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REPORT OF GEOLOGY
ON PARTS OF EASTERN GASPE

by

I.W. Jones and H.W. McGerrigle

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REPORT OF GEOLOGY

ON PARTS OF EASTERN GASPE

Townships of Larocque, Galt, and portions of Laforce, Baillargeon and Baie de Gaspé Sud

by I.W. Jones and H.W. McGerrigle

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REPORT OF GEOLOGY

ON PARTS OF EASTERN GASPE

by I.W. Jones and H.W. McGerrigle

GENERAL STATEMENT

The presence of petroleum springs or seepages in eastern Gaspé, known more than a hundred years ago, attracted early attention to this district as a possible producer of petroleum in commercial quantities. In fact, attempts to find oil by drilling were started here in 1860, only a short time after the advent of the world's petroleum industry on a large scale. Between that time and 1902, but particularly after 1890, several wells were drilled in eastern Gaspé. The failure of these wells to obtain commercial quantities of oil - although a small production was obtained from many of them - discouraged further active interest in this district, apart from a slight revival in 1913, when a well was unsuccessfully drilled at some distance southeast of the scenes of the earlier activities.

It had been felt for some time that this region warranted re-study, especially as the geological work in this section of eastern Gaspé had all been of a general or reconnaissance nature. It was highly desirable to have more detailed information, so that such conclusions regarding oil possibilities as were drawn might be based on reasonably complete data. It was hoped that a detailed study might settle definitely the question as to whether the drilling could be considered as having effectively tested the region, and would determine whether further search for oil should be considered.

With the principal aim of determining whether geological conditions favour renewed attempts by drilling to find petroleum in commercial quantity, the Quebec Bureau of Mines began investigations in this eastern part of Gaspé in 1937. The geology of the region is being studied in a detailed manner, and, of course, due attention is being given at the same time to the possibilities of finding any other mineral deposits of economic importance.

The investigations now under way are a further development of the work carried out by the late Dr. W.A. Parks for the Quebec Bureau of Mines in 1929, when he compiled the existing information on the region and supplemented the compilation by observations he made in the field during a brief study of the geological conditions in an area of widespread extent. The present investigations are also the continuation - but in a more detailed manner - of the studies made in recent years by Jones, one of the authors of this report, in adjoining areas north, west, and southwest of the one described in these pages.

In order to advance these investigations as rapidly as possible, a second party was placed in the field in addition to the one that has been occupied during past years with the geology of Gaspé peninsula. This second party was under the direction of McGerrigle, co-author of this report. He covered the southern part of the area, bordering Saint-John river, in the townships of Laforce and Baillargeon, and during the last two weeks of the field-season he assisted the senior author in the completion of his area. The latter was in charge of the work in the area bordering York river and northward from there, comprising the townships of Larocque and Galt, and parts of the townships of Gaspé Baie Sud, Laforce, and Baillargeon. The boundary between the two investigations was about midway between the Saint-John and York rivers, but there was slight overlapping in some places, especially in the eastern part of the area, where the two rivers are not widely separated. In the preparation of this report, each investigator has written the section dealing with the geological conditions of his particular area; these introductory statements and the summary are written by Jones, with, of course, the collaboration of McGerrigle wherever reference is made to his (southern) part of the area.

As the investigations will be continued eastward into areas adjoining that covered in 1937, the present report should be considered essentially as of an interim nature, or as a report of the progress made to date. With the additional information to be obtained in the future work, both beyond the area already covered and probably within it if other investigators follow the lead already established, it is quite probable that some of our interpretations may require later modification. Thus, the accompanying map should also be

considered as an endeavour to show the geological conditions as they are believed to exist according to the information at present available, but the data so indicated are subject to periodical revision until the time when studies of the broader region have been completed.

SUMMARY

The oldest rocks within the area examined in 1937 are tightly squeezed limestones and shales, exposed along or occupying the anticlinal crest which follows near the Saint-John River valley for most of its course in this area. The age of these rocks is not as yet known with certainty, but they are either Upper Ordovician or Lower Silurian, with evidence at present tending to favour the first-mentioned age. Northward from these rocks, and on the north limb of the anticlinal zone just mentioned, succeedingly younger strata are met with as York river is approached. This succession is one of Silurian shales, limestones, conglomerates, and limestone grits, followed by Devonian shales and limestones, and, finally, by a thick series, also Devonian in age, composed principally of shales and sandstones. In the York River valley, the structure is primarily that of a major syncline. North of this river, as far as the northern limit of the area, the rocks are of Devonian age, with the exception of a small occurrence of possibly Silurian rocks in the northeastern corner of Galt township. An anticlinal structure extends across the area, its crest lying from two to six miles north of York river. To the north of this anticline, the structures do not appear to cross the area for its entire width; in the western part, a syncline, with its axis passing about two miles north of Dartmouth lake, and an anticline, extending along the north boundary of the area, reach as far east as Patewegia brook. East of this brook, in the most northern part of the area, the general structure is synclinal, but a subsidiary anticline is indicated crossing Galt brook about a mile north of the east-west centre-line of Galt township.

In addition to having been folded, the rocks in some places have been fractured and displaced along faults. Both reverse, or thrust, and normal faults are represented. There are believed to be two major zones of thrust-faulting - one of which is 1 to 3½ miles north of the Saint-John River anticline and the other passing presumably about half a mile north of Dartmouth lake. These thrust faults have a general easterly trend with the strike of the formations, but there are, in some parts, deviations from this general trend. The overthrusting implies movements from the south. The presumed normal faults trend in various directions. One zone of normal faulting, with a downthrow on the northeast side apparently of major dimension, trends southeasterly from the northern to the southern boundary of the area, crossing York river near the north-south centre-line of Baillargeon township. Other normal faults branch from this major fault and extend for variable distances from it.

Oil seepages may be seen issuing from the Devonian rocks of this area, particularly along the major northwest-southeast fault-zone just mentioned. Some Silurian rocks just east of the area, south of Saint-John river in York township, are also impregnated with petroliferous material, and oil seepages are reported to have been seen in the still older rocks of Ordovician or Silurian age near that river.

Of the 58 wells drilled in eastern Gaspé, 35 are in the area examined during 1937, and 10 others are only a short distance east. As a result of the observations made so far in this investigation, it is believed that very few of these wells were suitably located with respect to structures considered to be most favourable for oil accumulation. They are, for the most part, at or near synclinal axes. There are extensive areas with more favourable conditions farther up the flanks of the folds, toward the anticlinal crests. The present report suggests certain areas for further consideration in the event of renewed efforts to find petroleum here in commercial quantity.

Lead and zinc, as galena and sphalerite, have been found in fractured zones, particularly in the belt of normal faulting that follows near Patewegia brook.

THE SAINT-JOHN RIVER AREA

by H.W. McGerrigle

INTRODUCTION

Description of Area

Location and Access:

The area mapped by the writer during the 1937 field season consisted of some 70 square miles bordering the Saint-John river in Laforce and Baillargeon townships. In addition, reconnaissance traverses were made southward beyond the limits of the map-area and also eastward into York township as far as the Little Fork of the Saint-John river.

Access is gained to the area mapped by way of a main automobile road from Gaspé to Sunny Bank, a distance of seven miles, and thence for nine miles by motor truck or automobile to Paint lake.

Topography:

Topographically, the area is a dissected upland at a general level above the sea of 1,600 feet, with occasional hills rising to 2,000 feet. Sharp cutting by streams has resulted in many steep-sided valleys and a generally rough topography. The maximum relief, from the lowest valley to the highest summit, is 1,450 feet.

The major topographic feature is the valley of the Saint-John river. This river, which has cut to a depth of more than 1,000 feet below the general level of the surrounding country, flows through a valley that averages one mile in width from crest to crest. The valley follows a course slightly north of east from the western edge of the area for twenty miles, essentially forming the southern limit of the area mapped. Near the centre-line of Baillargeon township, the river swings sharply northward and continues on this course for about two miles before resuming its easterly direction. Where the river turns northward, however, the valley continues its eastward course, and it is a logical deduction that the Saint-John river once flowed eastward through this continuation of the valley (now occupied in part by Lazy Bogan brook) and into what is now a major tributary of the Saint-John, namely, the Big Fork. The average gradient of the river is thirteen feet to the mile. There are no falls in this part of the Saint-John, but many rapids occur and the river in general is shallow.

Agricultural Possibilities:

The generally rough nature of the country precludes the possibility of developing it as farm land. Also, while bedrock rarely shows except along the stream courses, there is, nevertheless, a general absence of soil suitable for cultivation. Broad flats occur along the course of the Saint-John river and these, at first sight, suggest the possibility of being developed agriculturally. However, they are underlain for the most part by gravels, with sand or loam seen but occasionally and then in relatively small patches.

Timber:

The greater part of the area has been swept by forest fires, and in these sections the prevailing young growth is poplar. On the flats on the north side of the Saint-John river in Laforce township and in the western half of Baillargeon township, and on the south side of the river generally, there are stands consisting mainly of fir and spruce. Cedar, Birch, and poplar are fairly abundant, while pine is rare and scattered. On the hills south of the river, beyond the limits of the map-are, good stands suitable for pulp-wood were noted in several places.

Method of Work

A topographic map of the area, furnished by the Bureau of Mines, greatly facilitated the field work. The map is on a scale of four inches to one mile and has a contour interval of fifty feet.

Traverses were made at intervals of half a mile or less, with particular attention directed to the stream courses. The traverses were plotted directly onto the topographic map.

Acknowledgments

The writer was ably assisted in the field by R.A. Brown, graduate student at McGill University, Roger Provost, student at l'Ecole Polytechnique, Montreal, and Wilton Miller, of Sunny Bank, Gaspé county. Howard Mullin, of York Centre, Gaspé county, gave valuable aid in the reconnaissance work in York township.

Particular adknowledgment is made to Dr. G.A. Cooper, Assistant Curator, United States National Museum, Washington, D.C., for examination of, and advice on, many fossils collected by the writer in this area.

Previous Work

A survey of the Saint-John river from its mouth to Indian Fork, a distance of about 50 miles, was made by A. Murray in 1844. His report, containing and outline of the geology, was published in 1846 (1) and is summarized also in Geology of Canada, 1863, (p. 409). Murray recognized the fact that the Saint-John river follows closely a major anticlinal axis throughout the greater part of the present area and for some distance westward. He noted, also, that limestones occur along the river, and thus along the anticlinal axis, and are overlain to the north and south by sandstones. In 1863, Logan placed these rocks in his Gaspé Limestone and Gaspé Sandstone series, respectively.

Parks (2), in 1929, discussed the general geology of the region, and the map accompanying his report shows the courses of the major structural features as then recognized. Although, in the body of the report, he gave no new geological data concerning the present area, his map delimits, more closely than Murray or Logan had done, the anticlinal axis along the Saint-John and also the boundary between the 'Gaspé Limestones' and the 'Gaspé Sandstones' north of the river.

In 1936, Jones (3) mapped an area immediately westward of the present and including the extension to the west of the anticlinal referred to above. In that area, the beds forming the anticline are stated by Jones to be of Silurian, and possibly of Ordovician, age, which suggests at once the probability that the limestones of the present area, previously mapped as Gaspé limestones of Devonian age, are not all of that age and that older rocks are included. The actual presence of rocks older than previously recognized will be demonstrated in the following pages.

DESCRIPTIVE GEOLOGY

Upper Ordovician or Lower Silurian

Three formations occupying stratigraphic positions near the top of the Ordovician or the base of the Silurian occur, over a width of about two miles transverse to their strike, along the western boundary of the area. They may be followed eastward in gradually decreasing width for sixteen miles, beyond which they disappear beneath younger strata. Their eastern termination is in the valley of Lazy Bogan brook about one mile east of the centre-line of Baillargeon township. The best exposures of these three formations are in scattered outcrops along the Saint-John river.

The lowest of the formations is most easily accessible from the trail along the north side of the Saint-John river, at Little Indian pool, near the western boundary of the area; at the mouth of a small brook half a mile below the pool; and again at Peter's camp, about five miles farther down the river. This formation consists predominantly of dark grey to black, very fine-grained, somewhat argillaceous, limestones. They weather dirty grey to light grey and buff. Some of the beds exposed are several feet thick; others

(1) Murray, A., On the Topography and Geology of the Matane, Ste. Anne, and St. John Rivers: Geol. Surv. Can., Rept. of Prog. 1845-46.
(2) Parks, W.A., Report on the Oil Gas Resources of the Province of Quebec; Que. Bur. Mines, Ann. Rept., Part B, 1929.
(3) Jones, I.W., Mount Alexander Map-Area, Gaspé County; Que. Bur., Mines, Ann. Rept., Part D, 1936.

