer mapped the boundaries of the Silurian formations of Manitoulin and adjoining islands, and a short visit was paid to the western end of the island again in the summer of 1916.

In 1920 the writer spent six weeks on the eastern end of Manitoulin island investigating the structure. The results were published in the Geological Survey Summary Report for 1920.

In more recent years graduate students from the University of Toronto have made special stratigraphic studies of the Manitoulin region, and these have been most generously placed at the writer's disposal by Dr. W.A. Parks and Mr. Harold G. Way.

The writer entered the field on June 15, 1935, and left it on September 11. He was ably assisted by D. K. Stadelman, a student from the University of Toronto. It was possible to visit practically all parts of Manitoulin island and the adjoining Cloche island and Cloche peninsula, as well as the more important neighbouring islands, including Cockburn island. Fitzwilliam island and its neighbouring islands southeast of Manitoulin island had been visited in 1912 and 1915 and were not revisited. Great Duck island, however, was visited for the first time.

Considerable attention was devoted to a complete re-mapping of the Ordovician boundaries of Manitoulin island, Cloche island, Cloche peninsula, Little Cloche island, Clapperton island, Strawberry island, Rabbit island, and William island. The other islands of the North channel offer no possibilities for the occurrence of oil or gas because of the shallow and eroded condition of any Trenton dolomite that may be found on them, and their geological boundaries have been taken from the maps by Dr. Bell.

The structural map accompanying this report has been prepared from all evidence available, viz., observed attitude of rock outcrops, elevations of formational contacts, and well

records. It is most unfortunate that of all the wells drilled in this region only a very few reliable logs are available. From these definite elevations have been obtained for the top of the Trenton, the most valuable and convenient horizon to use as a datum plane for structural mapping. Its value is due to the fact that the oil horizon is in the proper part of the Trenton and that it is the most definite horizon to determine, being overlain directly by the black Collingwood shale.

The depth of the Trenton below the base of the cliff-forming Manitoulin dolomite, is 475 feet, as ascertained from wells drilled west of Manitowaning near the Manitoulin dolomite cliffs. This depth appears to hold very closely for the area east of West bay, although determinative measurements have to be made over an intervening distance of a mile and so are liable to error due to the variable dip of the formations. The logs of the wells drilled at Gore bay establish a thickness of 400 feet between the base of the Manitoulin dolomite and the top of the Trenton dolomite. As no determinations are available elsewhere in the western part of Manitoulin island, the sub-surface contours have been adjusted to allow for a decreasing depth of the Trenton of 5 feet a mile from West bay to Gore bay. To the west of Gore bay the depth is taken as 400 feet. Such allowances for variation in thicknesses of formations are not likely to change or obscure the portrayal of structural features, although they do swing the contours to the south, westward of an axis through West bay and Mindemoya lake. Such a swing is, however, in harmony with the observed swing of the outcrop of the Trenton along the north side of the islands.

As may be seen from this discussion, the accuracy of the sub-surface structure map varies from place to place,

according to the kind of information available and the distance from points of observed facts. Thus full lines are based upon actual outcrops of the top of the Trenton or well records that give the depth to the top of the Trenton, or observed contacts, such as the base of the Manitoulin dolomite, the depth to the Trenton being known.

Broken lines are used where uncertainty arising from distance from observed data or lack of information leaves the structure somewhat in doubt.

Dotted lines indicate that the structure has been drawn from hypothetical evidence, such as general dip of formations, parallelism of structures, etc.

CHAPTER II

Description of Formations

Precambrian. The oldest rock formations outcropping in the Manitoulin area are schists and quartzites of Precambrian age. The schists occur on the northeast side of Cloche peninsula and Great Cloche island, quartzites occurring elsewhere. The Precambrian formations were folded and deeply dissected by erosion in pre-Ordovician time. The knolls of quartzite protruding through the Palaeozoic strata stand 145 feet or more above lake Huron, and the intervening valleys, now filled with Ordovician limestones and shales, are of considerable depth. Moreover, the quartzite ridges have been markedly reduced by glaciation, probably as much as 25 per cent of their present height. The contact surfaces beneath the Ordovician strata are much stained with iron oxide and the lower sedimentary rocks include pebbles and sand derived from the crystalline rocks. The higher formations, such as the Collingwood shale, lack the basal clastics, but the Precambrian surface shows deep weathering and there is considerable decayed rock at the contact.

Lowville. The earliest Ordovician in the Manitoulin region has been divided by Foerste into three members, viz., in ascending order, the Lowville, Leray, and Black River limestones. The Lowville is well exposed in the railway cuts along the northwestern side of Cloche peninsula, where Foerste studied it, and also along the northern side of Great Cloche island, at the northeast corner of Cloche peninsula, and the northeast corner of Birch island. At the first-named locality, red and mottled sandstone and nodular red shales overlie the erosion surface of the Precambrian quartzite, succeeded by red and green-gray,

limy beds a short distance up. Foerste says[1] "only the upper

[1] International Geological Congress Guide Book No. 5, p. 85.

part of these shales, 70 feet thick, are exposed above lake level. Fossils are found a mile south of the northwestern angle of the peninsula, in a hard brownish clay stratum a short distance above the level of the railway. The southward dip of the strata is sufficient to carry them below lake level about a mile before Swift Current is reached."

Leray.[2] The Leray has been described by Foerste as follows:

[2] Ibid., pp. 85-86

"The overlying strata consist chiefly of soft whitish limestones of variable character, which are reddish only where near one of the Precambrian quartzite ranges or knolls ..... These limestones are referred to the Upper or Leray division of the Lowville, and terminate, at the top, in a series of very fine-grained, much harder limestones, 11 feet thick, resembling the "Birdseye" limestones of New York. These "Birdseye" limestones are exposed at intervals for a distance of almost a mile along the railway south of Swift Current, and contain very few fossils. The immediately underlying strata ..... contain a fauna sufficient to identify the horizon, although not usually well preserved".

The lower limestones of this series are exposed in a 15-foot section near the head of Green bay, on the west side of Cloche channel, and over the southern part of Cloche peninsula. This limestone is very scraggy, and of a brown colour, worm burrows and large nautiloids being prominent fossils in it.

An excellent section of the upper or Birdseye member of this formation is exposed in two quarrries near the railway,

near Swift Current at the eastern end of Cloche island. The section is about 20 feet thick, and is composed of fine-grained, bluish grey limestone in 6- to 10-inch beds with shale partings showing mud-cracks. Brown, scraggy-weathering limestone caps the section and may be the base of the next higher division. The "Birdseye" limestone is lithographic in grain and has a well-marked, conchoidal fracture. It is spotted with elongate masses of transparent calcite, giving it its "birdseye" appearance.

Foerste does not give an estimated thickness for the Leray member. In the section described above, brown-weathering limestone is exposed at water-level, 10 feet below the base of the Birdseye division, and the brown limestone has been shown to be at least 15 feet thick on Green bay. This gives a minimum thickness for the formation of 35 feet, and it is more probably about 60 feet thick.

Black River Limestones. These were described by Foerste as follows:[1] "Overlying the Leray division of the Lowville are darker limestones ..... These are the beds to which formerly the term "Black River" was restricted ..... The lower part of the section, 80 feet thick, ... is exposed for a mile south of Swift Current. The upper part of the section occupies the remainder of the distance across Cloche island. The dip of these strata changes constantly, owing to their deposition among the ranges of Huronian quartzites and schists. The angle is so low and variable that it is impossible to determine, even approximately, the thickness of the various formations."

This division evidently begins with the rough, brown-weathering limestone at the top of the Birdseye section in the quarry near Swift Current. It is a highly fossiliferous, impure

[1] Ibid., p. 86.

limestone, weathering into soft, nodular masses. As stated by Foerste, it is most difficult to estimate the thickness of this division, but it is probably not more than 120 feet, allowing 80 feet for the lower part as calculated by Foerste and 40 feet for the upper part.

Trenton. The Trenton has been divided by Foerste into two major subdivisions. Of the lower, Foerste says (ibid., page 87): "The lowest Trenton strata exposed along the line of railway, occur near the northeastern shore of Goat island, and are referred to the Curdsville division of Kentucky".

This dolomitic limestone is highly fossiliferous, is of a light grey colour, with a greenish cast on bedding planes, and weathers brown. It is highly argillaceous, and breaks down readily on weathering. Foerste does not hazard an estimate of the thickness of the "Curdsville" limestone, but it outcrops over Goat island, and allowing for the southerly dip of the formations as averaging about 40 feet a mile, the thickness represented is probably about 25 feet.

The higher subdivision of the Trenton includes the Prasopora simulatrix horizon, which Foerste defined as the lowest strata found at the water's edge, east of Little Current. The section here to the base of the black Collingwood shale is 65 feet thick. The limestone is thinly bedded, highly argillaceous, and in most places full of fossils; but these weather out most easily along the shaly partings and so seem to be concentrated within certain zones. The occurrence of large percentages of shaly material all through the limestone, and the presence of current marks suggest shallow water conditions of origin.

In chemical properties the limestone approaches a true dolomite, analysing 32 per cent of magnesium carbonate to 47.10 per cent of calcium carbonate. A considerable porosity in most

cases accompanies a high percentage of magnesium, but the high percentage of argillaceous impurities, up to 10 per cent tends to fill up the pore spaces. This limestone is nevertheless the oil-bearing formation of this region. From the logs given in this report, it is evident that most of the definitely recorded production came from an horizon 12 to 20 feet below the top of the Trenton.

