

RG 105(A)

GASTONGUAY - MOURIER AREA, GASPE-NORTH, GASPE-SOUTH, AND BONAVENTURE COUNTIES

Documents complémentaires

Additional Files



Licence



License

Cette première page a été ajoutée
au document et ne fait pas partie du
rapport tel que soumis par les auteurs.

Énergie et Ressources
naturelles

Québec 

QUEBEC DEPARTMENT OF NATURAL RESOURCES

RENÉ LÉVESQUE, Minister

P.-E. AUGER, Deputy Minister

GEOLOGICAL EXPLORATION SERVICE

H.W. McGERRIGLE, Chief

GEOLOGICAL REPORT 105

GASTONGUAY-MOURIER AREA

GASPÉ-NORTH, GASPÉ-SOUTH, AND

BONAVENTURE COUNTIES

by

W. B. SKIDMORE

QUEBEC

1965

ADDENDUM

Since revision of this report in 1961, paleontological work on both old and new fossil collections from several localities in eastern Gaspé Peninsula has cast doubt on some of the age assignments given here.

In particular, graptolites from the basal part of the original Cape Bon Ami formation of the Forillon section, previously dated as Silurian, have more recently been assigned to the Lower Devonian, and the age of the underlying St. Alban Formation has also been confirmed as Lower Devonian*. This seems to necessitate a return to McGerrigle's view that the variegated beds below the Cape Bon Ami in places transgress the Silurian-Devonian boundary. (See especially pp. 11-12, 15, 32, 52)

W. B. S., March, 1966.

- * Boucot, A. J. (1965) Silurian stratigraphy of Gaspé Peninsula, Quebec: Am. Assoc. Petroleum Geologists Bull., v. 49, no. 12, pp. 2295-2303.
Berry, W. B. N. (1965) Comments on graptolites: Ibid., pp. 2303-2305.
Burk, C. F. Jr. (1965) Reply: Ibid., pp. 2305-2316.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	2
Acknowledgements	3
Location	3
Previous Work	4
Field Work	4
GEOGRAPHY	5
New Geographic Names	5
Drainage and Topography	5
Climate and Vegetation	7
Resources and Settlement	7
Access and Transportation	8
DESCRIPTIVE GEOLOGY	9
Regional Outline	9
Local Outline	13
White Head Formation	14
Table of Units	15
Mount Alexandre Group	18
Northern Belt	18
Southern Belt	20
Volcanic Rocks	21
Structural Features	24
Fossils and Age	24
Sirois Formation	25
Laforce Member	26
Upper Member	29
Structural Features	32
Cape Bon Ami Formation	32
Fortin Group	36
Grande Grève Formation	39
York River Formation	41
Intrusive Rocks	43
Pleistocene and Recent	47
The Sandstones	50
Stratigraphic Contacts	51
White Head - Sirois - Mount Alexandre	51
Sirois - Cape Bon Ami	52
Mount Alexandre - Fortin	52
Intra-Devonian	52
Structure	53
Folds and Faults	53
Cleavage and Joints	55

	<u>Page</u>
CORRELATION	55
Mount Alexander and Sirois	55
Fortin	56
General	57
TECTONIC HISTORY	57
GEOMORPHIC DEVELOPMENT	60
ECONOMIC GEOLOGY	62
Metallic Minerals	62
Non-metallic Deposits	63
Petroleum	63
BIBLIOGRAPHY	64

APPENDIX

Fossil Localities	67
White Head Formation	67
Mount Alexandre Group	67
Lower	67
Upper	67
Sirois Formation	67
Laforce member	67
Upper member	68
Cape Bon Ami Formation	70
Fortin Group	70
Grande Grève Formation	71
York River Formation	71
ALPHABETICAL INDEX	72

ILLUSTRATIONS

Map

No. 1481 - Gastonguay-Mourier Area (In pocket)

Figures

1 - Composition of sand and silt fraction of sandy rocks	48
2 - Comparison of maximum grain size with percentage of rock fragments in sand and silt of sandy rocks	49
3 - Stratigraphic diagram, Gastonguay-Mourier area	58

Plates

- I - A. Gaspé upland surface, with entrenched valleys. South of Mourier brook.
- B. Entrenched valley of upper St-Jean river.
- II - A.-B. Altered, ribbed limestone of the White Head formation, close to diabase intrusion. St-Jean-Sud river.
- III - A. Small diabase intrusion in White Head limestone. Otter brook.
- B. Silty shale and siltstone of the upper Mount Alexandre group. Mourier brook.
- IV - A.-B. Volcanic conglomerate of the lower Sirois formation. Hillside west of Tommy brook.
- V - A. Small-scale contortions in sandy-banded limestone of the Cape Bon Ami formation. Sinnett brook. Note cross-cutting cleavage.
- B. Small-scale contortions in pebbly limestone of the Fortin group. Mourier brook. Note cross-cutting cleavage.
- VI - A. Vertical fracture partings in siliceous limestone of the Fortin group. Bonaventure river.
- B. Steeply dipping fracture partings in siliceous limestone of the Fortin group. Patterson brook. Bedding dips moderately to left.
- VII - A. Upper St-Jean river valley from the northeast. Gaspé upland (Surface II) in background. Elevated St-Jean valley (Surface III) in middle ground. Present river flows about 150 feet below Surface III.
- B. Triangle lake (Surface III) from the west. Lower Sirois hills in background.

GASTONGUAY-MOURIER AREA

GASPE-NORTH, GASPE-SOUTH, AND BONAVENTURE COUNTIES

by W. B. Skidmore

Abstract

The Gastonguay-Mourier area covers 265 square miles in the eastern interior of Gaspé Peninsula. It lies across the southern part of the central Silurian-Devonian belt of the peninsula. It is underlain by sedimentary and volcanic rocks of Late Ordovician to Early Devonian age, with small basic intrusions of Silurian to Devonian age. The rocks are in northeasterly-trending folds, with accompanying thrust faults, and high-angle faults. These structures are cut by southeasterly-trending shear faults.

The northern half of the area is underlain by a sequence of five formations. The oldest formation, the Upper Ordovician White Head, is overlain by the Silurian Sirois followed by three Devonian formations: the Cape Bon Ami, Grande Grève, and York River. These rocks lie in fault contact, on the south, with the Devonian Fortin group. In eastern Gaspé the Fortin intervenes between the Grande Grève and York River formations, but in the present area it apparently includes equivalents of all three of the Cape Bon Ami, Grande Grève, and York River formations. Rocks attributed to the Grande Grève and York River have been mapped as such. The remaining, major part of the Fortin is believed to be mainly, or entirely, the Cape Bon Ami formation. However, the rocks have been mapped as undivided Fortin, pending further work. The remaining part of the south half of the area is occupied by the Silurian Mount Alexandre group. The upper part of this group is here correlated with the Sirois formation.

An erosional unconformity is recognized between the White Head formation and overlying Silurian rocks. A slight angular unconformity is also indicated between the Mount Alexandre and Fortin groups.

Lithological comparisons suggest that the Silurian rocks are in large part of intra-geosynclinal origin, whereas the Devonian rocks were mainly derived from the crystalline basement. Evidence also suggests that the Silurian rocks, in particular those of the Sirois formation, were deposited in a less rapidly sinking basin than were the Devonian rocks. Confirmatory evidence is cited for the theory that the Fortin group and the Gaspé Limestones were mainly derived from a source to the south.

The Gaspé upland, which forms the higher ground of the area, is identified in this region as an erosion surface of late maturity. A later erosion surface evidently reached a stage of late youth. The present surface is in early youth.

Some possible sites of petroleum accumulation are indicated.

INTRODUCTION

Gaspé Peninsula is the northern extremity of the Appalachian Mountains of the continental mainland. Geological mapping has been carried on there since 1843, when William Logan began the work of the Geological Survey of Canada. Today the general geology of the peninsula is fairly well known, but not much more than half of it has been systematically mapped. This report, the result of two summers' field work, in 1955 and 1956, represents an addition of some 265 square miles to the area mapped and described. The map-area is situated in the eastern interior of the peninsula. It forms the central link in a continuous north-south strip across the peninsula, which was completed in 1957, with the mapping of the Honrat West area (Skidmore, 1958). [The other map-areas involved are: the Upper York River area (Jones, 1936), the New Carlisle area (Badgley, 1956), and the Madeleine River area (McGerrigle, 1959).]

The area is underlain by folded and faulted sedimentary and volcanic rocks, with some small intrusions. The sedimentary and volcanic rocks are divided into seven major stratigraphic units. The northern half of the area is underlain by a continuous sequence of sedimentary rocks belonging to five of these units, and ranging from Ordovician to Devonian in age. The remaining two units, which occupy most of the south half of the area, are apparently equivalent to parts of the main sequence. The correlation of these units, and the detection of any unconformities, were the chief problems posed.

An earlier draft of this report was submitted as a dissertation in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Princeton University (Skidmore, 1959). The present version has been revised and brought up to date in 1961.

Acknowledgements

The writer is indebted to Mr. A. Coffin of the Howard Smith Paper Company in Gaspé, to Mr. J. Campbell of Cascapedia, and to many other citizens of the Gaspé coast, for information and assistance on many occasions.

The bryozoans were identified by Dr. Madeleine A. Fritz of the Royal Ontario Museum. The other fossils were originally identified by the writer, under the guidance of Professor B.F. Howell of Princeton University, but the brachiopods have since been re-examined and re-evaluated by Professor A.J. Boucot at Massachusetts Institute of Technology. Many of the fossils were collected by Professor Howell during a short visit to the writer's field party.

The writer also received valuable assistance and advice from many other members of the staffs of the Department of Geology at Princeton, and the Quebec Department of Natural Resources, particularly Dr. H.W. McGerrigle and Dr. Pierre Sauvé in Quebec, and Professors E. Sampson, H.H. Hess, and P. MacClintock in Princeton.

Location

The area is bounded on the east and west by longitudes $65^{\circ}15'$ and $65^{\circ}30'$, respectively, and on the south by latitude $48^{\circ}30'$. The northern boundary is formed by the east-west centre line of Holland township and, in the northeast, by York river. The area is thus situated a few miles east of the centre of Gaspé Peninsula, and its northwest corner is about 3 miles south of the town of Murdochville.

In Gaspé-North county it covers part of Holland township and a small southwestern corner of Fletcher township; in Gaspé-South county almost all of Gastonguay township, and parts of Sirois, Vondenvelden, and Raudin townships; and in Bonaventure county parts of Mourier, Guéguen, and Reboul townships.

Previous Work

Adjoining areas on the northeast and east were mapped by I.W. Jones (1936,1938) in 1935 and 1936 respectively. The second of these, the Mount Alexander area, overlaps the present area by 2 3/4 miles on the east side, for a distance of about 15 miles south from York river.

In 1942, H.W. McGerrigle made a reconnaissance survey of Bonaventure river, up to its head at Bonaventure lake. Later in the same year A.E. Miller and E.R. Miller, then working as field assistants to McGerrigle, made a reconnaissance traverse through the northern part of the area, between York river and St-Jean-Sud river.

The northwest quarter of Holland township, which lies immediately north of the present area, and contains the Gaspé Copper mine, was mapped in detail by J.J. Brummer (1955) in 1953 and 1954.

Elsewhere in the peninsula work has been going on almost continuously since 1843, and, although much of it concerns the rocks of the present area, it is unnecessary to list all the different investigations here. The bibliography at the end of the report contains the more important references, including some that are not referred to directly in the body of the report.

Field Work

Aerial photographs and topographic maps from the Surveys and Mapping branch of the Department of Mines and Technical Surveys, Ottawa, were used in the field work. Traverses were plotted on the topographic maps, which had a scale of 2 inches to the mile, and a contour interval of 50 feet. The final base map was compiled from these maps, and maps of the Department of Lands and Forests, Quebec.

The Upper St.-Jean road, and its branch to Oat Cake brook, were surveyed by chain and compass. All other roads were surveyed by pace and compass, except those shown on the aerial photographs, which were traversed by pacing only. All of the larger streams, and most of the smaller ones, were also traversed by pacing. Intervening areas were traversed by pace and compass, at intervals not usually greater than half a mile.

The best, and most plentiful, outcrops are along the larger streams and their steep valley walls; particularly the York, the St-Jean, the St-Jean-Sud, the Bonaventure, and Mourier brook.

Common, but usually less well exposed, outcrops are found along the roads. Elsewhere outcrops are rare, and in some extensive areas absent. In these areas considerable assistance was obtained from critical study of the loose debris. Forest fires in the area have greatly assisted geological work by increasing the visibility, and, through increased soil erosion, by actually increasing the number of outcrops on the steeper slopes.

During the 1955 field season traversing was shared by the writer with Eric A. Rowley, graduate student of Dalhousie University, and Raymond Dallaire, an undergraduate of the Montreal Ecole Polytechnique. General assistants were Numa Marcotte of Laval University, Richard Miller of Wakeham, and Hartley Stewart of York Centre. The cook was the late Thomas H. Patterson of Haldimand East.

In 1956 the traversing was shared with Charles M. Keeler, undergraduate of Yale University, and Adrien DeBlois of Laval University. The general assistants were Yves Rousseau of Laval University, Howard Gallichan of Sandy Beach, and Sherman MacRae, Glen E. Moore, and Sheldon Moore, all of Haldimand. The cook was Andrew Adams of Rivière-aux-Renards.

GEOGRAPHY

New Geographic Names

The two main branches of St-Jean-Sud river have been named Camp-Onze and Camp-Dix brooks, after the old lumber camps situated on them. Camp-Douze lake is similarly named from the lumber camp on its shore. Other new names are Triangle lake, Triangle brook, and Bluebell brook.

Drainage and Topography

The streams of the area belong to three of the major drainage systems of Gaspé Peninsula: the York, St. Jean, and Bonaventure. York river, which drains the northeastern fringe of the area, and St. Jean river, which drains most of the northern half, both flow eastward into Gaspé bay. The headwaters of the St. Jean are almost entirely included in the area. The southern half of the area drains south and west into Bonaventure river, and thence south into Chaleurs bay.

The area, in common with almost the whole of Gaspé Peninsula, is a dissected upland. The upland surface lies mostly between about 1,500 feet and 2,000 feet above sea-level, though some hills rise as high as 2,400 feet. The topography of this surface has a distinct northeasterly trend, parallel to the geologic structure, and the ranges of higher hills are usually to be correlated with bands of more resistant rock. The most prominent examples are the Mount Alexandre range at the south end of the area, underlain by volcanic rocks, and the range of hills close to the south fork of the St.-Jean, underlain by coarse sandstones and conglomerates. Similarly, prominent depressions, such as those along the upper course of the St.-Jean, along Triangle brook, and along the lower part of the Mourier Brook valley, follow belts of soft limestone and shale.

The larger streams are sharply incised to as much as 700 feet below the upland, and the lowest point in the area, on Bonaventure river, is only 600 feet above the sea. The drainage is partly adjusted to structure. As already mentioned the upper St.-Jean, lower Mourier brook, and Triangle brook follow geologic trends. Throughout the area there is a tendency for stream courses to be aligned either parallel to the general strike (about N.70°E.), or approximately at right angles, along a trend probably imposed by the principal joint system. In a zone of tightly folded sandstones and siltstones of the York River formation, at the south end of the area, these trends have produced a well developed trellis drainage pattern.

Lakes are few and small, and most are on the upland surface at the heads of brooks draining into the Bonaventure. On the upland, the brooks flow in shallow, open valleys. Thence, they descend rapidly, through steep, V-shaped valleys, to the level of the main rivers. Along the lower courses of the streams are narrow valley flats, never more than half a mile wide. On the Bonaventure the flats extend from 600 feet to about 1,200 feet above sea-level, and on the St.-Jean from 900 feet to 1,600 feet. However, the rivers flow over rocky beds, and, with gradients of 25 or more feet per mile, carry loads of very coarse detritus.

The topography is typically fluvial, and shows practically no evidence of glaciation. The only exceptions noted were the rounded, cirque-like heads of a few small gullies. These may mark the sites of persistent snow-banks.

Climate and Vegetation

A meteorological station has been established at Murdochville, 3 miles north of the area, since September, 1952. The records of this station*, which is 1,900 feet above sea-level, indicate that the climate belongs to Köppen's class Dc, that is, subarctic. The average temperature is about 34°F., the averages for January and July being 13°F. and 59°F. respectively. The record low and high temperatures recorded between September, 1952, and December, 1956, were -24°F. and 90°F. The average annual precipitation over the same period was 45.46 inches. Usually only July and August are free from frosts, and thaws may occur at any time in the winter, so that freeze and thaw action takes place during about nine months of the year.

The area was originally covered by coniferous forest, but the greater part of it has been burnt over by forest fires; the southern part in 1924, and the northern and central parts in 1941. The new tree cover consists mainly of small birch, poplar, pin-cherry, and mountain ash. Spruce and fir are usually less common, and smaller, particularly in the more recently burnt area. The remaining small stands of original forest are made up almost entirely of spruce and balsam fir, usually attaining heights of about 40 feet, together with a few large birches.

Resources and Settlement

On the hills the soil is mostly thin. In the burnt areas much of its organic content has been destroyed, and the ground is covered by a fine, silty rubble, overgrown by moss. In the flat valley bottoms there is a dark, organic soil up to about a foot thick, and these are the only places which may be suitable for agriculture. However, they are so restricted, and so remote, as to make their colonization in the near future very unlikely.

Since the fires a great deal of pulp-wood has been salvaged from the dead trees, but most of the better stands have now been worked out, and only small-scale operations continue. Good stands of green lumber remain in some places, but they are apparently too small and too remote to be of much commercial interest at present.

Although the St. Jean and Bonaventure are noted salmon streams, few of the salmon ascend into the limits of the map-area. Small trout are common in all of the lakes and streams.

*Quebec Department of Trade and Commerce (1952-1956).

Moose, black bear, and deer are the most common of the larger animals. Small numbers of caribou are seen occasionally. Beaver are common, particularly on Mourier brook. Grouse are plentiful.

There are no permanent inhabitants in the area. During the summer of 1955 two small groups were occupied in cutting pulp-wood in the area north of the St. Jean, and had established temporary camps there. Moose-hunters enter the area in the fall, frequenting especially the small lakes on the headwaters of Mourier and Triangle brooks. Lumber camps are to be found wherever the roads penetrate, but most of them are in a very poor state of repair.

Access and Transportation

Access to, and communication within, the northern and central parts of the area is provided by a number of dirt roads built by the International Paper Company of Canada and the Howard Smith Paper Company. Since no large-scale lumbering operations have been conducted in the area for several years, most of these roads have not been maintained. Even in 1956 they were in poor condition, and many of them may now (1961) be impassable.

The easiest access to the northern end of the area is provided by a road leading south from the Mine road connecting Murdochville and Gaspé. It leaves the Mine road about 3 miles southeast of Murdochville, at the site of Peninsular Oil Corporation's well P.O.C. No. 1, and runs southward to St. Jean river. Bending to the southeast, it runs along the left side of the river for some 6 miles, then leaves the river to run eastward out of the area. It rejoins the Mine road some 12 miles farther to the northeast. This road is referred to in this report as the Upper St. Jean road.

About 16 miles from Murdochville, at Oat Cake brook, another road leads southward from the Mine road, and sends two branches to the north bank of York river, at places which can be forded by a truck at low water. One of these, at the mouth of Oat Cake brook, is close to the east edge of the area; the other, about 3 1/2 miles to the northwest, at Trois-Ruisseaux camp. Roads run south from both places to join the Upper St. Jean road.

The best route into the central part of the area is the road from Gaspé that follows the valley of the St. Jean. Just above the main forks of the St. Jean, about 42 miles from Gaspé, and 1 1/2 miles east of the area, it crosses from the right to the left bank of the river, and thence runs northward to join the Upper St. Jean road. About a mile

below the forks a branch road runs south up the valley of Murray brook. About 1 1/2 miles up, it bends to the southwest, and enters the area at a point some 2 1/2 miles south of St-Jean-Sud river. It penetrates to within 4 miles of the west edge of the area.

The easiest way into the south end of the area is by canoe up Bonaventure river, from the south. A gravel road from the settlement of Robidoux leads to a point on the river about 20 miles below Mourier brook, and the canoe trip from there can be made in a day, with the use of an outboard motor, when the river is not too low. An old wagon road, which is now overgrown, follows up the valley of the Bonaventure, and a branch of it that runs up the valley of Mourier brook and continues for some 6 miles to the east is a good trail.

