Suggested Title:

THE BIG BERRY MOUNTAINS, GASPÉ PENINSULA

by

C. CARBONNEAU

GEOLOGY

of the

BIG BERRY MOUNTAINS

MAP-AREA

GASPE PENINSULA, QUEBEC

A Thesis

Submitted to

the Faculty of Graduate Studies and Research

in Partial Fulfilment of

the Requirements for the Degree of

Doctor of Philosophy

in the

Department of Geological Sciences

McGill University

by

C. Carbonneau

Montreal

April, 1953

TABLE OF CONTENTS

CHAPTER I

Introduction

CHAPTER 2

General Character of the area

CHAPTER 3

Stratigraphy

Page

CHAPTER 4

Paleontology and Correlation

CHAPTER 5

Petrography of the Gaspé sandstones

CHAPTER 6

Petrology of the Gaspé sandstones

CHAPTER 7

Geological History and Conclusions

ILLUSTRATIONS

Plates

Page

Figures

CHAPTER I

INTRODUCTION

INTRODUCTORY STATEMENT:

Gaspé peninsula forms a tongue of land which extends into the Gulf of St. Lawrence, in the eastern part of the Province of Quebec. From its western boundary, the valley of the Matapedia river, to its eastern one, the Bay of Gaspé, the peninsula has a length of approximately 150 miles and a width, between the St. Lawrence estuary and the Bay of Chaleurs, of between 70 and 90 miles.

The rocks exposed at the eastern end of the peninsula, in the general vicinity of the town of Gaspé, are limestones and sandstones of Devonian age which Logan (1863) termed the Gaspé limestones and the Gaspé sandstones (Fig. 1). Similar rocks underlie the Big Berry Mountains, and it is the stratigraphy, paleontology, petrography, petrology and historical geology of these rocks in relation of the type-sections of Eastern Gaspé which constitute the main object of the present investigation.

The field work, performed during the seasons of 1950 and 1951, was undertaken in order to study the economic possibilities of the area and to make a general geological examination as part of the broader mapping program done by the Quebec Department of Mines. For reasons of convenience of map publication and in order to present a unified structural picture, parts of adjacent regions previously mapped are included in the present study. Due acknowledgment to authors for these additions will be made at the end of this chapter.

LOCATION AND AREA:

The Big Berry Mountains map-area is located approximately in the center of Gaspé peninsula (Fig. 1). Its southern limit is 30 miles north of Tracadigash bay, on the Bay of Chaleurs. The area is bounded by longitudes 66° and 66° 30' west, and latitudes 48° 30' and 48° 45' north; it occupies 400 square miles.

Within the boundaries of the map-area parts of 4 of the 5 counties of the peninsula are included. Bonaventure county (Marcil township) occupies a small portion of the southeastern corner of the map-area. Immediately to the north, a strip of land, ten miles wide, belonging to Matapedia county (Gravier and Clarke townships) runs across the south-central part of the area. Of the remaining portion of the map-area, the northwestern part is occupied by Matane county (Dunière and Richard townships), and the northeastern part by Gaspé-nord county (Baldwin township).

REGIONAL TERMINOLOGY:

The area takes its name from a prominent escarpment which runs east-west, parallel to and slightly south of latitude 48° 40' (Fig. 2). On his trip across the peninsula in 1844, Logan climbed a portion of the escarpment in the vicinity of the Cascapedia river (Plate 1). Which side of the river was ascended was not stated, but, on finding abundant blueberries on the slope of this hill, Logan gave it the name of Berry Mountain without specifying whether or not the name should apply to the entire escarpment or only to the particular hill.

Ells (1883, p. 9) applied the term Big Berry Mountains for "a range of lofty hills (which) cross the Cascapedia". He gave no explanation as to the origin of the adjective "Big". Ells (ibid.) used the term Little Berry Mountains for the tract of rugged topography "in the neighborhood of the Square Forks" where there is no particular mountain range but a deeply dissected upland. Among local people neither term, apparently, was ever used. At the present time, local Gaspé people apply the term Berry Mountain (singular) to the first hill of the escarpment, east of the Cascapedia river and the term Mount Noble for the first big hill west of the same river (Fig. 3).