Table of Formations

Middle, or Lower, Devonian	Feldspathic sandstones with shale interzones
Lower Devonian	Limestones, well-bedded, typically siliceous to cherty (Grande Grève formation)
	Limestones, interbedded, dark, soft, crystalline limestones and greyish calcareous sandstones (Bon Ami formation)
Silurian, with probably some Devonian	Greenish-grey, fine, arenaceous limestones and finely bedded, calcareous siltstones
Middle Silurian	Coarse conglomerate with interbeds of finely bedded, calcareous siltstones; conglomerate grades laterally (westward) into limestone grit
	Massive limestone, grey, with wind-blown quartz grains
Lower Silurian	Shale, green, with one to two-inch interbeds of limestone and fine-grained sandstones
or	Limestone, well-bedded, in layers averaging one to two inches in thickness; dark, dense, weathering to dove colour
Upper Ordovician	Limestone, well-bedded for most part, dark, somewhat argillaceous; interbeds of crystalline limestone and arenaceous limestone

are quite thin. Typically, however, they are from half an inch to three inches in thickness, with the individual beds separated by seams and thin layers of dark grey calcareous shale. Occasional interbeds of grey crystalline limestone, often dolomitic, and of arenaceous limestone, occur. The crystalline limestone contains many fragments of fossils, particularly crinoid stems, and a few recognizable forms.

The succeeding, younger, formation is also limestone. One of the best exposures, and the most easterly as well as the most accessible, is on the north bank of the Saint-John a few hundred feet above No. 3 camp. The rock is dark, dense, very fine-grained, and occurs in beds of one to two inches in thickness. This limestone resembles the underlying formation and pernaps should be placed with it as a lithological unit. Distinguishing features are its fine, smooth, and even texture, the light grey or dove colour on the weathered surface, and the apparent greater purity of the limestone. Also, it shows the effects of metamorphism to a lesser degree than the lower formation.

The uppermost of the three formations is shale. It is best and most conveniently seen on the road, and along the north bank of the Saint-John river, at the mouth of a small brook about one mile west of Cameron's camp. The shale is dark green, soft, with interbeds about one inch in thickness of cross-bedded arenaceous limestone and calcareous sandstone.

The strata of these three formations, and particularly of the lowest, are arranged in small, complex folds subsidiary to the Saint-John River anticline. Drag-folding on a small scale is a common feature in the two limestone formations. Cleavage is strongly developed in the lower limestone and in the shale. Its general trend is east-west and the dip is usually steep, either to the north or to the south. Fracturing and small-scale faulting are of frequent occurrence. Calcite veins filling joints and fractures are conspicuously developed in many exposures of both limestone formations.

The complexity of structure makes it impossible to form any close estimate of the thickness of this group of formations. However, inasmuch as they are exposed over a width of a little more than a mile on the northern limb of the Saint-John River anticline, and as the dips are generally in excess of forty-five degrees, although variable in direction a thickness that is considerable, and probably in excess of 4,000 feet, is indicated. The lowest formation possibly accounts for some 3,000 feet or more of this total thickness, and the second or upper limestone for 1,000 feet. The shale formation is about 400 feet thick.

Fossils have been found only near the base of the lowest of the three formations, in the interbedded crystalline limestones already referred to. Specimens collected from exposures on the north bank of the Saint-John river, about one mile down-stream from the Laforce-Sirois boundary, were kindly examined for the writer by Dr. G.A. Cooper, assistant curator of the United States National Museum, at Washington, D.C., who identified the following forms:

Bilobites sp.
Streptis cf. S. monilifera altosinuata Holtedahl
Triplesia sp.
Coelospira sp.
Dayia ?? sp.

These fossils show an Upper Ordovician or Lower Silurian age for the beds. Further examination of the fossils, and perhaps more extensive collections, will be needed to determine their exact posiion in the stratigraphic column.

Middle Silurian

The dominating lithological feature of the Middle Silurian in this area is a large conglomerate lens. Underlying the conglomerate, and following immediately upon the shale formation mentioned above, is a massive limestone. The conglomerate is interbedded with and overlain by fine-grained, and finely bedded, arenaceous limestones and calcareous siltstones.

The series traverses the area in a band averaging less than half a mile in width from the Laforce-Sirois township-line to the southeastern corner of the area. Its trend is slightly south of east. These Middle Silurian beds appear only on the northern limb of the Saint-John River anticline except in the extreme east of the area, where they occupy a position on the axis of the fold. They are best exposed in the escarpments on the north side of the valley occupied by Lazy Bogan brook and on the north side of the Saint-John River valley from the Owl Capes westward for about eight miles.

The lowest formation, or bed, of the Middle Silurian is a massive limestone about 75 feet thick. The rock is fine-grained, grey to dark grey on fresh surfaces, weathering light grey. It carries scattered pebbles and also lenses and patches of conglomerate. The pebbles are mainly limestone similar to that of the underlying Lower Silurian or Upper Ordovician limestone formations. In the western part of the area, the massive limestone is overlain by coarse limestone grit, the grains of which are mainly limestone fragments with some of quartz. The matrix is argillaceous limestone or calcareous shale. This rock was not actually seen in place, but it forms a large part of the débris in the line of strike of the conglomerate. The material of this débris includes also finer grained, calcareous sandstone and, less commonly, small-pebble conglomerate. About three miles east of the western boundary of the area, the limestone grit and associated rocks give place along the strike to conglomerate with interbeds of fine, finely banded, cross-bedded, micaceous, arenaceous limestones or calcareous siltstones. Proceeding eastward, there is, in general, an increasing thickness of the conglomerate. Its greatest development in the area is at the Owl Capes and on the north side of the valley occupied by Lazy Bogan brook. The fine-grained sedimentaries occur here as interbeds, but they are much subordinate to the conglomerate. The maximum thickness of the conglomerate formation is about 800 feet.

The pebbles of the conglomerate are largely limestone which resembles in character that of one or other of the two underlying limestone formations. They are sub-angular in

shape. The rock also contains well-rounded pebbles of quartz, chert, and volcanics, and, less commonly, of jasper and porphyritic diorite. Evidently these well rounded pebbles, with the exception of the diorite, were derived from a distance, and possibly from the volcanic area to the south and southwest, in the district about Alexander and Observation mountains. The porphyritic diorite pebbles are probably local, since rock of the same type occurs at the southern border of the area, in Laforce township. The matrix of the conglomerate varies from relatively pure, fine-grained limestone to coarse limestone-grit and to calcareous shale.

The massive limestone below the conglomerate has yielded but few and rather poorly preserved fossils, mainly Favosites sp. In the matrix of the conglomerate as exposed in the vicinity of the Owl Capes, Favosites and Stromatoporoids are fairly abundant. About two miles east and two and a half miles north of the southwest corner of the area, the conglomerate matrix yielded Monograptus clintonensis (identification by the writer; confirmed by T.H. Clark). In addition to the graptolite, and associated with it on the same piece of rock, were immature brachiopods and also several ostracods. Clark (1) reports that the latter, while poorly preserved, seem to belong to the Middle Silurian genera Beyrichia and Kloedenia. Cooper (2) has made the following identifications of fossils collected from the conglomerate matrix at localities outside of the area:

Lot 2. - South of the area, at the cliff between Porcupine and Burnt Jam brooks:

Conchidium sp.
Camarotoechia sp.
Proetus sp.

Lot 10A. - South of the area, on the Big Fork of the Saint-John, Baillargeon township:

Favosites sp. of the type of F. forbesi
Favosites sp., with small cells.

According to Cooper, the specimens in both lots indicate a Silurian age.

Although the number of fossils collected and identified from this formation is small, its Middle Silurian age is fairly well established.

Silurian and Devonian

As stated above, the Middle Silurian conglomerate formation is interbedded with fine-grained, calcareous sandstones to siltstones. Such strata overlie the conglomerate and are succeeded upward to the base of the Bon Ami (Lower Devonian) formation by fine-grained, greenish-grey, soft, impure limestones associated with similar limestones of dark colour. Many of the beds are strongly arenaceous. These rocks are indicated as 'Silurian and Devonian' in age for the reason that strata corresponding to the Lower Devonian Saint-Alban formation probably are included with strata of evident Silurian age. The scarcity of exposures of beds representing this group, and the close lithological similarity between the lowest Devonian and the highest Silurian rocks in this area, make it difficult to determine their stratigraphic boundaries. This could be done only with the aid of fossils.

In the present work, no fossils were found in the rocks mapped as belonging to this group. Fossils were found, however, to the east of the area and also to the south in rocks occupying, in each case - unless disturbed by faulting - a stratigraphic position not far above the conglomerate. The fossils collected from such rocks to the south of the area were determined by Cooper as probably Devonian, and those from occurrences to the east as Silurian. The rocks enclosing the Devonian forms were very similar lithologically to those of some of the Silurian localities.

Inasmuch as a further and more detailed field study will be made in 1938 of the area including the fossil localities referred to above, it is advisable to await the hoped-for more complete information as a basis for continuing the discussion of the Silurian-Devonian relationships in this area.

(1) Clark, T.H., personal communication.
(2) Cooper, G.A., personal communication.

Lower Devonian

The Lower Devonian of the present area is essentially the Gaspé Limestone series of Logan. This series, at the type section of the Forillon, was divided by Clarke (1) into three formations, namely, from oldest to youngest, the Saint-Alban, Bon Ami, and Grande Grève. The characteristic lithologies of the Bon Ami and Grande Grève formations can be recognized in the present area. The Saint-Alban formation may be present, but if so it resembles so closely the Silurian beds overlying the conglomerate, described above, as to make their separation on lithological grounds very difficult, if not impossible.

The lower part of the recognized Lower Devonian in this area, corresponding essentially to the Bon Ami, consists of dark, fine, argillaceous limestones, dark, finely crystalline limestones, and fine-grained, calcareous sandstones. Interbeds of feldspathic sandstone up to six inches in thickness also occur. These softer beds are succeeded upward by strata of the grand Grève formation, consisting mainly of dark, siliceous and cherty limestones in beds averaging two inches to four inches in thickness. Thin layers of shale, sometimes arenaceous, often separate the limestone beds.

On the basis of width of exposure and general or average dip, the thickness of the Lower Devonian limestones is estimated to be upwards of 4,000 feet. While some folding and faulting has disturbed the succession in various places, a thickness of this order is indicated almost throughout the length of exposure of the Lower Devonian in the present area. This is about double the thickness (2,010 feet) of the combined Saint-Alban, Bon Ami, and Grande Grève formations at the type section (2) and much in excess of the thickness (2,500) feet given by Alcock (3) for the presumed equivalent beds north of Portage river.

The Lower Devonian limestones of the present area overlie strata of Silurian age and underlie the Lower or Middle Devonian Gaspé sandstones. The lower contact was not observed. Likewise, the upper contact was not observed within the area mapped during the present investigation, although its position could be determined closely in several places. There was no evidence of unconformity between the limestone and the Gaspé Sandstone series.

The Lower Devonian age of the Grand Grève, Bon Ami, and Saint-Alban formations is generally accepted. In the present area, few fossils have been found in the formations that are described and mapped as Lower Devonian, but such as have been collected bear out the evidence of lithology and stratigraphic position for correlating them with the Grande Grève and the Bon Ami.

The following fossil forms have been recognized:

(a) Maitland's pool Saint-John river. Grande Grève: Dalmanites dolbelli (one pygidium); Cephalopods - two, small, straight, poorly preserved

(b) Ross Lake trail, near Saint-John River portage road. Grande Grève, loose material: Dictyonema sp., r.; Proetus sp., c - possibly new; Plant fragments - c.

(c) South of the area, on Porcupine brook. Bon Ami or Saint-Alban (fossils identified by Cooper): Atrypa sp., large; Chonetes sp., coarse ribbed; Leptostrophia? sp.

Lower, or Middle, Devonian

The Lower Devonian limestones in this area are succeeded northward, and are immediately overlain, by the 'Gaspé Sandstone' series. The strata consist of greenish-grey, feldspathic sandstones, for the most part with common interbeds and interzones of greenish shale up to 100 feet thick. Also, there are occasional limestone beds, some of which carry an abundance of marine fossils. Seams and layers, up to two inches thick, of bituminous matter are of frequent occurrence. Cross-bedding and ripple marks are common features in the sandstone, and rain prints are seen occasionally in shaly layers separating sandstone beds. At one place, on the north bank of the Saint-John river about half a mile west of the Baillargeon-York line, good examples of cut-and-fill structure are exposed. It is

(1) Clarke, J.M., Early Devonic of New York and Eastern North America; N.Y. State Mus. Mem. 9, Vol. I, 1908.
(2) Logan, Sir William, Geology of Canada, 1863, p. 393.
(3) Alcock, F.J., Geology of Chaleur Bay Region; Geol. Surv. Can., 1935, Mem. 183, p. 68.

evident from these structures that currents of water cut into, and in some places through, beds of sandstone that were only partly lithified, isolated portions of them, and wore them down to forms resembling boulders. These boulder-like structures are not to be confused with the concretions which, in certain zones, are of common occurrence.

The 'Gaspé Sandstone series' of Logan is generally accepted as being Middle Devonian in age, and the change from Lower to Middle Devonian in the type area around Gaspé has been placed at the 'Gaspé Limestone'-'Gaspé Sandstone' contact. However, in 1935, Jones (1) provisionally designated the lower part of the Gaspé sandstones as possibly Lower Devonian in age, and applied to this part the name 'York Lake series'.