Except on the Bonaventure, travel by canoe is either impossible or too difficult to be worth while. Foot travel is difficult throughout most of the area. In the northern and central parts, which were burnt over most recently, the ground is littered with fallen trees. In the southern part the dead trees have mostly rotted away, and the ground is more open, although the second growth brush is thick in many places. In some small areas where the two fires have overlapped the ground is almost completely clear, and walking is very easy. The remaining patches of green woods usually provide moderately good travelling, except in the frequent areas of "blow-down". These varying types of woodland can all be recognized on aerial photographs, which are an invaluable aid to travel.

DESCRIPTIVE GEOLOGY

Regional Outline

The Appalachian Mountains reach their northeastern extremity on the North American mainland on the shores of the Gulf of St. Lawrence. The deformed belt is here nearly 400 miles wide, and embraces all of the Maritime Provinces of Canada, and a part of southeastern Quebec. Forming the northwestern side of this extremity is Gaspé Peninsula, about 85 miles wide at its widest, bounded on the north and east by the estuary of the River St. Lawrence and the Gulf of St. Lawrence, and separated from New Brunswick on the south by Chaleurs bay.

The main geological structures of the peninsula run approximately parallel to its north coast. That is to say, in the western part of the peninsula they trend at about N.70°E., but about 40 miles from its east end they begin to bend southwards, and in the vicinity of Gaspé bay are trending about S.55°E.

There is good evidence in the peninsula for two distinct periods of strong deformation: the Taconic in Late Ordovician time, and the Acadian in Middle and Late Devonian time. The pre-Taconic rocks crop out chiefly in a belt that extends from the north coast to a distance of up to 24 miles inland. They are mainly Lower and Middle Ordovician, but include small amounts of Middle and Upper Cambrian. They are quite severely deformed.

The rocks of the northern belt are overlain to the south with angular unconformity by Silurian rocks, succeeded in turn by Devonian. Silurian and Devonian sedimentary and volcanic rocks occupy almost all the main central belt of the peninsula. This is nearly 40 miles wide along most of its length, though it narrows to about 20 miles at its east end. There appear to be no important angular unconformities within these rocks, though there is evidence for erosional disconformities in some places (see McGerrigle, 1950, p. 97). In general, deformation is moderate and metamorphism, slight.

The central Silurian-Devonian belt is bordered on the south by a continuous belt of Ordovician sedimentary rocks. These rocks are not yet well known, but apparently the belt is mainly composed of Upper Ordovician limestones. It also contains some shales, sandstones, and conglomerates, which may be older (Skidmore, 1953). Middle (?) and Upper Cambrian rocks occupy a small area at the east end of the belt. Farther to the south, the Chaleurs Bay coastal region is occupied by rocks ranging from pre-Ordovician and Middle Ordovician, through Silurian and Devonian to the Pennsylvanian(?) Bonaventure formation. The Bonaventure formation is, in most places, only gently folded, and lies with angular unconformity on the older rocks.

The glacial history of the peninsula has been discussed at some length by McGerrigle (1952). He concluded that the peninsula has been covered by a continental glacier, although its deposits are surprisingly slight. On the south side of the Shickshocks they are represented only by widely scattered erratics. The continental glaciation was followed by a period of restricted ice-cap and valley glaciation in the high areas of the Shickshocks and the Béland - Upper York highland.

Inasmuch as this report is concerned with rocks from Late Ordovician to Early Devonian age, their regional setting is discussed in somewhat more detail below.

It has already been mentioned that Upper Ordovician limestones occur in an east-west strip through the southern part of the peninsula. This was a reference to the Matapedia group, an assemblage consisting mainly of fine-grained, grey limestones, with minor shales. This group crops out also within the eastern part of the central Silurian-Devonian belt, along the St. John River anticline. Its internal relations are not yet well understood, and it should be pointed out that its dating is based on a few fossil collections from a large area. Its total age span is not known. Recent developments suggest that it may include Silurian rocks (see p. 17). Rocks belonging to this assemblage at the east end of the peninsula were assigned by Kindle (1936; Alcock, 1935, pp. 24-26) to two formations: the Pabos and White Head. They were defined in separate areas, and their relation was unknown. Shortly afterwards, Jones (1938, pp. 11-12) tentatively correlated rocks mapped on the St. John River anticline with the White Head. Later, McGerrigle (1950, pp. 29-33) assigned rocks at the east end of the St. John River anticline, and also in the main belt to the south, to both the Pabos and White Head formations, the White Head being above, immediately underlying Silurian rocks. In neither region, however, was he able to map a boundary between the two formations, and it remains doubtful whether they are justifiable units.

The overlying Silurian rocks are nowhere seen to be in angular unconformity with the Matapedia group or the White Head formation. However, there is evidence for an erosional disconformity (McGerrigle, 1950, p. 29). Silurian rocks are widespread. Their areas of exposure are along the north and south boundaries of the central Silurian-Devonian belt, and on several anticlinal structures within the belt, and also close to the south coast of the peninsula. The largest, and best known, area is that of the Chaleurs Bay group on the south coast. The Silurian units present in the Gastonguay-Mourier area are the Mount Alexandre group and the Sirois formation. The latter name is new. The two units are geographically separated, but are probably partly equivalent. The Silurian rocks are predominantly limestones, silty limestones, siltstones, and shales. The purer limestones are often very fossiliferous or "reefy". The siltier rocks characteristically are greenish or reddish. In most places the lower part of the section also includes calcareous sandstones, or quartzites, and conglomerates. Thick volcanic sequences occur in the more southerly exposures.

This general description includes some rocks in the eastern part of the peninsula that until recently have been regarded as either Lower Devonian or doubtful Silurian-Devonian. These are the St. Alban formation, and part of the original type section of the overlying Cape Bon Ami formation, together with several small areas of

similar rocks, indicated on McGerrigle's map of the peninsula (1953) as "Silurian-Devonian: St. Alban and Middle Silurian types". In some places these rocks can be traced laterally into undoubted Silurian, and their lithology is in general similar to that of the Silurian rocks. Their Devonian datings were based mainly on brachiopods. These datings were discredited, in the opinion of the writer, by Cumming's discovery of Silurian monograptids in the basal part of the original Cape Bon Ami formation, at the type section on Forillon peninsula (Cumming, 1959). It would appear that there is now no strong reason to consider the St. Alban and other Silurian-type rocks as other than Silurian. The graptolite-bearing beds at Forillon peninsula have subsequently been removed from the Cape Bon Ami formation (Burk, 1959, pp. 11-18).

In the northern part of the central Silurian-Devonian belt the Silurian and probably Silurian rocks are overlain by dark grey, argillaceous to finely sandy limestones, with some grey shales, which constitute the Cape Bon Ami formation, as now defined. (Inland, the Cape Bon Ami, as mapped, has never included green and red rocks of the Silurian type.) In its more southerly exposures it contains in addition considerable amounts of sandstone, conglomerate, and siliceous limestone (McGerrigle, 1950, p. 61). The Cape Bon Ami formation is dated as Early Devonian. However, since the underlying rocks are nowhere dated as younger than lower Ludlow, and since there is no observable break between them, it is possible that the Silurian-Devonian boundary lies somewhat above the lithological transition, within the Cape Bon Ami formation.

The Cape Bon Ami formation is overlain by the Grande Grève formation. The chief distinction between them is the hard, siliceous character of the Grande Grève. Its rocks are commonly calcareous cherts, porcellanites, or siltstones, rather than limestones. The Early Devonian age of the Grande Grève has not been disputed.

Overlying the Grande Grève formation are the Gaspé Sandstones. Four formations are recognized within this group, but only the lowermost, the York River, concerns the present work. This is composed mainly of greenish grey, feldspathic sandstone and shale. In the west-central part of the peninsula (the Big Berry Mountains region) the formation also includes volcanic rocks. The age of the York River has been given by various authors as Oriskanian, Onondagan, and Hamiltonian (see Cooper et al., 1942, pp. 1760-1761; McGerrigle, 1950, pp. 87-90; Carbonneau, 1959, p. 49; Boucot and Cumming, 1953). According to the latest information it is probably of Esopus (middle Lower Devonian) age (Boucot, personal communication, 1961). In some inland areas rocks of

Grande Grève and York River types are interbedded to form a transition zone up to 4,000 feet thick. Where the zone is sufficiently thick and continuous to be mapped it is known as the York Lake series or York Lake facies.

The above remarks on the Devonian apply to the northern part of the Silurian-Devonian belt (north of the St. John River anticline), and to its eastern extremity. The southern part of the belt, from about 10 miles west of Malbaie bay to the Matapedia valley, is occupied by rocks known to be of Early Devonian age, whose exact relation to the standard Devonian sequence is not yet known. The rocks have been referred to as the Fortin series or formation.* Lithologically they are mainly dark grey, shaly slates and limestones, with interbeds of feldspathic sandstone and conglomerate. At the east end of the belt the group appears to occupy roughly the same stratigraphic position as the York Lake series, that is it underlies York River sandstone, and overlies Grande Grève limestone. With regard to its extension to the west McGerrigle wrote (1950, p. 76), "...the series rests against Silurian or Silurian-Devonian, and the Grande Grève and Cape Bon Ami formations were not recognized. Inasmuch as these latter formations are persistent in the belt to the north of the Saint-Jean (John) River anticline, and are present in the eastern part of the Malbaie synclinal structure, it is reasonable to expect them here also. This reasoning has led us to explain their absence by faulting, whereby the Fortin series was let down graben-like on both sides of the belt which it occupies. However, there is a possibility that the Fortin series in its western extension overlaps both of these formations, or that it includes both Cape Bon Ami and Grande Grève time without maintaining the characteristics of the formations. There are common beds, and some zones in the Fortin series composed of limestones very similar to the Cape Bon Ami and the Grand Grève types."

Devonian rocks south of the main central belt are confined to a small coastal area between Matapedia and Cascapedia. Here, Silurian to Lower Devonian sedimentary and volcanic rocks are overlain by sandstones, shales, and conglomerates of Early to Late Devonian age.

Local Outline

The Gastonguay-Mourier area lies across the southern half of the central Silurian-Devonian belt. Its northern half is underlain by a continuous sequence from the White Head formation, through the Sirois, Cape Bon Ami, and Grande Grève, to the York River formation. The total

*The present writer prefers to regard the Fortin, informally, as a group. See p. 37.

thickness of the sequence is about 14,000 feet. A slight unconformity is probably present between the White Head and Sirois. The rocks are folded and faulted, but have a gentle overall dip northwestward from the St. John River anticline.

These rocks lie in fault contact, on the south side, with the Fortin group. Areas on the south edge of the Fortin belt that the writer feels can be definitely assigned to the Grande Grève and York River formations have been mapped as such. Unfortunately these rocks are separated by faulting from the larger part of the Fortin group. This remaining part the writer believes to be mostly, if not entirely, equivalent to the Cape Bon Ami formation, but it has been mapped simply as Fortin, pending further work. The Mount Alexandre group of Silurian sedimentary and volcanic rocks occupies a strip partially separating the Fortin from the southern exposures of the Grande Grève formation, and recurs farther south. It appears to be overlain by the basal Fortin with slight unconformity. In the southeast corner of the area it overlies the White Head formation with probable slight unconformity.

Dykes and sills of basic composition intrude most of the formations, but are chiefly confined to Ordovician and Silurian rocks.

The surface is covered in most places by a mantle of unsorted debris, the result of weathering and mass-wasting. No continuous deposits of undoubted glacial origin were noted. However, boulder-sized erratics are common, most of them of nearby origin. Alluvial gravels up to 20 feet thick are exposed in the banks of some of the larger streams.

White Head Formation

The oldest rocks in the area are exposed along the crest of the St. John River anticline, and underlie the Sirois formation. Except for an interruption caused by a major fault, the belt of exposure runs northeast across the middle of the area. It varies in width from 2 3/4 miles at the east boundary to 1 mile at the west.

The eastern part of the zone within the present area, and its extension to the east, has been described by Jones (1938, pp. 11-12), and correlated with the White Head formation. McGerrigle (1950, pp. 31-32), working still farther east, assigned the rocks to two formations, the White Head and Pabos, which were, however, not separated on his map. As already mentioned (p. 11), the validity of these formations is doubtful. The writer has recognized no formational

Table of Units

Age	Group	Formation	Member	
Recent and Pleistocene				Stream and lake deposits. Weathering and mass-wasting deposits. Glacial erratics.
Devonian and Silurian				Basic intrusive rocks, mostly diabase.
Early Devonian ----- (Late Silurian?)	----- Fortin (South of St. John River anticline only)	York River		Feldspathic sandstone. Green mudstone, siltstone, and shale. Siliceous limestone.
		Grande Grève		Siliceous limestone, calcareous chert. Silty to sandy limestone.
		Cape Bon Ami		Sandy and silty limestone, calcareous siltstone, mudstone. Feldspathic sandstone, conglomerate. Siliceous limestone, calcareous chert.
Late to Middle* Silurian		Sirois	Upper	Green, grey, and red siltstone, mudstone, and limestone. Calcareous sandstone.
			Laforce	Sandy and silty limestone. Conglomerate. Calcarenite. Calcareous sandstone and siltstone.
(Late to Middle?) Silurian	Mount Alexandre			Varied limestones, siltstones, and shales. Sandstone. Basic lava and agglomerate.
Middle Silurian? to Late Ordovician	Matapedia	White Head	Upper	Green to grey, slaty shale. Calcareous sandstone. Grey limestone.
			Lower	Grey limestone.

* "Middle Silurian" is to be understood as approximately equivalent to the Wenlockian and upper Llandoveryian of Britain.

division in the present area. The rocks are all assigned to the White Head, which is regarded as a convenient term for the upper part of the Matapedia Group rather than as a well defined formation. However, an attempt has been made to map the shale member that Jones and McGerrigle recognized at the top of the White Head.

The major, lower, part of the formation occupies the core of the anticline, and is exposed along its axis, except in the centre of the area, where apparently a saddle structure in the anticline results in the concealment of this lower part beneath the upper member. The best outcrops are along the lower part of St-Jean-Sud river. The rocks are almost entirely grey limestones, weathering light grey to buff. The most characteristic type is a dark grey to brownish grey, smooth, dense limestone, with smooth, rounded weathering surfaces of dove-grey colour. It occurs in 1/2-inch to 1-foot beds, with shaly partings, or interbeds of silty limestone up to 8 inches thick. In thin section, the rock is seen to consist mainly of microcrystalline carbonate, with occasional opaque flecks, and rare quartz silt. Selective chemical analysis of one specimen showed it to contain about 83% calcite, 4% dolomite, and 7% silica. Grey, shaly and silty limestones are also abundant, especially in the outcrops along St-Jean-Sud river. Elsewhere they are less commonly seen, probably because they are less resistant to weathering than the dense limestone, which crops out in many places along the walls of the smaller gullies. Some beds, mostly less than 4 inches thick, of light grey or brownish grey, fine-grained, crystalline limestone are found throughout. They are commonly silty, and may be finely laminated and cross-laminated. Other rock types represented only by single outcrops are: grey limestone conglomerate with rounded cobbles up to 6 inches in diameter of dense limestone, shaly limestone, shale, and black chert, in a matrix of sandy, crinoidal limestone; black, non-calcareous, slaty mudstone, with 1/8-inch to 1/2-inch bands of dark grey limestone; and smooth, brownish grey, cherty dolomite.

The upper, shale, member is not well exposed, but appears to occupy bands up to about 2,000 feet wide on either side of the limestone core. These bands apparently meet across the anticlinal axis in the middle of the area, as mentioned above. The best outcrops are on a northern tributary of Triangle brook, and on the road between Camp 5 and Camp 8. The member consists mainly of green to dark grey, non-calcareous, slaty shale, with beds of fine-grained, calcareous, quartzose sandstone. There are also interbeds of pure to shaly limestone, similar to those in the lower part of the formation. One outcrop of intraformational conglomerate was seen, containing elongate fragments of smooth, grey limestone, and calcareous shale, in a matrix of medium-grained, calcareous, quartzose sandstone.

The formation is intruded by very common diabasic sills and dykes. These produce a marked contact-metamorphic effect on the country rocks, which appears to be mainly one of silicification. Rocks close to the largest intrusions, although almost unaltered in appearance, are mostly very hard, and non-calcareous. Close to the smaller intrusions the silicification is less complete. It may be confined to certain beds, giving the weathered outcrop a strongly ribbed appearance (Plate II), or to spheroidal nodules about 1/2 to 2 cm. in diameter.

The rocks are much folded and faulted, and cleavage is well developed in the more argillaceous types. The complexity of the structure makes any accurate estimate of thickness impossible. McGerrigle believed the combined thickness of Pabos and White Head to exceed 4,000 feet, the Pabos accounting for 3,000 feet, the White Head limestone for 1,000 feet, and the upper shale and sandstone member for about 400 feet. In the present area there seems to be at least 1,300 feet of limestone exposed, and the thickness of the upper member seems to range from zero to nearly 1,000 feet. It is not known whether this variation is primary, or the result of subsequent erosion or structural complications.

Scarcely any fossils of any significance were found in the White Head. A corrugated structure on bedding surfaces of smooth limestone is assigned to the worm genus Helminthoides. Outside the area, an outcrop of fine-grained sandstone, mapped as White Head by Jones, revealed poorly preserved graptolites, probably belonging to the genus Diplograptus. The latter would indicate a Middle Ordovician to Early Silurian age. Fossils collected from the White Head and Pabos limestones in other areas have all been considered to indicate Late Ordovician age (McGerrigle, 1950, pp. 30-33). No fossils have been found in rocks definitely assigned to the upper member of the White Head, to the writer's knowledge. However, Cumming (1959, pp. 25-28) collected upper Llandovery (Silurian) graptolites from green and grey shales that appeared to overlie the White Head formation, near the east end of the St. John River anticline. He assigned these beds to a new formation, the Burnt Jam Brook, but Burk (1959, pp. 28-31) has suggested that they may belong to the upper member of the White Head. The elucidation of these dating problems must await further work. Possibly the Pabos and White Head formations span a stratigraphic interval from Upper Ordovician to upper Llandoveryan.

The extreme southeastern corner of the area is probably also underlain by the White Head formation, although it does not crop out. The contact as mapped is based on subsequent work in the area to the south (Skidmore, 1958), and reference to aerial photographs.

Mount Alexandre Group

This unit of Silurian sedimentary and volcanic rocks was first described by Jones (1938, pp. 12-16), and later by McGerrigle (1950, pp. 43-45), who referred to it as the Mount Alexandre "series". The writer prefers the term "group", since the unit is lithologically defined. It is not divided into formal formations, but will clearly be susceptible to such division once its structure is fully understood.

The group forms a belt, 6 to 7 miles wide, trending east-west across the south end of the Mount Alexander area. The rocks occupying the northern part of the belt extend westward into the present area, and continue in a southwesterly direction to within about 1 1/2 miles of its west edge. The zone is from 1 1/2 to 2 1/2 miles wide and roughly coincident with the lower part of the valley of Mourier brook. The rocks are well exposed only along the brook itself. The total thickness of the beds exposed in this belt is probably of the order of 8,000 feet.

These rocks are overlain on the northwest by the Fortin group. On the southeast they are separated by a fault-block of younger rocks (Grande Grève and York River) from a second belt of the Mount Alexandre group, at the south end of the area. This belt has a maximum width of about 3 1/2 miles, and may contain a total of as much as 16,000 feet of strata. Its connection with the Mount Alexandre rocks of the area to the east is uncertain. The group is apparently underlain by White Head rocks in the southeast corner of the area.

Northern Belt

The geological structure within the northern belt remains doubtful, and therefore the stratigraphic sequence cannot be presented with certainty. However, most evidence within the area suggests that the belt is an anticline plunging southwest, and that the volcanic rocks lie along the axis of the anticline. Using this hypothesis, one may divide the rocks into three units of formational rank: a volcanic unit, a limestone unit, and a shale unit, in ascending order. (Rocks apparently underlying the volcanics are represented by a single outcrop of grey, calcareous shale.)

The band of volcanic rocks is about 5,000 feet wide at the east edge of the area, but narrows rapidly, and terminates 4 miles from the west edge. The maximum thickness exposed is probably about 3,000 feet. The rocks are massive, brown to reddish brown weathering andesitic or basaltic lavas. They are dark green, purplish green, or

dark red, aphanitic to fine grained and mostly porphyritic. Hand specimens which do not appear porphyritic to the naked eye are mostly seen in thin section to contain phenocrysts. The phenocrysts, for the most part, are laths of light green feldspar up to 1 cm. long. In many places there are also small, dark phenocrysts, about 1 mm. across, with bright red rims, which are thought to be olivine pseudomorphs. Amygdules are very abundant in places, particularly in the less porphyritic rocks. They are composed of white, crystalline calcite in masses up to 5 cm. across, or of dark green chlorite with radial structure, or, more rarely, of white chalcedony. Vesicular cavities may also be filled by amorphous, chloritic or hematitic material. Where the rock is brecciated it may contain thin stringers of calcite, chlorite, and hematite. More detailed petrography is given in a following section on the volcanic rocks.