Jones (1930, p. 10) refers to the Berry Mountain range as the part of the escarpment in the general vicinity of the Cascapedia river and shows Berry Mountain on the map accompanying his report as the first big hill to the east of Cascapedia river. The Dominion Topographical Bureau, however, has retained the name Big Berry Mountains and, apparently, applies it to the entire escarpment west of the Cascapedia river. The writer is inclined to adopt this usage, but to extend the name to the whole escarpment, as well to the east as to the west of the Cascapedia river, since the escarpment is a single physical feature cut across by the Cascapedia river

Figure 1 : - Map showing location and area covered by this thesis.

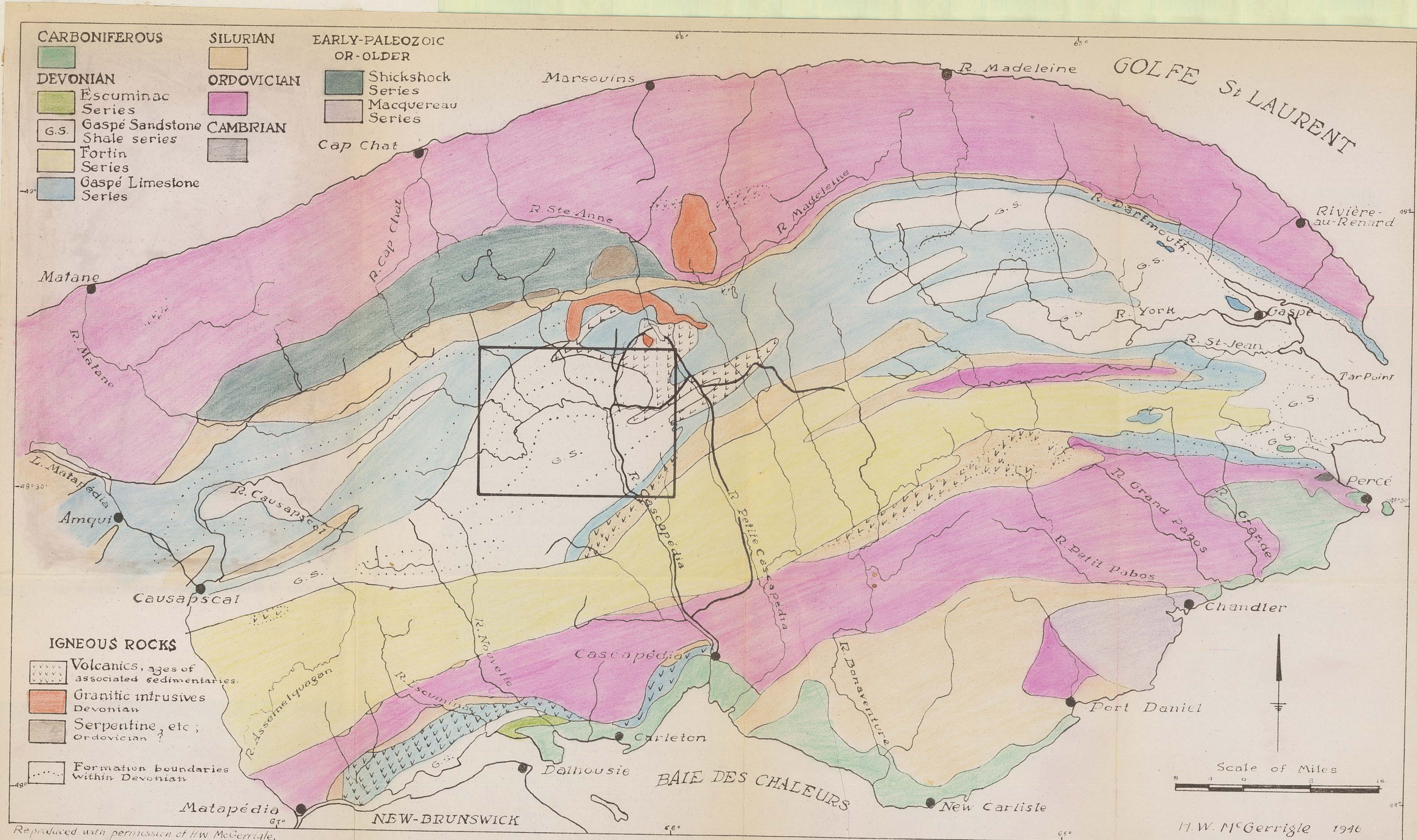


FIG. I MAP SHOWING OUTLINE OF THE GEOLOGY OF GASPE PENINSULA AND LOCATION OF AREA COVERED BY THIS REPORT.

Fig

Plate 1 : - The valley of the Cascapedia river where it cuts through the Big Berry Mountains. Looking northwest.

(Plate 1). Consequently, in this study, the term Big Berry Mountains (plural) will apply to the whole escarpment: from Berry Mountain lake in the east to the western boundary of the area. Berry Mountain (singular) will be used as Jones (ibid.) and local inhabitants use it. The awkward terminology Big Berry Mountains escarpment will also often be used to avoid confusion. All the names applied to brooks, rivers and physical features in this study are the names used by local fishing guides, lumber workers and/or government officers.

FIELD WORK:

The Quebec Department of Mines provided the writer with various base maps at the scale of half a mile to the inch. A stream and road map drawn largely from aerial photographs and made by the Dominion Topographical Bureau was found to be reasonably accurate. To this base map, the writer added the information concerning the townships, counties and surveyed lines as shown on the plans of the Quebec Department of Lands and Forests. Rechecking and corrections of the stream locations were made as the field work progressed. The aerial photographs for the general region were taken by the Royal Canadian Air Force for the Department of National Defence, Ottawa.

The geological information was plotted on the base map at the scale of half a mile to the inch. Traverses were made at irregular intervals along brooks and across divides by the pace and compass method. These traverses were planned so as to leave not more than three quarters of a mile of unexamined ground between them. A few traverses were also made along hill flanks where hill exposures were thought to be present. More than 90 per cent of the brooks and rivers were travelled and all trails and roads were examined.