The estimated thicknesses of the formations recorded so far, that is from the top of the Precambrian to the top of the Trenton total 340 feet. A well drilled at Gore bay (See below) gives this thickness as 350 feet, confirming the estimate. As the Precambrian surface is markedly irregular, lower beds may be locally missing. The formations probably vary considerably in thickness from place to place.

Collingwood. The Collingwood formation was formerly called the Utica, as it is similar lithologically to the Utica formation of New York. It consists of dark grey to black, bituminous shale, variously reported in well records as from 20 to 60 feet thick. Its black colour makes it the most easily recognized of all the beds cut by the drill, and in consequence the top of the Trenton which it overlies is easily and accurately determined.

The Collingwood shale rests unconformably upon the Trenton, as may be seen at various localities near Little Current. This relationship has been carefully described by Caley and Sproule.[1] The best exposed example of this unconformity

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[1] Geol. Surv., Canada, Mem. 202

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may be seen in an old quarry north of Sheguiandah, on the shore of Sheguiandah bay. There a limestone bed below the contact has been eroded so as to vary from 27 to 2 inches in thickness. "The conglomerate at the contact is composed of angular to well-rounded

pebbles fused into a sandy lime matrix."[1]

[1] Sproule, J.C. Geol. Surv., Canada, Mem. 202, p. 99

These well-marked contact conditions are of considerable importance as they indicate a high porosity for the upper part of the Trenton beds, suitable for petroleum accumulation. As shown above, it is generally within the upper 12 to 20 feet of these beds that oil has been found.

By distillation tests the Collingwood shales south of Little Current have been shown to yield 4.8 to 8.1 Imperial gallons of petroleum a ton.[2]

[2] Geol. Surv., Canada, Sum. Rept. 1920, pt. D, p. 32.

Sheguiandah. Foerste has given the name "Sheguiandah" to the strata of Manitoulin island immediately overlying the Collingwood. He says[3] "the lower part of the Sheguiandah or Eden formation

[3] Geol. Surv., Canada, Mem. 138, p. 28.

consists of shale or clay, and only the extreme top contains limestone in any abundance. ..... the total thickness of the Sheguiandah on Manitoulin island probably does not exceed 125 feet ....."

The lower part of the Sheguiandah, overlying the Collingwood shale, consists of soft, grey, fissile shale which appears to grade upward from the Collingwood, the transition being marked by the gradual lessening of bituminous content. As such contacts weather readily into shaly shingle and clay the exact bedded exposure has not been seen by the writer. These shales are rich in beautifully preserved bryozoa.

Wekwemikongsing. Foerste has used the name Wekwemikongsing for the division succeeding the Sheguiandah. Of it he says:[1]

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[1] Ibid., p. 28

"The Maysville member of the Upper Ordovician on Manitoulin island is only about 150 feet thick, is rarely well exposed, and consists chiefly of shales interbedded with argillaceous limestone ....."

This formation is best exposed in the famous Clay Cliffs north of Wekwemikongsing and just south of cape Smith.

Richmond The Richmond, youngest Ordovician division occurring, is the lowest of the cliff-forming limestones on Manitoulin island. Such cliffs occur on the Wekwinikong reserve south of Smith bay, at Ten Mile point, across the peninsula south of Little Current, and in headlands to the westward as far as cape Robert. The limestones are also well exposed at Kagawong and at Francis falls northwest of Manitowaning. They are impure, dolomitic limestone, resembling the Trenton dolomite in general characters, but containing less magnesia. The upper beds are more resistant to weathering than the lower. Foerste recognized two subdivisions, the Meaford and Kagawong.

Meaford.[1] Of the Meaford Foerste says:[2] "This formation, named

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[1] In the legend of the accompanying map, the term Meaford has been inadvertently omitted from the description of division 4.

[2] Memoir 138, p. 51.

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from the exposures near Meaford, Ontario, although better exposed on Manitoulin island, includes the lowest horizon of the Richmond in southern Ontario, up to the base of the Gore Bay reef."

In Guide Book No. 5 (page 80) Foerste includes 40 feet of strata in the Clay Cliff section in the Lower Richmond, corresponding with his later described Meaford division.

Kagawong. In the Kagawong member of the Richmond, Foerste includes all the strata on Manitoulin island from the Stromatocerium reef horizon upward. This lower Stromatocerium reef is missing at Manitowaning and "is approximately represented by an horizon in which Columnaria and Calapoecia are fairly abundant. Westward, this horizon is represented by the Gore Bay Columnaria reef" (Foerste, page 81, Guide Book V). "It is assumed that the Gore Bay reef is the base of a new faunal zone, notwithstanding that all the corals characterizing this zone occur also at lower horizons, though in fewer numbers and of smaller size. Above this reef the strata become more aronaceous, although this arenaceous element is very fine-grained and does not result in a gramular texture" (Foerste, Memoir 138, page 52).

Foerste gives no thickness for the Kagawong member, but in Memoir 83, page 105, in a section of the Richmond formation as exposed at the falls 3½ miles northwest of Kagawong, he gives a complete Richmond section 127½ feet thick, of which the lower 46 feet, beginning with the Hebertella insculpta zone and ending below the Columnaria and Calapoecia, or G ·e Bay coral reef, is referred to the upper part of the Waynesville (Ohio and Indiana) section (Meaford) and the upper 81 feet to the Whitewater, including Saluda (Kagawong member).

At Manitowaning Foerste (Ibid., pages 120-122) gives the section as follows:

Meaford, starting 6 feet above the bay, with Hebertella insculpta zone 26 feet thick to Gore Bay reef

horizon, and upper Kagawong member 130 feet thick to the approximate base of the Manitoulin dolomite.

Accepting 60 feet as the thickness of the Collingwood shale, the section as given above from the top of the Trenton to the base of the Manitoulin dolomite is 462 feet. From a well record west of Manitowaning, starting 10 feet below the base of the Manitoulin dolomite, the depth to the Trenton is 465 feet, which makes the total thickness 475 feet, a remarkably close check of stratigraphic measurements. The same formations at Gore bay measure only 400 feet by well record, or 75 feet less than in the eastern part of the island.

Manitoulin. The Kagawong is overlain by the Silurian Manitoulin dolomite which is the second cliff-forming dolomite of the region, its edge being marked by a sinuous escarpment with exposed faces varying from 10 to 50 feet in height, and extending from the east end of Manitoulin island as far west as Vidal bay. The dolomite is bluish or greenish on fresh fracture, but weathers grey or buff, closely resembling the Niagara dolomite. The lower and upper beds tend to be thin and argillaceous, but there is much variation, due to lateral changes in lithology and to conditions of weathering. Exposed cliffs tend to maintain a more massive character than jointed areas, opened by quarrying. Near the top of the dolomite reefs or "bioherms" are locally developed, accompanied by noticeable thickening of the formation. Such examples are to be seen at Gibraltar cliff near the foot of Manitowaning bay, near Green bay, and elsewhere.

The basal contact of the Manitoulin dolomite is with the upper Richmond (Kagawong) shaly dolomite. The beds appear to be conformable, but there is a sharp break in lithology, some change in chemical composition, and a complete change in fossil content. The greater hardness of the Manitoulin dolomite is

evident in the overhang almost universal in sections.

The total thickness of the Manitoulin dolomite is probably about 60 feet where the "reefs" occur and somewhat less elsewhere.

Cabot Head. The Cabot Head shale, in its restricted sense, rests upon the Manitoulin dolomite and is overlain by the Dyer Bay dolomite. Its characters on Manitoulin island are best observed on the road west of West Bay Indian village, extending toward Kagawong, where the section in ascending order is as follows (Memoir III, page 34): "40 feet of soft red shale; 1 3/4 feet of hard, green shale, calcareous at the base; 10 feet of soft, red shale; 5 feet of soft, green shale; succeeded by fine-grained Dyer Bay dolomite." This shale formation appears to be unfossiliferous, and its total thickness is thus about 57 feet. Other sections are partly exposed at the north end of Fitzwilliam Island, at Tamarack cove, along the eastern extension of Lake Manitou, one-half mile west of Ice Lake on the road to Gore Bay, near the site of the former Indian village on Campbell Bay, at water-level at the end of the point between Campbell and Helen Bays, and along the east side of Lake Wolsey and elsewhere. The green beds vary in their location in the formation and appear to be local lenses. In some cases, indeed, the green colour may be due to leaching and reduction of the iron content of the shale by contact with decaying organic material.

Although the exact contact with the underlying Manitoulin dolomite is not known to the writer it is probably conformable, as the lower shales appear to be green and somewhat limy. The upper contact appears to be transitional from green shale to shaly dolomite of the Dyer Bay formation.

Dyer Bay. The Dyer Bay dolomite is thin-bedded, shaly dolomite, weathering light grey or pea-green, and commonly beautifully mud-cracked and ripple-marked. Most of these Dyer Bay beds are cut by two sets of vertical joints. In spite of their shaly characters they tend to be resistant to weathering and wave action and project out from the Niagara cliffs into bodies of water or over land areas, in some cases forming small cliffs. They are somewhat conspicuous at the northeastern extremity of Fitzwilliam island where they are 10 feet thick, at Tamarack cove where they are 15 feet thick, on both sides of South bay, on the southeast side of lake Manitou where they are about 12 feet thick, just north of a lakelet, near Excelsior post office, where they are about 25 feet thick, west of Ice lake on the Gore Bay road, on the north end of the island in Mindemoya lake, on the west side of Kagawong lake, along the points on the south side of Bayfield sound, on Cumberland and Meldrum points, and along the north side of Cockburn island.