Apparently overlying the lavas on both sides, and curving around the southwest end of the plunging anticline, is a sequence of generally calcareous sedimentary rocks. The lithological assemblages on the two sides of the lava band are very similar. That on the north side appears to be more varied, but this may be a result of more complete exposure. The thickness of these rocks is estimated at about 2,000 feet. They are mostly calcareous, or more rarely dolomitic, siltstones and silty shales, and may be greenish grey, grey, or brown. In some places they contain grey, fine-grained sandstone beds up to 6 inches thick. Other rock types occur in great variety, though as a rule each type was seen in only two or three outcrops. These types include: grey, silty limestone; smooth, dense, brown limestone; finely crystalline, bituminous, brown limestone; grey, greenish grey, and brown, non-calcareous shale; and finely crystalline, green or creamy brown, orange-weathering dolomite. At two places within 200 feet of the lava on its south side are outcrops of conglomeratic limestone and of conglomerate. They contain rounded boulders, up to 2 feet across, of dark green, amygdular porphyry; light green, aphanitic igneous rock; and grey limestone; also pebbles of grey shale, and quartz. The matrix is light green, finely crystalline, sandy limestone, and a thin section of this showed the detrital grains to be about 75% volcanic. The volcanic rock is extremely fine, and dark, with a few small feldspar phenocrysts. One grain contained a possible olivine pseudomorph, similar to those in the nearby lavas. The remaining detrital grains are quartz, fine limestone, and feldspar. About 800 feet north of the lava band is another outcrop of conglomeratic limestone. This is dark grey to black, silty limestone, with angular pebbles of brown, finely crystalline limestone; light green, aphanitic igneous rock; and quartz; and a single 5-foot boulder of green, amygdular porphyry.

Overlying the predominantly calcareous sequence on the northwest are about 3,000 feet of greenish grey, grey, and brown, non-calcareous shales and siltstones, with a little greenish grey or grey, dolomitic and calcareous siltstone. A thin section of one specimen, described in the field as a brown, argillaceous siltstone, revealed it to be a mudstone containing about 12% subangular quartz silt, 5% weathered feldspar, and a little muscovite, in an argillaceous matrix containing shreds of mica and chlorite, and dark brown limonitic material.

Southern Belt

The southern belt, in general, dips to the northwest. It may be divided into three subsidiary units: an upper sedimentary unit, a middle volcanic unit, and a lower unit of mixed sedimentary and volcanic rocks.

The lower unit is exposed only along short sections of Reboul brook and its tributaries. Its basal part is not well exposed, and the position of the contact with the underlying White Head formation is uncertain. However, apparently this basal part consists of about 2,400 feet of grey, smooth to silty limestones, which weather light grey to brown. One outcrop, about at the base, contains 1-foot beds of conglomerates, with grey limestone pebbles up to 3 inches. The limestones are overlain by about 2,000 feet of interbedded sedimentary and volcanic rocks. The sedimentary rocks are mostly light grey to greenish grey, soft, shaly to silty limestones. Near the top of the unit is an unknown thickness (at least 10 feet) of sandy, crystalline limestone made up of abundant, well-rounded, fine to medium grains of quartz, along with shell fragments, in a matrix of pink and white, crystalline calcite. The igneous rocks are light to dark green, aphanitic to fine grained, and composed mostly of feldspar with interstitial chloritic material. They contain abundant calcite amygdules. The only well exposed body is about 50 feet thick and has a scoriaceous top. Loose debris of fine agglomerate was found at one place.

The overlying volcanic unit occupies a band which has a maximum width of about 2 1/2 miles. Subsequent mapping (Skidmore, 1958) has shown that it narrows rapidly to the southwest. The structure within the band is unknown, but possibly the narrowing is chiefly due to variation in original thickness. If so, the maximum thickness of the unit could be as high as 10,000 feet. More probably the thickness is considerably less, and the great width of the belt is due to structural complications. The volcanics are best exposed on the tributary gullies of Cotton brook, on its south side. They comprise both massive lavas and agglomerates, with

some possible crystal tuffs. The lavas are very similar to those of the northern belt, though there appears to be a higher proportion of the dark red type. They are generally porphyritic, with common amygdules of calcite, chlorite, and chalcedony, and rare amygdules of fibrous zeolite. The rocks are described in more detail below. The agglomerates contain rounded lava fragments up to 2 feet across.

The volcanic rocks are overlain by nearly 2,000 feet of limestones, which are exposed on the lower part of Cotton brook. Their colours are brown, or greenish grey, and their textures smooth, silty, or finely crystalline. Some beds contain fine quartz sand. The brown, crystalline limestone is mostly fossiliferous, and has a strong bituminous odour. In one place it was seen to be composed mainly of recrystallized stromatoporoids and algae. A narrow band of agglomerate, with fragments of dark green porphyry, and aphanitic igneous rock, is included in the limestone, at about the top of the exposed section. The larger fragments are well rounded, and the smaller ones are mostly angular.

Volcanic Rocks

The examination of twelve thin sections, and selective chemical analysis of nine specimens, indicate that the lavas may be divided into two broad types on the basis of colour, namely dark green and dark red.

The dark green lavas consist mainly of plagioclase, pyroxene, chlorite, magnetite, and pyrite, commonly set in a dark, cryptocrystalline matrix. The texture is porphyritic, commonly glomeroporphyritic, and intersertal or intergranular. The groundmass plagioclase occurs in slender laths, usually about 0.5 mm. long. According to their combined albite-Carlsbad twin extinction angles they have usually the composition of labradorite or andesine, more rarely of oligoclase. The feldspar phenocrysts are broad laths, up to 8 mm. long, of bytownite or labradorite or, more rarely, andesine. Many are zoned. The feldspar is more or less sericitized in many specimens. The total visible feldspar content of the rock is 52-62%. The pyroxene occurs in grains up to about 1 mm. across, and makes up about 20% of the rock. It is all clinopyroxene, and is partly pigeonitic. Chlorite occurs mainly as a cryptocrystalline filling between grains, but is also seen in platy crystals, veinlets, and amygdules. It may form as much as 20% of the rock. Besides magnetite and pyrite, the opaque minerals include hematite and traces of chalcopyrite. Sphene is fairly common in some sections. These minerals between them may occupy 6-12% of any thin section. Carbonate

is seen in amygdules, veinlets, and the fine matrix, and may constitute up to 10% of the rock. The small, red-rimmed phenocrysts of some hand specimens are seen in thin section to consist of irregular patches of carbonate and chlorite, with some possible serpentine, occupying pseudomorphs in the shape of olivine crystals. The red rims are of hematite, and possibly iddingsite.

The six analysed specimens of this group show a fairly consistent composition. The average composition, and the range of values for each constituent, are as follows:

	<u>Average</u>	<u>Minimum</u>	<u>Maximum</u>
	%	%	%
SiO ₂	47.94	46.81	48.68
Al ₂ O ₃	17.54	15.41	19.21
CaO	9.76	7.70	11.76
MgO	5.12	3.36	7.18
FeO	5.49	4.90	5.92
Fe ₂ O ₃	3.61	1.74	4.70
Na ₂ O	3.40	2.79	4.32
K ₂ O	0.71	0.38	1.50
CO ₂	2.42	1.02	5.50
H ₂ O	2.62	1.23	3.84
Total	<u>98.61%</u>		

Assuming the alumina present was all contained in feldspars, the analyses indicate normative plagioclase contents of 50-65%, with compositions between about An₃₅ and An₅₅, together with 2-9% of orthoclase. The rocks would be considered as basalts according to their silica content, and as ranging from andesite to basalt according to the content and type of feldspar. The high contents of CO₂ and H₂O, which tend to be correlated, suggest a certain amount of metasomatism.

The dark red lavas, as seen in thin section, are marked by their high content of red and brown iron "ore". They all contain a high proportion of plagioclase feldspar, but the content of visible pyroxene and chlorite is very variable. Probably these finer-grained minerals are partly masked by opaque material. The texture is, in most cases, porphyritic, and intergranular or intersertal. Examples of pilotaxitic texture are common. The groundmass feldspar laths are 0.1-0.5 mm. long, and the phenocrysts range up to 7 mm. The feldspars are commonly altered, but where fresh were identified as oligoclase in

all but one section. The exception contains labradorite and is also the only one containing zoned phenocrysts. The content of visible feldspar is 57-74%. Visible grains of clino-pyroxene, some of them pigeonitic, up to 0.5 mm. in size, may constitute up to 15% of the rock, but in some sections are apparently absent. Similarly chlorite, and fine chloritic matrix material, make up as much as 30% of some sections, but are apparently absent in others. Olivine pseudomorphs do not seem to occur in the rocks of this group, but some sections reveal probable pseudomorphs after amphibole, containing chlorite, carbonate, and in some cases biotite, enclosed by a hematite rim. These may form more than 5% of the rock. The apparent total content of pyroxene, amphibole, and chlorite is 5-30%. Besides the brown and red, semi-opaque to opaque iron "ore", the opaque minerals are magnetite and pyrite, with traces of chalcopyrite. These minerals between them may occupy 15-30% of a given section. Spene is common in some sections. Carbonate material is mostly confined to amygdules and veinlets. Biotite is an accessory mineral in some sections.

Three partial analyses of rocks of this group were obtained. They are presented separately below:

	$\frac{1}{\%}$	$\frac{2}{\%}$	$\frac{3}{\%}$
SiO ₂	50.87	58.76	59.48
Al ₂ O ₃	19.32	16.08	15.46
CaO	8.97	5.70	2.01
MgO	2.86	1.76	1.62
FeO	1.77	1.13	2.48
Fe ₂ O ₃	7.19	3.53	4.44
Na ₂ O	4.51	7.25	6.78
K ₂ O	1.21	0.93	0.90
CO ₂	0.66	2.44	0.27
H ₂ O	0.88	0.89	1.69
Total	98.24%	98.47%	95.13%
Approximate)	67% An ₄₃	70% An ₁₂	66% An ₁₃
Normative)	plagioclase	plagioclase	plagioclase
Feldspar)	7% orthoclase	5% orthoclase	5% orthoclase

It can be seen that although the above analyses differ considerably among themselves they show consistent differences from the analyses of the dark green group, being higher in silica and soda and lower in magnesia, and having a much higher ratio of ferric to ferrous iron.

The first analysis, which corresponds with the single section containing labradorite, is essentially that of an andesite, though low in silica. The other two, with their high contents of sodic plagioclase, approach the composition of keratophyre.

Structural Features

The sedimentary rocks of the Mount Alexandre group are mostly characterized by undisturbed parallel beds ranging from fine laminae to beds about a foot thick. Individual silty beds may be cross-bedded. Slump structures, or other signs of contemporaneous disturbance, were not observed.

The southern belt appears to be little deformed. Although the dips are steep, the bedding strikes are consistent, and minor folds seem to be confined to the region north of the volcanics. Secondary cleavage is only slightly developed. The structure in the northern belt is more complex, with considerable local variation in the strike and dip of the bedding. Even here, however, the direction of dip may be consistent for as far as 5,000 feet across the strike. Cleavage is recognizable in all the more argillaceous rocks, but is rarely well developed.

Fossils and Age

The fossils found in the Mount Alexandre group were:
from below the volcanics, south belt; Atrypa "reticularis", dalmanellid,
rhynchonellid, Eophacons orestes;
from above the volcanics, south belt; algae, stromatoporoids,
zaphrentid corals;
from above the volcanics, north belt; zaphrentid, carbonaceous
material, sinuous fucoids.

The only useful species is Eophacons (Phacops) orestes, which occurs in the Llandoveryian Jupiter and Gun River formations of Anticosti island (Iwnehofel, 1928, pp. 97, 87).

Jones collected a large number of fossils from the group in the area to the east that indicated a Silurian age and correlation with the Chaleurs Bay group (Jones, 1938, pp. 14-15). More recently, Burk (1959, pp. 35-36) has collected graptolites of late Wenlock and

early Ludlow age from unmapped Mount Alexandre rocks (apparently below the volcanics) to the east. All that can be said in summary at present is that the Mount Alexandre group is of Silurian age, possibly extending from the lower Ludlow down into the Llandovery.

Sirois Formation

The Sirois formation includes probably all the Silurian rocks of the northern half of the area. They are certainly equivalent in age to a part of the Mount Alexandre group, but their correlation is sufficiently insecure, and their lithology sufficiently distinctive, to warrant their description as a separate formation. To the east of the present area the formation has been mapped by Jones (1938) and McGerrigle (1950). It was referred to by Jones simply as the northern Silurian belt, and by McGerrigle as the St. John River Silurian-Devonian belt. The name Sirois has previously been used only in two unpublished theses (Skidmore, 1959; Burk, 1959), and is here formally proposed for the first time.

The Sirois overlies the White Head along both sides of the St. John River anticline, except where it is faulted out on the south side. In addition it is partly exposed on two anticlines farther northwest. It is best exposed along St-Jean river and St-Jean-Sud river. The section which extends for 3 miles along St-Jean-Sud river, above and below Camp 8, is designated the type section. It is by no means completely exposed, but is the best section of the whole formation, or of its upper part, known to the writer. (Burk (1959, p.32) has proposed a separate type section for the Laforce member or formation. See below.) The name Sirois is derived from the township in which a part of the section lies. The estimated thickness at the type section is about 4,000 feet, but farther north it must be considerably more.

There is a clear lithologic distinction between the upper and lower parts of the formation, which merit description as separate members. In fact Burk, working farther eastwards on the St. John River anticline, recognized two separate formations, using the name Sirois for the upper formation, and the name Laforce for the lower (Burk, 1959, pp. 31-32). The present writer prefers to regard the whole sequence as a single formation, partly because of the practical difficulty of mapping the two divisions separately, and partly because of a suggestion that the lower division thins rapidly towards the west in the present area, and may wedge out completely. An attempt has, nevertheless, been made to map in the contact, and Burk's name Laforce is retained for the lower member.

Laforce Member

The Laforce member is exposed only on the St. John River anticline, where it borders the White Head formation in bands up to 8,000 feet wide. It is nowhere completely exposed in the area, though there are good exposures on St-Jean-Sud river (the Sirois type section) and several hills to the south. Its thickness at the type section is estimated at about 1,800 feet, but, as mentioned, it appears to be thinner in the western part of the area, and may be absent in places.

Its base is exposed only at the type section. Here the lowest 100 feet or so consists of light grey, massive, sandy, crystalline limestone with a few bands of rounded, quartz and limestone pebbles up to 1/4 inch in diameter. The rest of the member consists of similar sandy limestone; limestone grit and limestone conglomerate; calcareous sandstone and volcanic conglomerate; and calcareous siltstone and silty limestone. These are interbedded, in beds from a few inches to about 100 feet thick.

In thin section, the sandy, crystalline limestone is seen to be a very coarsely sandy, bioclastic limestone containing about 20% of detrital fragments in a matrix of fossil debris and recrystallized calcite. The detrital fragments are mostly subrounded grains and granules of very fine limestone, argillaceous and silty limestone, and calcareous shale, together with some well-rounded quartz grains up to about 1 mm. across. There appears to be very little argillaceous material.

The limestone grit is a light grey to brownish grey, coarse calcarenite, composed mainly of fragments of limestone and shale, and rounded quartz grains, set in a calcite cement. The weathered surface is very rough and hackly. Many of the limestone fragments are of the smooth, dove-weathered, White Head type. Thin sections show the rock to contain about 10% quartz, and pure quartzite, sand and silt; 40% other rock particles; 15% clastic calcite; 30% calcite cement; and a small amount of orthoclase feldspar. The rock particles include silty and argillaceous limestone; very fine, pure limestone; organic limestone; fine dolomite; silty shale or slate; impure, fine quartzite, or hornfels; and quartz-feldspar schist. The clastic calcite is mostly organic, with some vein calcite, pellets, and a few oölites. The average grain size is about 0.5 mm., but quartz grains range up to about 1 mm., and rock particles, to 2 mm. The sand-size grains, including organic calcite, are rounded to well rounded, and the silt particles rounded to subangular. The calcite cement is clear, and its crystals average about 0.2 mm. across.

These calcarenites include common beds, a few inches to 2 feet thick, of intraformational conglomerate, which contain flat, subangular fragments of silty limestone, similar to that in adjacent beds. Subrounded fragments of Silurian corals are also common in many beds.

Quite distinct from these clean arenites and conglomerates are some less common beds of poorly sorted sandstone. They are medium to very coarse grained, calcareous, and mostly greenish. One such bed was seen to contain subrounded pebbles of silty limestone and fragments of Silurian corals. The sandstones are variable in composition as seen in thin section, but all fall into the class of calcareous, lithic wackes*. One specimen, collected from the north side of the St. John River anticline, consists of about 10% quartz and chert, 45% rock grains, 10% clastic calcite, 10% argillaceous matrix, and 15% calcite cement. The larger grains are rounded to subrounded, and the smaller are subangular. The rock fragments include silty shale; silty and finely sandy limestone and dolomite; pure, fine limestone; quartz hornfels and fine, calcareous quartzite; quartz-feldspar-chlorite schist; fine volcanic rock; and fine granite.

Near the south edge of the Sirois outcrop area, on the south side of the St. John River anticline, there are several occurrences of volcanic conglomerate, and the poorly sorted sandstones in this region also have a high content of volcanic rock. Two thin sections have the following approximate compositions:

	<u>1</u>	<u>2</u>
	%	%
Quartz, chert, quartzite	10	5
Unstable rock grains	30	60
Plagioclase	5	5
Clastic calcite	5	5
Chloritic and opaque matrix	30	15
Calcite cement and replacement	20	10

The grains are subangular to subrounded, and many are deformed. The rock fragments are mostly volcanic, some of them finely porphyritic, and consist mainly of feldspar, chlorite, and magnetite. Trachytic texture is common. Many grains of rock and of feldspar are partly replaced by calcite, and their boundaries are indistinct. Where fresh the feldspar appears to be oligoclase. A few grains of shale and schist are also seen.

* Here, as elsewhere throughout the report, the sandstone classification of Gilbert is used (Williams, Turner, and Gilbert, 1954, pp. 292-293).

The volcanic conglomerates occur in lenses up to at least 100 feet thick within the bottom 500 feet of the formation. They contain well-rounded pebbles and cobbles, up to 10 inches in diameter, of dark green feldspar porphyry, and aphanitic igneous rock, very similar in appearance to the Mount Alexandre lavas. Pebbles less than 3 inches across may be angular, and are of more varied types, including pink feldspar porphyry, grey limestone, and quartzose sandstone. The matrix is a tough, dark green, very coarse greywacke, which in places is difficult to distinguish from the enclosed igneous fragments, although here and there it contains common fossil fragments. A thin section of the matrix showed the following approximate composition:

	Per cent
Volcanic rock grains	55
Plagioclase	15
Clastic calcite	10
Chloritic matrix	15
Calcite cement	5

Quartz silt is very rare. The detrital grains are rounded to subrounded. The volcanic rocks are very fine, commonly porphyritic, aggregates of abundant feldspar with chlorite and magnetite. The feldspar grains appear to be oligoclase, and may be partly or entirely replaced by calcite.

Three thin sections from boulders in these conglomerates consist mainly of plagioclase, in a matrix of chloritic material and pyrite. The texture is porphyritic, and pilotaxitic to trachytic. The groundmass feldspar laths are about 0.2 mm. long, and phenocrysts range up to 7 mm. The feldspar is commonly replaced by calcite, and appears to be oligoclase and andesine. The content of visible feldspar is 58-68%. One specimen contained possible pseudomorphs after olivine, and another apparent pseudomorphs after amphibole.

The rest of the member is made up of greenish grey and grey, calcareous siltstones and very fine sandstones, and silty limestones, in generally laminated beds up to a few inches thick. The detrital fractions of the rocks are mostly subangular quartz, with a little feldspar and varying quantities of mica. One section contained a few small grains of shale, volcanic rock, and argillaceous limestone. The rocks may be well sorted, with clear calcite cement, or contain as much as 25% argillaceous matrix.