Barometric readings, taken at various points on all traverses, were corrected by the record of a control barometer read every hour at the base camp. Elevations for base points in the area were carried from bench marks established in 1937, along the Cascapedia river, by the Quebec Stream Commission.

During the summer of 1950, efficient assistance in geological mapping was rendered by T.J. Perry, a graduate student of the University of Toronto, and Raymond Paquet, an undergraduate student from Laval University. As general assistants, Fabien and Viateur Lapointe from St. Léon, Matapedia County, Gaston and Luc Arsenault from Bonaventure, Bonaventure County, Victor Boudreau and Gérard Bujold from St. Jules, Bonaventure County performed their duties satisfactorily.

During 1951, the writer was assisted by G.V. Mueller, a graduate student of McGill University. The general assistants were C.P. Jackson of Bishop University, Gérard Bujold of St. Jules, Willie, Jean, Gaston and Luc Arsenault from Bonaventure County. All fulfilled their duties in a capable manner.

PREVIOUS WORK:

Because of its abundant geological problems and beautiful coastal scenery, Gaspé peninsula has excited the interest of geologists for many years. Logan (1843) did his first geological work in Canada, as director of the Geological Survey, along the coast of the peninsula. He first intended to investigate the possibilities for coal.

Up to fairly recently, the geology of the interior had received little attention due partly to the inhospitable character of the mountainous country. However, Logan in 1844 made a complete traverse across the peninsula. He ascended the Cap Chat river, went over the divide to the Bay of Chaleurs drainage basin, and reached a small tributary of Miner brook in the northwest corner of the present area, at Conical Mountain (Fig. 3). He and his assistants then built three spruce bark canoes and in them descended Miner Brook, the Lake Branch and the Grand Cascapedia river to its mouth. The geological information gathered during this trip is recorded in the Reports of Progress for 1844 and 1863 of the Geological Survey of Canada. Other parts of the interior of Gaspé were surveyed by Logan's assistants (Murray 1844, 1845; Richardson 1857, 1858; Bell, 1858) but their reports do not closely concern the geology of the present area.