In the present work, the writer saw little of the sandstones overlying the Lower Devonian limestones, except in the eastern half of Baillargeon township. Here, the sandstones are faulted down against the limestones, and the sandstone base is concealed. As a probable result of this faulting, the characteristic lithology of the York Lake series was not recognized by the writer. At the one locality where fossils were found, the forms are of the types occurring near Gaspé and considered to represent the Middle Devonian. The fossil locality is about two-thirds of a mile west of the Baillargeon-York township-line, on the south bank of the Saint-John river. The following forms occur abundantly:

Rensselaeria ovoides gaspensis
Leptocoelia flabellites
Leptostrophia blainvilli
Chonostrophia dawsoni
Spirifer gaspensis
Chonetes hudsonicus gaspensis

Igneous Rocks

Volcanic rocks do not occur in this area. One small outcrop of intrusive igneous rock, porphyritic diorite, was seen. This is in the valley of a small stream at the southern boundary of the area, in the eastern part of Laforce township. Boulders of igneous rock identical with that of the outcrop are abundant on the upland surfaces to the west-southwest over a distance of two miles. While this boulder-area may mark the approximate position of the intrusive body, it is not possible with present information to estimate closely either its area or form.

The rock is a porphyritic diorite, with phenocrysts of feldspar up to one-quarter of an inch in length. The matrix is fine to medium in grain, greenish, and composed mainly of oligoclase feldspar and hornblende with considerable chlorite. Biotite, quartz, and magnetite are also present in the rock.

The diorite was not seen in contact with the surrounding sedimentaries. It lies within the area of the higher Ordovician or Silurian limestone formation (dove-weathering limestone), and it is perhaps intrusive into that formation. Boulders and pebbles of very similar, if not identical, igneous rock occur in the Middle Silurian conglomerate. While these may have been derived from another and more distant source, they are taken tentatively as evidence that the intrusion antedated the conglomerate. Thus it is concluded that the diorite is of an age not younger than Middle Silurian.

Occasional loose blocks of igneous rock, ranging in composition from syenite to diabase, were found at a few other places in the western part of the area, but it is doubted that these are closely in place.

STRUCTURE

The dominant structural feature of the area is the 'Saint-John River anticline'(2). The eastward-plunging axis of this fold follows closely the valley of the Saint-John river from the western boundary of the area to the sharp northward bend of the river near the

(1) Jones, I.W., Upper York River Map-Area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rept., 1935, Pt. D, pp. 15-22.
(2) Referred to on Ells' map, 1902, as the Malbaie anticline, and by Parks, 1929, as the Point Saint-Peter anticline.

centre-line of Baillargeon township. In this distance, the trend of the axis is almost directly east. The anticlinal axis leaves the area on a course slightly south of east about three miles west of the Baillargeon-York tonwship-line. This fold has not as yet been traced through to the coast and therefore cannot be definitely correlated with a particular structure in the coastal region.

Drag-folds of greater or lesser magnitude are common and are particularly apparent in the lowest member of the Ordovician or Silurian group and in the Lower Devonian limestones.

Faulting on a small scale is common throughout the area, and, while perhaps not more frequent, is more often observed in the hard limestones of the Grande Grève than in the other formations. Brecciation of the limestone over a width of a few feet often accompanies the faults and in some places is the only observable evidence that movement has taken place. Such brecciated zones may be seen at Paint lake and on the Baillargeon centre-line between Paint lake and the Saint-John river.

A fault of major proportions enters the area from the east, two-thirds of a mile south of the Saint-John river. From the eastern boundary, it follows a northwesterly course to the Saint-John. It is assumed that this fault continues through Third lake and joins with a fault cutting across the York river. It is of the normal type with downthrow on the north side, bringing the Lower or Middle Devonian sandstones down against the Lower Devonian Grande Grève limestones. Inasmuch as good horizon markers are lacking in the sandstones, the mount of displacement is not definitely known.

As shown on the accompanying map, it is assumed that a strong thrust-fault with a southward-dipping plane occurs on the north side of the axis of the Saint-John River anticline. The chief evidences for this thrust are, first, the necessity of a thrust or of a normal fault with downthrow on the north side to explain the close approach of the Middle Silurian conglomerate to the Lower Devonian Grande Grève beds at the Owl Capes; second, the apparent elimination of the Grande Grève formation in the western part, and of the Bon Ami formation in the eastern part, of the area; third, a thrust such as assumed would help explain why, in the western part of the area, the older formations appear to occupy positions too far to the north in relation to topography and a more regular structure; and finally, the course of this assumed thrust checks closely with the mapped course (1) of an assumed thrust in the area adjoining to the west.

ECONOMIC GEOLOGY

Lead and Zinc

No occurrences of metallic minerals were noted in this area, apart from scattered crystals of pyrite in limestones and small nodules of granular pyrite or marcasite in the Gaspé sandstones. In places along the Big Fork of the Saint-John, to the east and south of the present area, veins of calcite carrying galena and sphalerite were observed, but the occurrences are too small to be of economic interest. The veins often accompany faults.

Marl

Attention was given to the bottom deposits of Paint lake as a possible source of marl. A composite sample of the mud submitted for determination of the lime and insoluble content gave 52.14 per cent lime and 1.02 per cent insolubles, the balance being mainly carbon dioxide. Under the microscope, no organic structures were observed.

Oil Possibilities

Indications of oil in this area are not common. The Lower Silurian limestones along the Saint-John river have a bituminous rather than a petroliferous odour, but freshly broken pieces of these rocks gave, in most cases tried, a faint oil-film when placed in water. Occasionally, vugs and thin seams or fractures in the Lower Devonian Grande Grève limestones are oil-filled. This was noted particularly in the upper part of the formation, along the Saint-John River valley between the Owl Capes and Third lake. The oil is dark brown and fairly heavy. Thin seams, as well as layers up to one inch thick, of bituminous matter occur here and there in the Gaspé sandstones. These burn readily and with much the same result as in the burning of tar.

(1) Jones, I.W., personal communication.

Oil seeps are few, if present at all, in the area. One seep is reliably reported to exist, or to have existed a few years ago, on the flat adjacent to, and on the east side of, the mouth of Burnt Jam brook. No evidence of this seep was seen by the writer except a faint 'bear-mark' on the trunk of a tree near the supposed site of the oil seep. However, in view of the credible nature of the testimony, the writer is inclined to accept as a fact that an oil seep did exist in the locality indicated. If a fact, it would point very definitely to a source of oil in rocks older than any heretofore suspected of being oil-bearing in this region, for a seep here would imply that some, at least, of the oil had its source in the oldest, Ordovician or Silurian, rocks of the district.

Further evidence pointing to a source of oil below the Gaspé limestones (Lower Devonian) is afforded at a locality on Ascah's brook, within, and near the western boundary of, York township, east of the present area. Here, a reef limestone, composed mainly of stromatopores and corals, reeks of petroleum when freshly broken. The age of this reef limestone is Middle Silurian.

The dominant structure of the area - the Saint-John River anticline - is denuded deeply, except in the eastern part. The oldest formations of the district are exposed along the axis of this anticline from the western boundary of the area to within a few miles of the eastern boundary. This denudation is detrimental to the chances of oil in commercial quantities remaining within the structure. Also, the anticline is sharper than what is considered the optimum for the retention of commercial quantities of oil. Cross-folding, such as produces dome and basin structures, has not been recognized to any important extent along this anticline.

In view of the conditions outlined above, the possibility of obtaining oil in commercial quantities along the greater part of the 'crest' of the Saint-John River anticline seems slight. However, in the eastern part of the area, toward the York-Baillargeon line, lesser erosion or denudation, together with the gentle eastward plunge of the fold, give increasing cover to the anticline. This condition combines with more gentle dips, and hence a less sharp fold, to provide more favourable conditions for the accumulation and retention of oil. All of these conditions become more apparent to the southeastward of the area, in York township. Consequently, it has been recommended that the area to the southeast be examined in detail, and this will be done during 1938.

No part of the area considered in this section of the report has been prospected for oil by drilling. No wells were drilled in Laforce township. The one well drilled in Baillargeon township, on the northern side of Fourth lake, will be mentioned in the following section of this report by I.W. Jones. Three wells have been drilled in York township in the eastern continuation of the area. One of these is located on the north bank of the Saint-John river, one mile east of the York-Baillargeon line. The other two are on either side of the Little Fork of the Saint-John, on the south side of the river, in the central part of York township. All of these wells penetrated the sandstone and entered the limestone. The results of the drilling were negative.

THE YORK RIVER AREA

by I.W. Jones

INTRODUCTION

Description of Area

Location and Area:

As outlined in the general statement at the commencement of this joint report, the portion of the region described in this section occupies the whole of Larocque and Galt township, and parts of Laforce, Baillargeon, and Baie de Gaspé Sud - an area of about 200 square miles. Of this total, 180 square miles was ground examined during the 1937 season. The remaining portion, in the northern part of the district, was studied in 1934 but is included here for the sake of presenting a more complete account of geological conditions in the region.

Means of Communication:

The eastern edge of the area, at York river, is about nine miles by motor-road from the village of Gaspé. This village is a seaport and the terminus of the railway that follows the bay of Chaleurs after leaving Matapedia, on the main line of the Canadian National railway. The road continues across the area by following the valley of York river. During the autumn of 1937, it was being enlarged and improved to permit use of motor vehicles at all times. The location of the roadway has been changed slightly in some places from its former position, but surveys of these changes have not been received in time to show them on the accompanying map.

Another road, known locally as the Howard Smith road, leaves the York River road about a mile and a half, east of the map-area and goes northwesterly, as indicated on the map, to Patewegia brook. In 1937, motor vehicles were able to travel this road to the boundary between Galt and Larocque townships. This roadway, formerly used in lumber operations, continues westerly from Patewegia brook to Mississippi brook and thence southerly to rejoin the main York River road a short distance east of the latter brook. In the last described part, from Patewegia brook, this road is now in need of repair before it could be used for waggons.

A waggon-road, in need of repair also, leaves the York River road just east of Galt brook and, going northwesterly, reaches Patewegia brook at the mouth of Sonneau brook.

These waggon-roads, at present unfit for vehicles, as well as others of a similar nature, are indicated on the accompanying map with the same symbol as trails. The few, more or less passable, trails are also indicated.

Topography and Drainage:

Physiographically, this region in general presents the same aspect as prevails throughout interior Gaspé. That is, it is an elevated region dissected by numerous valleys that are frequently deep and bordered by steep sides. The highest point in the area is Bald mountain, 2,440 feet above sea-level, near the northern boundary of Larocque township; the lowest point, about 50 feet above sea-level, is on York river at the eastern edge of the area. The valley bottoms are frequently 600 to more than 1,000 feet below the neighbouring highlands, which are usually from 1,200 to more than 2,000 feet above sea-level. The areas underlain by limestone formations tend to be more rugged and to have, as a rule, steeper slopes than those underlain by sandstones and shales. The attitude of the beds, however, sometimes influences the topography and, where the sandstone-shale formations are steeply inclined, there are apt to be high and steep ridges.

The principal drainage system is that of York river, which descends almost 600 feet in its course across the southern part of the area described in this section of the report. The main tributaries of this river that enter it from the north are Mississippi,

Patewegia (Big Fork), Galt (Little Fork), and Silver brooks, while on its south side the main tributaries (generally smaller than those on the north) are Edward (Bechervaise), Dinner Island, and Fourth Lake brooks. The reasons for adopting the names Patewegia and Galt for what have, in the past, been more commonly known as Big Fork and Little Fork, respectively, have been given in the writer's report for 1934. The name 'Edward' for Bechervaise brook is given here for the first time, as the latter is the name of a tributary of the Dartmouth river; Edward lake, from which the new name of the brook is taken, has long been known as such. Dartmouth river, with some of its tributaries, drains the northern part of the area.

There are relatively few lakes in this region. The principal ones, in that covered by the writer, are Dartmouth, Edward, Twin, Fourth, and Third lakes.

Agricultural Possibilities:

There is little possibility, in this area, for agricultural development on an extensive scale, mainly because physiographic conditions are unfavourable: in most of the region, the slope of the ground is too great. Furthermore, even where the land is flat or has a gentle slope, soil appears to be lacking. In the few river-flats, the soil is gravelly; and, on the slopes and uplands, the soil, derived from the decay of the underlying bedrock, usually contains such an abundance of rock fragments as to be unsuitable for farming purposes. Rock fragments and scarcity of soil are particularly characteristic of areas in which sandstones are common.

Timber Resources:

Balsam fir, black spruce, white spruce, and birch are the prevailing types of trees in this area. Pine and cedar are relatively scarce. Fairly large areas bordering the York River valley in the western part of Galt and in Larocque township have been ravaged by fire and are now covered with a young second-growth. Extensive cutting has been done in other areas, but there yet remain some commercial stands of timber, the extent and value of which are undoubtedly know to the few companies that own or control by lease most of the timber rights in this region.

The bark-beetle and saw-fly have caused extensive damage, so much so as to have almost completely destroyed the white spruce. The black spruce stands have been attacked, also, the damages ranging from a low percentage in the least affected areas to more than seventy per cent in other places. Federal and provincial authorities dealing with forestry matters, with the co-operation of the timber companies, are taking steps to combat this menace, principally by the distribution of parasites that, it is hoped, will destroy these pests. Collections of saw-fly cocoons were made by request during the present investigation and sent to the organization concerned with the study of this problem.