At one locality, on St-Jean-Sud river, there is a 10-foot lens of limestone conglomerate that is unusual in that it contains well-rounded boulders, up to 1 foot in diameter, of fine, dove-weathered limestone. They rest, together with some angular, edgewise cobbles of silty limestone, in a matrix of greenish grey, crinoidal limestone. This is, stratigraphically, the highest conglomerate found in the Sirois formation, and is taken as the top of the Laforce member.

Fossils collected from the Laforce member have been identified as follows:

Algae?	<u>Astrocerium</u> cf. <u>hisingeri</u>
Stromatoporoids	<u>Favosites</u> <u>gothlandicus</u> ?
<u>Amplexus shumardi</u>	<u>Monograptus</u> <u>clintonensis</u>
<u>Astrocerium constrictum</u> ?	<u>Monograptus</u> cf. <u>regularis</u>

The corals, stromatoporoids, and algae were all collected from conglomerates or coarse calcarenites, and showed some signs of wear. The fauna is of Silurian age. Amplexus shumardi is a Niagaran species (Bassler, 1950). Monograptus clintonensis is abundant in the Clinton of New York (Ruedemann, 1947, p. 476), and is also found in the lower Jupiter of Anticosti (Twenhofel, 1928, p. 84). A variety of the same species is reported from the Gascons formation of the Chaleurs Bay group (Northrop, 1939, p. 138).

Fossils collected by other workers from the Laforce member, or rocks now assigned to it, farther east along the anticline confirm the Silurian dating (McGerrigle, 1950, pp. 40-42; Cumming, 1959, p. 29; Burk, 1959, p. 29). Burk has assigned a more precise date of lower Wenlock, on the basis of graptolites collected by McGerrigle, Cumming, Skidmore, and himself.

Upper Member

The upper member is exposed along the northwest side of the St. John River anticline in a band up to 6,000 feet wide, bordering the Laforce member. On the southeast side it is cut out by a fault, except perhaps towards the west edge of the area. There are no outcrops there, but loose debris suggests its presence. It is also exposed farther northwest on two northeastward-plunging anticlines. Apart from the type section, it is best exposed on the main branch of St. Jean river, along a 5-mile stretch below Camp 24, on the middle one of the three anticlines. Its estimated thickness at the type section is 2,200

feet, but to the west it appears to thicken at the expense of the Laforce member. Also, in Peninsular Oil Corporation's hole P.O.C. No. 1, about 14 miles to the northwest and just outside the north edge of the map-area, 6,030 feet of similar beds have been penetrated without reaching their base (Brummer, 1955, p. 15).

The rocks are mainly green, greenish grey, and grey, calcareous siltstones and silty mudstones, and silty limestones. The limestones are aphanitic to finely crystalline. The rocks are commonly finely laminated and cross-laminated, and are in beds from 1 inch to about 30 inches thick. Some of them, however, particularly the green type, are massive. The green and greenish grey zones contain some dark red or reddish brown, calcareous siltstones or mudstones, mostly in massive beds less than 10 feet thick. Thin sections show the green phase to contain chloritic material in the argillaceous matrix, whereas the reddish brown phase contains limonite. The detrital fraction is chiefly angular to subangular quartz, with varied amounts of feldspar and mica.

Common calcareous sandstone beds, from 1 inch to 10 feet thick, range from fine to coarse in grain, and are variable in appearance. They are mostly characterized, however, by greenish shades, and high content of clastic calcite, commonly crinoidal. In thin section, four specimens were all revealed to be lithic sandstones; one of them a clean arenite, the other three lithic wackes with more than 10% argillaceous matrix. The arenite, a coarse-grained, green sandstone, has the following approximate composition:

	Per cent
Quartz	20
Feldspar	5
Rock grains	20
Crystalline calcite grains	5
Fine calcite cement	45
Opaque (mostly pyrite)	5

The rock grains include micro-granite or quartz-feldspar schist, and aphanitic limestone. The grains are subrounded to subangular and poorly sorted.

The three specimens of lithic wacke have the following compositions:

	1 (Fine grained) %	2 (Coarse grained) %	3 %
Quartz, quartzite, chert	12	10	11
Feldspar	13	9	10
Unstable rock grains	20	30	32
Clastic crystalline calcite	9	16	12
Chloritic matrix	33	13	20
Calcite cement	10	18	13
Opaque	3	4	2

The rock grains are mostly quartz-feldspar schist, granite, chlorite schist, and fine limestone. The grains are subangular to subrounded.

One-inch to 2-inch beds of very smooth, grey and pink limestone occur in some outcrops. In the type section, about 8 feet above the conglomerate forming the top of the lower member, there is a 2-inch bed of grey limestone composed almost entirely of crinoid columnals.

Fossils collected from the upper member of the Sirois formation include the following:

Slender, hematized plant axes	<u>Pentamerus</u> ? sp.
Boring sponge	<u>Platyceras</u> ? sp.
<u>Astrocerium hisingeri</u> ?	<u>Scutellum pompilius</u> pygidium
<u>Leptaena "rhomboidalis"</u>	Small dalmanitid cephalon
<u>Levena</u> ? sp.	<u>Monograptus varians</u> var. <u>tenuis</u>
<u>Orthostrophia</u> ? sp.	<u>Monograptus chimaera</u>

The fauna is of lower Ludlow age, as indicated chiefly by the graptolites (which were found up to within 120 feet of the top of the formation). Monograptus chimaera and M. varians both occur in the lower Ludlow of Britain (Elles and Wood, 1918; Ruedemann, 1947, pp. 489-490). Varieties of these same species were found in the Gascons formation of the Chaleurs Bay group by Badgley (1956, p. 17). Scutellum (Goldius) pompilius was found in the West Point formation of the same group by Northrop (1938, pp. 231-233).

Earlier fossil collections from rocks apparently belonging to the upper member of the Sirois formation, towards the east end of the St. John River anticline, were regarded as indicating Early Devonian age, as were also collections from the St. Alban formation and other rocks of eastern Gaspé that bear a resemblance to the Sirois (McGerrigle, 1950, pp. 35-60). More recent work, in particular the discovery of Silurian graptolites in many places, has tended to discredit these datings, and all of these rocks are now regarded as being of Silurian age (Cumming, 1959; Burk, 1959, pp. 11-22). Burk assigns his Sirois formation (the upper member of this report) to the upper Wenlock and lower Ludlow (1959, p. 29).

Structural Features

Small-scale cross-bedding is very common, within beds, in the silty rocks of the upper Sirois. The round-boulder conglomerates tend to be in lenses rather than continuous beds. Apart from these features the bedding is characteristically parallel, and undisturbed.

In most places the formation is not much folded, except for open folds of at least a mile across, although minor faults are common. Cleavage is poorly developed, possibly because of the lack of fine argillaceous rocks. However, many outcrops are fractured in irregular fashion.

Cape Bon Ami Formation

The Cape Bon Ami formation represents the base of the Devonian system in northern and eastern Gaspé Peninsula, and everywhere overlies rocks of Middle to Late Silurian age.

It was named by J.M. Clarke (1908), and has its type section at Forillon peninsula on the east coast. The original section has undergone many revisions, chiefly due to the fact that its lower part contains rocks of variegated colour that resemble the Silurian rocks of the region (e.g. the Sirois formation), and which have, in fact, lately been found to contain Silurian monograptids (Cumming, 1959, p. 19). As mapped inland from the type section the base of the formation has always been placed at the top of the variegated beds, and the writer has continued this practice.

The formation is exposed on the two most northerly anticlines of the area. On the northernmost it occupies an area of small and uncertain size, and crops out in only one place. On the southeast side of the second anticline, however, it occupies a synclinal belt about 3 miles wide. It is best exposed on the lower part of St. Jean river within the area, and the brooks entering it from the north, and on St-Jean-Sud river in the vicinity of Camp 9. Its thickness on the nose of the second anticline appears to be about 2,000 feet.

For the most part the formation consists of dark grey, sandy and silty limestone, with some calcareous siltstone and silty mudstone. The rock is soft to moderately hard, and weathers light brown or reddish brown. Most commonly it contains laminae and thin beds to 1 cm. of fine- to medium-grained sand. Tiny white specks of calcite are a common feature, and black, carbonaceous material is concentrated on some bedding planes. A few outcrops of pebbly limestone were found, containing rounded pebbles of quartz, red and black chert, and aphanitic igneous rock. In thin section, the matrices vary from clear, fine calcite, to almost opaque, brown, limonitic, and possibly carbonaceous, material. Considerable variation may be observed within a single thin section. The dark material tends to be aligned in thin strings parallel to the cleavage. In some thin sections the outlines of small rod-like structures can be seen in the calcite, a few of them preserved in cryptocrystalline silica. They are probably sponge spicules. Small dolomite rhombs are rare. The sand and silt is subrounded to subangular, and frequently concentrated in thin laminae. The proportions of combined quartz, quartzite, and chert, feldspar, and rock grains, are variable, and any one of the three may be predominant. All three may be partly replaced by calcite, though with the quartz the replacement is confined to the borders of the grains. The rock grains are mostly fine-grained granitic rock, quartz-feldspar hornfels or schist, cryptocrystalline to very fine volcanic rocks, and silty slate or shale. The feldspar is too much altered for identification. Muscovite and clastic, organic calcite are usually accessory. Selective analysis of two specimens showed the proportion of magnesium carbonate to calcium carbonate to be about 5% or less.

There are also common beds, up to about 5 feet thick, of very fine- to medium-grained, grey, feldspathic and calcareous sandstone. The feldspar is commonly visible in hand specimens. Characteristically the sandstones weather with rusty specks. In places they contain small pebbles of dark grey shale and calcareous shale. Conglomerate was found at two places in outcrop and at several places in debris. It contains

rounded pebbles, up to about 1 inch in diameter, of quartz, red and black chert, aphanitic igneous rock, and shale, in a matrix of similar feldspathic and calcareous sandstone. In thin section, three out of four sandstone specimens proved to be calcareous, lithic wackes, the fourth being a calcareous, lithic arenite. The detrital grains are angular to subrounded. The percentages of the main sand and silt components in the four sections are as follows:

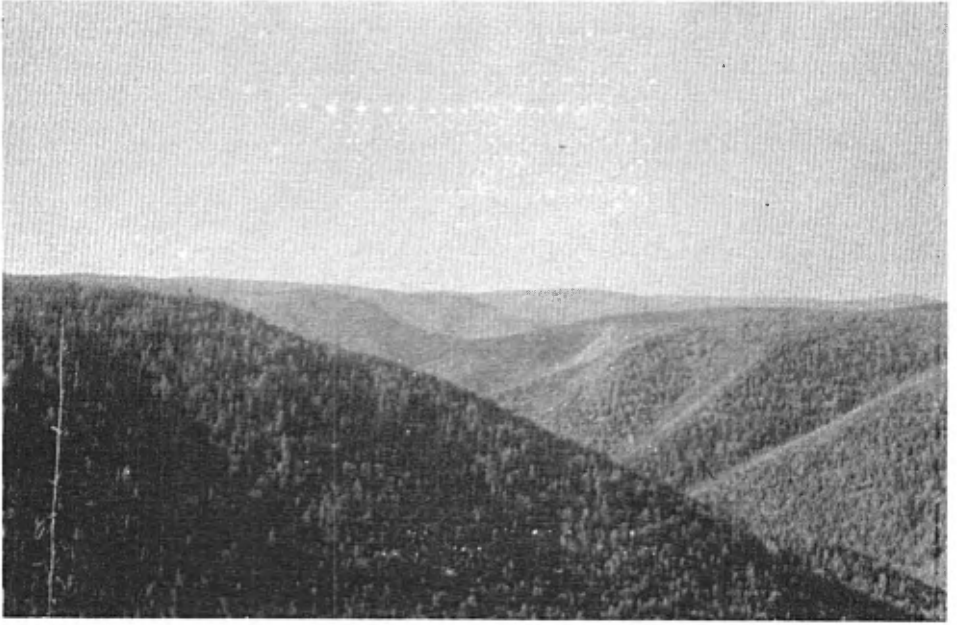
	1	2	3	4
	(Very fine wacke)		(Medium-grained wacke)	(Medium-grained, pebbly arenite)
	%	%	%	%
Quartz, chert, quartzite	26	20	18	25
Rock grains	14	23	23	25
Feldspar	10	12	5	10
Clastic calcite	8	-	-	5
	---	---	---	---
Total	58%	55%	46%	65%

There is much replacement of grains by calcite. The rock grains are fine feldspathic rocks of granitic and ophitic textures, shale, quartz-mica schist and phyllite, and cryptocrystalline volcanic rock. The feldspar is usually altered, but includes some fresh plagioclase. Muscovite and biotite are common accessories. The matrix of the wackes is dark brown to opaque, and limonitic. Calcite cement is mostly fairly clear, but may be intimately mixed with the matrix. Small dolomite rhombs are rare. The arenite specimen contains a little chert cement.

In the outcrops along York river, and the few outcrops to the north and west of them, the formation is somewhat different. It is here a medium to dark grey, soft to moderately hard, silty limestone, in beds up to 3 feet thick. It contains no appreciable sand fraction, and few sandstone beds. The rocks resemble more closely the Cape Bon Ami formation as exposed to the north and east than in the major part of the present area.

In the lower half of the formation are several zones of hard to very hard, light brown weathering, siliceous limestone or calcareous chert. This is particularly conspicuous at the base of the formation, where about 100 feet of very hard rock immediately overlies

PLATE I



A — Gaspé upland surface, with entrenched valleys. South of Mourier brook.

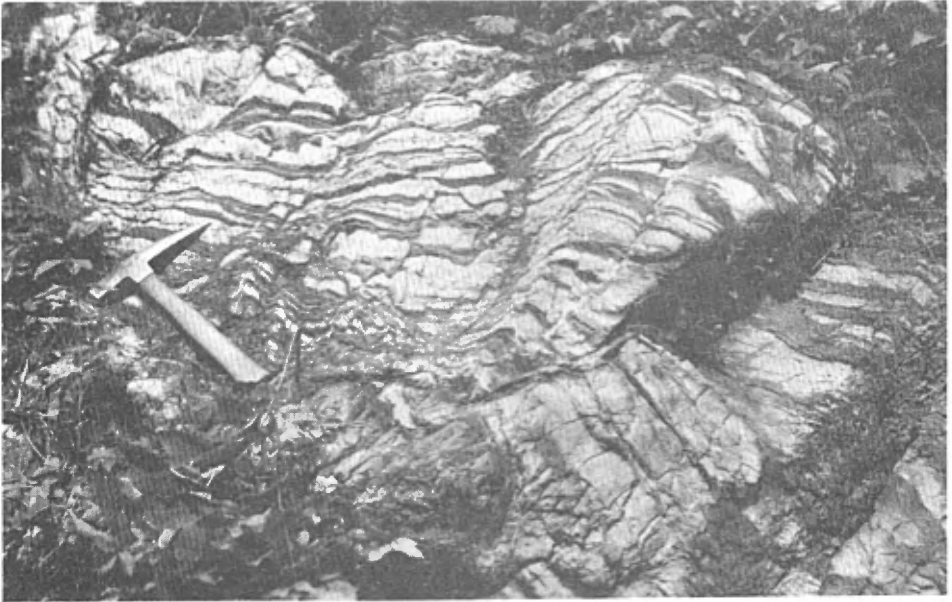


B — Entrenched valley of upper St-Jean river.

PLATE II



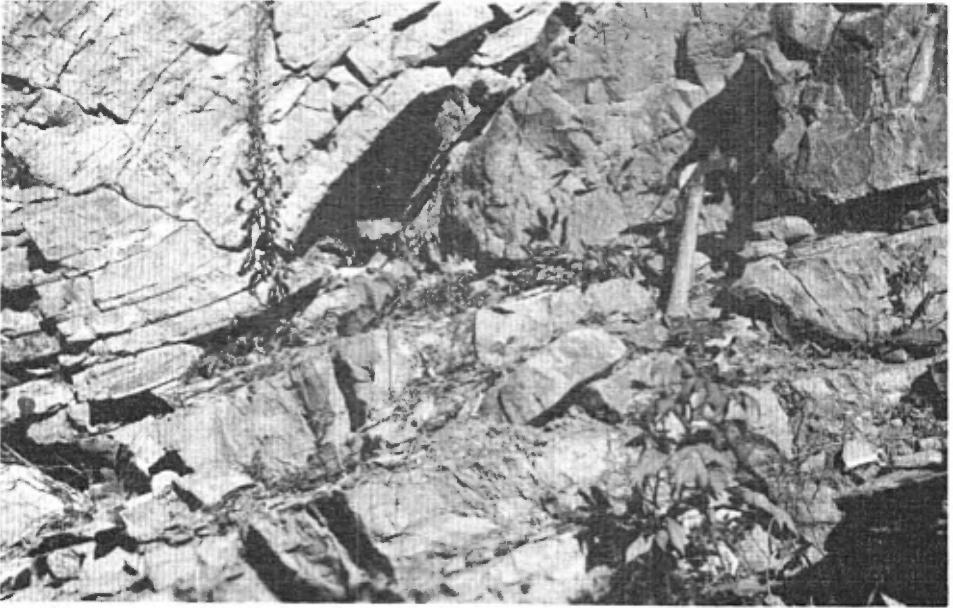
A



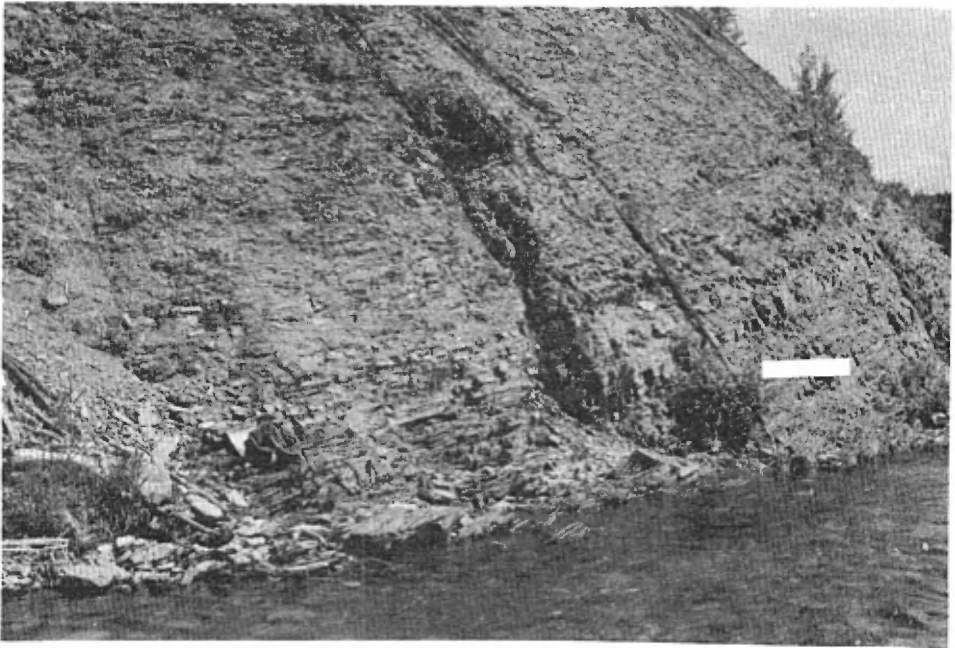
B

Altered, ribbed limestone of the White Head formation, close to diabase intrusion. St-Jean-Sud river.

PLATE III



A — Small diabase intrusion in White Head limestone. Otter brook.



B — Silty shale and siltstone of the upper Mount Alexandre group. Mourier brook.

PLATE IV



A



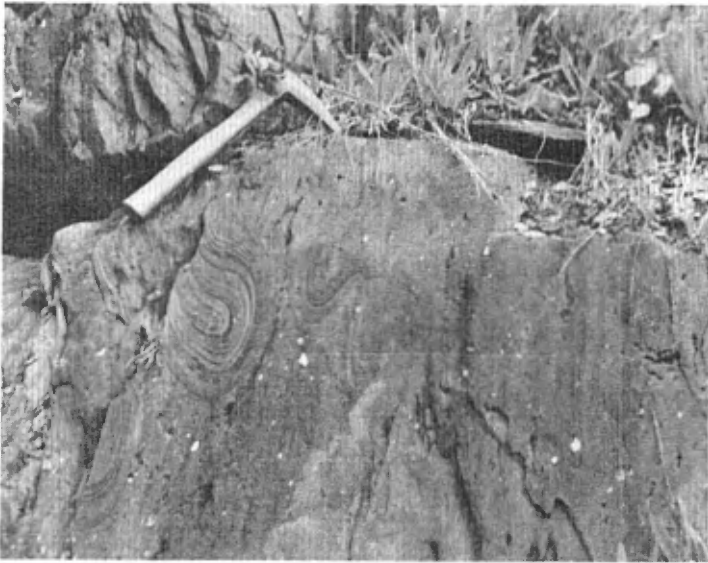
B

Volcanic conglomerate of the lower Sirois formation. Hillside west of Tommy brook.