The lower contact of the Dyer Bay formation with the Cabot Head shale appears to be transitional, and the upper beds appear to grade into the overlying, green, calcareous, Wingfield shale. The section west of Excelsior illustrates these conditions. Twenty-five feet of thin-bedded, porcellaneous dolomite and interbedded shale overlie 5 feet of soft, green, Cabot Head shale, as already described. A few inches of grey, semi-crystalline dolomites occur near the middle, the Virgiana zone being just below and the Ostracoda zone 6 or 7 feet higher up. The dolomites are overlain by 7 feet of green, calcareous shale (Wingfield) which in turn is overlain by 24 feet of thin-bedded Niagara dolomite.

Wingfield Shale. The Wingfield shale is well defined at its type locality on Bruce peninsula, where it consists of 32 feet

of firm green shale. On Manitoulin island, however, the shale is much thinner and is rarely well exposed. In the section cited above about 7 feet of green, calcareous shale overlies the Dyer Bay beds. On the north side of Cockburn island, just west of Tolsmayville, some 4 or 5 feet of waterlime rock appears to represent this horizon. At Tamarack cove over 22 feet of shale overlies the Dyer Bay beds and the thickness between this point and West bay appears to gradually diminish, as do the Cataract members.

Lockport Dolomite. This great cliff-making formation, here, as elsewhere in southwestern Ontario, forms the Niagara escarpment, the most conspicuous landscape feature of the region. It extends in a sinuous line from near Tamarack cove on the east westward through Cockburn island, and thence through Drummond island into Michigan. Submerged locally by bays and lakes, this line of white rocky cliffs has a length greatly in excess of the extent of the islands.

The most characteristic section of Lockport dolomite occurs in the vicinity of Fossil hill, about 7 miles southwest of Manitowaning. Starting above the Wingfield shale the section is as follows, in ascending order: 35 feet thin-bedded dolomite; 35 feet thicker bedded dolomite; 50 feet thick-bedded dolomite with a profuse coral horizon (Fossil hill) 20 feet up; 30 feet rather unfossiliferous dolomite; 20 feet coral-bearing dolomite; 4 to 5 feet dolomite containing many Pentamerus oblongus at the top; 25 feet dolomite containing many branching bryozoa near the middle; 30 feet white-weathering, massive, unfossiliferous dolomite represented largely by residual blocks at the top of the escarpment. This section totals 230 feet; its top occurs at "High Hill" which has a height of 1,020 feet above sea-level and is probably the highest point on Manitoulin island. It seems

probable that the upper, massive beds are the highest occurring in the island, being approximately the equivalent of those appearing at South Baymouth and elsewhere on the south shore.

Higher beds, however, occur on the western end of Fitzwilliam island. These are thin-bedded, platy, brown to grey dolomite, containing considerable argillaceous, and perhaps some bituminous, material. In some places these beds are hummocky, and dipping gently to the southwest they underlie the Guelph dolomite described below.

These thin, argillaceous beds are clearly a northern extension of the Eramosa member of the Lockport dolomite described on page 62 of Memoir III, corresponding with the more southern occurrences in all essentials. Their thickness on Fitzwilliam island is difficult to estimate because of the low dip, hummocky nature, and lack of cliff sections. They are also gradational into the underlying dolomite. On Halfway rock, Bruce peninsula, 30 miles to the southeast, they are 30 feet thick, and this is probably their approximate thickness on Fitzwilliam island.

Upper beds of the Eramosa division outcrop on the northeastern ends of Lucas and Yeo islands, south of Fitzwilliam island. The hummocky dolomite occurring along the south shore of Manitoulin island east and west of South Baymouth is probably the top of the lower dolomite from which the Eramosa beds have been stripped. Although the writer has examined most of the south shore of Manitoulin island, he has never been able to identify any Eramosa beds along it.

Guelph Dolomite. The scraggy, somewhat porous, saccharoidal, yellow- to brown-weathering Guelph dolomite outcropping over large areas of southwestern Ontario has been traced northward

by the writer through Bruce peninsula and the small islands to the north to Lucas, Yeo, and Fitzwilliam islands. There only the basal part of the formation is present, and the identification of the strata is dependant upon their position above the Eramosa beds and their content of typical Guelph fossils such as the large, thick-shelled brachiopod Rhinobolus galtensis.

Although no further Guelph outcrops are known to the westward within Canadian territory, it is quite possible that Guelph strata may underlie Duck islands. Such an occurrence depends upon the dip of the formations from the Manitoulin shore southward, and the thickness of the overlying glacial drift, which, as discussed elsewhere, is now shown by drilling to be over 240 feet thick.

CHAPTER III

Structure

Manitoulin island is underlain by a series of hard and soft sedimentary formations dipping to the south away from the outcrop of the crystalline, Precambrian rocks upon which they rest. This south dip varies generally from 20 to 50 feet a mile, with an average of about 35 feet. It is obvious that in such a large area smaller structures must be superimposed upon the main structure, due either to irregularities in the old basement, or to subsequent earth movements. The most obvious of these minor structures occur on the north side of the island near the outcropping of the crystalline rocks, which possessed a decidedly irregular surface in Precambrian time. Other folds of lesser intensity are visible in one or two localities, but as a rule subsidiary structures are of such a remarkably gentle nature that ordinary methods of determination fail to detect them.

Except for the very few obvious structures, detailed methods had to be used for the determination of any gentle folds that might be present. As many wells had been drilled, the logs might be expected to indicate the structure of the areas tested. Relatively few logs, however, are available, and still fewer have the requisite information of exact location, depth to key horizon, etc. Well logs have, however, been used as far as applicable. In 1920 and again in 1935 the writer used the determination of recognizable horizons for the main structural control. As the oil occurs in the Trenton and in general within its upper 15 feet, the top of the Trenton dolomite is the most valuable datum plane. Fortunately this is clearly marked by its contact with the overlying black shale of the Collingwood formation.

So far as possible the outcrop of the Collingwood-Trenton contact was traced and elevations were obtained along it. The next higher horizon marker of first rank is the contact between the top of the Ordovician (Kagawong formation) and the base of the Silurian (Manitoulin dolomite formation). The elevations of the top of the Trenton based upon this well-marked horizon are subject to errors arising from the varying thicknesses of the intervening formations. As explained elsewhere, the depth from the base of the Manitoulin dolomite to the top of the Trenton dolomite is about 475 feet at Manitowaning, as determined by well records; it is estimated to be about the same at West bay, from outcrop observations; but at Gore bay it is only 400 feet, as determined from well records. As no accurate estimates can be made for intervening areas, a gradual lessening of thickness has been allowed between West bay and Gore bay, of 5 feet a mile. West of Gore bay the thickness is taken as 400 feet.

South of the Manitoulin escarpment the best horizon marker is the Dyer Bay formation, consisting of 12 to 15 feet of thin-bedded, argillaceous dolomites. These beds have been used where exposed, the thickness from their top, or the closely super-adjacent base of the Niagara escarpment, to the base of the Manitoulin dolomite being taken as 110 feet which is the measurement made at Rockville at the west end of Manitou lake.

South of the Niagara escarpment no definite horizon has been established by the writer, and structure has to be based upon a few determinable dips and strikes, upon two or three well records, and the general trend of the topographic features. In general the higher massive beds of the Lockport dolomite form the southern shore-line of Manitoulin island, and their general trend has been used as a guide in drawing the sub-surface

structural contour lines. These upper beds tend to be hummocky and local domes form many of the smaller points along the shore. This hummocky character makes it practically impossible to use strike and dip to determine regional structures.

Depending upon the accuracy of the information and measurements, the sub-surface structural contours are indicated by three kinds of lines. Full lines are based upon outcrops of the top of the Trenton, upon definite well records, or upon carefully determined stratigraphic horizons. Broken lines indicate lack of exact information, but represent a fair degree of accuracy. Lines in the form of dots are based upon general information, and may be accepted as representing only the expected structure of the region.

Near Precambrian Contact. The sedimentary formations exhibit a number of local structures in the vicinity of their contact with the underlying Precambrian formations on Great Cloche island and peninsula, and in the vicinity of Shequiandah. These are mainly due to the irregularities in the old Precambrian floor, and are what are known as "initial dips." On Cloche island and in the vicinity only the lowest Ordovician formations are involved, and as they are thin, and not petroliferous, these structres are not of commercial importance. The local structres on Clapperton, Strawberry, and other islands, including formations below the Collingwood, are probably due to initial dips, and again, even though the Trenton may be present in part, there is no protective cover present, and there is, consequently, no hope of commercial petroleum accumulation.