Water-Power Possibilities:

Should the need arise, hydro-electric power may be developed in this area, but not on a large-scale. Along parts of York river, the stream narrows from a width of nearly 200 feet to about 25 to 40 feet where it flows between walls of almost flat-lying beds of coarse sandstone. Such places would afford sites for the construction of dams in possible power developments. For a section of the river, beginning about half a mile below Falls brook and extending some 7½ miles downstream, the Quebec Streams Commission has indicated a fall of 249 feet (1). In this section, the Commission considers five dams could be built with heights of 50, 16, 53, 44, and 81 feet, giving falls of water respectively of 50, 23, 57, 58, and 81 feet. It is estimated that, on the basis of a minimum flow of 122 cubic feet, these sites, in the order mentioned, could produce 566, 255, 630, 640, and 900 horsepower.

Fourth Lake brook descends about 490 feet in 2½ miles of its gorge-like course from the lake to York river. Along this stretch there are several chutes and falls, one of which, 50 feet high, is about half a mile from the mouth of the brook. Whether there is sufficient volume of water and whether hydro-electric power may be developed from this stream are questions for the consideration of authorities on such matters. Undoubtedly, it would, at the best, be no more than a small development, and would supply only a limited need. Patewegia, Galt, and Silver brooks have narrow, gorge-like sections that may, likewise, be given consideration should small water-power developments be found desirable.

(1) Quebec Streams Commission, XIIth Rept., 1923.

Previous Geological Work

James Richardson (1), in 1857, in the course of some explorations of territory west and north of here, crossed the northwestern corner of this area.

In 1862, Robert Bell explored the Dartmouth, York, Malbaie, and Grande rivers. The results of his investigations are incorporated in Logan's report of 1863 (2). In his ascent of York river, Bell reached as far as Whitehouse brook, which is about 12 miles upstream from the western boundary of the present area.

In 1902, R.W. Ells (3) gave an account of the geological conditions in the district and a summary of the results obtained in the several oil-wells that had been drilled. In this report, Ells condemned the region as a possible producer of oil in commercial quantity; but, it is probably fitting here to state that this investigation was a reconnaissance, or inspection, visit that was necessarily brief, since Ells spent only a few days in doing the field-work. Consequently, it gave a very incomplete, and in the writer's opinion, an erroneous impression of the geological conditions prevailing there.

W.A. Parks (4), in 1929, reviewed the work that had been done in this region and spent about two months in examining the geology over an area twice as large as that covered by the investigations of 1937 which are described in this joint report. Recognizing that the duration of his investigation was too short, Parks stated in his report that his"conclusions, in detail at least, must be regarded only as possible or provisional. Much closer study is required to justify statements approaching finality". The work of Parks, however, was a distinct contribution to our knowledge of this region.

Adjacent areas to the north, west, and southwest were examined by the present writer in 1934, 1935, and 1936 (5).

Field Work and Acknowledgments

The field work for the present report occupied a period of nearly four months in the summer and autumn of 1937. A strip about three miles wide, in the northernmost part of Larocque and Galt townships, had been examined in 1934, but was, in part, restudied during the work of 1937.

The maps used as a base were those of the Quebec Department of Lands and Forests, showing the surveyed lines of Galt and Baillargeon townships, and others showing the surveys of York river and some of its tributaries. A contour map on a scale of a quarter of a mile to one inch, with a countour interval of fifty feet, prepared by parties despatched from the Quebec Bureau of Mines, was available after the investigations had advanced. The writer made the contour map of the northern three miles of the area and modified some features of th the maps that were supplied.

Traverses for geological information were made along most of the stream courses and at frequent intervals (seldom more than half a mile apart, and often closer than this) in various directions across the region. These traverses were usually made by pacing, with compass and aneroid, but sometimes a chain was also used for measuring distances.

The writer is much indebted to Mr. F.J. Richmond, of Gaspé, for his interest in the work and for the considerable assistance he gave in the gathering of information, especially that relating to former well-drilling operations.

Sincere thanks are due to Dr. E. M. Kindle, Geological Survey of Canada, who, as in former years, very kindly examined and reported on the fossils that were collected during this investigation.

In the field work, efficient assistance was given by Alfred E. Miller, Charles Boulva, Wilson Miller, and Elvin Miller. It is a pleasure to record also the willing services rendered by C. Adams, G. Devlin, D. Patterson, and E. Beaulieu, attached to the party in various capacities.

(1) Geol. Surv. Can., Rept. of Prog., 1857.
(2) Geology of Canada, Geol. Surv. Can., 1863, pp. 880-886.
(3) Geol. Surv. Can., Summ. Rept., 1902, pp. 339-363.
(4) Que. Bur. Mines, Ann. Rept., Pt. B, 1929.
(5) Que. Bur. Mines, Ann. Rept., Pt. D, 1935; Pt. D, 1934, 35, 36.

DESCRIPTIVE GEOLOGY

General Statement

Most of the rocks in the area described by this section of the report are of sedimentary origin, but, in the northeast corner of Galt township, there is a small area of igneous rocks, mostly, if not all, of volcanic origin.

Outcrops are abundant in many of the streams and in some places on the hillsides. Considerable information on the nature of the bed-rock is also obtainable from a study of the loose rock débris beneath the moss and roots of overturned trees, as, in most places away from the stream beds, this loose débris represents the underlying solid rock. In fact, as the accompanying map illustrates, the evidence of this loose débris has often been considered as sufficiently conclusive to establish boundaries between formations and to interpret structural conditions that may exist.

The following table indicates the types of rocks encountered and their order of succession:

Table of Formations

Middle, or Post-Middle, Devonian	Amphibolite, diorite
Middle (or Lower?) Devonian	Shale, sandstone, quartzite, limestone
Lower Devonian	Cherty limestone, chert, limestone, shale (Grande Grève formation)
	Argillaceous limestone, shale, calcareous sandstone (Bon Ami formation)
Silurian	Limestone, shale, conglomerate, sandstone
Silurian (?)	Volcanic flows and tuff

Silurian (?)

In the northeast corner of Galt township, on Salmon-hole brook, there are some volcanic and intrusive igneous rocks that were mapped and described in the writer's report for 1934 (1). All these igneous rocks have been mapped as a unit, even though, as was pointed out in the 1934 report, there may be a wide difference of age represented by the several types. Without much more detailed work, necessitating stripping of unexposed parts, it would be impossible to differentiate satisfactorily these rock-types and show their true relationships.

The rocks of undoubted volcanic origin are of various kinds. A dark green schistose variety, in places amygdular, appears to be of flow origin. Overlying this are tuffaceous volcanics, which for the most part represent fragmental material deposited under water. These clastic tuffs are mostly light green to grey in colour, and some of them have a banded appearance. In texture, they are fine to coarse. Some have angular fragments and may be termed volcanic breccias; others, with more worn fragments, may be classed as agglomerates. As the top of this series is approached, there is a tendency to increase in the content of sedimentary material, producing in some cases a tuffaceous sedimentary rock. These volcanic rocks are all so highly altered that it is difficult to

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1934, pp. 19-21, 33-35. The description in the present report is largely taken from that of 1934.

determine their original composition with certainty, but they probably were andesite flows in the lower part of the series and andesitic tuffs in the upper and southeastern part.

The age of this volcanic series cannot as yet be established. On Salmon-hole brook, the overlying rock is a conglomerate containing pebbles of quartz with some, also, of the clastic tuff. This conglomerate grades upward in a short space to sandstone and then to a limestone containing fossils considered to be of Middle Silurian age. It is apparent, then, that these volcanic flows and tuffs are not younger than Middle Silurian. In 1934, it was suggested that they might be of that age, but that possibly they might be of Ordovician age. Since the investigations of 1936 (1), when thick Silurian volcanic flows were found in the Mount Alexander area, the impression is strengthened that the volcanics of Salmon-hole brook also are of that age, but some doubt of this classification must still be expressed. The intrusive rocks associated with these volcanics may be as young as Middle Devonian, or even younger, as is mentioned in a later part of the present report.

Silurian

Rocks believed to be of Silurian age were found in 1934 along Salmon-hole brook, in the northeastern corner of Galt township. This occurrence, which is of limited extent, was not re-visited in 1937, but a brief description, based on that in the report for 1934 (2), is introduced here in order to give a complete account of the formations represented in the area at present under discussion.

The clastic volcanic and tuffaceous rocks, just described, are overlain by a seven-foot band of conglomerate containing pebbles of quartz, quartzite, and volcanic material. This conglomerate grades quickly to a greenish-grey sandstone, and, in a space of 30 feet stratigraphically, grades upward to calcareous sandstone, arenaceous limestone, and then massive, light grey to almost white, crystalline limestone beds containing abundant fossils. A short distance farther up the stream, the limestones are of the dark grey type more characteristic of the Devonian.

Fossils, indicating a Silurian age for these rocks, were collected. They were determined as being: fragments of bryozoa and crinoid stems, Favosites sp. (resembles F. hisingeri), Pholidops sp., Dalmanella cf. elegantula (Dalman), Chonetes Jerseyensis Weller, Hindella congregata var. pusilla Swartz?, Rhynchospira cf. glabosa Hall, Gypidula sp., Atrypa reticularis (Linn.), Spirifer cf. corallinensis Grabau, Nucleospira? sp., Stromatopora? aporita Parks (teste Parks).

Lower Devonian

In the coastal sections east of this area, a group of rocks, classified as being of Lower Devonian age, have long been known as the Gaspé Limestone series, limestones being the predominant beds. The series there has been divided by J.M. Clarke (3) into the Saint-Alban, Bon Ami, and Grande Grève formations. The oldest of these, the Saint-Alban, is not exposed in the area examined by the writer in 1937; it undoubtedly underlies the area at depth, but is everywhere covered by strata of younger age. The Bon Ami formation is represented only to a slight extent in surface exposures, although it undoubtedly underlies almost the entire region. The highest member of the series, the Grande Grève formation, however, is abundantly distributed in various parts of the area.

The Bon Ami - which, in its known developments in neighbouring regions, is composed mainly of dark grey, argillaceous limestone, calcareous shale, shale, and some calcareous sandstone - may just make its appearance at the surface in the anticlinal and faulted zone that extends west of Patewegia brook in blocks 33, 34, and 35. If it is exposed there, it is to such a small extent that it cannot be indicated on the scale of the accompanying map. Bon Ami rocks, however, must at least be close to the surface in that part of the area. A narrow belt crossing Salmon-hole brook, in the northeast corner of Galt township, has been indicated on the map as being possibly of the Bon Ami formation, but this classification must be considered as provisional only, as the occurrence was mapped in a reconnaissance manner during 1934, when no division was made between these several Lower Devonian formations. If the beds are Bon Ami, they are harder and less argillaceous than usual. An extensive area south of York river, in the western part of Laforce township, contains typically Bon Ami types of rock and, on the strength of their lithological characters, these rocks have been indicated on the accompanying map as belonging to that

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1936.
(2) Que. Bur. Mines, Ann. Rept., Pt. D, pp. 26-28, 1934.
(3) Clarke, J.M., Early Devonic of New York and Eastern North America; N.Y. State Mus., Mem. 9, Vol. I, 1908.

formation. Such an interpretation signifies the absence of the Grande Grève formation in a locality where it would have been expected, and consequently this absence is believed to be due to a fault that has brought the Bon Ami formation against the shale-sandstone series that is younger than the Grande Grève limestones.

The Grande Grève formation is characterized by a great preponderance of hard, bluish-grey limestone and cherty limestone. A few shale zones were observed, and in some places there are bands and thin lenses of chert. That there may be some sandstone in this formation is indicated by occasional mention of this type of rock in the records of well-borings. As indicated on the map accompanying this report, the Grande Grève formation is usually exposed in east-west trending belts that make the crests and higher flanks of anticlinal folds. Abundant outcrops of these rocks may be observed, among other places, along Mississippi brook and its west branch, and along Patewegia brook. The following fossils, collected at various localities, were determined by Dr. E.M. Kindle, of the Geological Survey of Canada, and were assigned by him to the Grande Grève:

Lot F2.- Patewegia brook, about 2½ miles south of the north boundary of Larocque township:

Orbiculoidea sp.
Conularia cf. desiderata var. tuzio Clarke
Phacops logani var. gaspensis Clarke
Dalmanites phacoptyx Hall and Clarke

Lot F3.- 14-inch band of calcareous sandstone near top of the Grande Grève, overlain by 10 feet of thin-bedded limestone and shale and underlain by great thickness of cherty limestone typical of the formation; Mississippi brook, 1,950 feet east and 400 feet north of the southwest corner of block 27:

Crinoid stems
Leptaena rhomboidalis Wilckens
Leptocoelia flabellites (Conrad)
Etonia peculiaris (Conrad)

Lot F4.- Villeneuve brook, 13,500 feet east and 13,500 feet south of northwest corner of block 34:

Schuchertella becraftensis Clarke
Leptocoelia flabellites (Con.)
Dalmanites phacoptyx Hall and Clark
Fragmentary fossils - not determinable.