In 1883, Ells did some reconnaissance work on the Lake and Salmon Branches of the Cascapedia river and gave some information on the geology of the Cascapedia river in the present area. In the same year, Low ascended the Ste.Anne river to Lake Ste. Anne, portaged over to the head-waters of the west branch of the Little Cascapedia river and descended that river to its mouth. The latter part of this traverse, from the head-waters of the Little Cascapedia river to Beaver brook, is approximately parallel to and a short distance to the east of the eastern boundary of the area.

In 1909, lead and zinc-bearing veins were discovered in Lemieux township, less than four miles to the north of the present area. During the field seasons of 1917 and 1918, Mailhiot (1919) mapped a small area around the Federal Zinc and Lead Mine. A small part of his map overlaps the present area in Lemieux township.

In 1918 and 1919, Coleman made a brief examination of the Berry Mountain area as part of his broader regional studies on the physiography and glacial geology of Gaspé peninsula.

Alcock (1922, 1926) devoted the field seasons of 1921, 1922, 1923, 1924 and 1927 to the detailed examination of the geology of the Federal Mine and the area to the north. His results are summarized in his memoir on the geology of Mount Albert which occupies the region immediately to the north of the eastern half of the present area.

In 1929, Jones (1930) mapped some 50 square miles, north and west of Berry Mountain (Fig. 2). The following year, he added the Lesseps map-area to the northeast of the present area. From then until 1938, he continually worked eastward and northward, from the interior of the peninsula to the Gaspé coast.

During the field seasons of 1942 and 1943, P.E. Anger (1943), under the guidance of J.E. Gill, made a detailed underground and surface geology map of the Federal Mine area.

From 1942 to 1944, as part of a broad revision and reconnaissance mapping program, H.W. McGerrigle (1)* travelled most of the large rivers and brooks of the interior of the peninsula, including the present area. His results are summarized in Fig. 1.

During the seasons of 1947, 1948 and 1949, H.W. McGerrigle (1) mapped a belt, included between longitude 66° 15' and 66° 30' west, from Miner brook in the present area, northerly to the north shore of the peninsula, in the Gulf of St. Lawrence.

---

(1)* Unpublished manuscripts in the files of the Quebec Department of Mines.

ACKNOWLEDGMENTS:

The writer is indebted to all his assistants for the part they took in helping to map a country which offers certain travelling difficulties. His gratitude goes also to the officers of the Cascapedia Manufacturing and Trading company for their willingness to give information regarding camp sites, travelling facilities and local names.

Dr. I.W. Jones and Dr. H.W. McGerrigle kindly offered the writer permission to use their reports upon some of their previously mapped areas. Accordingly, the Berry Mountain map-area (1) and the region west of longitude 66° 15' and north of Miner brook (2) are included in the present study (Fig. 2). The author's claim to originality concerning these areas is that he revisited most of the exposures of the Berry Mountain map-area, that he also saw most of the significant exposures of Dr. McGerrigle's area when he was an assistant on the party. In 1950 also, two days were devoted by the writer to the geological section along Miner Brook and in that general vicinity.

Fossils were identified and lists of them were made by Dr. E.M. Kindle and Dr. T.H. Clark respectively for Dr. Jones' and Dr. McGerrigle's areas.

---

(1) Jones, I.W., The Berry Mountain area, Quebec Bureau of Mines Ann. Rept. for 1929 pt D, 1930.

(2) McGerrigle, H.W., The Tourelle-Lake Cascapedia area, Unpublished manuscript in the files of the Quebec Department of Mines, 1950.