In the vicinity of Shequiandah, including Pine and Bass lakes, there are two large and four smaller ridges and domes

of quartzite projecting through the Trenton and Collingwood formations. Just north of Shequiandah the highway is cut through the contact of Collingwood shale resting upon the eroded surface of Precambrian quartzite. The platy bedding of the quartzite dips to the north at an angle of 70 to 74 degrees and the black shale lies in depressions near the top and on the south side with varying southerly dips up to 40 degrees. The old quartzite surface is much weathered and some of the decayed, rusty rock appears to be a residue from the Precambrain rock mantle. The quartzite above the shale has been smoothly polished by glaciation, and at one place the angle of this surface meets that of the Precambrian erosion surface at about 45 degrees. The contact west of the road is somewhat flatter, so that it seems improbable that the shale-quartzite contact has been steepened by subsequent movement. This outcrop of Collingwood shale lies at an elevation about 120 feet higher than that of the outcrops of shale along Shequiandah harbour, although the thickness is probably not more than about 40 feet. The sedimentary formations in this vicinity dip in general away from the quartzite ridges, and it appears that the resulting structures are mostly of initial dip origin, although there may have been some warping in post-Collingwood time.

At the outlet of Bass lake basal arkose with a lime cement rests upon the irregular surface of the quartzite, evidently representing a basal phase of Trenton sedimentation.

The structures resulting from the Shequiandah quartzite ridges extend westward about a mile toward Perch lake.

Perch Lake Anticline. South of Perch lake there rises one of the best-defined anticlines known on Manitoulin island. The small creek that empties Perch lake is practically in the syncline, the crest of the anticline being near the township boundary $\frac{1}{2}$ mile

to the south. The topographic rise is about 120 feet, and the structural rise probably 100. Dips on the north and south of the crest run as high as 6 degrees, and the closure to the south is about the same as that to the north. The extension of this anticline to the west is probably about a mile, with a closure estimated at 50 feet. To the eastward the structure appears to rise into the dome surrounding the quartzite hill north of Pine lake. A flat offshoot of the Pine Lake dome appears to extend southwesterly for about 2 miles.

The Perch Lake structure and its associate, the Pine Lake structure, are in line with the quartzite ridges exposed to the east, and appear to rest upon extensions of these basal irregularities. It would be of much commercial value, could it be determined whether any appreciable thickness of Trenton dolomite overlies the quartzite or whether it is missing as in the structures near Sheguiandah, described above.

The Gore Bay Monocline. A well-defined, south-dipping monocline is visable on both sides of Gore Bay harbour. The axis extends slightly north of west and the measured dip is 120 feet to the south in about $\frac{3}{4}$ mile. To the north the dip is inappreciable for about $\frac{3}{4}$ mile, beyond which it is increased to about 30 feet a mile, which is about the regional dip. As may be seen from the accompanying map the crest of the fold practically crosses the north side of the harbour. To the south the dip becomes regional again. This monocline is based upon definite surface elevations of the base of the Manitoulin dolomite and upon the records of the wells drilled in the south end of Gore Bay town, which happens to be on the toe of the monocline. It is thus the second best defined structure in the region. There is reason to believe that the face of the monocline is somewhat bowed outward toward the south, but otherwise there is

no indication of closure to the east or west, and there is, as stated above, only a flattening toward the north.

As the top of the Trenton occurs 400 feet below the base of the Manitoulin dolomite (determined from the Gore Bay wells) its occurrence at the entrance to Gore bay has been reliably calculated to lie at an elevation of 450 feet above sea-level, or at a depth of 22 fathoms below the level of lake Huron. As a depth of 25 fathoms is shown on the chart, about one mile northeast of Janet head and northwest of East bluff, the Trenton has evidently been stripped of its covering of Collingwood shale about 3 miles north of the crest of the monocline. The probable relation of this condition to petroleum accumulation is discussed elsewhere.

Rattlesnake Harbour Structure. The presence of Lockport dolomite on Wall island, apparently representing the Fossil Hill coral horizon, indicates a structural depression, as is clearly shown on the map by the occurrence of Richmond strata to the west on the Manitoulin shore and to the east on Club island, and the presence of the Dyer Bay beds on the northeast point of Fitzwilliam island. It is clear, therefore, that between Rattlesnake harbour and Wall island, and evidently close to Northeast point, there is a marked structural elevation. Whether this is dome or anticline it is difficult to say. The dip to the north is estimated at 100 feet in the distance of 1 mile, assuring at least that amount of closure. The dip to the south is approximately that of the region, 40 to 50 feet a mile. It is doubtful whether there is any west closure, but there is probably a closure to the east, as indicated on the map.

The depth to the Trenton is estimated at 580 feet at Northeast point, which is the nearest land location to the top of the structure. As the water to the west across Owen channel is

nowhere more than 18 fathoms deep, and no more than 25 fathoms for 6 miles to the east, the top of the Trenton dolomite is well protected by the Collingwood shale and other overlying formations to a total depth of more than 400 feet.

Manitowaning Structure. Well records and stratigraphic evidence indicate a gentle anticline extending southwesterly from near the head of Smith bay to the southeast of the town of Manitowaning. This was indicated in the structural map accompanying the writer's Summary Report for 1920, part D, page 51. The syncline to the west is clearly defined, and the oil prospect west of Manitowaning is situated on a gentle structural terrace to the west of the syncline. The small amounts of oil obtained on this structure are about in keeping with its ill-defined and gentle nature. That the test wells located on the better-defined anticline to the southeast were of so little promise is a discouraging factor in the further development of this area.

Cape Smith Structures(?) The records of the Cape Smith and Wekwemikong wells are so indefinite in essential information as to location, thicknesses of formation, etc., that structures in this vicinity can be little more than guessed at. The northern extension of the Manitowaning anticline toward Wekwemikong has already been mentioned, and the map shows the inferred shape of the folds in the vicinity.

Other Structures. Gentle curves in the structural contours of the accompanying map are suggestive of very broad and gentle anticlines and synclines. The best authenticated of these occur in the western half of Bayfield sound, and in the area between Silver lake and cape Robert. One dry well has already been drilled on this western structure, and the merit of such vague structural undulations for petroleum accumulations is rather doubtful.

Wells drilled for oil on Manitoulin Island

1 to 3. A group of three old wells near cape Smith.

4 to 11. Wells near Wekwemikong.

12. Well on road to Wekwemikong, southeast of Buzwales cove.

13 to 15. Wells near Stevens cove.

16. Well near Wekwemikongsing.

17. Old well (location not known) south of South bay.

18 to 21. Wells near Manitowaning.

22 to 30. A group of wells in an oil field west of Manitowaning.

31 to 35. A group of wells about 3 miles northwest of Manitowaning.

36. Well near Lily lake.

37. Well near Tehkummah.

38 to 40. Poirier wells at Ten Mile point.

41 to 62 and 63. A group of twenty-three wells near Pine lake, including the Kyto Oil field.

64. Well southwest of Perch lake.

65. Well near Honora.

66. Well at Providence Bay.

67 to 70. Four wells at Gore Bay

71. Well 1½ miles southwest of Gore Bay.

72. Well near Silver lake.

CHAPTER IV

Petroleum and Natural Gas

The Josuit missionaries who first ministered to the Indians of Ekaentoton (Grand Manitoulin) island in 1648 probably knew of the presence of oil springs near the eastern end of tho island. In his historical sketch, Mr. Major[1] says:

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[1] Bibliography, No. 6, p. 64

"Parties in Montreal who had read in the relations des Jesuites that there existed in Grand Manitoulin Island, a mysterious spring flowing, as the Indians believed, from the entrails of the Great Manitou in which rock oil was found that cured all human diseases, started stealthily like Jason in pursuit of the golden fleece and they landed at Wekwemikong." The writer has failed to confirm the statement referred to but it is probable that, as stated by Major, the missionaries directed the early oil seekers to the oil spring near Wekwemikong on Smith bay.

T. Sterry Hunt, in his admirable paper "Notes on the History of Petroleum or Rock Oil" (4 (a), page 321) says: "On the Great Manitoulin island, also, according to Mr. Murray, a petroleum spring issues from the Utica slate ....."

Hunt repeats this statement (4 (b), page 252).

In the same report Robert Bell (page 179) says: "Springs of petroleum have been found on the south side of Wekwemikong Bay, where three or four wells are now being sunk.... Surface oil is said to have been found at Bob's Portage, on the east side of Manitowaning bay, and also in She-gui-an-dah bay, and upon Strawberry island. A petroleum spring, on one of the islands north of Maple Point, is referred to in your

General Report of 1863."

Hunt, in his earlier report, refers to the oil that may be distilled from the Utica shale, and cites the occurrence of oil and bitumen in Trenton limestone. Bell (page 179) refers to the 1863 report (pages 523 and 790) which mentions a bituminous dolomitic limestone, a specimen of which had been brought from Grand Manitoulin island, containing about 8 per cent of solid bitumen or mineral pitch. In the Geology of Canada 1863, page 523, the following reference occurs: "A brown crystalline porous magnesian limestone from the Grand Manitoulin island, had in like manner portions of asphaltum in its interstices, and contained from 7.4 to 8.8 per cent of soluble bitumen." (page 288) "..... the possibility of its (petroleum) occurrence in available quantities in some part of the Trenton formation should not be lost sight of ....."

The oil spring on the south side of Smith bay was visited by the writer in 1920 and described in his report of that year (11 (G), p. 27). It is located in a small bay just east of Sturgeon point and about 10 feet from the water's edge. The water, which shows no flow, is on a level with that of the bay, and high waves must wash into it. The surface was covered with a thick coating of oil. The distance from the town of Wekwemikong around the shore is nearly 4 miles. Antoine Trudeau, who owned the land, reported that one winter he saw a spring of oil coming up through the ice near the centre of Smith bay. A similar showing of oil was reported as having been seen by an Indian in Manitowaning bay somewhere near Ten Mile point.