Lot F59.- Galt brook, little more than 3 miles from its mouth; about 50 feet below top of the series on south side of the anticline at this locality:

Leptaena rhomboidalis Wilckens?
Chonetes billingsi Clarke
Anoplia nucleata Hall

Lot F60.- Galt brook, about 3¾ miles from its mouth, top of Grande Grève series, north side of the anticline:

Spirifer arenosus

These Lower Devonian, predominantly limestone, formations are undoubtedly thicker in this area than in their type section, at the coast, in the vicinity of cape Gaspé. In that type section, the combined thickness of Saint-Alban, Bon Ami, and Grande Grève formations has been given as 2,010 feet (1). No estimate can be made of the thickness of the Saint-Alban in the area at present under discussion, because of its absence in surface exposures and because, even though it is exposed in nearby areas, it cannot as yet be differentiated from underlying, similar rocks of Silurian age. Although the Bon Ami formation is not sufficiently well exposed in the area examined by the writer in 1937 to permit estimating its thickness there, some idea of this feature is obtainable in neighbouring regions. In the area to the west, a review of the observations made in 1935 indicates a

(1) Logan, Sir W.E., Geology of Canada, 1863, p. 393.

possible thickness of about 2,000 feet for this formation. Such a thickness in itself is about equal to that of all three formations in the type coastal section. The Grande Grève formation, as well as can be estimated from exposures and from cross-sections, appears to be about 4,500 feet thick, or more than twice the combined thickness of the Saint-Alban, Bon Ami, and Grande Grève formations as measured in the type section.

Lower, or Middle, Devonian

Overlying the limestone series just described, and occupying a large part of the area, is a thick series consisting predominantly of shales and sandstones. It usually occupies the synclinal areas and lower flanks of the folds. This group of rocks was formerly referred to the 'Gaspé Sandstone' series and classified as Middle Devonian; but, in his work of 1934 and 1935 in regions north and west of this area, the writer began to suspect a Lower Devonian age for at least a part of this series. Limestones, similar to the Grande Grève, were found interbedded with shales and sandstones in the lower part of the series on Dartmouth river, in the western part of De Beaujeu township. Farther west, the limestones become more abundant, until, at the head of York river, where they are the predominant rock-type, the series cannot readily be differentiated from the limestones of the underlying Grande Grève formation. In view of these features, it was suggested that part, at least, of the so-called 'Gaspé Sandstone' series may be of Lower Devonian age. This possibility was indicated in the reports and maps for 1934 and 1935, and in the latter year the name 'York Lake series' was tentatively applied to this group of doubtful age. The problem remains unsolved after the further investigation of 1937. Most, if not all, of these strata observed in the present area would be correlated with the 'York Lake series', but their age classification must remain in doubt at least until completion of further investigations that are under way.

In the area examined in 1937, a prominent rock-type within this series is a dull, dark greenish-grey shale. In places, it is the predominant rock in several hundred feet of an exposed section. In fact, the abundance of shale leads to the thought that the name 'Gaspé Sandstones', formerly given to the series, is misleading and should be discontinued unless it is found in later work that is to be done that it may still be employed for a definite, higher part of the series as exposed in the coastal sections. Associated with these shales there are fine-grained, argillaceous, feldspathic sandstones. Calcareous shales and sandstones are also found in the lower thousand feet of the series, and in some beds the calcareous content is sufficiently high to permit of their being termed impure limestones. In this same lower zone there are some shales and argillaceous sandstones that contain limestone and shale concretions, and there are zones displaying cut-and-fill structures, as mentioned by McGerrigle earlier in this joint report. Another rock-type, which may serve as a useful horizon marker, has been observed in several localities in this area as well as in neighbouring regions already described; it is a white to light grey quartzite and quartzitic sandstone. It has been observed in varying thicknesses ranging to thirty feet and more. One such horizon is about 200 feet (estimates in different localities varying from 150 to 250 feet)above the limestone series as exposed in this area. Further study is required to establish whether or not there is more than one horizon of this type. Another type of rock which is developed as rather thick beds in some places is a massive, light grey, coarse-grained, feldspathic sandstone. Its stratigraphic position and extent have yet to be determined, but from present observations it appears to be about 2,000 feet above the Grande Grève limestones. Feldspathic sandstones also are distributed at various horizons throughout the series. A feature that has been observed in some beds is the presence of curved, shale-filled worm-borings. It is not known yet whether these fillings can be used as horizon-markers. Thin bituminous and resinous bands were observed in some places. Some of the beds in the series are undoubtedly marine deposits, but others - displaying cross-bedding and ripple marks, and containing plant fragments - are of continental origin.

Fossils are abundant in some layers of shale and calcareous sandstone, particularly in the lower 1,200 feet of the series. At least six horizons are known where fossils compose almost the entire beds in which they are found. Some localities easy of access where these fossiliferous layers may be observed are along Fourth Lake brook - at many places between Fourth lake and York river - and along Patewegia brook - at a number of points for a quarter of a mile upstream from the crossing of the York River road. An abundant collection of fossils was made from this series in various parts of the area. These, kindly determined by Dr. E.M. Kindle, are listed below.

F54.- Fourth Lake brook. Large block 1½ inches thick, near mouth of the brook. The size of the block suggests that rock is in place not far up the brook.

Leptostrophia blainvillii Billings
Leptocoelia flabellites (Conrad)
Tentaculites carteri Clarke

F25.- Fourth Lake brook, 1,500 feet upstream from its mouth at York river, Baillargeon township:

Chonostrophia dawsoni Bill.
Renssalaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings
Spirifer cf. arenosus (Conrad)
Aviculopecten sp. cf. A. princeps
Aviculopecten textilis (Hall)
Diaphorostoma perceense Clarke

F53.- Fourth Lake brook, 1,550 feet upstream from where it enters York river.

Leptostrophia blainvillii Billings
Schuchertella becraftensis Clarke
Leptocoelia flabellites (Conrad)
Spirifer gaspensis Billings
Tentaculites carteri Clarke
Machaeracanthus cf. sulcatus Newberry

F26.- Fourth Lake brook, 1,720 feet from its junction with York river.

Orbiculoidea montis Clarke
Leptostrophia blainvillii (Billings)
Leptocoelia flabellites (Conrad)
Spirifer gaspensis Billings
Sphenotus truncatus (Conrad)
Aviculopecten sp.

F48.- Fourth Lake brook, at 50-foot fals about 2,500 feet from mouth of brook at York river.

Crinoid stems
Leptostrophia blainvilli (Billings)
Leptocoelia flabellites (Conrad)
Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings
Spirifer varicosus Hall var.
Sphenotus truncatus (Conrad)
Actinopteria cf. communis (Hall)
Phacops sp.

F27.- Fourth Lake brook, 2,870 feet from its junction with York river

Leptocoelia flabellites (Conrad)
Spirifer gaspensis Billings

F29.- Fourth Lake brook, 3,760 feet upstream from its junction with York river.

Leptostrophia blainvillii Billings
Rensselaeria ovoides gaspensis Clarke

F30.- Fourth Lake brook, 4,460 feet from its junction with York river.

Chonostrophia dawsoni (Billings)

F31.- Fourth Lake brook, 5,670 feet from its junction with York river.

Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings

F32.- Fourth Lake brook, 6,630 feet from its junction with York river.

Aviculopecten cf. jumeau Clarke

F33.- Fourth Lake brook, 6,980 feet from its junction with York river.

Chonostrophia dawsoni Billings.

F46.- Fourth Lake brook, about 7,300 feet from its junction with York river

Spirifer gaspensis Billings
Renssaeleria ovoides gaspensis Clarke

F37.- Fourth Lake brook, 7,530 feet upstream from its junction with York river.

Aviculopecten sp. cf. A. princeps

F34.- Fourth Lake brook, 9,170 feet from its junction with York river.

Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings

F45.- Fourth Lake brook, about 7,940 feet from its junction with York river.

Chonostrophia dawsoni Billings
Spirifer gaspensis Billings

F35.- Fourth Lake brook, 9,620 feet upstream from its junction with York river.

A single specimen represents this lot. It is a mould of an unusual type of fossil which may be a Dentalium.

F36.- Fourth Lake brook, 11,560 feet from its juntion with York river.

Plant fragments
Favosites sp.
Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings

F20.- Twin Lakes brook, 480 feet upstream from its junction with York river.

Devonaster eucharis (Hall) var. goldringae Ruedemann
(Ruedemann, R., A Devonian Starfish from Gaspé; N.Y. State Mus., Bull. No. 267, p. 79, 1 pl. 1926)

F20. is of exceptional interest because it is a new starfish locality - the third known - in the Gaspé sandstone. All three are in the York River valley and not many miles apart. F20 is about 6½ miles west of the Fourth Lake Brook section which furnished the first-discovered specimen. At each locality, only a single specimen has been found. That at F20 is associated with numerous plant fragments in a green sandstone.

F15.- No. 20 brook, 240 feet upstream from P.O.T. (1) oil-well No. 20:

Spirifer gaspensis Billings

F16.- No. 20 brook, 440 feet upstream from P.O.T. oil-well No.20.

Leptocoelia flabellites
Spirifer gaspensis (striae and fimbriate marking exceptional)

F17.- No. 20 brook, 600 feet upstream from P.O.T. oil-well No.20.

Spirifer gaspensis Billings

(1) Petroleum Oil Trust.

F18.- No. 20 brook, 1,000 feet upstream from P.O.T. oil-well No. 20.

Spirifer gaspensis Billings

F19.- No. 20 brook, 1,730 feet upstream from P.O.T. oil-well No. 20.

Leptocoelia flabellites (Conrad)

F5.- Block 35, 2,000 feet west of corner of blocks 27 and 34, Larocque township:

Leptaena rhomboidalis (Wilckens)

F14.- Mississippi brook, 2,960 feet downstream from crossing of road, or 8,170 feet upstream from mouth of brook.

Leptocoelia flabellites (Conrad)

F7.- 3,000 feet east of west boundary of Laforce township and 3,000 feet south of York river, from loose slabs of sandstone (5 pieces):

Leptocoelia flabellites (Conrad)
Rensselaeria ovoides gaspensis Clarke

F8.- From Edward (Bechervaise) brook, about 6,000 feet east of west boundary of Laforce township and about 2½ miles south of York river.

Spirifer gaspensis Billings
Gosseletia ? sp.
Palaeoneilo cf. maxima (Conrad)

F10.- Dinner Island brook, 4,400 feet upstream from mouth of brook (block 46):

Rensselaeria ovoides gaspensis Clarke
Leptocoelia flabellites (Conrad)
Spirifer gaspensis Billings

F11.- Dinner Island brook, 4,450 feet upstream from mouth of brook, from large exposure of shale with lenses of limestone up to 6 feet long:

Schuchertella cf. woolworthana var. gaspensis Clarke
Chonetes sp.
Leptocoelia flabellites (Conrad)
Spirifer gaspensis Billings
Nucula cf. randalli Hall

F12.- Near south boundary of block 47 and about one mile west of east boundary of Laforce township, from loose slab:

Spirifer gaspensis Billings

F21.- 3,700 feet east of northernmost of Twin lakes, or 12,560 feet south and 3,480 feet west of mouth of Mississippi brook.

Leptostrophia blainvilli (Billings)
Leptocoelia flabellites (Conrad)
Chonostrophia dawsoni (Billings)
Spirifer gaspensis Billings

F24.- On brook that trail follows between Fourth lake and Ross lake - about 480 feet up the brook from its mouth at Fourth lake - loose piece in gravel:

Leptocoelia flabellites (Conrad)

F38.- Near east side of Laforce township, two miles south and 3,000 feet east of where the east boundary of Laforce township crosses York river.

Leptocoelia flabellites (Conrad)
Chonetes sp.

F39.- Larocque township, outcrop on brook that passes by No. 17 oil-well, 2,500 feet up the brook (northerly) from No. 17 well:

Lepidodendron sp.

F23.- On boundary between Laforce and Baillargeon townships, 250 feet north of mile-post VII, or 2 miles plus 200 feet south of York river:

Leptostrophia blainvillii
Leptocoelia flabellites (Conrad)
Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings

F1.- East branch of Patewegia (Big Fork) brook, about 1 mile plus 2,500 feet south, and 1,200 feet west, of northeast corner of Larocque township:

Spirifer gaspensis Billings

F42.- Patewegia (Big Fork) brook, 1,420 feet upstream from where York River road crosses it:

Leptocoelia flabellites (Conrad)
Chonetes sp.
Rensselaeria ovoides var.
Spirifer gaspensis Billings

F43.- Patewegia (Big Fork) brook, 580 feet upstream from where York River road crosses it:

Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings
Holopea gaspesia Clarke

F44.- Patewegia (Big Fork) brook, 120 feet upstream from where York River road crosses it:

Plant fragments
Leptocoelia flabellites (Conrad)

F50.- At mouth of brook that enters York river from south, 6,000 feet west of N.-S. centre line of Baillargeon township:

Plant fragments
Rensselaeria ovoides var. gaspensis Clarke
Leptocoelia flabellites (Conrad)
Nuculites cf. oblongata (Conrad) (intermediate between N. oblongata and N. cuneiformis)

F51.- Brook entering south side of the York river, 6,000 feet west of N.-S. centre-line of Baillargeon township, 220 feet up from its mouth:

Aviculopecten sp.
Nucula ? sp.