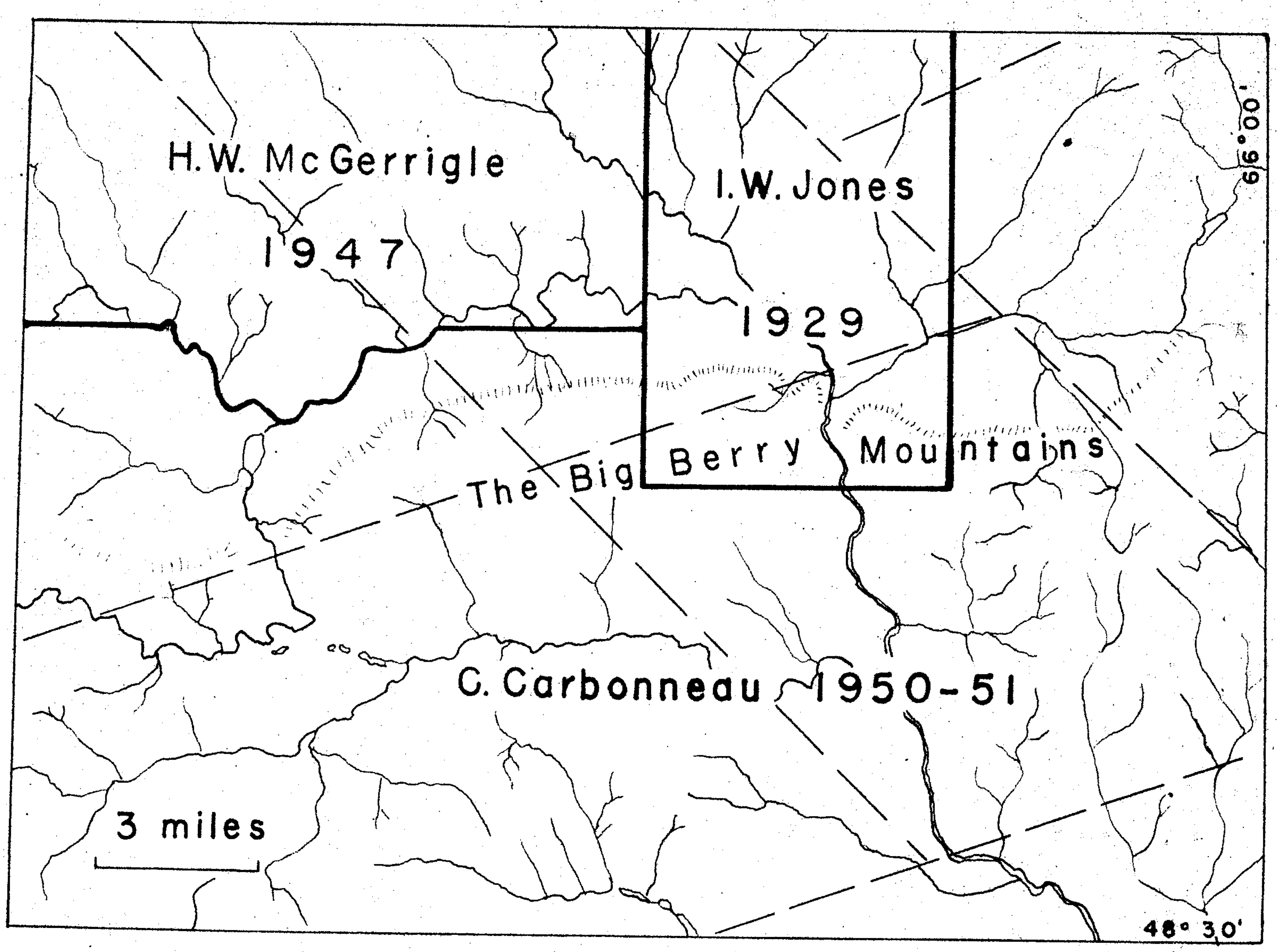


Figure 2 : - Map showing the location of the Big Berry Mountains escarpment and the portions of the area mapped by various authors.

These lists are shown in this study as they were in the original reports and, through the present author, thanks are extended to Dr. Clark for these identifications. All other fossils found in the Big Berry Mountains area were identified by the writer and the attempt of correlation, stratigraphic descriptions and interpretations, tentative geological history and conclusions are products of his own efforts.