Favourable conditions for the occurrence and accumulation of oil are indicated by the presence of the black Utica shale that overlies the Trenton limestone. This shale outcrops at Little Current and Shequiandah, and at various other

places on the northeastern part of the island. Dipping to the south beneath the younger sediments it forms an effective cap rock for the Trenton limestone, which is the petroliferous formation. Similar relations occur in the Dover oil field west of Chatham, Ontario, and in the Trenton oil fields of Ohio.

The Utica shale is variously reported from the wells as being from 20 to 60 feet thick. It is a low-grade oil-shale, samples collected by the writer from near Little Current and Shoguiandah in 1920 yielding 8.1 and 4.8 Imperial gallons of petroleum a ton of shale on destructive distillation. Thus a relatively large reserve of hydrocarbons is present in the shale, and it is not surprising that some petroleum and natural gas occur in the underlying Trenton limestone.

Wekwemikong Indian Reserve. As is generally the case, the first wells were dug near the most prominent oil spring, that on the south side of Smith bay. Here the Manitoulin Oil Company, organized in Montreal, put down five wells. Of these Hunt says in part (4 (b), pp. 252-253): "One of the wells there sunk gave soil 10, shales 140, limestone 316 = 466 feet, at which depth the boring was suspended ----- At 220 feet from the surface a vein of oil was encountered, and another, six feet lower; the well has yielded, in all, seven or eight barrels of oil with much gas. This is designated by the Manitoulin Oil Company, as well No. 2, about two miles from which is No. 1. This, after 32 feet of soil, and 100 feet of black shale, penetrated 340 feet of the limestone, to which succeeded 52 feet of a red siliceous sandstone, the last 20 feet very hard. There the boring ceased. At 192 feet from the surface was met a vein of saline water, and at 193, 248, and 270 feet veins of oil. From this well 120 barrels of excellent petroleum have been obtained, but the supply has now ceased. ..... At a position inter-

mediate between the last two wells, is another, No. 5, which gave soil 21, shale, etc. 230, limestone 179 = 430 feet, the boring being still continued. A vein was struck in the limestone, 288 feet from the surface, and has given a few gallons of oil. At 92 feet, saline water was met with, less strong, however, than in the previous wells. Two other borings, Nos. 3 and 4, are now in progress. It is evident that these wells, penetrating the Hudson river and Utica formations, find the oil in the limestones of the Trenton group."

Hunt reports on the brine from well No. 1 as follows (page 272): The vein was met 192 feet from the surface and 60 feet in the Trenton limestone. "The water, as sent to me, was intensely bitter and saline to the taste; it contained no trace of sulphates, nor yet barium nor strontium. It was not examined for bromides or iodides, which however, were probably present. The analysis of this water gave for 1000 parts -

Chloride of sodium	4.800
Chloride of potassium	.792
Chloride of calcium	12.420
Chloride of magnesium	3.650
	21.662

In most waters of this class, the proportion of chloride of potassium is small, rarely attaining to one-hundredth of the alkaline chlorides, but in the Manitoulin water it amounts to not less than 16.6 per cent, or more than 3.7 per cent of the entire solid matters, a proportion as great as in modern sea water."

In the files of the Geological Survey there are the records of three wells, marked Manitoulin, Algoma, 1863, driller, Jos. Ward. They apparently refer to Nos. 2, 1, and 5

as described by Hunt. The records differ so materially from those given as to cast much doubt upon their reliability. The discrepancies may be due to the interpretations by different drillers. The records are given for comparison.

No. 1. Location, cape Smith, south of Whiskey island and 200 feet from the shore.

Elevation 10 feet above lake Huron.

	Thickness Feet	Depth Feet
Surface	20	20
Shale	120	140
Limestone	370	510
Sandstone	40	550

Yield of oil at 300 feet

No. 2. Location, half-way between No. 1 and No. 3 and one-half mile south.

	Feet
Elevation	656
Surface	15
Shale	110
Limestone	175
Depth	300

Yield of oil and water, "the largest flow on the Manitoulin."

No. 3. Location, 2 miles north (should be east by north) of No. 1, and about 200 feet from the shore ("South Mequimakong Mission").

Elevation 591 - A.M.T.

	Thickness Feet	Depth Feet
Surface	5	5
Shale	110	115
Limestone	285	400

Yield of oil at 300 feet.

The writer saw the site of an old well about one-eighth of a mile east by north of the oil spring mentioned above. It is about 200 feet from the shore, about 10 feet above water-level, and the caved-in pit is about 18 feet across. Mr. Trudeau reported it drilled to a depth of about 300 feet, some fifty years previous to 1920, and to have struck oil. This well, marked No. 1 on the map, appears to be No. 1 as noted above, and probably No. 2 well described by Hunt. The writer is at a loss, however, to explain the reference to Whisky island, as he knows of no island along this shore, nor is any shown on any map or chart consulted. It may have been a sand or gravel bar appearing at very low water. Sites of wells No. 2 and No. 3 of the accompanying map were not seen by the writer, and their location is approximated from the description given above.

The inference may be drawn from these old records that the formational dip along the south side of Smith bay is from 10 to 12 feet a mile to the westward, and the top of the Trenton near the oil spring is about 140 feet below the level of lake Huron. The oil spring, and the oil reported as having been recovered, bear testimony to the petroliferous character of the Trenton and the brine, with its resemblance to marine water, suggests relative freedom from dilution by water from the bay.") Oil is reported from depths between 35 and 185 feet in the Trenton limestone.

It is reported that the Manitoulin Oil Company gave up its operations because of difficulties with the Indians.

In 1905 the Northern Oil and Gas Company, of Chicago, drilled six wells about 2 miles southeast of Wekwemikong (10, vol. XV). Three were producers and three dry holes. "The wells were drilled at an elevation of 155 feet above the lake, and

produced in all about 500 barrels of oil, one well producing about 50 barrels in the first 12 hours after shooting." The lithological records, omitting the interpretation into formations, are as follows:

No. 1 well, elevation 736 feet A.M.T.

	Feet	
Limestone	50	
Light shale	250	
Grey shale	62	
Black shale	21	Top of Trenton at 383 feet.
Limestone	137	Gas at 398 feet.
Total depth	520	

No. 2 well.

	Feet	
Surface	34	
Limestone and shales	90	
Light shale	161	
Grey shale	65	
Black shale	9	Top of Trenton at 359 feet.
Limestone	50	Gas and oil at 380 feet.
Total depth	409	

No. 4 well.

	Feet	
Sand	15	
Limestone	50	
Light shale	250	
Dark shale	70	
Black shale	22	Top of Trenton at 407 feet.
Limestone	---	Salt water at 438 feet.

No. 5 well.

	Feet	
Sand	14	
Limestone	50	
Light shale	250	
Dark shale	94	Top of Trenton at 420 feet.
Black shale	12	Oil at 437 feet.

"No. 4 well is 640 feet northwest of No. 5. No. 1 is about the same distance northwest of No. 4, and No. 2 is about 500 feet northeast. Another well has been drilled northeast of No. 2 at an elevation of 55 feet, and the Huronian was struck at a depth of 625 feet. The oil is a very good quality, registering 36 Baume at 60 degrees."

J. Clarke and R. MacMillan, who worked on a number of the wells drilled near Wekwemikong, accompanied the writer to the locality, identified the wells, and furnished the following information.

No. 4. Near edge of swamp, below hill, drilled by Clement, from Sherbrooke, Quebec, about thirty years ago. This was a gusher for an hour or two, and the ground around is still saturated with oil. The casing still contains a light green oil, standing near the top. This and two or three neighbouring wells were pumped for a time. The well is said to be 450 feet deep and to contain 200 feet of 4⅝ inch casing.

No. 5 was not visited.

No. 6. Known as Gregory No. 1, is situated below the hill east of the highway and south of the stream. This was pumped by means of a spring-pole and is bubbling gas still.

No. 7. Drilled by Gregory, produced much salt water.

No. 8. This is known as Gregory No. 2. This was a promising well and pumped 32 barrels the day it was abandoned (cf. J. Clarke, who worked on it). Oil was struck 17 feet in the Trenton. Gas and salt water were struck at first, but oil was produced after two hours of pumping.

No. 9. This well was drilled in 1906 by George Gregory of Petrolia, Mr. Buller of Chicago being manager. It is about 500 feet deep, and was drilled 31 feet into the Trenton. It started with salt water, but after pumping for three days it went over to oil and flowed 100 barrels of oil into the tank in less than 1 hour. It finally went over to brine.

No. 10. This well was drilled to the "granite" at 750 feet in depth, the Trenton being struck at 500 feet. An 8-inch hole was carried down and a little salt water was struck.

No. 11. Drilled by Gregory. It pumped 100 barrels of oil for 1 day and then filled with white sand and never pumped again.

Another well is situated about 400 feet southeast of No. 11, but no information was available.

These wells were drilled during 1905, 1906, and 1907.