F52.- Loose piece on brook that enters south side of York river 6,000 feet west of Baillargeon N.-S. centre-line; location is 6,770 feet from mouth of brook:

Leptocoelia flabellites (Conrad)

F55.- Galt brook (Little Fork of York river), about 7,950 feet upstream from its mouth:

Leptostrophia blainvilli Billings
Chonostrophia dawsoni Billings
Spirifer gaspensis Billings
Aviculopecten sp.
Paracyclas cf. tenuis Hall

F58.- Between York river and Galt brook - about 4,500 feet west and 1,000 feet south of mouth of Galt brook; loose slabs 1 to 2 feet long, seem to be belong at or near here:

Crinoid columns
Rensselaeria ovoides gaspensis Clarke
Spirifer gaspensis Billings
Goniophora tethys Billings

F61.- Outcrop on brook flowing southeast, about 5,800 feet north and 200 feet west of southeast corner of Galt township:

Spirifer gaspensis Billings

F62.- 2,900 feet up small brook that enters Sonneau brook from north, the mouth of the small brook being about 5,300 feet upstream from the mouth of Sonneau brook:

Brachyprion major Clarke
Stropheodonta patersoni Hall var. precedens Clarke?
Meristella sp.
Spirifer cf. gaspensis Billings
Goniophora cf. hamiltonensis Hall
Mytilarca cf. nitida Billings
(length to width greater than in Billings figure)

F64.- Branch flowing southeast into Watering brook about 1,500 feet and 1,600 feet south of mile-post V of line between Galt and Baie de Gaspé Sud townships:

Rensselaeria ovoides gaspensis Clarke

F65.- Silver brook, 1,800 feet downstream from where E.-W. contre-line of Galt crosses the brook:

Rensselaeria ?
Modiomorpha cf. chapmani Williams

This faunule includes only one species well enough preserved to permit approximate determination. This is a pelecypod, Modiomorpha cf. chapmani Williams, which is closely allied to, if not identical with, M. chapmani of the Chapman sandstone of Maine.

F66.- Silver brook, 7,000 feet upstream from crossing of east boundary of Galt township:

Rensselaeria ovoides gaspensis Clarke

F67.- Silver brook, 5,150 feet upstream from crossing of east boundary of Galt township:

Modiomorpha ? sp.

F68.- Silver brook, 4,380 feet upstream from crossing of east boundary of Galt township:

Modiomorpha cf. inornata Billings
Palaeoneilc sp.

F69.- Silver brook, 1,860 feet downstream from crossing of line between Galt and Baie de Gaspé Sud townships:

Palaeoneilo sp.

F70.- Silver brook, 6,180 feet downstream from crossing of line between Galt and Baie de Gaspé Sud townships:

Spirifer gaspensis Billings
Rensselaeria ovoides gaspensis Clarke ?

F71.- Silver brook, 2,470 feet upstream from where York River road crosses it, Baie de Gaspé Sud township:

Rensselaeria ovoides gaspensis Clarke

Dr. Kindle ascribes the several lots of fossils listed above to the 'Gaspé Sandstone' series. This series has usually been considered as being of Middle Devonian age, and may be so, but, as already mentioned, the present writer has some doubt concerning that classification.

This series is the youngest of sedimentary origin in this area. As the top of the series is not exposed, no evidence is available here regarding its relationship with the younger formations that are to be found elsewhere in Gaspé peninsula. The base of the series is exposed, however, at two localities on Patewegia brook, in Larocque township, and also, it is believed, on Galt brook. These occurrences, as well as the general structural features, indicate that there are conformable relations between this shale-sandstone series and the underlying Lower Devonian, Grande Grève limestones. At the observed exposures, the change from the lower to the upper series is relatively sudden, but there is a gradational phase, with a thickness of about 10 to 15 feet, where there are several thin layers of limestone (not cherty, like the typical Grande Grève) interbedded with shale and argillaceous sandstone of the same type as is found in the thick shale-sandstone series being described. In other parts of Gaspé, a distinct unconformity has been considered to exist between the Gaspé limestones (Lower Devonian) and the Gaspé sandstones (considered as Middle Devonian). The apparently conformable relations in the present area add some strength to the suggestion that the shale-sandstone group here may be Lower, rather than Middle, Devonian, but further study of this problem is still required.

In the coastal sections, a thickness of more than 7,000 feet has been ascribed to the Gaspé Sandstone series. The greatest thickness of the shale-sandstone series in this area is about 5,000 feet, but, without doubt, only a part of the series is represented here.

Middle, or Post-Middle, Devonian

As stated in the report for 1934 (1), there are some igneous rocks on Salmonhole brook that may be of intrusive origin. They are associated with the Silurian (?) volcanics that have already been described. The types believed to be intrusive are now dark green in colour and metamorphosed. Thin sections show that they are hornblende schist, or amphibolite, containing green hornblende and plagioclase in abundance, with little or no pyroxene, the minerals being in more or less parallel alignment. The rock may originally have been a diorite, or, if the hornblende is an altered product from pyroxene, as in part it appears to be, the rock may have been a gabbro. Some dark, almost black, glistening, finely crystalline rock was also observed, of fresher appearance than that just described, but in thin section showing a similar composition. It is a diorite, and probably the latest of different types of intrusives.

No definite assurance has been obtained of the age of these intrusive rocks. From the fact that similar rocks were found along the presumed fault-contact between the volcanics and the younger shale-sandstone series, it is thought that the intrusions may have entered along that fault and would, consequently, be younger than at least part of the shale-sandstone series; that is, they may be Middle Devonian or even later.

STRUCTURE

As elsewhere in almost all of Gaspé, the strata of this region have been subjected to folding movements such that, in general, there is a succession of anticlinal and synclinal folds. In some places, the rocks broke during these folding movements and thrust-faults were produced; in other places (probably after the release of the fold-producing pressures), there was faulting of the 'normal' type, by which blocks of strata moved downward with various amounts of displacement. The accompanying map and cross-sections indicate the various structural features as interpreted from the information at present available.

Viewing the region in general, it is observed that the predominating structure in the southern part, bordering Saint-John river, is that of an anticline, as has been described by McGerrigle in an earlier section of this joint report. For most of its length in this region, the crest of this structure is occupied by strata that exhibit, particularly by the presence of pronounced cleavage, a greater degree of deformation than is generally evident in the younger strata occupying the remainder of the region. This feature may be due to these rocks being, as is quite possible, of Ordovician age

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1934, pp. 33-35.

and to their having been subjected to the intense pressures that are known, from evidence elsewhere in Gaspé, to have been exerted at the close of Ordovician time. These older rocks were again subjected to the later pressures that produced movements in the Silurian and Devonian formations.

Proceeding northward, the strata between the Saint-John and York rivers belong to successively younger formations and occupy the northern flank of the Saint-John River anticline and the southern flank of the major synclinal basin that follows the valley of York river. In Laforce township, the strata in this zone frequently have a steep dip, probably as a result of their having been pushed to that attitude by the overthrusting movement along the fault that is indicated there. Farther east, in Baillargeon township, where the overthrust fault is farther south, the inclination of the northward-dipping beds is more moderate.

The York River syncline follows approximately the valley of that stream for most of its length across the area. It is a broad structure, with a rather flat or gently-rolling bottom. This character, with the added feature of cross-bedding in the low-dipping strata, introduces difficulty in some places in localizing the main axis of the syncline. On the accompanying map, a gap has been left in the tracing of this axis in the faulted zone that crosses York river between the north-south centre-line of Baillargeon township and the east boundary of Galt township. The synclinal character of the folding there appears to have been destroyed or obscured by block-faulting of major proportions.

Northward for some distance from the York River syncline, the strata dip southward to form the northern limb of that fold or the southern limb of the succeeding anticlinal, the crest of which is from two to six miles north of the river. In Larocque township, this anticline, to which the name 'Mississippi' may be applied, is accompanied by faults - some of which were probably produced with the folding movements and others later- which appear as branches from the major normal-fault zone that cuts across this anticlinal near the intersection of Patewegia brook and the Galt-Larocque line. These faults are accompanied by subsidiary folding, particularly where they appear to die out toward the west before reaching Mississippi brook. As in the case of the York River syncline, a gap has been indicated in the tracing of the Mississippi anticline where it is traversed by the fault-zone just mentioned. East of this fault-zone, in Galt township and in the western part of the township of Baie de Gaspé Sud, the prolongation of the Mississippi anticline appears to be a rather uniform structure, little, if at all, affected by faulting. There is some indication of a doming character of the fold at Galt brook, where the Grande Grève limestones at the crest are surrounded on all sides by the younger series of shales and sandstones.

North of the Mississippi anticline, the structures apparently are not continuous across the area. In Larocque township, the succeeding fold is the syncline that crosses Dartmouth river about two miles north of Dartmouth lake. The axis of this syncline, which has been observed in the region west of this area, crosses Mississippi brook and can be traced with a fair degree of confidence north of the old Howard Smith road to almost as far east as Patewegia brook. The syncline is not in evidence at this latter brook; it may have merged with the anticline that succeeds it to the north or it may have been destroyed by the faulting movements that took place along the Patewegia valley. It is possible that the shallow syncline that makes it appearance farther east, and that crosses the central part of Galt township, may be the prolongation of the syncline just described.

The northernmost structure in Larocque township is the Bald Mountain anticline, the axis of which just enters the area at the high ridge known by that name. It is the eastward prolongation of the anticline that was mapped in 1935 as crossing Patch (Madeleine Fork) brook in the region west of that examined in 1937. This anticline cannot be traced beyond Bald mountain; it appears to fade out there, unless the Patewegia fault-zone has caused its obliteration. Farther east, there is no evidence of the prolongation of that fold, but the low Galt anticline, crossing Galt brook about a mile north of the east-west centre-line of Galt township, may be a re-expression of the same anticlinal folding.

A synclinal area that extends northwestward for several miles enters the northeastern corner of Larocque township and continues southeastward to pass just north of the Galt anticline. It appears to fade out, however, near Silver brook, and probably merges into some broader structure.

The strata, in addition to dipping toward or away from the axes of folding, also, at these axes, plunge in various directions so as to produce dome-like or basin-like

structures. The York River syncline, for example, plunges eastward in the western part of the area, but east of Narrows brook the plunge is toward the west. On the Mississippi anticline, the lithological character of the rocks indicates an elongated dome-like part in the region between Dartmouth lake and Mississippi brook. The probable dome on the same anticline at Galt brook has already been mentioned. Another elongated dome-effect is known to exist on the Bald Mountain anticline near Patch brook in the area west of that at present being described. Another feature of these folds is that the plunge on adjacent folds is usually in opposite directions and that the axes tend to converge toward each other.

Faulting, of which some mention has already been made, is a feature that would be expected in this region. In some parts of the area there has been intensive fracturing and movements along the fault-planes, but, it must be added, there are extensive regions where faulting is absent or of a minor character. Thrust-faulting, although present, is not as frequently developed as might have been expected. One fault of that type, apparently of major proportion, has been indicated as extending across the area between the Saint-John River anticline and the York River syncline. Its presence is assumed there mainly on the basis of a juxtaposition of different formations (classified on lithological evidence) that should be widely separate, but some deformation of strata also serves to indicate the probable presence of this fault. Another zone of thrust-faulting is inferred in the vicinity of the Mississippi anticline, on its southern flank; its presence is indicated by fault planes and highly disturbed strata at places on Mississippi brook and on Keg creek, just west of this map-area. This fault-zone, which between Mississippi brook and Dartmouth lake probably consists of two fault planes, appears to have its greatest expression west of Patewegia brook. No evidence of it was observed east of the northwest-southeast fault-zone that follows, in general, the valley of that stream. A third major fault of the overthrust type is assumed in the northeast corner of Galt township, where Silurian (?) volcanics apparently overlie Devonian shales and sandstones. Some subsidiary overthrusting is also indicated as crossing Salmon-hole brook a short distance southwest of the fault just mentioned. In these cases of faulting, the overthrusting was from a southward direction and probably represents fracturing of the strata during the post-Lower Devonian folding movements.

Normal faulting appears to be a pronounced feature in parts of this region. A major fault of this type, with a downthrow on its northeast side, has been assumed to extend southeasterly from the northern part of Larocque township (presumably on the west side of Patewegia brook there) and to follow the course of that valley nearly as far as Lizard Lake brook. From the latter point, it leaves the Patewegia valley and continues in the same general direction until it crosses York river at the north-south centre-line of Baillargeon township. From York river, it maintains the same southeasterly course, and, crossing Third lake, it finds its continuation in a similar fault traced by McGerrigle as extending across the area examined by him. The existence and extent of displacement along this fault can be realized by considering the conditions prevailing at York river near the centre-line of Baillargeon. At this point, there is a narrow and short exposure of much-distorted Grande Grève limestone which, by various methods of estimating, represents the remnant of what should have been a wide development of that rock at the axis of the syncline plunging west. The smallness of this occurrence is evidence of the existence of the fault. The extent of displacement may be judged from the fact that P.O.T. (1) well No. 6 a short distance northeastward on Galt brook, attained a depth of 3,640 feet without reaching the limestone. Also, about five miles east of this point, just beyond the map-area, P.O.T. well No. 12, which is located about at the synclinal axis, did not reach the limestone until a depth of 2,550 feet had been penetrated. It is, then, quite reasonable to assume a downthrow of at least 3,000 feet at the point where the fault crosses York river. The displacement appears to be somewhat less as the eastern side of Bald mountain is approached, in the northern part of Larocque township, but lack of evidence prevents knowing the extent of the fault in that part of the area or whether it continues farther in that direction than indicated.