PLATE V



A — Small-scale contortions in sandy-banded limestone of the Cape Bon Ami formation. Sinnett brook. Note cross-cutting cleavage.



B — Small-scale contortions in pebbly limestone of the Fortin group. Mourier brook. Note cross-cutting cleavage.

PLATE VI

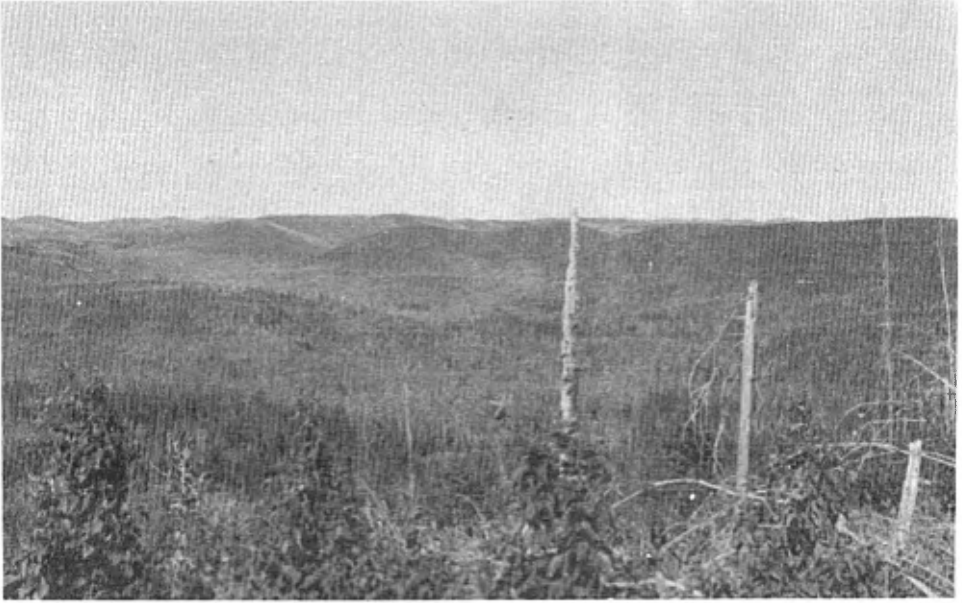


A — Vertical fracture partings in siliceous limestone of the Fortin group. Bonaventure river.



B — Steeply dipping fracture partings in siliceous limestone of the Fortin group. Patterson brook. Bedding dips moderately to left.

PLATE VII



A — Upper St-Jean river valley from the northeast. Gaspé upland (Surface II) in background. Elevated St-Jean valley (Surface III) in middle ground. Present river flows about 150 feet below Surface III.



B — Triangle lake (Surface III) from the west. Lower Sirosis hills in background.

the soft, greenish rocks of the Sirois formation. In practice this zone has been used to map the contact, because it is better exposed than the upper Sirois rocks and is easily traceable on the aerial photographs in most places. The rock is in finely laminated beds 1 inch to 6 inches thick. The laminations are very faint on the fresh surface, but commonly show up well on the weathered surface. The rock fractures in sharp, rectangular blocks.

In three thin sections, the rock appeared to contain 55%-95% of finely crystalline calcite, with rare dolomite rhombs, and up to 35% of cryptocrystalline silica. Sponge spicules, some of them well preserved, are abundant. Brown, semi-opaque matrix, and quartz silt are minor constituents. Analyses of the same three specimens show the content of calcite to range from 23% to 68%, with 6%-9% dolomite. The silica content ranges from 22% to 62%. The rocks therefore range from siliceous, magnesian limestone to calcareous, dolomitic, impure chert or porcellanite.

At its top the Cape Bon Ami grades into the Grande Grève formation, which is composed of similar siliceous rocks, and here also there is a zone of interbedded hard and soft rocks. This zone has been included in the Grande Grève formation.

The softer fine-grained rocks of the formation are in many places sharply contorted on a small scale (Plate V-A). The contorted strata occupy zones from a few inches to about 20 feet thick, and are overlain by undisturbed beds. The contortions are interpreted as the result of penecontemporaneous deformation, probably slump.

Strong cleavage is characteristic of these softer rocks, and cuts across the small bedding contortions. In thin section it appears to be slip cleavage. The bedding dips are moderate, but there are some minor tectonic folds. Both the folds and the cleavage are more intense than in the underlying Sirois formation. This is perhaps attributable to the higher proportion of soft, very argillaceous rocks.

The fossils collected from the Cape Bon Ami formation were identified as follows:

Square-sectioned crinoid column cf.
"Chonetes" sp.
Coelospira sp.
Leptocoelia ? sp.
Spinoplasia cf. gaspensis

Ancyrocrinus bulbosus
Bryozoans
Pleurodictyum ? sp.
Bactrites sp.
Worm trails or fucoids

Carbonaceous plant fragments are very common. The indicated age is Early Devonian, probably about the age of the New Scotland.

Elsewhere in the peninsula, the formation as here defined (not including the variegated Silurian beds at Forillon peninsula) has been similarly dated as Early Devonian. It is thought to belong mainly to the Helderberg, with possibly some transition into Oriskany time (McGerrigle, 1950, p. 63). However, since the formation everywhere rests conformably on Silurian rocks which are nowhere dated as younger than lower Ludlow, it is possible that the basal Cape Bon Ami may be Late Silurian.

Fortin Group

The Fortin group has previously been called the Fortin series or formation, but is here regarded as an informal group because: (a) it is defined chiefly by its lithological characteristics; (b) its age limits are uncertain; (c) it appears to contain equivalents of three formations recognized to the north and east, which, at least in some places, can be recognized within it.

The unit was first distinguished by Jones (1938, pp. 19-20), and named and described by McGerrigle (1950, pp. 75-78). In its type area, near the east end of the peninsula, the group underlies the York River formation, and overlies the Grande Grève. It thus occupies the stratigraphic position of the York Lake series, or facies. However, McGerrigle recognized the possibility that the group, as mapped, included rocks of Grande Grève and Cape Bon Ami age in its extension to the west. The present writer believes this in fact to be the case, and certain areas on the south side of the belt that seem to be referable with considerable certainty to the Grande Grève and York River formations have been mapped as such. The remaining part of the group within this area shows great lithological similarity to the Cape Bon Ami formation, and apparently occupies a similar stratigraphic position, immediately above the Silurian. It is however mapped, and described, as the Fortin group, partly because of the possibility that it includes rocks not referable to the Cape Bon Ami, and partly because of the uncertain status of the rest of the Fortin belt.

The group occupies a belt 5 to 10 miles wide across the southern half of the present area. It overlies the Mount Alexandre group to the south, and is bounded by faults to the north. It is best exposed on Bonaventure river, the upper part of Mourier brook, and several of the larger tributaries to Mourier brook on its north side. The structure is

too complex for any close estimate of thickness. The most that can be said is that the group is at least 1,500 feet thick, and possibly very much thicker.

In the present area, the group consists chiefly of dark grey, silty to finely sandy limestones and slaty mudstones, feldspathic sandstones, pebbly sandstones and limestones, and conglomerates.

The limestones and mudstones commonly contain finely sandy laminae, and are weathered brown. Tiny crystals of white calcite are visible in most specimens. Three thin sections show the detrital fraction to be subangular to angular silt and very fine sand, mostly quartz, with some feldspar, including fresh plagioclase. Muscovite is accessory. The matrix consists of varying proportions of carbonate, argillaceous material, and dark brown to opaque limonitic material. Indistinct laminae are formed by variations either in the proportions of limonitic material and silt, or in the grain size of the detrital fraction. Thin strings of dark matrix are also aligned parallel to the cleavage. Analyses of the same specimens showed the content of magnesium carbonate to be less than 3%.

Sandstone and conglomerate are more common in the Fortin than in the Cape Bon Ami. The sandstones are fine to coarse grained, greenish grey or brownish grey, and weathered light brown with rusty specks. Whitish-weathered feldspar is usually visible in hand specimen. Mica flakes and scraps of carbonaceous material are common. The rocks are slightly calcareous to non-calcareous. They are poorly sorted, and are identified in thin section as lithic wacke or arkosic wacke. The proportions of the main constituents in three specimens are as follows:

	(Fine grained) %	(Medium grained) %	(Medium coarse grained) %
Quartz, chert, quartzite	29	36	36
Unstable rock	8	15	24
Feldspar	18	9	12
Argillaceous matrix	32	22	25
Pyrite and limonite	9	6	3
Carbonate cement	3	10	-
Total	99%	98%	100%

The grains are angular to subrounded, and frequently etched. Quartz grains may be welded where in contact. The rock fragments include fine volcanic and granitic rocks, shale or slate, fine chlorite schist, and quartz-feldspar-mica schist. The feldspar is commonly altered, or replaced by calcite, but includes some fresh plagioclase. In the fine-grained specimen wavy strings of dark matrix parallel the cleavage, and give a sheared appearance to the section.

The conglomerates, pebbly sandstones, and pebbly limestones, contain rounded pebbles, up to about 1 1/2 inches, of white quartz, black, green, and red chert, white and pinkish quartzite, and aphanitic igneous rock. These are set in matrices of sandstone and sandy limestone similar to those described above.

In two broad bands along the southeast and northwest sides of the Fortin belt the group includes beds of siliceous limestones and calcareous cherts similar to those of the Grande Grève and lower Cape Bon Ami. The dips in the present area agree with the mapping to the east (Jones, 1938, p. 19) to suggest that the belt is, in general, synclinal. The siliceous rocks, therefore, are probably restricted to the lower half of the group. Along the southeastern border the base of the group is formed by about 200 feet of such rock. The rocks are medium to dark grey, faintly laminated, and weathered brown. They are in beds 1 inch. to 2 feet thick, and fracture in rectangular blocks. Thin beds of smooth, black chert are found in places. Three specimens that were thin-sectioned and analyzed all proved to be siliceous, dolomitic limestones. They consist mainly of very fine, clear to brown-stained carbonate. Angular to subangular, strongly etched quartz silt is a minor constituent. Siliceous sponge spicules, commonly replaced by calcite, are abundant. Dolomite rhombs and mica shreds are rare. Dark brown limonitic material is concentrated in thin laminae. Selective analyses gave percentages of silica from 27 to 45, of calcite from 42 to 63, and of dolomite from 10 to 12.

The soft, silty, sandy, and pebbly limestones of the group are commonly severely contorted, in the same manner as the similar rocks of the Cape Bon Ami formation (Plate V-B). The contortions are here, also, believed due to slumping while the rock was still plastic. The interbedded zones of harder, finer rock do not show such deformation.

The group as a whole is much folded, and there are many minor faults. In general, the dips are more gentle towards the south, and along the contact with the Mount Alexandre group the Fortin has fairly uniform low dips to the northwest. Cleavage is strongly developed

in the Fortin group, and is visible in almost every outcrop, including the sandstones. In the hard limestones it does not show on fresh surfaces, but is expressed on weathered surfaces as partings, spaced about 1 to 3 inches apart (Plate VI).

Carbonaceous plant fragments are common in many places in the Fortin. However the only identifiable fossils collected are a few bryozoans, collected outside the east boundary of the area. They have been identified by Dr. M.A. Fritz as follows:

Anastamopora quebecensis

Fenestella fortinensis

Dichotrypa sp.

Polypora orientalis

The collection also included Orthonychia sp., a small gastropod.

Anastamopora quebecensis has been found in the Fortin of Fortin township, and in the Four Mile Brook beds of Matapedia valley. Fenestella (Fenestrellina) fortinensis occurs in the Grande Grève. Polypora orientalis has been found in the Fortin in Power township, and also in the York River formation. (McGerrigle, 1950, pp. 72, 77, 82).

Fossils collected elsewhere from the Fortin compare most closely with those of the Grande Grève formation (McGerrigle, 1950, pp. 76-78). According to A.J. Boucot (personal communication, 1961) they indicate a Becraft-Oriskany age.

Grande Grève Formation

The Grande Grève formation was defined by Clarke (1908), and its type section is at Forillon peninsula, immediately overlying the Cape Bon Ami formation. It has been traced throughout eastern Gaspé at the same stratigraphic position.

In the northern part of the present area the formation crops out in three belts along the flanks and anticlinal axes of major folds, and also occupies the axial area of a subsidiary syncline in the northeast corner. It lies between the Cape Bon Ami formation below, and the York River formation above. At the south end of the area rocks of similar lithology, thought to belong to the same formation, underlie York River sandstone, and are faulted against Mount Alexandre and Fortin rocks. The formation is best exposed on York river, immediately northwest of Trois-Ruisseaux camp and again about 2 miles farther northwest, and on the Upper St-Jean road between Camps 24 and 25. At the last section its thickness is estimated at about 3,000 feet.

The Grande Grève is mostly composed of dark grey to brownish grey, moderately hard to very hard, siliceous limestone, and calcareous, impure chert. The rock is in beds from 1/2 inch to 1 foot thick, and weathers light brown to whitish brown. The weathered surfaces exhibit fine banding and lamination, and some small-scale cross-bedding. The rock fractures in sharp-edged, rectangular blocks. In places the freshly broken rock has a strong bituminous odour. Locally, beds of very smooth, calcareous chert occur. In the southern outcrop area there are some beds of finely sandy limestone up to 1 foot thick.

In three thin sections the rock appears to consist chiefly (75%-90%) of fine calcite. Sponge spicules are abundant; some are siliceous but most are replaced by calcite. Angular to subangular quartz silt makes up less than 5% of these specimens, and tends to be concentrated in thin laminae. In these laminae the calcite matrix is lighter, and coarser grained. Muscovite, dolomite rhombs, and calcareous pellets and fossil fragments, are accessory in some sections. Amorphous, brown to opaque material may occupy up to 15% of the section. Selective analyses of the three specimens give silica percentages from 32 to 52, calcite 24 to 48, and dolomite 12 to 14. These rocks are therefore siliceous, dolomitic limestones, and calcareous, dolomitic, impure cherts.* One thin section of the hard, sandy limestone showed it to consist of thin lenses (about 1 mm. thick) of alternate very fine, dark, probably siliceous carbonate, and coarser, sandy, fossiliferous limestone. The coarser lenses contain angular to rounded grains up to 0.5 mm. of quartz and fresh plagioclase, and fragments of sponge spicules, bryozoans, brachiopods, ostracods, and graptolites, up to more than 1 mm. The fine lenses also include much fossil material. The rock is a fine, bioclastic, siliceous limestone.

The lower 400 feet or so of the Grande Grève contains some softer, silty to finely sandy limestone of the Cape Bon Ami type. The two types are interbedded, in beds from 1 foot to 50 feet thick. In this zone the harder beds are undisturbed, while the intervening softer beds show intense contortion, probably due to slump. No bevelling was observed at the tops of the contorted beds, so that any slumping probably occurred after the deposition of the overlying harder rocks. Elsewhere the Grande Grève is in undisturbed parallel beds, except for rare small-scale crossbeds.

*The most careful work so far done on the Grande Grève rocks is that of Brummer (1955, pp. 23-30) in the area immediately to the north. He classified the rocks as bioclastic, calcareous siltstones. It is quite possible that much of the formation in the present area is also siltstone.

The formation, as a whole, has about the same structural complexity as the Cape Bon Ami formation. Outcrops are characterized by blocky jointing rather than by cleavage.

Sinuuous fucoids, or worm trails, are seen on many bedding surfaces. Identifiable fossils were collected only from one locality near the south end of the area, which gave:

Acrospirifer ? sp.

Cyrtina sp.

Beachia cf. thunii

Leptocoelia flabellites

"Chonetes" sp.

Strophomenoid

The indicated age is Oriskanian. The age of the Grande Grève elsewhere has been generally accepted as Oriskanian for some years (McGerrigle, 1950, p. 73), though Boucot (personal communication, 1961) suggests that its upper part is a little younger, being equivalent to the lower Esopus.

York River Formation

The York River is the lowest formation of the Gaspé Sandstone group, and conformably overlies the Grande Grève formation at Forillon peninsula, and throughout eastern Gaspé. In the present area it occupies the axial portions of two synclines in the northwestern part of the area, and a compound syncline near the south end. It is the youngest formation in the area, and, therefore, its original thickness is unknown. The thickness of the rocks remaining in most places seems to be about 2,000 feet. They are fairly well exposed on the more southerly of the two northern synclines, where it is crossed by York river and the Upper St. Jean road, and again on some of the small gullies tributary to Cotton brook on its north side.

The main constituent of the formation is a greenish grey or greenish brown, fine- to medium-grained, feldspathic and, in places, micaceous sandstone. The rock is massive, or in beds about a foot thick. It weathers greenish grey or reddish brown, with rust specks. The feldspar generally weathers white or grey, and is easily visible, but where fairly fresh it may be difficult to detect with a hand lens. In thin section, the rock is seen to consist chiefly of quartz (with some chert and quartzite), unstable rock particles, and altered or weathered feldspar, in an argillaceous or limonitic matrix. Accessory minerals are muscovite, biotite, and zircon. Carbonate was seen in only one of three thin sections. The proportions of the major constituents of these sections were:

	1	2	3
	%	%	%
Quartz, chert, quartzite	29	27	33
Unstable rock	32	23	27
Feldspar	15	11	14
Matrix	22	34	25
Total	<u>98%</u>	<u>95%</u>	<u>99%</u>

The rocks are classified as fine-to medium-grained lithic wackes. The grains are angular to subrounded. The rock grains are mostly fine granitic and volcanic types, with some slate and silty slate, and rare mica schist. The grains are closely packed, and in some places rock fragments and matrix are difficult to distinguish. Quartz grains may be welded where they are in contact.

A unique outcrop of coarse, volcanic arenite was found in the southern York River belt, immediately north of the Mount Alexandre volcanics. This contains more than 50% of rounded to subrounded volcanic particles, together with about 10% siltstone and silty shale grains, 15% feldspar, and a minor amount of quartz and chert.

In the southern belt there are also large quantities of massive, greenish grey, non-calcareous, argillaceous siltstone and silty mudstone. One thin section of this rock contains about 15% of subrounded to angular quartz silt, and 5% feldspar, with accessory muscovite and biotite. The argillaceous matrix is partly dark brown to opaque. The dark material tends to be concentrated in laminae, and is also aligned in thin strings parallel to the poorly developed cleavage. In the northern part of the area similar rock and some greenish grey shale are present, but rarely exposed.

On York river, one 2-foot bed of well-sorted, white, quartzose, feldspathic sandstone was seen, and debris of this type is abundant in some places along strike to the southwest.

In the most northerly of the York River synclines the lower part of the formation contains beds of hard, Grande Grève type, siliceous limestone, reaching thicknesses of at least 40 feet. The thickness of this zone of interbedding is uncertain, but appears to be somewhat less than 1,000 feet. To the north of the present area, where it is more persistent, and reaches a thickness of about 1,800 feet

(Brummer, 1955, p. 31), it has been mapped by Jones (1936) and Brummer as the York Lake series. McGerrigle (1954, pp. 43-44) considers it as a facies of the York River formation, and that practice is followed by the writer. In the more southerly exposures of the formation it does not appear to be present.

The structure within the York River formation appears to be simple in some places, but in other places there are sharp folds. In the southern belt, close to the fault contact with the Mount Alexandre group, the folds are nearly isoclinal. Cleavage is poorly to moderately developed in the finer rocks, and is expressed as widely spaced parting in the sandstones.

The fossils collected from the York River have been identified as follows:

<u>Beachia</u> ? sp.	<u>Nanothyris</u> sp.
<u>Costellirostra</u> ? sp.	<u>Platvorthis planoconvexa</u>
<u>Etyothyris gaspensis</u>	<u>Protoleptostrophia blainvillei</u>
<u>Howellella gaspensis</u>	<u>Schuchertella</u> sp.
<u>Leptaena "rhomboidalis"</u>	Leptostrophid
<u>Leptocoelia flabellites</u>	Dalmanitid pygidium

This is a typical lower York River fauna, and correlates with the Esopus (Boucot, personal communication, 1960).