It seems established that the wells visited include those described in the Report of the Bureau of Mines. The elevation (736 feet A.M.T.) there given corresponds reasonably well with the elevation (715) feet for the higher wells as obtained by the writer from aneroid readings. As the Indian land where these wells are located is entirely unsurveyed, considerable doubt remains in regard to the identity of the wells. This is unfortunate as the published report contains such definite logs that a relationship between productivity of wells and geological

structure could be worked out were the identification certain. As it is, No. 2 well of the Northern Oil and Gas Company appears to be located on the highest structure, the other wells down the dip to the southwest being, however, the larger producers of oil. The general conclusion to be drawn is that the Trenton formation in this vicinity contains some oil, but that the tests at this locality were on "edge water," that is on the edge of the real accumulation. Whether that accumulation will prove commercial or not remains to be proved. Accurate information regarding the various wells drilled in this vicinity would be worth the cost of several new wells to a company starting a testing program.

Messrs. Clarke and MacMillan furnished the following information regarding other wells drilled on the Indian reserve.

Gregory drilled two or three wells out on cape Smith. One was "a great gasser", but none produced oil.

No. 12. An old well west of the road about 4 miles southwest of Wekwemikong and now covered with stones. Gas pressure blew out the casing, and there was much salt water but very little oil.

Well No. 13 is situated about one mile farther southwest, and to the east on top of the hill. There is no record.

Well No. 14 was drilled near the shore and just south of the present gas station. The driller was Tom Rawlings, the depth about 450 feet, and a little salt water was struck. The first 300 feet of the drilling was through drift. Elevation above the bay about 10 feet.

Well No. 15 is situated on John King's farm between the barn and the road. The elevation is 50 feet above the bay. The depth was over 500 feet and salt water was struck.

Well No. 16 is located near the Wekwemikongsing school, but no record is available.

Well No. 17 was situated about 4 miles southeast of South Bay Indian village by the shore of a little lake. There is no record of it, nor was it visited.

Well No. 18, known as the Gurley well, is one mile south of Manitowaning and just south of the elbow of the road to the Indian reserve. It struck much salt water and a show of oil.

There appear to have been several other wells drilled by the Northern Oil and Gas Company before 1912, when they were granted the oil rights on 50,000 acres of land on the Indian reserve east of Manitowaning. Senator Poirier's estate holds the oil rights on a strip of territory 9,334 feet wide, lying south of Smith bay and extending from near Manitowaning bay eastward to Georgian bay, the area containing 10,000 acres. The Northern Oil and Gas Company hold the rights on the adjoining area of the same size to the south. The remainder of their 40,000 acres includes the whole of the southern end of the peninsula, extending northward nearly to the head of South bay. Thus only the central part of the reserve and the extreme northern portions are available for exploration by other interests.

Manitowaning and Vicinity. In 1907 the Benedum-Trees Oil Company of Pittsburgh, Pa., drilled five test wells about 1½ miles west of Manitowaning, on lot 44, con. 2, Assiginack tp. Of these wells Nos. 1, 2, and 3 were pumped, and produced at least 500 barrels of oil. When the casing was pulled out of No. 1 oil rose within one foot of the top (cf. Wm. McCauley of Manitowaning). In 1912 oil was being drawn from No. 2 by local farmers, by means of a sand pump. In 1920 all three

contained oil, and in 1935 oil was standing within 8 feet of the top of No. 2 and gas was bubbling through the oil. The log of No. 3 furnished by the Benedum-Trees Oil Company is as follows:

	Feet	Depth Feet
Surface soil etc.	14	14
Richmond limestone	116	130
Grey shale	280	410
Collingwood shale	20	430
Trenton limestone	47	477

Oil and gas at 442 feet.

This well is said to have produced 45 barrels of oil in fifteen minutes.

For well No. 4, situated south of the road, no record is available.

Well No. 5 was drilled by Clide Potts, for Benedum-Trees. The well was finished with the men working ankle-deep in oil. It was plugged immediately near the top of the casing, after which it flowed out beneath and appeared at the surface some distance to the north. There was no water appearing with the oil (cf. Mr. McCauley).

The log of the well drilled on lot 45 (the Watson farm) is as follows:

	Feet	Depth Feet
Surface	6	6
Richmond limestone	124	130
Shale	175	305
Trenton limestone	261	566

Oil from 464 to 474 feet.

In 1920 H.C. Gordon drilled a well near the road. The Trenton limestone was struck at about 445 feet from the surface. At about 17 feet in the Trenton limestone considerable gas and a little oil were obtained. After shooting with dynamite considerable salt water was produced.

The Allan well was drilled by Wm. Allan of Campbellford for the Manitoulin Oil Company in 1929, the driller being R. MacMillan of Manitowaning. The record in the Geological Survey files is as follows:

	Feet
Surface	1[illegible]
Brown and grey dolomite	200
Dark grey shale	170
Dark grey bituminous shale	30
Light grey dolomite	40

The depth was later recorded as 467 feet, and Mr. Marshall says it was drilled to 476 feet and that 18 feet of "oil sand" was penetrated.

The Marshall well was drilled in 1933 by John McCorkindale, 8th Street West, Owen Sound. The depth was 490 feet. Eighteen feet of "oil sand" was penetrated at 480 feet with a "strong flow of gas" and a showing of yellow oil. There was not enough water to drill with. The well was shot, but never cleaned out (cf. James P. Marshall, 1530 - 4th Avenue West, Owen Sound, the owner of the old Lehman farm, who accompanied the writer over the property in July 1935).

From the records of the three wells available it may be seen that there is a gentle dip of the formations toward the southwest.

The wells recorded above are marked 22 to 30 on the accompanying map.

Other wells in the vicinity of Manitowaning are described below, the numbers referring to the map notation.

No. 19. Near the southeast end of lot 35, con. II, Assiginack tp., on the farm formerly owned by Wm. Tucker. This well flowed gas for some years.

No. 20. Lot 30, con. II, Assiginack tp. A show of oil is reported.

No. 21. Lot 23, con. IV, Assiginack tp. No record.

No. 31 is known as the H.C. Gordon well No. 1, and was drilled by that gentleman in 1920 (11 (G), p. 28). "It is situated about 70 yards from the east line and 90 yards from the north line of lot 50, con. II, Assiginack tp. The top of the well is about 10 feet below the base of the Manitoulin dolomite, of the Cataract formation, as exposed a few rods away, and the log, taken by the writer, from samples, is as follows:

	Feet	Depth Feet
Surface	5	5
Hard, dark grey limestone and shale	360	365
Grey shale	20	385
Brown shale	65	450
Black shale	15	465
Trenton		
Grey, semicrystalline limestone	15	480
Calcareous shale	5	485
Semicrystalline limestone	65	550

This well was dry except for a small show of gas."

No. 32. Near the south end of lot 51, con. I, Assiginack tp. No record.

No. 33. Near the north end of lot 51, con. I, AAssiginack tp. No record.

No. 34. About 85 yards from the west line and 30 yards from the south line of lot 22, con. I, Shequiandah tp.

Elevation about 645 feet A.M.T. By Senator Pascal Poirier. Completed Feb. 9, 1932. Dry hole.

	Thickness Feet
Surface	11
Richmond limestone	34
Grey shale	280
Dark shale	69
Trenton limestone	40
Total depth	434

No water, perfectly dry hole.

No. 35. Near the middle of the east side of lot 20, con. I, Sheguiandah tp. No record.

No. 36. About 525 yards from the northwest corner and 40 yards from the west line of lot 6, con. II, Sheguiandah tp., on the farm of Andrew Lane. Elevation about 740 feet A.M.T. Commenced No. 1, 1906, completed May 27, 1907.

	Thickness Feet	Depth Feet
Surface	10	10
Silurian	170	180
Limestone, shale, etc.	315	495
Collingwood shale	22	517
Trenton limestone	112	629

Gas and oil at 532 feet

No. 37. Lot 4, con. XIV, Assiginack tp. Drilled by Gib Wallace for Manitowaning Oil Company. Depth 210 feet. The samples from this well in the Geological Survey have been examined by Mr. C.S. Evans, whose report is as follows:

Feet	
5 - 10	Fine- to medium-grained, buff-grey dolomite - a little chert in which are fragments of corals.
10 - 20	Fine to medium, grey dolomite - a little chert.
20 - 25	Fine to medium, grey limestone - grey, shaly limestone - a few fragments of brown bituminous shale - bryozoa.
25 - 30	Missing.
30 - 35	Fine to medium, grey limestone - grey, shaly limestone.
35 - 40	Missing.
40 - 45	Fine, grey dolomite.
45 - 55	Fine, grey, shaly limestone - grey shale, fossiliferous.
55 - 60	Medium-grained, buff dolomite.
60 - 65	As above, with some chert.
65 - 70	Fossiliferous, grey, shaly limestone.
70 - 115	Medium-grained, buff dolomite - some chert - few crinoid stems.
115 - 135	Fine, buff dolomite.
135 - 150	Fine, light grey dolomite.
150 - 155	Fine, buff-grey dolomite.
155 - 170	Fine, drab-grey, limy shale and shaly limestone - fossiliferous.
170 - 175	Medium buff dolomite.
175 - 195	Quite fine-grained, light grey dolomite and shaly dolomite - some greenish shale and a few sand grains.
195 - 210	Fine to medium, buff and grey dolomite.

The section is Lockport throughout unless the lower 20 feet include some Dyer Bay beds.

No. 38. About 40 yards east of the west line and 100 yards north of the south line of lot 21, con. XI, Sheguiandah tp. Elevation about 860 feet A.M.T. By Senator Poirier. Completed Jan. 23, 1932. A dry hole.