To Dr. I.W. Jones, chief of the mapping division of the Quebec Department of Mines, sincere gratitude is expressed for the permission to use the data collected in the field in the preparation of this thesis.

Throughout both field and laboratory work, Dr. H.W. McGerrigle has been of invaluable assistance, and to him and to Dr. T.H. Clark of McGill University, the author is indebted for the time and interest given in the guidance, corroboration, provision for access to maps, field notes, fossils collections, and for the technical advice which was freely forthcoming when requested. Furthermore, during a full week at the end of the summer of 1950, Dr. H.W. McGerrigle guided the writer to the type-sections and diagnostic exposures of the Gaspé Devonian in the classic area of Eastern Gaspé.

Thanks are due to Mr. L.M. Cumming of the Geological Survey of Canada who kindly checked the identification of the Monograptids and offered the four photographs of this group shown in plates 33 to 36. To Mr. Cumming, and also to Mr. A.J. Boucot now of the U.S. national museum, sincere gratitude is expressed for the enlightening discussions on the paleontology and the broad features of sedimentation of the Gaspé Devonian.

Dr. S.J. Nelson of the University of New Brunswick guided the writer in the identification of the corals found in the area. He also very kindly read critically the first manuscript of this thesis, an assistance for which the writer is very grateful.

Finally the writer is indebted to his wife who drew the final copy of the geological map accompanying this study.

CHAPTER 2

GENERAL CHARACTER OF THE AREA

RELIEF:

The present area is essentially a highly dissected upland ending at the Big Berry Mountains escarpment. North of the escarpment lies a broad depression - the Lake Branch depression - running east-west along most of its length but roughly crescentic in shape (Fig. 3 and Pl. 2).

In places, the upland has rather irregular topography; in other places, there are several tracts of land at an average elevation of 2,000 feet which are almost level. The latter are occasionally marshy and dotted with ponds.

Besides the Lake Branch depression, the Square Forks lakes depression, located in the southwestern part of the area, departs from this general picture of a dissected upland.

From the north, the Big Berry Mountains appear as a hogback-like escarpment rising more than a thousand feet above the bottom of the Lake Branch depression. The escarpment first rises approximately two miles directly south of Berry Mountain lake in the eastern part of the area. It then follows a course slightly south of west for seven miles, is cut through by the Cascapedia river near the mouth of Berry Mountain brook and then keeps its course for ten more miles to the valley of the Inlet river. It becomes progressively lower west of Mount