Another normal fault is presumed, from various indications, to leave the last-mentioned fault just north of Lizard Lake brook and extend also southeastward, but farther north than the one just described. The downthrow along this fault is on the southwest side, so that the resultant effect is that of a long, wedge-shaped block that dropped downward between the two fault planes.

There are other faults of the 'normal' type, as indicated on the accompanying map, some with downthrow in one direction, others in the opposite direction. Some of these faults apparently caused the downthrow of blocks of various shapes and dimensions, and in some cases there appear to be blocks that were left relatively stationary while the strata all around

(1) Petroleum Oil Trust.

them slumped downward. Such a block, triangular in shape, between the west branch of Mississippi brook and tha trail leading from the York River road to Dartmouth lake, is most readily explained in this fashion. Although no outcrops of limestone were observed there, abundant angular blocks of this rock are strewn over the surface in many places and, very probably, a diligent search would reveal actual outcrops; but the rocks nearby, and apparently surrounding the limestone, are of the younger shale-sandstone series.

As already mentioned, this block-faulting of a 'normal' type probably took place at some time after the exertion of the forces that produced the regional folding; the normal faults probably represent the planes along which slumping took place when there was release from the pressure that produced the folding. However, some of the fractures along which normal faulting took place may have existed prior to these downward movements. The major fault-zone, following the Patewegia valley and crossing Third lake, may, for example, have been initially weakened during the period of folding and overthrusting. That this zone may have formed the eastern margin of an overthrusting movement is indicated by the greater extent of folding and overthrust-faulting on the western side of that zone. It may be added that, in addition to blocks having moved downward vertically, there is evidence that they also had some movement southward at the same time.

GLACIATION

As in almost all other sections of interior Gaspé that the writer has examined, there is little or no evidence of continental glaciation in the area at present under discussion. However, attention may be called to one feature that may have a bearing on this matter and that is difficult to explain: it is the finding of a well-worn, heavy boulder of anorthosite, ten inches in diameter, on the gravels of Mississippi brook, about 2¾ miles upstream from the mouth of Villeneuve brook. This was found at an elevation of about 1,300 feet above sea-level. The source of this boulder cannot, from our present knowledge, be placed in Gaspé, although a body of anorthosite may yet be discovered somewhere in the peninsula and it may be found that the boulder reached the vicinity of its present position by means of local glaciers. Three similar boulders were found in 1934 in the Dartmouth River area (1), at elevations of 530, 370, and 290 feet above sea-level. It was suggested at that time that an arm of the sea may have extended up the Dartmouth valley and that the anorthosite boulders were transported by ice-floes and deposited at the margin of that body of water. Such an explanation was believed tenable in view of the fact that marine terraces have been found along the north coast at levels now more than 400 feet above sea-level. It does not seem, however, that this explanation can be applied to the boulder found on Patewegia brook at such a greater elevation.

With the exception of this inexplicable occurrence of an anorthosite boulder, almost all other rock débris found in the region can with assurance be said to have originated within the drainage systems represented there. Nearly always, the débris found away from the stream-beds represents the solid bed-rock underneath or nearby. Some boulders of diabase found at various places on both sides of the divide between the York and Saint-John rivers may have been carried there by streams having courses different from the present streams, or they may have been carried by glacial action. If by the latter means, however, the glaciers would probably have been of local origin, as similar diabase has been found as outcrops not far distant, in the region west and southwest of that examined in 1937.

ECONOMIC GEOLOGY

Lead and Zinc

Both galena and sphalerite have been found in a few places in this area. Most of the occurrences are in brecciated Grande Grève limestones in or near faulted and fractured zones. Another noteworthy feature is that they are apparently near the upper part of the limestone series, just as is the case with the several lead-zinc showings that have been observed in the region bordering Gaspé bay (2).

One of the occurrences in the present map-area has already been described in the report for 1934 (3), namely, that near the mouth of a tributary entering Patewegia brook

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1934, p. 37.
(2) Que. Bur. Mines, Ann. Rept., Pt. D, 1932, pp. 35-43; Pt. D, 1934, pp. 41-42.
(3) Loc. cit.

from the west, just south of the northern boundary of block 33. There is nothing to add to that description except that now it is known that this small deposit is near the zone of large-scale faulting which follows the Patewegia valley at this place.

Another fractured-limestone zone that in places carries galena and sphalerite was observed along the brook that flows to Patewegia brook from the west and crosses the Larocque-Galt line midway between mile-posts VI and VII. At one place, about half a mile westerly from the township line, a breccia-zone about eight feet wide trends in a general east-west direction. In it there are lenses, up to one by three inches, of sphalerite and also scattered crystals and grains of this mineral. So far as observed, the mineralization is confined to a veinlet of calcite which has a width varying from one to three inches and a length of eighteen feet. At the point where the township-line crosses the brook referred to, a few specks of sphalerite were observed with calcite in an east-west fractured zone of limestone about 20 inches wide. Galena, also, is scattered through narrow, irregular veinlets of calcite over a width of ten inches on each side of the fractured zone, and occurs in small amount in the limestone bordering these veinlets.

Some galena and sphalerite have also been found on Lizard Lake brook, in the northern part of block 41. This occurrence, which was noted briefly in a previous report (1), is about 1,600 feet downstream from the point where the north boundary of the block crosses the brook. Beyond the fact that the mineralization occurs in a zone of brecciated limestone, little could be seen here at the time of our visit in 1937. Since that time, however, some claims have been staked and prospecting has been carried on by trenching. It is reported that some veins have been traced for a distance of about 150 feet north from the exposures on the brook. The mineralized zone trends northerly, but at places the veins follow for short distances the strike of the steep southward-dipping limestones. The recent work has shown that there are in this zone two principal veins, 15 to 30 feet apart, with a few narrow veinlets between them. They usually dip steeply east. The veins consist of calcite and brecciated limestone with rusty cavities and patches where zinc-bearing minerals, apparently, have been leached away. Galena is scattered in the veins and in places forms narrow seams; one of these seams, half an inch to three inches wide, follows the wall of one of the vein-zones. Sphalerite also is scattered through the vein-material, as well as occurring in small clusters. The veins are said to vary in width from a few inches to several feet.

A few specks of sphalerite were observed in slightly fractured limestone at the southern end of the body of limestone exposed on Galt brook.

Mineralization of small extent was also noted in the shale-sandstone series that overlies the Grande Grève limestone. A loose piece of sandstone, found about 800 feet east of Petroleum Oil Trust well No. 42 (?), showed veinlets of calcite containing specks of galena. Some large faults are presumed to pass by this locality. Specks of sphalerite are reported to have been found in the calcite veinlets that cut sandstones in outcrops on the south side of York river, about 500 feet upstream from Flatrock brook.

The origin of the metallic minerals in these several occurrences is not known. Intrusive rocks, which might indicate an igneous source for these minerals, are not much in evidence within the area, with the exception possibly of some in the northeast corner of Galt township. In neighbouring regions, too, only a few widely-separated and small occurrences of igneous rock are known. It may well be that the solutions bearing the lead and zinc minerals came from a distant source, and it is possible, also, that they were not of igneous origin.

Although the known occurrences of these minerals are small and non-commercial, they indicate that attention should continue to be given to the possibility of sometime finding larger deposits that may be of economic value, especially in the fractured areas and in brecciated zones near the top of the Grande Grève limestone series.

Petroleum

Introductory Statement:

At various times there has been active search for petroleum in certain sections of the area mapped in 1937 and of the region extending eastward from there to the coast. Oil seepages in Gaspé were recorded as early as 1836, and in 1860 the first wells were

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1932, pp. 39-40.

drilled to test two of these occurrences (1). Between that year and the beginning of the present century, a number of wells were drilled in various localities, but none of these efforts met with success.

As already stated in the introductory remarks of this report, one of the main objects of the present investigation has been to determine whether these earlier attempts constituted an effective test of the region's oil possibilities and - by conducting detailed geological studies (which had not previously been made) - to determine whether further attempts to find oil here in commercial quantity are warranted.

Descriptions of the stratigraphical and lithological conditions prevailing in this area have already been given in earlier pages of this report, and little need be added here concerning these matters. The structural conditions which have such an important bearing on problems relating to petroleum, will receive further attention, and mention will be made of other features that enter into the questions here involved.

Existence and Quality of Petroleum:

Seepages of petroleum are known at several points within the area mapped during 1937, as well as beyond its limits. The locations of those observed have been indicated on the accompanying map.

There are at least three such occurrences in block 41, Galt township. They are in the bottom of the valley in which are situated the well of the International Oil Company and wells No. 41 (?) and No. 42 (?) of the Petroleum Oil Trust. In the vicinity of each of these wells, three or four seepages occur close together, the oil that appears at the surface being dark and thick, probably owing to the lighter constituents having evaporated during exposure. Undoubtedly, this oil is escaping along the major faults, or along fractures related to them, that pass by these localities. The seepages at the farthest west of these three groups come from the fault-contact between the Grande Grève limestones and the younger shale-sandstone series; at the other two localities, the underlying rock is undoubtedly that of the latter series, but they are not far distant from the zones of major faulting. An interesting feature in connection with these seepages is that smears of the oil may be seen on nearby trees against which bears, probably using the oil as an insecticide, have rubbed themselves after rolling in the oil-pools. These bear-markings proved a useful aid in locating some of these seepages where brushy undergrowth more or less concealed them.

Some seepages, with freely-flowing, amber-green oil, were observed at localities northwest of those just mentioned. One of these in the southwestern part of block 32, on Sonneau brook about a quarter of a mile from its mouth, is from gravels at the edge of the brook, but it undoubtedly comes from underlying Grande Grève limestone that outcrops nearby. These outcrops indicate that this locality is on the crest of a sharp anticline. A seepage of similar type was observed coming from outcrops of limestone that form the crest of the same anticline at the point where it crosses Patewegia brook in block 33, about half a mile upstream from the crossing of the Galt-Larocque township-line. There is a third seepage of greenish oil about 4,500 feet farther upstream along this brook, coming from much contorted limestone that is believed to be near the major fault-zone already mentioned. A fourth locality where there are two freely-flowing seepages of amber-green oil is in the northwestern corner of block 33, along the stream that enters Patewegia brook there from the southwest; the seepages are in gravels, but, again, they undoubtedly come from an underlying anticlinal zone in the Grande Grève limestones.

A little oil was observed in the restricted exposure of limestone along the fault-zone near York river, at the north-south centre-line of Baillargeon township. Another seepage has been recorded, in earlier reports, from the shale-sandstone series on Silver brook; this was not seen during the present investigation, but failure to find it may be owing to the presence of gravels that have been spread over this locality by the winding brook, with its changeable course. Undoubtedly, the seepages that have been mentioned are not the only ones within the area examined by the writer.

Bituminous material and an odour of petroleum were observed in the Grande Grève limestones in several places, particularly in outcrops along Patewegia brook and at the northern end of the limestone area on Galt brook. Furthermore, thin bituminous and resinous layers are common in certain zones in the shale-sandstone series overlying those lime-

(1) For historical summary, see Parks, W.A., Report on the Oil and Gas Resources of the Province of Quebec; Que. Bur. Mines, Ann. Rept., Pt. B, 1929, p. 7 et seq.

stones - for example, on Narrows brook - but, apparently, such zones are not as abundant or as thickly developed as reported occurrences farther east and southeast of this map-area. With further relation to the presence of bituminous matter in the rocks of this region, reference should also be made to that section of this report written by McGerrigle, where mention is made of some similar features in that part of the area bordering Saint-John river.

Petroleum was encountered in many of the wells that were drilled in this region and it may yet be seen flowing from them or standing in their casings. Some oil was obtained from the shale-sandstone series, but the larger productions (although never great) came from the contact of this series and the underlying Grande Grève limestones or from within the latter formation. Further reference to these wells is made in a later section of this report.

The oil obtained from the wells is variously coloured - green, dark brown, claret-red, or amber; the base is classified as paraffin to intermediate; and the gravity varies for different wells from about 30° to 47° A.P.I. (1).

Source of the Oil:

While, as indicated above, oil has been found in both major divisions of the Devonian strata - that is, in the shale-sandstone series and in the older, predominantly limestone series, - it is considered very probable that most, if not all, of the oil was originally formed within the limestone series or (and) even in older formations. That formations older than Devonian may be a source of at least some oil is indicated by various features that have been observed at localities outside the present map-area: for example, bituminous matter and a strong odour of petroleum have been observed in highly fossiliferous (reef) limestone of Silurian age in the western part of York township (range VI), south of Saint-John river (this locality was noted in the writer's report for 1934 (2) and confirmation of it was made by McGerrigle during the present investigation). This petroliferous zone is tentatively referred to the Silurian conglomeratic zone that has been shown as a unit on the accompanying map. McGerrigle has already mentioned, in his section of this report, another possible seepage near the mouth of Burnt Jam brook, on the south side of Saint-John river, which, if it exists, indicates a still older horizon of oil-bearing strata. The rocks at this place are either Lower Silurian or Upper Ordovician, with present evidence favouring the older age. Oil-bearing shales are known in Ordovician formations in other parts of Gaspé peninsula.