	Thickness Feet
Surface	1
Richmond limestone	50
Grey shale	255
Dark shale	92
Trenton limestone	125
Total depth	523

Gas 210 and 426 feet. Seepage of salt water at 523 feet. Gas was bubbling up through fresh water in July 1935.

No. 39[1]. Near the southwest corner, 100 feet from each line of lot 24, con. XI, Sheguiandah tp. Elevation about 850 feet A.M.T. Drilled for Senator Poirier. Completed Jan. 7, 1932. Dry hole.

[1] Ontario Dept. of Mines, vol. XLII, pt. V, 1933, p. 43.

	Thickness Feet
Surface	1
Richmond limestone	40
Grey shale	272
Collingwood shale	60
Trenton limestone	37
Total depth	410

Show of gas 200 and 400 feet. Salt water at 400 feet.

No. 40[1]. About 170 yards west of east line and 50 yards north of south line of lot 18, con. XIII, Sheguiandah tp. (Senator Poirier). Elevation about 870 feet A.M.T. Completed

[1] Ontario Dept. of Mines, vol. XLII, pt. V, 1933, p. 43.

March 19, 1932. Dry hole.

	Thickness Feet
Surface	5
Richmond limestone	47
Grey shale	282
Collingwood shale (black)	56
Trenton limestone	40
Total depth	430

Black water at 420 feet.

Wells Nos. 41 to 62. The Kyto Oil Field. In 1912 Senator Pascal Poirier started intensive drilling on lots 3 and 4, cons. VIII and IX, Bidwell tp. (11 (G), p. 28). "At least twenty wells were drilled at this locality, of which eleven are said to have produced oil, and three to have had traces of oil. The drilling contractor stated that some of these wells produced as much as 27 barrels a day for a short time. Four are reported as dry. Following is an analysis of a sample of oil from Renny Byers' farm, lot 3, con. IX, Bidwell tp., Green bay, Manitoulin island.

Specific gravity at 15.5° C. - 0.864

Distillation - continuous method.

First drop	100° C.
Up to 150°C.	10%
150 - 200°C.	7%
200 - 250°C.	8%
250 - 300°C.	11%
300 - 350°C.	18%
Residue (by difference)	46%

Calorific value:

Calories per gram, gross	10600
B.T.U. per lb. gross	19080

Sulphur: 0.2 %." Sp. gr. Baume = 32

"During 1920, three wells were drilled on the old Poirier leases, No. 1 being dry, No. 2 producing some oil with a small amount of salty, sulphur water (at a depth of 403 feet), and No. 3 not being reported on. The top of the Trenton in No. 2 was struck at 384 feet 3 inches in depth or 10 feet higher than in No. 1. The log of No. 1 as determined by the writer from samples is as follows:

Well drilled by Kyto Oil Company, near southeast corner of lot IV, con. IX, Bidwell tp.

	Thickness	Depth
	Feet	Feet
Surface clay	5	5
Buff limestone	11	16
Grey shale	356	372
Black Utica shale	28	400
Light coloured, hard, semi-crystalline limestone	9	409
Show of oil at		418

No. 64. On the north end of lot 24, con. XI, Bidwell tp. Drilled by Senator Poirier. It finished in slate possibly 500 feet deep.

A well is also reported on lot 17, con. XII, Bidwell tp. No information.

No. 65. Near middle of south end of lot 34, con. I, Howland tp., drilled by Senator Poirier. The well stopped a few feet in the black Utica shale with no show of gas or oil.

No. 66. Providence Bay. At Providence bay, about 30 feet east of the road and 100 yards from the wharf. This well was drilled about 1906 by H.F. Slater of Toronto, who reported to the writer that he struck the Trenton limestone at about 960 feet from the surface and drilled about 100 feet into it when the tools were lost and never recovered. It is plugged with a wooden plug, but

escaping gas may still be burned. Elevation 25 feet above lake Huron.

Wells Nos. 67 to 70. Gore Bay. In 1909 four wells were drilled in the southern part of the town of Gore Bay. Mr. Ben Johnson, still resident in Gore Bay, worked with the drillers, Brake and Buchanan, and furnished the following information.

The most northerly well produced no oil. No. 2, on Mr. Brett's property, and No. 3 pumped 100 barrels of oil between them, along with much black water. Tools were lost in No. 3 and the well was abandoned. Mr. Brett piped his well to his machine shop and used the gas for some time.

Well No. 4 was shot and produced no oil afterward.

The following record in the files of the Geological Survey is probably that of well No. 3. Elevation about 610 feet A.M.T.

	Thickness	Depth
	Feet	Feet
Drift	1	1
Limestone	45	46
Blue shale	89	135
Limestone	1	136
Shale	29	165
Limestone	1	166
Blue shale	90	256
Brown shale	60	316
Black shale	15	331
Trenton limestone	250	581

Oil was struck at 425 feet.

A log made by Mr. C.S. Evans from samples 447-23 in the Geological Survey follows. As the depth to the Trenton is 19 feet greater than in the log given above, the well is probably

No. 4 which starts at a higher level.

Feet		
0 -	10	Medium-grained, light grey and grey, dolomitic limestone.
10 -	60	Medium-grained, grey dolomite.
60 -	85	As above, with some shaly dolomite.
85 -	270	Grey shale with some limy bands.
270 -	275	Grey shale with a little brownish shale.
275 -	350	Brown, bituminous shale.
350 -	400	Medium-grained, somewhat dolomitic limestone-grey.
400 -	515	Medium-grained, grey limestone.
515 -	525	Medium-grained, grey limestone and shaly limestone.
525 -	535	Medium-grained, grey limestone.
535 -	545	Medium-grained, grey limestone - a little green shale - a few rounded sand grains in limestone.
545 -	555	Medium-grained, grey limestone and dark grey, shaly limestone.
555 -	585	Medium-grained, grey limestone - some shaly limestone.
585 -	605	Medium-grained, grey limestone - dark grey, shaly limestone - some sand grains.
605 -	675	Medium-grained, grey and dark grey limestone - shaly limestone - some green shale - fair amount of sand grains.
675 -	695	Coarse, well-rounded sand grains (all quartz).
695 -	700	Quartz grains and weathered granite.

Bottom of well.

This may be interpreted as:

	Feet
Richmond	0 - 85
Grey shale	85 - 275
Dark shale	275 - 350
Trenton and lower formations	350 - 675
Basal sandstone	675 - 695
Sandstone and weathered granite	695 - 700

Mr. Johnson also reported a well on the rear of lot 13, range VIII, Gordon tp., and one on Alex Purvis' farm about 1½ miles west of town, both of which were dry.

No. 71. Lot 10, West range, Gordon tp. This is reported by Mr. Ben Johnson of Gore Bay as having been a dry well.

No. 72. On the northwest corner of lot 20, con. XI, Robinson tp., 2.5 miles north of Silverwater corners and 40 feet east of the road allowance. Mr. Alex Kemp of Silverwater reports that this well was drilled in 1908 or 1909 by Brake and Buchanan for Mr. Alexander of Oklahoma. Fresh water was struck at 66 feet. No oil or gas were struck, but when finished at a depth of 1,074 feet it filled with salt water.

Following are two analyses of oil (11 (G), p. 30): A - lot 44, con. XI, Assiginack tp., B - M.W. Brott's farm, lot 6, north side of Hall street, Gore Bay - probably well No. 2.

	A	B
At 15.5° C. specific gravity	0.877	0.881
Distillation continues		
First drop	220° C.	180° C.
Up to 250°	10%	9%
250 - 300°	20%	19%
300 - 350°	18%	18%
Residue (by difference)	52%	54%

Note: The yield obtained between 300 and 350 degrees is uncertain owing to the tube of the condenser being clogged with the wax formed. This holds for both samples.

Calorific value -	A	B
Calories per gram gross	10790	10800
B.T.U. per pound gross	19430	19440
Sulphur	0.2%	0.2%

The specific gravity in degrees Beaume is 29.6 for A and 28.9 for B.

Great Duck Island. Well No. 73 is situated about one-quarter of a mile north of the little harbour on Great Duck island, which is in the small bay opposite Outer Duck island. The well was started in 1935 by Detroit and Windsor interests, the driller being E. Randall of Petrolia. Later his brother, Fred, took over the drilling and he has furnished the following record:

	Feet
Sand and gravel	to 152
Boulders	152 - 162
Gravel and sand	162 - 190
Hard clay	190 - 230
Gravel	230 - 240
Loose white sand	240 - 243

Water occurs in all the sediments except the hard clay or "hardpan."

Elevation of the top of the well above lake Huron about 25 feet.

Conclusions to be Drawn from Drilling

The drilling recorded above has demonstrated the presence of small accumulations of petroleum at four localities on Manitoulin island, viz.: near Wekwemikong; west of Manitowaning; southeast of Pine lake; and at Gore bay. The writer is of the opinion that the Pine Lake and Manitowaning areas have been sufficiently tested, and are not of commercial value. As the Wekwemikong field appears to have been abandoned while still producing oil, a small production might be obtained from one or two of the abandoned wells, or from new wells drilled near by. Some of the wells have never been properly plugged, and water has doubtless damaged the field. No large production is indicated.

The Gore Bay wells are typical of "edgewater" conditions, such as might be expected from their location on the margin of the monocline described under "Structure". Their oil and gas content are good auguries for production from the structure nearby.

The wild-cat wells scattered over the rest of the island show practically no promise, but it must be remembered that several of them did not penetrate the Collingwood shale, and of the rest the records are very unsatisfactory.