Intrusive Rocks

Sills and dykes are common in the Ordovician and Silurian rocks, particularly in the former. Two occur in the basal part of the Cape Bon Ami formation, but none were seen in Fortin or Grande Grève rocks. A single outcrop was noted in an area assigned to the York River formation, in the southeast part of the area, though no York River rocks are visible nearby. The intrusions are mostly less than 30 feet thick, but a few are much larger. The largest is a sill close to 500 feet thick, at the top of the White Head formation on St-Jean-Sud river. It can be traced by debris and a few outcrops for 1 1/2 miles along strike, and may extend farther. A large dyke, nearly 400 feet thick, is intruded at the base of the Cape Bon Ami on St-Jean river, close to the east edge of the area.

Most of the rocks are light to dark grey, greenish grey, or green, and aphanitic to medium grained. The grain size varies roughly with the size of the intrusion. The visibly crystalline rocks are seen to be made up chiefly of light greenish feldspar, with some black pyroxene or amphibole, in a dark, chloritic matrix. The fine-grained types are commonly porphyritic, with feldspar laths up to about 1/2 inch long, and slightly smaller pyroxene crystals. The medium-grained types may have a blotchy appearance owing to relative concentrations of light and dark minerals in separate areas. Magnetite and pyrite are visible in most specimens, and pyrite may form thin, continuous films on joint surfaces. The rock weathers brown, with whitish feldspar crystals.

Eleven thin sections show the rocks to have intersertal to intergranular textures. The three invariable constituents are feldspar, chlorite, and opaque iron "ore". The feldspar makes up 55%-75% of the rock, and occurs in laths ranging from about 0.25 mm. to 2 mm. in length, with phenocrysts to 4 mm. It is mostly altered, and largely replaced by calcite and chlorite. Where fresh it is identified as plagioclase, varying from lauradorite to oligoclase in different sections. Fine chlorite makes up 10%-20% of the rock, apart from its occurrence as an obvious replacement mineral. Opaque granules and crystals have been identified as pyrite, magnetite, titaniferous magnetite, and ilmenite. Traces of hematite and chalcopyrite were also recorded. Sphene occurs in a few sections, some of it replacing magnetite. In one section leucoxene replaces skeleton crystals of ilmenite. These iron and titanium "ores" occupy 5%-15% of the sections.

Augite is identified in most sections, and may form up to 15% of the rock, as broad, subhedral crystals up to 4 mm. long. It is commonly replaced by chlorite, or more rarely by hornblende. Calcite, apart from its obvious replacement of other minerals, may occur in the interstitial matrix, and form up to 10% of the rock. Rare accessory minerals are apatite, biotite, and quartz.

Selective analyses of six specimens gave fairly consistent results, corresponding with the composition of diabase. The average analysis, and the minimum and maximum values for each constituent, are given below:

	<u>Average</u> %	<u>Minimum</u> %	<u>Maximum</u> %
SiO ₂	45.12	42.58	47.56
Al ₂ O ₃	15.77	15.17	16.38
CaO	7.20	6.12	7.85
MgO	6.50	5.21	7.56
FeO	8.90	7.89	10.52
Fe ₂ O ₃	3.11	2.04	4.96
Na ₂ O	3.22	2.62	3.77
K ₂ O	0.75	0.31	1.72
CO ₂	2.18	0.04	5.70
H ₂ O	<u>3.76</u>	<u>3.19</u>	<u>4.52</u>
Total	96.51%		

Approximate calculations of normative feldspars from these figures gave percentages of plagioclase between 50 and 55, with compositions from An₄₀ to An₅₅. Added to these are percentages of orthoclase from 2 to 10.

One thin section, from a 14-inch-wide dyke intruded in calcareous siltstone, is unusual in containing about 35% of hornblende, without pyroxene. The hornblende is largely altered to magnetite, calcite, and chlorite. The feldspar content appears to be no more than about 40%. The calcite content is more than 20%, including replacements. The analysis corresponding to this specimen follows:

	%
SiO ₂	40.24
Al ₂ O ₃	13.87
CaO	11.25
MgO	8.46
FeO	5.05
Fe ₂ O ₃	2.74
Na ₂ O	2.32
K ₂ O	2.37
CO ₂	6.24
H ₂ O	3.73
Total	<u>96.27%</u>

These figures correspond to a normative feldspar content of about 40% plagioclase (An₅₀) and 15% orthoclase.

One 8-foot dyke in the White Head formation, on St-Jean-Sud river, is of somewhat different type. This is a pink rock, composed mostly of pink feldspar in a chloritic matrix, with blebs of white calcite. It is seen in thin section to contain about 70% of altered feldspar. This is reddish, particularly along the edges of the crystals. The matrix is of chloritic material and biotite, with accessory opaque minerals, calcite, sphene, and quartz. Rocks of similar appearance were found in debris at a couple of places just north of the northern belt of the Mount Alexandre volcanics.

Some of the igneous bodies mapped as sills in the southeastern corner of the area, near the base of the Mount Alexandre group, bear calcite amygdules and may be lava flows rather than intrusions. In thin section, one such rock revealed a slightly pilotaxitic texture. The rock consists of about 65% feldspar (including some phenocrysts), partly replaced by calcite, about 20% chlorite, 10% pyrite and sphene, and 5% calcite. The feldspar appears to be albite. Selective analysis of this specimen gave:

	%
SiO ₂	49.79
Al ₂ O ₃	15.71
CaO	5.37
MgO	3.74
FeO	6.56
Fe ₂ O ₃	2.26
Na ₂ O	5.30
K ₂ O	1.45
CO ₂	3.28
H ₂ O	3.11
	<hr/>
Total	96.57%

This corresponds to a normative feldspar content of about 60% plagioclase (An₂₅) and 10% orthoclase.

Inasmuch as intrusive rocks are much more common in rocks older than the Mount Alexandre volcanics than in those younger, and as they bear a general resemblance to the less silicic of the lavas, it seems likely that most of the intrusions were related to the volcanism, and are of Silurian age. However, intrusions are also found in the Cape Bon Ami and York River formations, and so intrusive activity must have continued at least into Early Devonian time. Some of these later intrusions seem to be related to major normal faults.

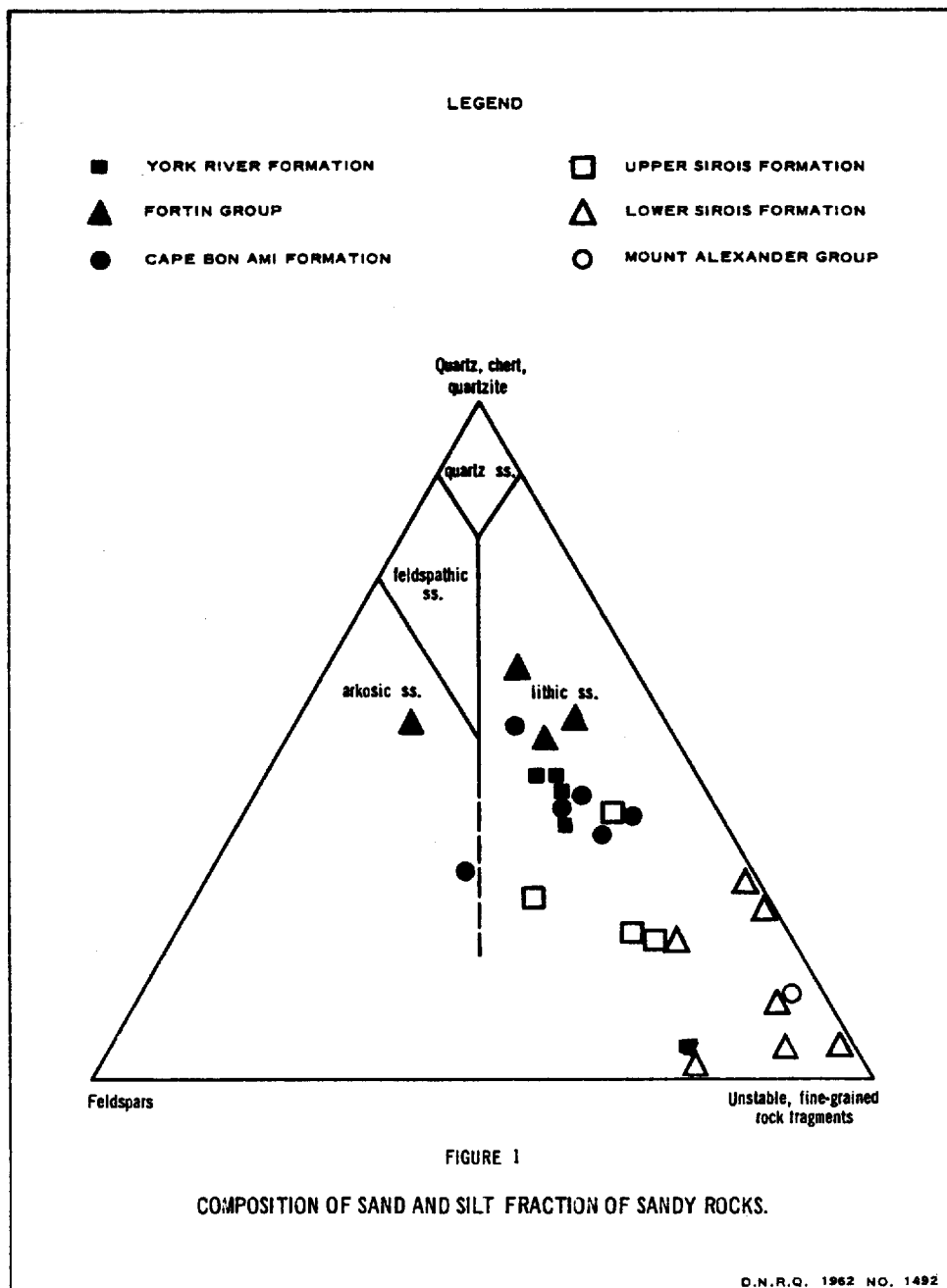
Pleistocene and Recent

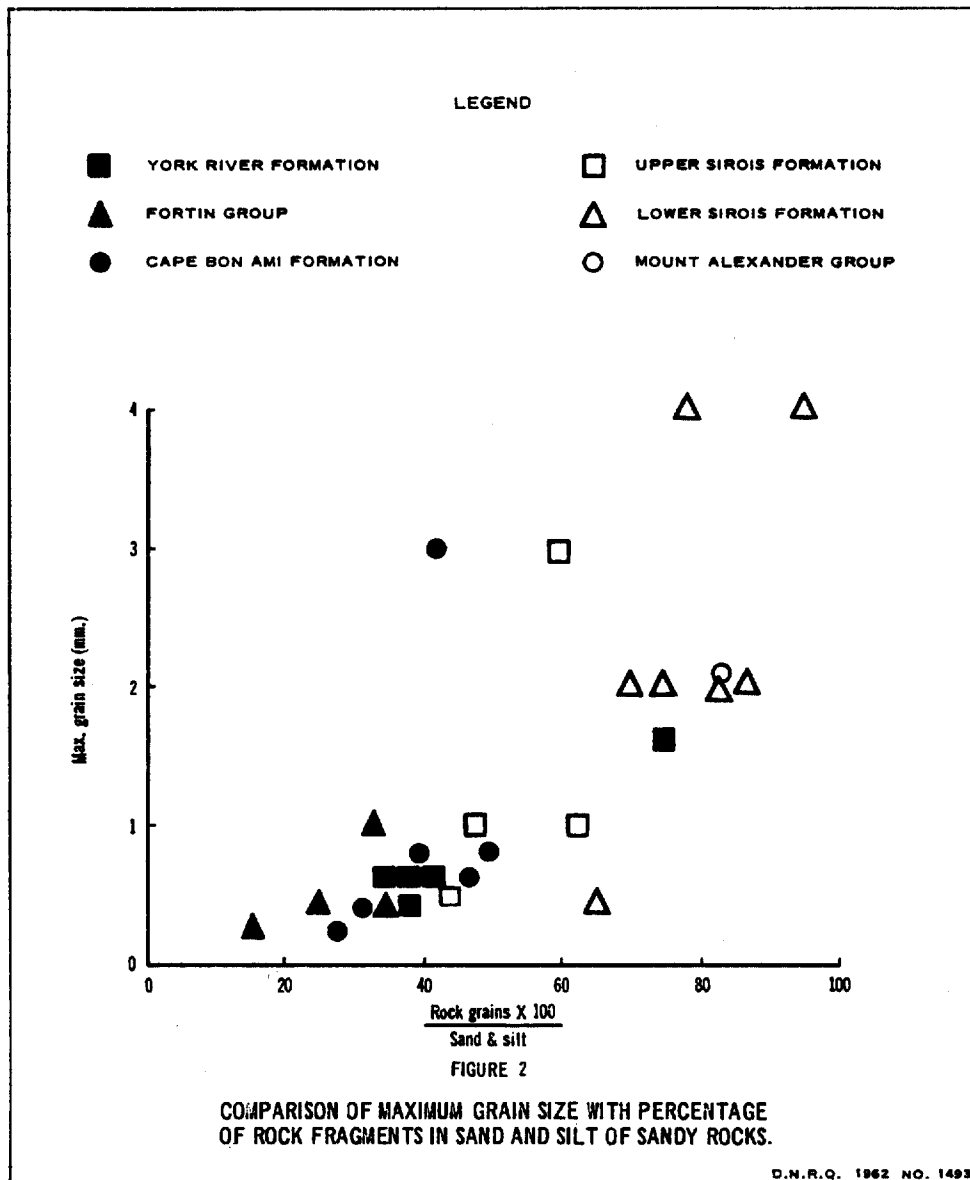
Glacial deposits, and other evidences of glaciation, have been recognized in many parts of the peninsula by several different investigators (see McGerrigle, 1952). It may now be accepted as an established fact that the peninsula was overridden by at least one continental ice sheet during the Pleistocene, although its deposits were unusually slight. The closing stages of glaciation were marked by valley glaciers at the higher elevations. In particular Brummer (1955, pp.54-59) found evidence of valley glaciation on the headwaters of York river, immediately north of the present area. He found all the major valleys to have rounded, glaciated profiles, and their floors to be covered by drift. However, he considered it doubtful if the glaciers moved south and eastward out of his map-area (the northwest quarter of Holland township). Soils on the upland surface were considered residual and probably post-glacial, the evidence for ice-sheet glaciation being restricted to some striae, and scattered erratics.

In the present area, no continuous deposits of definitely glacial origin and no positive physiographic evidence of glaciation were noted. None of the outcrops have smoothed or striated surfaces. The upland surface is covered by a mantle of weathered debris, at least 2 feet thick in most places, that is approximately in place.

However, erratic boulders are common. A few of these came from outside the area, and include boulders of gneissic granite, which may have come from the Tabletop region or the north shore of the St. Lawrence, and quartz-feldspar porphyry and altered Grande Grève siltstone from the Murdochville area immediately to the north. In addition, boulders, and some smaller debris, of easily recognizable local rocks are found well to the south of their outcrops, in places where they could not have been carried by the present drainage. In particular, boulders of lower Sirois conglomerate and calcarenite are very common up to about 2 1/2 miles south of their outcrops. The movement appears to have been a little east of south.

At, or near, the bottoms of many of the valleys and gullies unconsolidated deposits (in one place at least 15 feet thick) of unsorted, unstratified rock material are exposed. It has the general appearance of glacial drift. However, the rock fragments are all of immediately local origin, and are not striated or faceted. Moreover, the deposits have little clay content. It is thought that this material is the result of weathering, and has moved down slope under the influence of gravity and frost action. The deposits are particularly apparent at





higher elevations, where even the steepest gullies contain 3 feet or more of this material, though it is washed to a fairly well sorted gravel in the brook beds. There are no outcrops on most of these higher gullies. In contrast, the steep gullies at lower elevations contain no such deposits, and are characterized by outcrops and rock falls. This fact is thought to be contributory evidence for two stages of gully erosion (see p. 62).

Alluvial gravels occur along the courses of all the larger streams. On lower Mourier brook and on Bonaventure river some cuts expose as much as 20 feet of stratified gravel. Small alluvial cones are seen some places where steep tributaries issue on to the narrow valley flats. The small lakes are floored by white marl deposits, with abundant small pelecypod and gastropod shells.

The Sandstones

The sandstones of the area, of whatever age, are characterized by their high content of rock fragments. Because of this they are most conveniently classified by the system of Gilbert (Williams, Turner, and Gilbert, 1954). An attempt to estimate the content of feldspars in the fine igneous rock particles would be of doubtful value. Figure 1 shows the sand and silt fractions of all thin sections of finely sandy to pebbly rocks on the Gilbert triangular diagram. The diagram illustrates clearly that, although all the sands are substantially lithic, the Silurian, and particularly the Laforce, sands are far more so. However, it might be expected that the proportion of lithic fragments is related to grain size. Figure 2, a plot of the lithic content of the sand and silt against the maximum grain size in each section, shows, in fact, a considerable degree of correlation between the two variables. It appears to indicate, nevertheless, that in a general way the Silurian sands are more lithic than Devonian ones of equal maximum grain size. It should be mentioned that the single highly lithic York River specimen represents a unique outcrop of volcanic sandstone.

The Gilbert diagram also indicates that the Laforce sands have a tendency to a lower content of free feldspar. This correlates with their high content of sedimentary, as opposed to igneous and metamorphic, rock particles.

Stratigraphic Contacts

White Head - Sirois - Mount Alexandre

It was suggested by both Jones (1938, p. 23) and McGerrigle (1950, p. 96) that the Sirois formation rests unconformably on the White Head. The arguments in favour of such an unconformity are: (1) the greater intensity of deformation in the White Head limestones than in the Sirois; (2) the well established Ordovician-Silurian unconformity farther north, along the edge of the Silurian-Devonian belt; (3) the apparent variation in the thickness of the upper member of the White Head (see p. 17); (4) the presence of probable detritus of the White Head limestones in the lower Sirois (see p. 26). A fifth argument, the apparent time gap from Late Ordovician to Middle Silurian, has become doubtful in view of the possibility that the upper member of the White Head is Silurian (see p. 17).

On the other side of the question it can be stated that: (1) lithological differences between the White Head and Sirois could account in large part for the differences in intensity of deformation (The Devonian rocks are also more deformed than the Silurian in many places); (2) well established angular unconformities elsewhere in the region are between Silurian and Lower or Middle Ordovician, rather than Upper Ordovician rocks; (3) variation in thickness of the upper White Head could be primary, or owing to unrecognized structural complications; (4) there is no direct evidence of discordant relations (in the present area the contact is exposed only where it crosses St-Jean-Sud river, and here the situation is somewhat obscured by the intrusion of a large sill. Some of the altered beds above the sill are believed to belong to the White Head. They are overlain, after a covered interval of about 10 feet, by approximately parallel Sirois sandy limestone beds).

On balance, it may be considered probable that the White Head rocks were slightly deformed, uplifted, and eroded, before the deposition of the Sirois, but there is no clear evidence for a period of strong deformation.

At the south end of the area the situation is even less clear, owing to the scarcity of outcrops. However, study of aerial photographs reveals that the bedding strikes are apparently less consistent in the White Head here than in the Mount Alexandre; in fact, this characteristic has been used as an aid to mapping the contact.

Sirois - Cape Bon Ami

No Silurian above the lower Ludlow has been definitely recognized in Gaspé Peninsula. However, it should be pointed out that the lower Ludlow rocks have usually been recognized only by their monograptid faunas, and that monograptids are rare above the lower Ludlow. It is, therefore, possible that the Cape Bon Ami formation is transitional from Upper Silurian to Lower Devonian. Neither at the type section nor in the present area is there evidence for a stratigraphic break between the variegated Silurian rocks and the overlying Cape Bon Ami. On the other hand, there is no positive evidence for the existence of upper Ludlow equivalents, and the presence of a depositional hiatus cannot be disproved.

Mount Alexandre - Fortin

The contact between the Mount Alexandre and the Fortin in this area is believed to lie at about the same stratigraphic level as that between the Sirois and the Cape Bon Ami. However, between the two former units there is some structural discordance. The basal Fortin rocks strike consistently parallel to the contact, with low to moderate dips to the northwest. The Mount Alexandre rocks also dip northwest, and trend roughly parallel to the contact, but their strikes are, in detail, very irregular. The relations are similar to those between the White Head and Mount Alexandre, and, in the same way, may be accounted for, at least in part, by differences in competence, in view of the contrast between the soft shales and siltstones of the Mount Alexandre and the overlying very hard, siliceous beds of the basal Fortin. Aside from this possibility the contact must be either a fault or an unconformity. In the area to the east, the contact was interpreted as a major fault (Jones, 1938, p. 24), and it is quite possible that such a fault continues across the present area, either at the contact or close to it. However, in the absence of any positive evidence for such a fault in this area, the contact is provisionally interpreted as a slight unconformity.