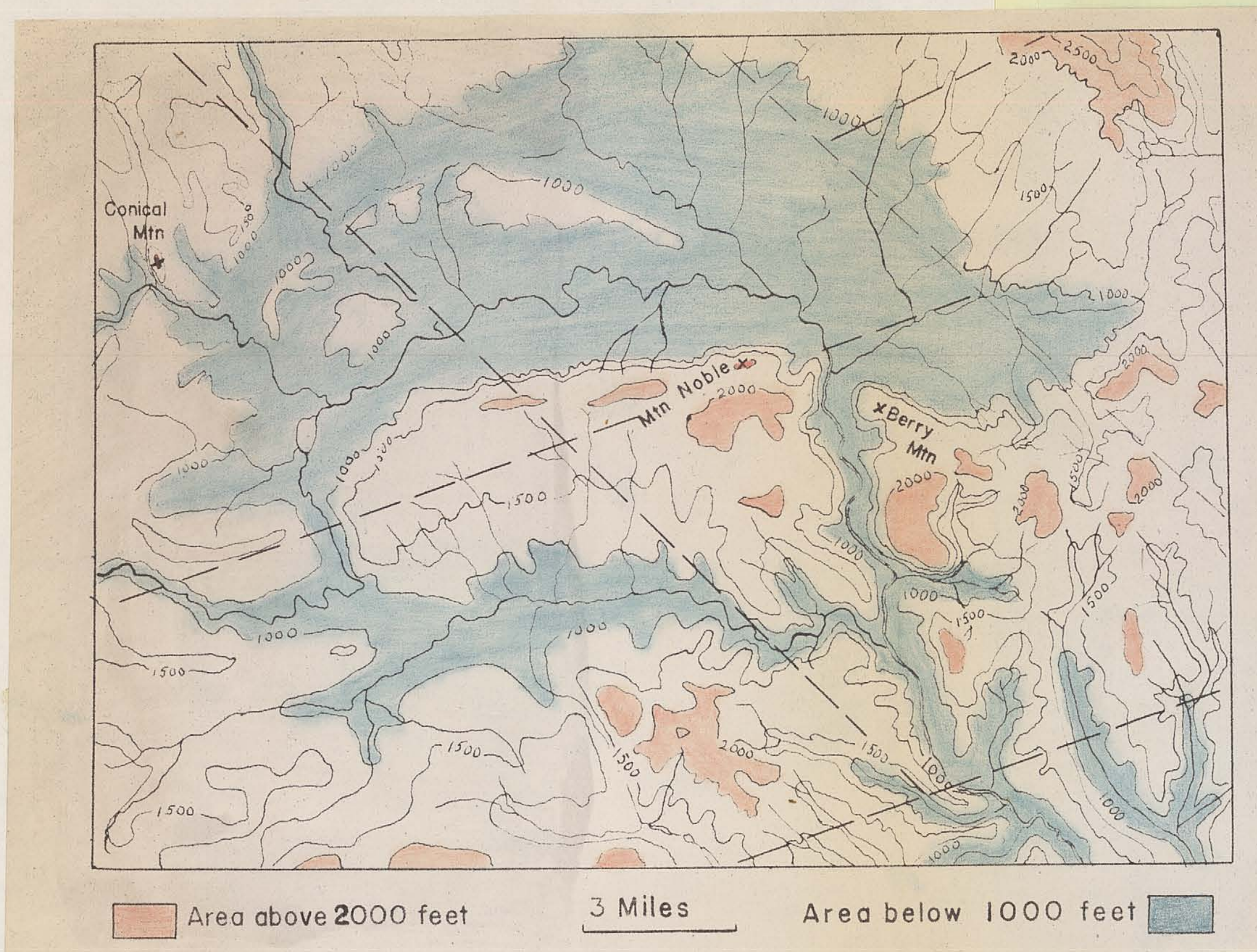


Figure 3 : - Topographic sketch-map of the Big Berry Mountains map-area.

Mount Albert Tabletop Mountains Berry Mountain

Plate 2 : - Panoramic view of the Lake Branch depression (central and eastern portion)
From Mount Noble tower, looking respectively north, northeast and east from left to right.

Plate 3 : - The western portion of the Big Berry Mountains escarpment. Looking west from Mount Noble tower.

Plate 4 : - The western portion of the Lake Branch depression in the morning fog. Rock ridge in the center right of the depression. Looking west from Mount Noble tower.

Noble (Pl. 3). West of the Inlet river, it is marked by a vertical drop of less than 600 feet. It dies off before reaching the western boundary of the area on approaching ground standing at higher elevation on account of resistant Devonian volcanics. West of the Inlet river the Big Berry Mountains escarpment cannot be considered as a hogback since it cuts across the strike of the rock formations. The maximum elevation of the central part of the escarpment is 2,145 feet above sea-level. Mount Noble and Berry Mountain are respectively 2,125 and 1,860 feet above sea-level (Fig. 2).

At the foot of the Big Berry Mountains escarpment, the Lake Branch depression extends toward the northern boundary of the area, with a maximum width of approximately six miles. It stands between 500 and 600 feet above sea-level along the Lake Branch of the Cascapedia river and the south branch of Berry Mountain brook. In the center of the depression and nearly parallel to it, a small hogback rises to an elevation of 1,000 feet, some 500 feet above the valley floors (Fig. 3 and Plate 4). This rock ridge can be first noticed immediately south of Miner brook, two miles northwest of Loon Lake. It then follows the curving trend of the rock formations, first northeasterly, then easterly and southeasterly. It is cut through by the Salmon Branch, one mile north of the Fork (1). It dies out just past the fork

---

(1) The locality known as "The Fork" is the point of junction between the Lake Branch and the Salmon Branch.

between the North and South branches of Berry Mountain brook. The total length of the ridge is approximately 17 miles.