In order to explore this region in a satisfactory manner it is necessary to determine whether the oil accumulations occur on anticlines or in synclines and then to test the most promising structures.

In his 1920 report the writer concluded that the petroleum of Manitoulin island was not accompanied by normal salt water, and that "the best oil wells are located well within the syncline." T. Sterry Hunt emphasized the similarity to sea water exhibited by the brine from the Cape Smith wells; and salt water has been reported from various other wells. No samples being available the evidence is inconclusive, as most observers fail to distinguish between salt water and sulphur water. A number of the wells stand full of water at the present time, but this is mostly of surface origin and so is essentially fresh.

There is also the problem, raised in the previous report, as to whether the oil and water occur at the same horizon. As important as this problem is, it cannot be answered satisfactorily at the present time. The history of the field, however, suggests that there was some saline water in association with the petroleum. The relation of the test wells to structure is not as clearly determined as could be wished, due to the lack

of a sufficient number of reliable well logs (See discussion below). Having reviewed the available evidence, however, and especially that furnished by the wells at Gore bay, where the structure is clearly defined, the writer feels obliged to differ with his previous conclusion, and to decide that oil is most likely to occur on Manitoulin island on the higher structures, in accordance with the normal law of anticlinal accumulation. In regard to the effect of bay water upon oil accumulation at the localities tested, it may be noted that the wells most likely to be so affected are those located at Cape Smith, and yet it was from these very wells that T. Sterry Hunt obtained the brine referred to above. That oil has escaped into the bay is shown by the Cape Smith spring, and the records cited above. The wells near Ten Mile point were in the writer's judgment doomed to be non-productive because of the nearby outcrop of the Trenton formation below the bay. It hardly seems probable, however, that the wells near Manitowaning, Pine lake, or Gore bay, have been seriously affected by bay water.

Conclusions Drawn from the Present Study

As shown above (See map also), the work of the past and previous seasons has demonstrated the occurrence of three well-defined structures in Manitoulin and adjacent islands, which have promise for oil and gas accumulation. These may be named the Gore Bay, Perch Lake, and Rattlesnake Harbour structures. The first two of these were recognized in 1915 and 1920, respectively, but the last was overlooked until this year, although indicated by the work of 1915.

The Gore Bay structure appears the most promising, for the following reasons. It is a well-defined monocline

with a descent of 120 feet on the south side within a distance of less than one mile, compared with the average regional slope of about 35 feet a mile. To the north the monocline merges into a practically flat structure about 1 mile across, to the north of which the regional dip of about 35 feet a mile is resumed. The structure is well defined on both sides of the harbour, and there is an excellent area for drilling both to east and west. Indications of oil occurrence are to be found in the wells in the south side of Gore Bay town, which were shown to contain oil and gas although located in the most unlikely place possible, at the foot of the monocline. The drilling required to test this structure is phenomenally shallow, as may be ascertained from the logs of the wells just cited. The Trenton limestone was struck in No. 4 well at a depth of 331 feet, and oil at 425 feet. In the northern part of town, near the wharf, the structure has elevated the formations 120 feet, and a location for drilling is available at about the same elevation above lake Huron (about 30 feet), so that the Trenton and oil horizon might be penetrated at about 210 and 305 feet, respectively. On the plateaus above, to the east and west, the drilling would be about 225 feet deeper. A 900-foot well on the upland would test all the formations right to the granite, judging by the log of No. 4 well at Gore bay.

Besides the lack of closure on the north side of this structure there is one condition unfavourable for oil retention, and that is the relatively short distance, to the north, at which the Trenton limestone outcrops below the waters of the North channel. At the entrance to Gore bay the top of the Trenton occurs at a probable elevation of 450 feet above sea-level, or about 22 fathoms below lake level. As twenty fathoms is

recorded by the chart in the middle of the entrance to the bay, and 25 fathoms occurs a short distance to the north, it seems clear that the Trenton formation has long since been stripped of its cover rock (Collingwood shale) about 3 miles north of the crest of the monocline, and exposed to the contact with fresh water. To what extent these conditions have been deleterious to oil retention in the monocline depends largely upon the porosity of the rock, and can be determined only by drilling.

The excellent harbour facilities at Gore bay, both for bringing in drilling supplies and for the shipment of oil, are obvious.

The Perch Lake anticline is a part of the complex structure in the vicinity of Sheguiandah so carefully explored by Senator Poirier near Pine lake. As shown in the above discussion on structure, the anticlines north of Sheguiandah and near Bass lake are due to the prominent ridges of Precambrian quartzite which formed irregularities on the bottom of the early Palaeozoic sea. The upper sediments of Trenton age barely lapped against the flanks of these ridges and the Collingwood shales scarcely covered their higher elevations. As the sediments became compacted into rock, the thicker parts became depressed more than the thinner parts, and in consequence the domes and anticlines were left clinging to the sides of the quartzite ridges. Obviously such structures are not suitable for oil, as the Trenton oil horizons are missing, and the quartzite beneath the Collingwood shale is entirely barren of oil due to its origin and metamorphism.

The alinement of the narrow anticline south of Perch lake with the Sheguiandah structures suggests most strongly that it, too, is underlain by a quartzite ridge. There is a

possibility, however, that in this case Trenton limestone may overlie the quartzite, thus providing a formation for oil accumulation. This narrow structure with a closure of over 50 feet on the west end and 100 feet to the north and south is the most clearly defined of all so far discovered on Manitoulin island, with the exception of those referred to around Sheguiandah. No records are available of the wells drilled by Senator Poirier to the west of this structure, but it is reported that they did not penetrate the Collingwood shale, and hence shed no light on the oil possibilities.

The Perch Lake anticline is to be considered as an untested structure which probably has most of the Trenton limestone missing, and in its place a ridge of Precambrian quartzite.

The Rattlesnake Harbour structure, as shown above, is indicated by the presence of Lockport dolomite on Wall island, whereas Cabot Head shale and Dyer Bay beds outcrop at the northeastern end of Fitzwilliam island around Rattlesnake harbour. The only part of the crest of the dome above water-level is, therefore, about Rattlesnake harbour, and there is, consequently, but little area available for oil exploration. Should the thickness of the formations remain the same as at Manitowaning, the estimated depth to the top of the Trenton would be about 585 feet, or, as the structure contours show it, at about sea-level.

The latest attempt at oil exploration, centred in Great Duck island, deserves special attention. It was stimulated by the success attained in the search for oil in the peninsula of Michigan, but it should be noted that the oil in northern Michigan is obtained mostly in the Dundee limestone of Middle Devonian age and there is no reasonable expectation of any

formation higher than Guelph dolomite occurring beneath the Duck islands.

The Duck islands are the crests of a heavy moraine left by the ice-sheet, the total thickness of which is in excess of the 243 feet penetrated by the drill. The underlying geology is to be inferred from that of Manitoulin island 10 miles to the north, and of Michigan 33 miles to the southwest. The neighbouring shores of Manitoulin island are composed of Lockport dolomite, probably representing an horizon near the top. The average dip of the formation across the island in this vicinity is about 30 feet to the mile toward the southwest, which would carry the top of the Lockport dolomite to a depth of 300 feet below the level of lake Huron at the new well, in case the dip is maintained. The thickness of the Guelph dolomite for this locality is not known, but it would certainly more than bridge the 80-foot gap between the projected top of the Lockport and the bottom of the bore-hole that is down about 220 feet below the level of lake Huron. The surface formation in Michigan is Devonian, proving that the general southwesterly dip continues across the lake. The Upper Silurian beds belonging to the Cayugan group consist of soft shales, including lenses of salt and gypsum, and soft water limes, all of which offered but little resistance to late Tertiary and Pleistocene erosion when the Lake Huron basin was formed. The erosion has quite generally swept away the Guelph dolomite also, leaving remnants only on the southwestern end of Fitzwilliam island and the small islands to the south. It seems probable therefore, that the well on Great Duck island should soon encounter either Guelph or Lockport dolomite, and that the top of the Trenton formation should be penetrated at a depth of about 600 to 650 feet below sea-level, or 1,200 feet, in round figures, from the surface.

The general structural relationships for oil occurrence are rather unfavourable, in that the Duck islands are situated well down the dip of the formations. There may, however, be subsidiary structures in this locality that are favourable for oil accumulation. It is to be sincerely hoped that the well now started may be continued until a thorough test has been made.

In order that the oil possibilities of Manitoulin island and vicinity may be tested under the most favourable conditions, it is recommended that the Gore Bay structure be selected as the first to drill. In case commercial oil is struck at this locality, the Perch Lake and Rattlesnake Harbour structures may next be tested. New wells might also be drilled to the north and west of the Wekwemikong wells, as these seem to be the most promising so far drilled.

It does not seem probable that the Manitoulin island will ever be a large producer of oil, but there is room for further exploration on Barrie island, in the area west of Meldrum bay, and on Cockburn island, where no drilling has been done so far. In the absence of ascertained structures, such drilling must be of a "wild-cat" nature, and accurate logs of all wells should be kept as an aid to further development.

The accompanying structural map has been prepared to record known information and to suggest the general depth and shape of the top of the Trenton formation. Great care should be taken not to drill for oil near localities where the Trenton formation is laid bare beneath water bodies, as in such cases petroleum generally escapes. Such conditions may be ascertained from a comparative study of the accompanying structural map and the charts of lake Huron.

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