Intra-Devonian

The contacts between Cape Bon Ami and Grande Grève and between Grande Grève and York River are apparently conformable. In many places they are gradational, with interbedding of the respective rock types.

Structure

Folds and Faults

Throughout much of the area outcrops are widely spaced. In addition, rocks of similar lithology occur in different formations, and it is not always possible to be certain of the formation to which any particular outcrop belongs. Therefore, although many of the structures shown on the accompanying map are approximately correct, others are only tentative explanations based on incomplete evidence. These doubtful structures will be distinguished in the following paragraphs.

The area is divided, structurally, into four main blocks, separated by major faults that, in general, run approximately parallel to the general strike of the region, i.e. a little north of east.

The northernmost block occupies roughly the northern half of the area. It contains a continuous sequence of five formations, the White Head, Sirois, Cape Bon Ami, Grande Grève, and York River. It is crossed by six major folds, all trending northeast. Across these folds there is a slight regional dip to the northwest, so that the oldest rocks are exposed only in the southeast and the youngest, only in the northwest. The general form of the folds is quite clear, although the exact position of the formational contacts is not everywhere certain. The southernmost major anticline, the St. John River anticline, plunges gently southwest. The other folds to the northwest plunge northeast, so that Sirois rocks exposed on the two more northerly anticlines are overlain to the northeast by the Cape Bon Ami and Grande Grève. Minor folds of various magnitudes are recognized within these broad structures. In most cases they cannot be certainly traced for any distance.

On the northernmost anticline in the area a narrow belt of Sirois rocks is exposed on St. Jean river. Between the outcrops of Sirois and of Grande Grève there are no unmistakable Cape Bon Ami rocks either in outcrop or in debris. Moreover, the horizontal distance between Sirois and Grande Grève outcrops on both sides of the fold is less than 2,000 feet. The occurrence of some debris of breccia, and a study of the aerial photographs, confirm the probability of a fault on each side of the anticline. The directions of dip of the faults are unknown, but the core of the anticline has moved upwards relative to its flanks.

On the northwest limb of the next anticline to the southeast a thrust fault has already been mapped on the northeast side of York river (McGerrigle, 1950). Its continuation across the present area is based mainly on the absence of lower Cape Bon Ami beds and study of the aerial photographs. The fault dips to the southeast, the rocks on the southeast side being thrust northwestward. It is apparently cut by a transverse shear fault, along which the rocks on the northeast side are displaced about a mile to the southeast.

The south limit of the block is another major fault, which brings the Sirois and White Head formations in contact with the younger Fortin rocks to the south. In the area to the east the fault was interpreted as normal, with downthrow on the south side (Jones, 1938, p. 24), and no evidence to the contrary was observed in the present area. This fault is cut by a major shear fault, with movement to the southeast on the northeast side. The trace of the latter fault is very clear on the aerial photographs, and its displacement of the geological formations is obvious, the horizontal separation being about 3 1/2 miles.

The second structural block is occupied by the Fortin and Mount Alexandre groups. The Fortin occupies a broad belt of general synclinal form, bordered on the southeast by an apparently anticlinal belt of Mount Alexandre rocks. The contact between the two groups was interpreted by Jones (1938, p. 24) in the area immediately to the east, as a major fault. In the present area there is no direct evidence for such a fault, and the contact is presumed to be a slight unconformity (p. 52). The Mount Alexandre rocks plunge out to the southwest, and are overlain in that direction by the Fortin. The contact here is displaced by two east-west faults, apparently forming a horst structure. The northernmost has an apparent vertical separation of some 2,500 feet up on the south side. The continuation of this fault to the northeast is proposed principally to account for the absence of volcanic rocks on the north limb of the anticline farther east.

The next structural block to the south is occupied by Grande Grève and York River rocks. These are brought down to lie against the Mount Alexandre and Fortin by a major fault which runs northeast across the area. As much as 5,500 feet of the stratigraphic sequence is cut out by this fault, and the vertical separation on it must be at least that great. The Grande Grève and York River rocks apparently lie in a southwest-plunging, compound syncline. However, at the east end of the syncline there are no outcrops, and the structure is hypothetical, being based on topographic trends. Presumably the Grande Grève is underlain on the east by the Cape Bon Ami (or Fortin) and Mount Alexandre.

This third structural block is bounded on the south by another major fault. The trace of this is strongly curved, convex to the north, and suggests a thrust. In that case Mount Alexandre rocks have been thrust northwestward onto the Devonian.

The Mount Alexandre rocks of the southernmost block apparently dip consistently to the northwest, except for some minor folds close to the northwest boundary fault.

Cleavage and Joints

Cleavage is in evidence throughout the area, though it is only well developed in the White Head, Fortin, and Cape Bon Ami. In thin sections of Fortin and Cape Bon Ami rocks there is no recognizable orientation of mineral grains parallel to the cleavage, and the cleavage appears to be a close fracture or slip type rather than true slaty cleavage. However, it is probable that flow cleavage does occur in the slaty rocks of the White Head.

The strike of the cleavage is generally approximately parallel to the major fold axes, although there are marked local variations. In the northern half of the area, north of the St. John River anticline, the cleavage dip is vertical, or steep in either direction. South of the St. John River anticline the cleavage as a rule dips steeply to the northwest.

The principal joints, throughout the area, strike northwest, approximately at right angles to the cleavage, and have dips close to the vertical.

CORRELATION

Mount Alexandre and Sirois

There is no certain basis for detailed correlation between the two belts of the Mount Alexandre group. However, in the absence of evidence to the contrary, the simplest assumption is that the volcanic rocks in the two belts are equivalent. In this case the predominantly calcareous beds overlying the volcanics in each belt would also be equivalent. Both are characterized in part by brown, smooth to crystalline limestones. The upper, non-calcareous beds of the northern belt would be cut out by faulting in the south.

The Mount Alexandre group and the Sirois formation are both Silurian, although the precise age limits of the Mount Alexandre are not known. Compared with the Ordovician and Devonian rocks the two units are generally similar lithologically, but there is little correspondence in detail, and the manner of correlation is not obvious. Perhaps the best evidence is that of the volcanic conglomerates. These occur near the base of the Sirois on its south side, and a little above the lavas in the Mount Alexandre. The Laforce conglomerates are, in places at least, so overwhelmingly volcanic as to suggest that they were derived from a close, and entirely volcanic, terrane, perhaps even from an actively volcanic source. The only nearby volcanics that are old enough are those of the Mount Alexandre. Therefore the base of the Sirois is tentatively correlated with the upper part of the Mount Alexandre lavas. In this case the lower Sirois sandy limestones and calcarenites would be correlatable with the calcareous rocks of the upper Mount Alexandre, and the silty and argillaceous beds of the upper Sirois with the siltstones and shales of the upper Mount Alexandre. The lower Mount Alexandre is probably not represented to the north, unless perhaps, by the upper member of the White Head.

If this correlation is correct, it would appear that the Mount Alexandre lavas are of about Wenlock age. In this case they could not be correlated with the volcanics in the Chaleurs Bay group at Black Cape. These latter are at the level of the West Point formation, and lie well up in the Ludlow. It would appear rather that the Mount Alexandre volcanics correlate approximately with the La Vieille formation. Any detailed correlation between the Sirois and Mount Alexandre sections and the Chaleurs Bay group is, however, not feasible at this stage.

Fortin

The general lithological assemblages of the Cape Bon Ami formation and that part of the area mapped as Fortin are very similar. In addition both units contain fine, siliceous, calcareous rocks in their lower parts. The bases of both units, resting on the Silurian, are defined by thick beds of siliceous rock. It therefore seems very probable that, in this area, the two units are equivalent. It is believed that equivalents of the Grande Grève and York River formations south of the St. John River anticline have been recognized, and mapped, as such. However, it must be pointed out that the siliceous rocks of the Cape Bon Ami, Fortin, and Grande Grève are practically identical, and the sandstones of the Cape Bon Ami, Fortin, and York River are also very similar. It is possible, therefore, that some Grande Grève and York River rocks are included in the area mapped as Fortin. Farther east the Fortin undoubtedly does contain Grande Grève and York Lake equivalents.

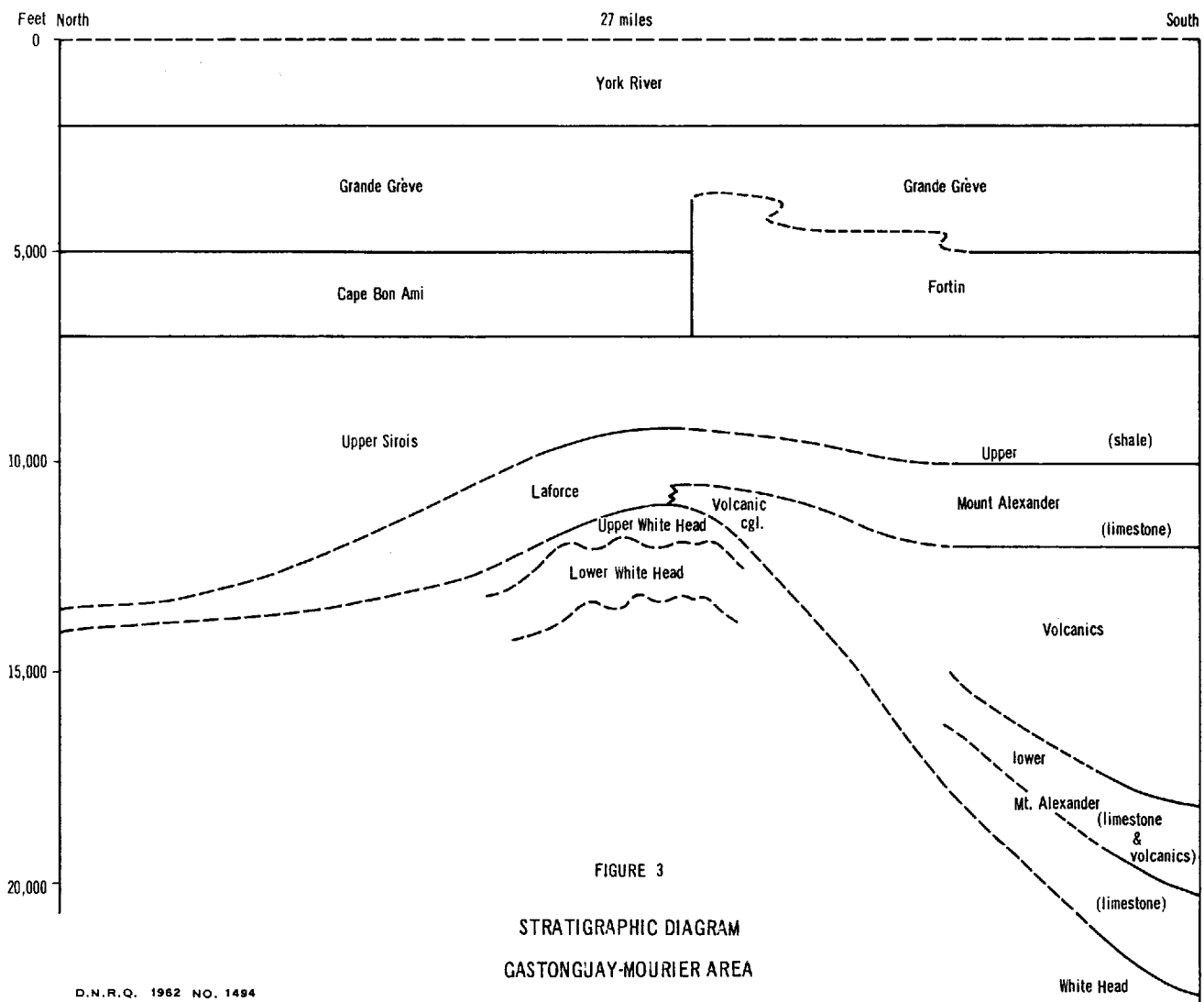
General

Figure 3 is a stratigraphic diagram of the Gastonguay-Mourier area. It purports to show a north-south vertical section of the area as it was before the Acadian revolution. It must be emphasized that it is only tentative, and includes many uncertain interpretations. The vertical exaggeration is about five times.

TECTONIC HISTORY

No attempt is made here to reconstruct the complete geologic history of the area. Such an attempt must await more careful work, and a better understanding of the geology of the peninsula as a whole. However, certain comments and suggestions follow.

1. The fact that no distinct angular unconformity is observed between Upper Ordovician and Silurian rocks does not suggest any major revolution in the interval between. Nor does the character of the White Head formation indicate orogenic activity in the region during its deposition. The possibility remains that the main stage of Taconian deformation in Gaspé Peninsula took place a little earlier, in early Late Ordovician time.
2. The universally lithic character of the sands of the area, from Middle Silurian to Early Devonian age, suggests a continually high ratio of erosion to weathering rate in the source areas during that time. This in turn suggests continually active tectonic conditions in the source areas.
3. The relatively more lithic character of the Laforce in comparison with the younger rocks, associated as it is with coarser grain size, suggests either relatively more active tectonic conditions, or a closer source. The higher proportion of sedimentary and volcanic particles in the Laforce sands, compared with the largely metamorphic and plutonic content of the younger rocks, confirms the likelihood of a close source. In fact, the coarse clastics of the lower Sirois are thought to be mainly derived from the White Head formation, and the Mount Alexandre volcanics. It seems probable that they were the result of local upheavals and volcanism within the Silurian sedimentary trough. The upper Sirois is transitional in many respects between the Laforce and the Devonian.



D.N.R.Q. 1962 NO. 1494

4. The Sirois rocks, in comparison with the Devonian, are relatively well sorted. They are characterized by fine cross-bedding rather than by slump structures and graded bedding. They would appear to have been deposited in a relatively stable trough, where the rate of subsidence was not usually greater than the rate of deposition. Although they contain graptolites, fragmental shelly material is far more common. The same remarks apply, with less force, to the Mount Alexandre group. Thus, although the Silurian sequence contains a considerable thickness of volcanic rocks, it is distinctly not typically eugeosynclinal.

5. In most places in Gaspé Peninsula there is no detectable unconformity between Silurian and Devonian rocks. However, the disconformable relation between the Mount Alexandre and Fortin groups indicates that locally there was some slight deformation and erosion between Silurian and Early Devonian times.

6. The Devonian sandstones are largely composed of metamorphic and granitic rock material. The source of this material was probably outside the limits of the Devonian trough. Roliff (1952, pp. 56-59) concluded that the thicker and more clastic character of the Gaspé Limestone sequence to the south indicates the principal source in this direction. In the present area the more sandy character of the Cape Bon Ami formation south of York river and the still more clastic, and somewhat less calcareous, character of the Fortin group, support this conclusion for rocks of Cape Bon Ami age. The Grande Grève formation shows little lateral variation. Carbonneau (1953, pp. 204-209; 1959, p.43) concluded, on the basis of a very detailed investigation, that the Gaspé Sandstones (including the York River formation) were derived from the Canadian shield, and the Ordovician Quebec group, to the north. The writer has no quarrel with this conclusion. However, Carbonneau's chief argument, that the Canadian shield is the only known area of crystalline rocks of sufficient extent and proximity to have provided a suitable source, would be weakened by any conclusion that the very similar Cape Bon Ami and Fortin sands were derived from the south.

7. The Devonian rocks south of York river are, in general, poorly sorted. The softer carbonate rocks of the Fortin and Cape Bon Ami are characterized by plastic deformation, which probably occurred soon after deposition. These facts point to deposition in a basin which was usually unstable, with subsidence outpacing deposition. The fine siliceous rocks of the Fortin, Cape Bon Ami, and Grande Grève may represent times during which little clastic material was available from the source areas.

8. The Sirois formation on St-Jean-Sud river is only 4,000 feet thick. This compares with at least 6,700 feet for the same formation in Holland township to the north, and a possible composite thickness approaching 19,000 feet for the Mount Alexandre group (see Figure 3). This indicates that the St. John River anticline was already a positive element in Silurian time, sinking less rapidly than the areas on either side.

McGerrigle (1950, p. 78) has suggested that an Early Devonian barrier along the St. John River anticline, separating two depositional troughs, "would help explain some of the differences between the northern and southern representatives of the Gaspé Limestones". In the present area, however, the transition from the typical argillaceous limestones of the Cape Bon Ami to the sandy southern facies occurs shortly south of York river. There is no abrupt lithological change across the St. John River anticline, from Cape Bon Ami to Fortin.

9. The major structures of the region comprise northeasterly-trending folds, thrusts, and high-angle faults, and southeasterly-trending shear faults. The folds and thrusts are presumably the result of the main compressive phase of the Acadian revolution. The high-angle faults may be assumed to be normal faults, in the absence of evidence to the contrary, and presumably date from a succeeding period of tensional forces. The shear faults cut across both thrusts and normal faults and indicate a clockwise couple, with movement to the southeast on the northeast side, consonant with the proposed shear zone between the Maritime Provinces and Newfoundland (see Tectonic Map of Canada, Geological Association of Canada, 1950).

GEOMORPHIC DEVELOPMENT

Alcock has presented a fairly complete account of the geomorphology of the Chaleurs Bay region, and related it to erosion surfaces throughout Gaspé Peninsula and the Maritime Provinces (1935, pp. 109-116). He recognized, first, a high upland which forms the tops of the Shickshock mountains in northern Gaspé, at an elevation of about 3,700 feet. He went on to say (p. 114):

"The upland of Nova Scotia has been termed the Atlantic upland, and it seems evident that the uplands of Newfoundland, Gaspe, and New Brunswick are to be correlated with it. It truncates complicated geological structure and clearly represents a peneplained surface. The present elevation of the Atlantic upland is due to a general warping which was differential in character, the greatest elevation taking place to the north and west in central Gaspe.

"The Lower plateau of Gaspé, which is best seen north of the Shickshock range, represents the development of a second peneplain formed on the softer rocks, after a period of uplift. Owing to greater hardness and resistance to weathering or to favourable locations along divides, parts of the old surface were little affected by this later cycle of erosion. The 1,200-foot surface of Tobique area (New Brunswick) is thought to correspond to the 2,000-foot surface developed on limestone country immediately south of the Shickshocks. Below the Atlantic upland in Nova Scotia are carved lowlands of great extent where the surface rocks consist of soft shales and sandstones of the Carboniferous system. This new plain lies from 300 to 500 feet below the upland.

"The present valleys mark a new cycle of erosion. Many of these in Gaspé and northern New Brunswick show evidence of two stages, upper gentle slopes being truncated by lower steeper ones. The extremely youthful character of these lower parts of the valleys ...suggests that the uplift that inaugurated this late stage took place comparatively recently, probably late in the Pliocene.

"The uplift that initiated this late stage carried the region to a height greater than that at which it stands at present. Borings in the valley of the Restigouche at Matapédia show 70 feet of unconsolidated material below the level of the river and Chaleur Bay itself has a depth of over 300 feet".

The Atlantic upland (which may be referred to here as Surface I) is apparently not represented in the present area, which lies only about 25 miles southeast of the Shickshocks, and whose highest points reach only 2,400 feet.

The main Gaspé upland (Alcock's "lower plateau of Gaspé") may be referred to as Surface II. It is well preserved in the present area, its lower limits being defined by the highest convex slope-breaks, or truncations, on the valley walls and hill flanks. It is by no means a flat surface, since these slope-breaks can be traced from an elevation of 1,400 feet to 2,200 feet within the area. Its total relief in the area must have been at least 1,000 feet. The surface apparently reached a stage of late maturity, and was well adjusted to the underlying structure. The ranges underlain by the lower Sirosis and the southern

Mount Alexandre volcanics were already prominent. The surface does include broad areas of gentle relief, particularly on the Fortin belt, and even more notably on the Matapedia limestones south of the map-area. However, these areas cannot be called peneplains since they are strictly controlled by structure. The cross-cutting Bonaventure valley could scarcely have been developed at this time, or at any time since, leaving aside the possibility of superposition from a sedimentary cover. It was presumably inherited from the well developed peneplain of Surface I. Surface II has an overall slope to the south, and near the Chaleurs Bay coast is only about 1,000 feet above sea-level.

Surface III, which is represented by the upper, more gentle slopes of the valley sides near the Chaleurs Bay coast, is better preserved in this inland area. It forms the broad, elevated valleys of Triangle brook and the upper St. Jean (Plate VII). It is on this surface that most of the lakes of the area are found. The slope-breaks marking its lower limits can be traced from 1,000 feet above sea-level to about 1,800 feet. The total relief of the surface within the area was therefore at least 1,400 feet. It apparently reached a stage of late youth. Although it is in places well adjusted to structure, this is probably mainly because its drainage was inherited from that of Surface II.