Structure:

The fact that saline and sulphurous waters exist in the strata, as shown by the presence of springs of this nature and by the finding of such water in many of the wells that were drilled, suggests that anticlinal folds, or positions on their flanks, are more favourable for the finding of oil than are the synclines.

On earlier pages of this report, it has been pointed out that the area is characterized structurally by a series of folds. As supplementing the written description, and illustrating more clearly the nature of these folds, reference should be made to the geological map of the region and, especially, to the cross-sections that accompany it.

It is readily apparent, after observation of the several exposures along the major streams - or, instead, of the cross-sections - that there are well-defined anticlinal zones, along the flanks of which the strata dip at moderate angles for appreciable distances across the strike of the formations. Undoubtedly, there are places in this area where structural conditions are not unfavourable for oil accumulation insofar as the 'anticlinal theory' is concerned - provided, of course, for commercial development, that there is sufficient oil and that other essential requirements are fulfilled.

Faults and other fractured or highly distorted zones exist in some parts of the region, and in such places the chances of finding oil in commercial quantity are slight. By no means, however, can the area be considered as having been so excessively fractured by faulting that no part remains where favourable conditions might exist. In fact, there are wide zones with otherwise favourable structure where faulting, if present, is of negligible importance. Furthermore, in some of the faulted zones, structural conditions are not completely unfavourable and, in some cases where the strata are considerably broken by faulting in the surface exposures, it is possible that the faults die out before attaining depths that are still within reach of the drill.

(1) Several analyses are given in Que. Bur. Mines, Ann. Rept., Pt. B, 1929, and in Mines Branch, Dept. of Mines, Ottawa, Pub. No. 765. Complete analyses of samples collected by the writer are under way. A.P.I. - American Petroleum Institute scale.
(2) Que. Bur. Mines, Ann. Rept., Pt D, 1934, p. 39.

The opinions expressed here are quite at variance with those advanced by Ells in 1902 (1), when he gave the impression that the rocks of this region are too steeply inclined, and that the faults are too numerous, to permit the retention of oil in the strata. Ells further stated that the anticlines, "instead of being in low, gently inclined strata, are sharply defined; the inclinations of the opposing sides are often steep and the axes probably complicated by faults, as can be seen in several cases". His report, condemning the area, probably served at that time a useful end in curbing unwise ventures in this field, but it must be said, without necessarily claiming that oil exists there in quantity, that Ells gave a generally erroneous description of the structural conditions in this region. His opinions, as well as can be judged from any records, were based on too brief an examination of the evidence as exposed in the field.

Previous Drilling:

Extensive drilling operations were conducted in eastern Gaspé, mainly during the latter part of the last century, and, in all, fifty-eight wells were drilled. Thirty-five of these were drilled within the area covered by this report, and ten others only a short distance beyond its eastern limit. These drilling operations ceased in 1902 or 1903, but in 1913 a well was drilled at a locality about ten miles southeast of this field.

The sites of some of these wells are not readily found at the present time, but all but two of those within this map-area were seen during the present investigation. These two are the Petroleum Oil Trust No. 6 well on Galt brook, not far upstream from the main road, and the old Campbell well, on Silver brook. What are believed to be the sites of these wells were visited, but the wells themselves were not seen, being now concealed by the extensive gravels of these brooks. Two wells were observed of which no mention has been made in published reports and of which no written record has yet been found; they are thought to be the last two wells drilled by the Petroleum Oil Trust, and on the accompanying map they have been designated as wells Nos. 41 (?) and 42 (?) of that Company. They are near the centre of block 41, in Galt township. As well as can be ascertained, these wells were drilled during 1902 and 1903. Well No. 41 (?), according to one of the drillers, Mr. Ben Miller of Sunny Bank, was begun in the shale-sandstone series but encountered the limestones not far below the surface; the hole was abandoned at a depth of about 500 or 600 feet on account of difficulties in drilling. No information could be obtained regarding the history of well No. 42 (?), in which oil is still standing in the casing at a depth of 20 feet; one of the men who drilled this well is still living in Gaspé, but he does not recall any details concerning it.

Little need be added here to the records of the wells as published in the reports by Ells and Parks. There are some slight discrepancies between various records. The elevations given for many of the well-sites are incorrect, and some of the wells are wrongly located on the maps. But the conclusions to be drawn from these borings are not affected by these inaccuracies. It may be mentioned, however, that the record of P.O.T. well No. 25, at Fourth lake, has been confused by Parks with that of No. 26; the depth to the limestone contact at No. 25 is 625 feet, instead of 2,200 feet as recorded by Parks.

In all the wells situated within the present map-area, the drilling started in beds of the shale-sandstone series. With the exception of the Campbell well, on Silver brook, which went to a depth of only 600 feet, and P.O.T. well No. 41 (?), the depths of the holes range from 1,500 to 3,640 feet. Some of the borings ended in the shale-sandstone series, and some penetrated for varying depths into the Grande Grève limestones. With the equipment available at that time, difficulty was encountered in drilling the hard, cherty zones of the latter formation, and few of the holes penetrated far in these zones.

Oil was obtained in several of the wells, and it still flows in small quantity from some of them. The oil was obtained from both the shale-sandstone series and the underlying limestone series, but the larger productions were obtained at the contact of the two or in the limestones.

While, in the early history of these operations, little may have been known of the conditions under which oil is usually found, and there is thus some excuse for the unsuitable locations of the earlier efforts, it is quite apparent that most of the wells were located with mistaken ideas, or with little consideration, concerning the geological conditions surrounding them. Most of the wells (including those beyond the limits of the area covered by the present investigation) are situated in synclines, or much closer to synclinal axes than they are to the axes of anticlines. There is no doubt that the anticlinal structures, which

(1) Ells, R.W., Geol. Surv. Can., Summ. Rept., 1902, pp. 339-363.

in present-day practice would receive the first attention, have at the best been only meagrely tested. The fact that some oil was found in the synclines may perhaps be considered as a feature to encourage search farther up the flanks of the folds.

As far as the area examined in 1937 is concerned, the shale-sandstone series (Middle or Lower Devonian, the youngest strata in the area) may be considered as having been tested fairly adequately by the drilling. Some wells, situated at or near anticlines, did not obtain commercial production in this series. It must be added, however, that, at least for the Mississippi anticline within this area, production would not be expected from this shale-sandstone series, as the structure with respect to this formation is 'open' - that is, all its beds are exposed somewhere at the surface on the structure, and any oil it may have contained has had opportunity to escape. Of the 58 wells that were drilled (within the present map-area and beyond it), only 32 penetrated the shale-sandstone series to the underlying limestone formation. Of these 32 wells, only 11 went more than 200 feet into the limestones, and it is doubtful if any of these eleven wells can be considered as having been favourably located with respect to structural conditions. It can be stated, then, that the drilling operations to date have not tested the possibilities of the Devonian limestones, or of the still older formations, in which there is known to be some oil.

Conclusions and Recommendations:

There is some oil of good quality in this region, as has long been known.

The wells that have been drilled cannot be considered as having properly tested the possibilities of finding oil here. They were either in synclinal areas - which applies to the majority of them - or they did not test all the possible stratigraphic horizons.

The structural conditions are not unfavourable, in certain parts of the area, for the retention of oil, provided the other necessary factors are present.

The accompanying map and cross-sections indicate localities that are worthy of consideration by well-financed organizations that are experienced in searching for oil and are prepared to assume the risks that inevitably attend such ventures. It must be understood that, in interpreting the structural conditions as illustrated, certain assumptions were necessary, particularly regarding the thickness of formations and their distribution from one part of the area to another. If any modification were made, however, it would be to lessen the estimates of thickness that have been made. It is quite possible, for example, that the indicated combined thickness of the Bon Ami and Grande Grève formations can be reduced by 1,500 to 2,000 feet in some places.

Some general remarks on the oil possibilities may be added here to supplement the information given by the map and cross-sections.

The Saint-John River anticline, as mentioned by McGerrigle in his section of this report, and that portion of the southern part of the area south of the overthrust fault which is assumed to extend across the region between the Saint-John and York rivers, are not considered as offering favourable structural conditions for the retention of oil. On the north side of that fault, still well up the northern flank of the anticlinal structure, the conditions are not wholly unfavourable, however, if the structure and depths of formations have been correctly interpreted. The western part of that zone, in Laforce township, does not appear favourable, because of the steepness of the strata and the probable excessive depth of the formations below the shale-sandstone series (see section I-J). Farther east, however, the Bon Ami (Lower Devonian), the un-subdivided Silurian-Devonian, and the Silurian conglomeratic formations appear, in places, to be within the depths that drills reach in modern practice. The Silurian conglomeratic formation (or some horizon not far removed from it) is, as will be recalled, one of the zones in which petroliferous rocks have been found. The Grande Grève formation in this belt, within the limits of the map-area, does not appear promising, as it is exposed to the surface or, in the western part, is too steep and at too great a depth. Needless to state, for this belt north of the overthrust fault to be structurally favourable would require that the fault-plane be a sealed one, not permitting the escape of oil that may have been in any of the formations mentioned.

On the Mississippi anticline, drilling near the south end, or not far south, of Dartmouth lake would probably avoid much of the hard, cherty limestones of the Grande Grève formation, but might still encounter as much as 2,000 feet of them. Possibilities of oil production in the Grande Grève rocks are not bright in this part of the area. If the struc-

tural conditions have been correctly interpreted, the Bon Ami formation could be reached by drilling at this locality, with the probability of encountering some faulting and repetition of strata, and a deep hole might reach the un-subdivided Silurian-Devonian and (at 7,000 feet?) the Silurian conglomeratic zone, if it exists there. Somewhat similar depths would be required to reach the same horizons on the crest of the fold north of the lake (see section I-J). Farther east, as illustrated by section G-H, faulted conditions prevail near the crest of this anticline, but, if the faults disappear with depth or flatten out, the Bon Ami and Silurian formations may be in reach of drilling. Also, as suggested by the same cross-section, there may be a monoclinal condition on the flank of this fold in the northern part of block 39 and the southern part of block 34 where deep holes might penetrate the Bon Ami and reach Silurian strata. Somewhat similar depths (7,000 feet?) would probably be required farther east (section E-F), and still greater depths near Patewegia brook, to reach the Silurian zones. At Galt brook, where the structure believed to be the continuation of the Mississippi anticline appears to be in the nature of a dome, the Grande Grève formation offers a more 'closed' condition than at the more western localities just mentioned. A drill here would probably test most of this formation and could reach into the Bon Ami, but, unless the formations are thinner here than farther west, the depths may be such as to discourage immediate testing of the Silurian zones at this locality. Section C-D illustrates the conditions that may exist here. It may be well to repeat here that much of the Grande Grève formation is hard, and any drilling project that would include this formation would need to take this feature into consideration. The same anticline farther east - at the eastern boundary of Galt township, for example, as illustrated in section A-B - appears to have more gently-dipping flanks than farther west. Drilling there would penetrate shale and sandstones, which are of little promise at that locality, and could test closed conditions for the Grande Grève formation. If the thickness of this formation is as great as in the western part of the area, a depth of more than 6,000 feet would probably be required to penetrate it.

Outcrops are not abundant in the vicinity of the Bald Mountain anticline, and further search should be made for information to confirm the impression that has been obtained of the conditions existing there. From the knowledge at present available, it appears that this structure is worthy of consideration. In the region west of the present map-area (1), the strata at the crest of this anticline on Patch brook belong to the bottom of the Lower Devonian formations and may even be, in part, of Silurian age. To the west and east of that brook, the crest is occupied by younger divisions of the Lower Devonian, thus indicating a dome-like character for the fold. A drill in that locality would avoid most, if not all, of the Lower Devonian, and would, if the conditions are correctly interpreted, test the Silurian and possibly older formations at relatively shallow depths. This anticline just reaches the northern boundary of the present map-area, near Bald mountain. The sequence of strata there may be somewhat as indicated in section G-H. If so, the hard Grande Grève limestones may be only thinly represented, if at all, on Dartmouth river at the crossing of the north boundary of Larocque township, and the lowest Devonian and Silurian strata should be within easy reach of a drill. The northern limb of this anticline, from the rather meagre information available, appears to offer the better structural conditions; dips on the northern limb appear to be the more uniform and at a moderate angle.

The Galt anticline, as indicated on Galt brook about a mile north of the centre-line of Galt township (see section C-D), seems to be a minor structure in comparison to the others that have been mentioned. Its economic possibilities could be better estimated if we had information from tests in some of the other, presumably more favourable, localities indicated in the foregoing paragraphs.

As this report is to be available to the public, it is probably appropriate to close with an expression of caution. While it has been concluded that structural conditions are not unfavourable to the finding of oil in parts of this region, no one can predict, without drilling, whether oil may or may not be found in commercial quantity; nor can it be stated at what depths or in what formation oil, if present, would be found before extensive drilling tests have been made, preferably in several places. The region is recommended to the serious consideration of those in search for oil, but, as is known by those with experience in such matters, drilling operations in regions such as this would call for large expenditures that should be undertaken only by concerns or individuals who are prepared to assume the considerable risks that are inevitable in ventures of this kind.

(1) Que. Bur. Mines, Ann. Rept., Pt. D, 1935.