The most recent rejuvenation has cut steep valleys into Surface III, and in many places on the lower courses of the streams has removed all traces of it. The modern rivers have many rapids and are not graded. However, some stretches seem to be graded with respect to local base-levels. The narrow valley flats may be partly the result of such local grading, and partly of accidental lateral erosion at river bends.

The latest rejuvenation has not reached as far up the streams as that of the previous cycle. Going up one of the larger brooks one may pass through a steep, rejuvenated valley, up into an open, mature valley, and thence up to the steep gullies of the previous cycle. It has already been mentioned (p. 50) that these higher gullies have few outcrops, and are apparently not being actively eroded at present.

ECONOMIC GEOLOGY

Metallic Minerals

No important metallic mineral occurrences were discovered. Magnetite and pyrite are common accessory minerals in all the igneous rocks, and in many of the sandstones. Hematite, ilmenite, and traces of chalcopyrite are seen also in the igneous rocks.

Non-metallic Deposits

Gravel is plentiful along all the larger streams. Marl deposits occur in most of the small lakes in the central part of the area, but too far from populated areas to have any interest at present.

Petroleum

Some calcareous rocks of the Grande Grève formation and of the upper Mount Alexandre group have a strong bituminous smell. The Grande Grève rocks may be too dense to form oil reservoirs, but those in the upper Mount Alexandre are reefy limestones with considerable coarse pore-space. The only possibility of a trap involving these latter rocks would seem to be along the fault separating the northern Mount Alexandre belt from the Grande Grève formation.

No other rocks of appreciable porosity are known in the area. However, it is possible that similar reefy limestones exist in the Laforce member in the subsurface. They are known to occur at about the same stratigraphic level to the north and east, as well as in the Mount Alexandre group. Also, the abundance of coral and other fossil fragments in outcrops of the Laforce calcarenites suggests the possibility of nearby reefs. Such reefs, if they exist, could most easily be reached on the two most northerly anticlines of the area. Their depth would be uncertain, but might not be more than 5,000 feet, possibly much less on the more southerly structure.

The possibility that Silurian reef structures could be located beneath the Fortin group should not be ignored. However the depth of burial here is unknown, and could be considerable.

BIBLIOGRAPHY

- ALCOCK, F.J. (1935) Geology of Chaleur Bay region; Geol. Surv. Canada, Mem. 183.
- BADGLEY, P.C. (1956) New Carlisle map-area, electoral district of Bonaventure; Que. Dep't Mines, G.R. 70.
- BASSLER, R.S. (1950) Faunal lists and descriptions of Paleozoic corals; Geol. Soc. Am., Mem. 44.
- BOUCOT, A.J., and CUMMING, L.M. (1953) Contributions to the age of the Gaspé Sandstone (abstract); Geol. Soc. Am. Bull., Vol. 64, p. 1397.
- BRUMMER, J.J. (1955) Geology of the northwest quarter of Holland township, Gaspé North, Quebec; Unpublished doctoral thesis, Department of Geological Sciences, McGill University.
- BURK, C.F. Jr. (1959) A regional study of the Silurian stratigraphy of Gaspé Peninsula, Quebec; Unpublished doctoral thesis, Northwestern University.
- CARBONNEAU, C. (1953) Geology of the Big Berry Mountains map-area, Gaspé Peninsula, Quebec; Doctoral thesis, Department of Geological Sciences, McGill University.
- (1959) Richard-Gravier area, Gaspé Peninsula; Que. Dep't Mines, G.R. 90.
- CLARKE, J.M. (1908-9) Early Devonian history of New York and eastern North America; N.Y. State Mus., Mem. 9, Pts. 1 and 2.
- (1912) A remarkable Siluric section on the Bay of Chaleur; in Notes on the geology of the Gulf of St. Lawrence, N.Y. State Mus., Bull. 158, pp. 120-126.
- (1913) Excursion in eastern Quebec and the Maritime Provinces; Dalhousie and the Gaspé Peninsula; 12th Intern. Geol. Congr., Canada, 1913, Guidebook 1, pp. 85-108, 110-118.
- COOPER, G.A. et al. (1942) Correlation of the Devonian sedimentary formations of North America; Geol. Soc. Am. Bull., Vol. 53, pp. 1729-1794.

- CRICKMAY, G.W. (1932) Evidence of Taconic orogeny in Matapedia valley, Quebec; Am. Journ. Sci., Vol. XXIV, pp. 368-386.
- CUMMING, L.M. (1955) Silurian and Lower Devonian sedimentary rocks of eastern Gaspé, Quebec; Doctoral thesis, University of Wisconsin.
- (1959) Silurian and Lower Devonian formations in the eastern part of Gaspé Peninsula, Quebec; G.S.C. Mem. 304.
- ELLES, G.L., and WOOD, E.M.R. (1918) A monograph of British graptolites; The Palaeontological Society, London.
- FINCH, V.C., and TREWARTHA, G.T. (1949) Elements of geography; McGraw-Hill Book Company, Inc., pp. 129-204.
- GEOLOGICAL ASSOCIATION OF CANADA (1950) Tectonic map of Canada; with the support of the Geol. Soc. Am.
- JONES, I.W. (1930) The Berry Mountain map-area, Gaspé; Que. Bur. Mines, Ann. Rep. for 1929, Pt. D, pp. 1-42.
- (1931) The Lesseps map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1930, Pt. D, pp. 195-226.
- (1932) The Bonnacamp map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1931, Pt. C, pp. 41-75.
- (1933) The Tabletop map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1932, Pt. D., pp. 3-32.
- (1935) Dartmouth River map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1934, Pt. D, pp. 3-44.
- (1936) Upper York River map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1935, Pt. D, pp. 3-28.
- (1938) Mount Alexander map-area, Gaspé Peninsula; Que. Bur. Mines, Ann. Rep. for 1936, Pt. D, pp. 5-26.
- JONES, I.W., and McGERRIGLE, H.W. (1939) Report of geology of parts of eastern Gaspé; Que. Bur. Mines, P.R. No 130.
- KINDLE, C.H. (1936) A geological map of southeastern Gaspé; The Eastern Geologist, No. 1
- LOGAN, W.E. (1846) Geol. Surv. Canada, Rep. of Prog. for 1844.

- LOGAN, W.E. (1863) Geology of Canada; Report of progress of the Geological Survey from its commencement to 1863.
- McGERRIGLE, H.W. (1950) The geology of eastern Gaspé; Que. Dep't. Mines, G.R. 35.
- (1952) Pleistocene glaciation of Gaspé Peninsula; Royal Soc. Canada Trans., ser. 3, Vol. XLVI, sect. IV, pp. 37-51.
- (1953) Gaspé Peninsula; Que. Dep't Mines, Geol. map No. 1000.
- (1954) The Tourelle and Courcelette areas, Gaspé Peninsula; Que. Dep't Mines, G.R. 62.
- (1959) Madeleine River area, electoral district of Gaspé-North; Que. Dep't Mines, G.R. 77.
- NORTHROP, S.A. (1939) Paleontology and stratigraphy of the Silurian rocks of the Port Daniel-Black Cape region, Gaspé; Geol. Soc. Am. Spec. Pap. No. 21.
- QUEBEC DEPARTMENT OF TRADE AND COMMERCE (1952-1956) Meteorological Bulletins, Sep. 1952 - Dec. 1956.
- ROLIFF, W.A. (1952) Oil occurrences of east central Gaspé; Royal Soc. Canada Trans., ser. 3, Vol. XLVI, sect. IV, pp. 53-67.
- RUEDEMANN, R. (1947) Graptolites of North America; Geol. Soc. Am. Mem. 19.
- RUSSELL, L.S. (1946) Preliminary report on the stratigraphy of the Gaspé Limestone series, Forillon peninsula, Cap des Rosiers township, county of Gaspé South; Que. Dep't Mines, P.R. No 195.
- SCHUCHERT, C. and DART, J.D. (1926) Stratigraphy of the Port Daniel-Gascons area of southeastern Quebec; Geol. Surv. Can. Mus. Bull. 44, pp. 35-58. Geol. series No. 46.
- SKIDMORE, W.B. (1958) Honorat West area, Bonaventure electoral district; Que. Dep't Mines, P.R. No. 366.
- (1959) The geology of the Gastonguay-Mourier area, Gaspé Peninsula; Doctoral thesis, Department of Geology, Princeton University.
- SWARTZ, C.K. et al. (1942) Correlation of the Silurian formations of North America; Geol. Soc. Am. Bull., Vol. 53, pp. 533-538.
- TWENHOFEL, W.H. (1927) Geology of Anticosti Island; Geol. Surv. Canada, Mem. 154.
- WILLIAMS, H. TURNER, F.J., and GILBERT, C.M. (1954) Petrography; W.H. Freeman and Company, San Francisco.

APPENDIX

Fossil Localities

White Head Formation

F-55-15 Smooth, grey limestone; St-Jean-Sud river, about 3,500 feet southeast of Sinnett brook:

Helminthoides ? sp.

F-55-41 Fine-grained sandstone; road on right bank St-Jean river, between Murray brook and main forks of St-Jean (outside the map-area):

Diplograptus ? sp.

Mount Alexandre Group

Lower

F-56-55 Greenish grey, silty limestone; immediately overlying thin volcanic flow on left bank of small brook entering Reboul brook from northeast about 1,500 feet from south edge of map-area:

Eophacops orestes

F-56-56 Sandy, crystalline limestone; left bank Reboul brook, about 3,000 feet from south edge of map-area:

Atrypa "reticularis"

Dalmanellid

Rhynchonellid

Upper

F-56-54 Brown, crystalline limestone; left bank Cotton brook, about 14,500 feet from its mouth:

Algae

Stromatoporoids

Zaphrentids

F-56-57 Grey, silty limestone; right bank Mourier brook, 3 1/2 miles northeast of its mouth:

Zaphrentid

Sirois Formation

Laforce Member

F-55-12 Siltstone, conglomerate, and sandy limestone; St-Jean-Sud river, just east of Sinnett brook:

13

14

Alga?

Astrocerium cf. hisingeri

Favosites gothlandicus ?

Monograptus cf. clintonensis

Monograptus cf. regularis

F-55-16 Green sandstone; about 7,000 feet up brook flowing south into St-Jean-Sud river, about 1/2 mile west of east edge of map-area:

Favosites gothlandicus ?

F-55-17 Limestone conglomerate; about 1 mile up brook flowing south into St-Jean-Sud river about 1/2 mile west of east edge of map-area:

Astrocerium cf. hisingeri

F-55-32 Limestone conglomerate; about 8,000 feet south of Camp 8:
33

Amplexus shumardi

Astrocerium constrictum ?

Astrocerium hisingeri ?

Favosites gothlandicus ?

F-55-36 Limestone conglomerate; about 1 mile west of Camp 4:

Stromatoporoids

Astrocerium constrictum ?

Favosites gothlandicus. ?

F-55-42 Large blocks of coarse calcarenite; about 4 miles up the road leading north from the main forks of the St. Jean (outside the map-area):

Monograptus clintonensis

F-56-60 Sandy limestone; about 1,000 feet north of trail to Presqu'île lake, and 2,000 feet west of road to Camp 9:

Monograptus cf. regularis

Upper Member

F-55-3 Grey, silty limestone; near the Upper St. Jean road, about 2,200 feet east of Camp 24:

Scutellum pompilius pygidium

F-55-4 Crinoidal sandstone; near Camp 21:

Leptaena "rhomboidalis"

F-55-11 Calcareous sandstone; St.-Jean river, about 4,000 feet below
Camp 21:

Astrocerium hisingeri ?

F-55-25 Greenish grey, silty limestone; St-Jean-Sud river, about
2,000 feet northeast of Camp 8:

Pentamerus ? sp.

Boring sponge

F-55-27 Grey limestone; St-Jean-Sud river, 4,000 feet northeast of
Camp 8:

Leptaena "rhomboidalis"

Levenea ? sp.

Orthostrophia ? sp.

Platyceras ? sp.

F-55-29 Grey limestone; St-Jean-Sud river, 5,000 feet northeast of
Camp 8:

Leptaena "rhomboidalis"

Pentamerus ? sp.

Small dalmanitid cephalon

F-55-48 Greenish grey, silty limestone; old road on left bank of brook
entering St.-Jean river from north 2,000 feet northwest of
Camp 20, about 4,000 feet from Upper St.-Jean road:

Monograptus chimaera

Monograptus varians var. tenuis

F-55-49 Greenish grey, silty limestone; about 7,000 feet down the road
leading south from Camp 21:

Monograptus chimaera ?

F-56-58 Angular debris of siltstone; near the head of Camp-Dix brook,
about 1,000 feet from the west edge of the map-area:

Monograptus cf. variens

Cape Bon Ami Formation

F-55-2 Grey, silty limestone; Upper St. Jean road, about 2,000 feet northwest of Camp 24:

Coelospira sp.

Spinoplasia cf. gaspensis

F-55-8 Grey, silty limestone; roads near Trois Ruisseaux Camp on York
10 river:

Coelospira sp.

Leptocoelia ? sp.

F-55-50 Pebbly sandstone; St. Jean river, about 6,000 feet southeast of Camp 19:

Pleurodictyum ? sp.

Bactrites sp.

Square-sectioned crinoid column cf. Ancyrocrinus bulbosus

Bryozoans

F-56-59 Weathered, silty debris; about 2,000 feet up the most westerly tributary on north side of brook leaving west edge of map-area about 12,000 feet north of Triangle brook:

"Chonetes" sp.

Fortin Group

F-55-40 Debris; on the road along Murray brook (outside the map-area):

Anastamopora quebecensis

Dychotrypa sp.

Fenestella fortinensis

Polypora orientalis

Orthonychia sp.

Grande Grève Formation

- F-56-67 Limestone; 2,500 feet north of Cotton brook, in south-running
68 gully 6,000 feet east of Bonaventure river:
69
70

Acrospirifer ? sp.

Beachia cf. thunii

"Chonetes" sp.

Cyrtina sp.

Leptocoelia flabellites

Strophomenoid

York River Formation

- F-55-51 Sandstone debris; second brook south of Yvon brook on southwest
side of York river, about 8,000 feet from the river:

Leptaena "rhomboidalis"

- F-56-62 Sandstone; right bank Cotton brook, about 4 1/2 miles from its
mouth:

Beachia ? sp.

Costellirostra ? sp.

Etymothyris gaspensis

Howellella gaspensis

Leptocoelia flabellites

Platyorthis planoconvexa

Protoleptostrophia blainvillei

- F-56-63 Sandstone; right bank Cotton brook, about 4 miles from its mouth:

Etymothyris gaspensis

Howellella gaspensis

Leptocoelia flabellites

Nanothyris sp.

Platyorthis sp.

Protoleptostrophia blainvillei

- F-56-64 Siltstone; about 3,000 feet south of Mourier brook, about 5
miles from its mouth:

Dalmanitid pygidium

- F-56-65 Siltstone; 1/2 mile west of Bonaventure river, 3/4 mile north
66 of south edge of map-area:

Schuchertella sp.

Leptostrophid

ALPHABETICAL INDEX

<u>Page</u>	<u>Page</u>
Access to area	8
Acknowledgements	3
Adams, A.-	
Cook for field party	5
Alcock, F.J.-	
Ref. to work by	11,60,64
Appendix	67
Badgley, P.C.-	
Ref. to work by	2,31,64
Bassler, R.S.-	
Ref. to work by	29,64
Bibliography	64
Boucot, A.J.-	
Ref. to work by	3,12,39,41 43,64
Brummer, J.J.-	
Ref. to work by	4,40,43,47,64
Burk, C.F. (jr.)	
Ref. to work by	12,17,24,25 29,32,64
Campbell, J.-	
Acknowledgement to	3
Cape Bon Ami formation	32
Cape Bon Ami formation	
Fossils in	70
Cape Bon Ami - Grande Grève	
contact	52
Cape Bon Ami - Sirois contact	52
Carbonneau, C.-	
Ref. to work by	12,59,64
Chalcopyrite	62
Clarke, J.M.-	
Ref. to work by	32,39,64
Cleavage in area	55
Climate of area	7
Coffin, A.-	
Acknowledgement to	3
Cooper, G.A. (et al.) -	
Ref. to work by	12,64
Correlation	55
Crickmay, G.W. -	
Ref. to work by	65
Cumming, L. M.-	
Ref. to work by	12,17,29,32 64,65
Dallaire, R.-	
Field assistant	5
Dart, J.D.-	
Ref. to work by	66
DeBlois, A.-	
Field assistant	5
Drainage of area	5
Elles, G.L.-	
Ref. to work by	31,65
Faults in area	53
Field work	4
Folds in area	53
Formations	1
Fortin group	
Fossils in	70
Fortin - Mount Alexander	
contact	52
Fossils	17,24,31,39
Fossil localities	67
Fritz, M.A.-	
Ref. to work by	3,39
Gallichan, H.-	
General assistant	5
Geological Association of Canada	
Ref. to map by	60,65
Geology -	
Descriptive	9
Economic	62
Geomorphic development	60
Gilbert, C.M.-	
Ref. to text by	27,50,66

<u>Page</u>	<u>Page</u>
Grande Grève - Cape Bon Ami	
contact 52	MacRae, S.-
Grande Grève formation 39	General assistant 5
Grande Grève formation -	Madeleine River area 2
Fossils in 71	Magnetite 62
Grande Grève - York River	Marcotte, N.-
contact 52	General assistant 5
Gravel 63	Marl 63
	McGerrigle, H.W.-
Hematite 62	Acknowledgement to 3
Hess, H.H.-	Ref. to work by ..2,4,10,11,12
Acknowledgement to 3	14,17,18,25,29,32,36,39,41,43
Honorat West area 2	47,51,60,65,66
Howell, B.F.-	Metallic minerals 62
Acknowledgement to 3	Miller, A.E.-
	Ref. to work by 4
Ilmenite 62	Miller, E.R.-
Intrusive rocks 43	Ref. to work by 4
	Miller, R.-
Joints in area 55	General assistant 5
Jones, I.W.-	Minerals, metallic 62
Ref. to work by 2,4,11,14	Moore, G.E.-
17,18,24,25,36,38,43,51,52,54,65	General assistant 5
	Moore, S.-
Keeler, C.M.-	General assistant 5
Field assistant 5	Mount Alexandre -
Kindle, C.H.-	Fortin contact 52
Ref. to work by11,65	Mount Alexandre group 18
	Mount Alexandre group -
Laforce member -	Fossils in 67
Fossils in 67,68,69	Mount Alexandre - Sirois -
Laforce member 26	White Head contacts 51
Lavas 21	
Limestone 11,20	New Carlisle area 2
Location of area 3	New geographic names 5
Logan, W.E.-	Non-metallic deposits 63
Ref. to work by 2,65,66	Northrop, S.A.-
	Ref. to work by 29,31,66
MacClintock, P.-	
Acknowledgement to 3	Outcrops in area 5,53

<u>Page</u>	<u>Page</u>
Patterson, T.H.-	Sirois - White Head - Mount
Cook for field party 5	Alexander contacts 51
Petroleum 63	Skidmore, W.B.-
Pleistocene deposits 47	Ref. to previous work by
Previous work in region 4	2,3,10,17,20,25,29,66
Pyrite 62	Stewart, H. -
Quebec Department of Trade and	General assistant 5
Commerce -	Stratigraphic contacts 51
Ref. to bulletins by 7,66	Stratigraphic units 2
Recent deposits..... 47	Structural features 24
Resources of area 7	Structure 53
Roliff, W.A.-	Swartz, C.K. (et al.) -
Ref. to work by 59,66	Ref. to work by 66
Rousseau, Y.-	Table of units 15
General assistant 5	Tectonic history 57
Rowley, E.A.-	Topography of area 5
Field assistant 5	Transportation 8
Ruedemann, R.-	Twenhofel, W.H.-
Ref. to work by 29,31,66	Ref. to work by 24,29,66
Russell, L.S.-	Units, table of 15
Ref. to work by 66	Upper York River area 2
Sampson, E.-	Vegetation of area 7
Acknowledgement to 3	Volcanic rocks 21
Sandstones 50	White Head formation 14
Sauvé, Pierre -	White Head formation -
Acknowledgement to 3	Fossils in 67
Schuchert, C.-	White Head - Sirois - Mount
Ref. to work by 66	Alexander contacts 51
Settlement in region 7	Wood, E. M. R.-
Sirois - Cape Bon Ami	Ref. to work by 31,65
contact 52	York River formation 41
Sirois formation 25,32	York River - Grande Grève
Sirois formation -	contact 52
Fossils in 67	