The topographic profile of the southwest quadrant of the area is more gentle than the profile to the east and northeast. The brooks in the upland, although still swift, are less entrenched. The center of this quadrant is occupied by the Square Forks lakes depression which is at an average elevation of 900 feet above sea-level (Plate 5). This depression has a width of two miles and a length of approximately seven miles in east-west direction.

Resistant volcanic rocks are responsible for irregularities in the skyline of the high plateau region. Among the most prominent features caused by these rocks, are two northeast-trending ridges, in the northwest and southeast corners of the map-area.

To summarize, the topography of the area is made of three main elements: a dissected flat upland and two depressions - the Lake Branch and Square Forks Lake depressions.

Plate 5 : - The Square Forks Lake depression. Looking northwest down the valley of Otter Brook.

DRAINAGE:

The area is drained by the Cascapedia river, and its tributaries. Only a very small portion of the waters in the northeastern corner of the area flow easterly toward the west branch of the Little Cascapedia river. On the other hand, the head-waters of the Nouvelle river stand very close to the southwestern boundary of the map.

In the present area, the Cascapedia river is a swift stream, powerful in freshet-time, approximately 200 feet wide. Concerning the behaviour of the river in the Berry Mountain area, Jones (1930, p. 7) writes:

"For about two miles below the junction of these two branches (The Salmon and Lake Branches), the river follows an easterly course along the north side of mount Noble, and then, it turns sharply to the south to cut through the Berry Mountain range.

The river and its two branches have winding courses and here and there are bays of calm water, locally called bogans. Some of these bogans represent former channels, and others are points where water re-enters the main channel after having followed courses concealed by gravel or swampy ground".

Several of the tributaries of the Cascapedia river are large streams. Going upstream on the east side of the Cascapedia river, the largest ones are: Big Jonathan brook, (West and East branches) Charles Vallée brook, Indian Falls brook, Berry Mountain brook (North and South branches), Brandy brook and Indian brook. On the west side of the Cascapedia river the largest tributaries are Charles Vallée west brook and the Square Forks river. The Lake Branch has three large tributaries: Go-A-Shore brook, Miner brook and the Inlet river. The above streams have widths varying between 30 and 60 feet at their mouths while Miner brook reaches 125 feet. Local inhabitants apply the term brook indiscriminantly to both gullies and large streams (E.g. England brook and Miner brook respectively 4 and 125 feet wide).

MEANS OF ACCESS AND COMMUNICATIONS:

The usual route followed into this part of the interior of the peninsula is the Cascapedia river road, also known as the Federal Mine road. This motor read is connected with Grand Cascapedia, a small village located three miles north of the Bay of Chaleurs (Fig. 1). The road follows closely the east bank of the Cascapedia river for a distance of approximately 36 miles to Berry Mountain brook. It then swings slightly north and keeps roughly this course to the Federal Zinc and Lead Co. camps, situated 45 miles from Grand Cascapedia.

At Grand Cascapedia, the Federal Mine road (Quebec Department of Mines road) is directly connected with the Perron boulevard which encircles the peninsula.

At a point 37 miles north of Grand Cascapedia, a motor road branches off the Federal Mine road and leads to a locality known as Lazy Bogan. A wagon-road, in places greatly obstructed by wind-falls, connects Lazy Bogan with the west-central part of the area (Loon Lake). This road follows fairly closely the north bank of the Lake Branch. Another wagon-road parallels the Salmon Branch of the Cascapedia river. A trail approximately 6 miles long goes up Go-A-Shore brook.

The southwest quadrant of the area can be reached by the Square Forks River trail. The Square Forks river is an east-flowing stream which enters the Cascapedia river at a point approximately 30 miles north of the village of Grand Cascapedia. The trail has a total length of ten miles and is connected at its western end to an old blazed trail which joins the Square Forks river to the Joshua lakes.

At the main fork of Berry Mountain brook, a motor road branches off easterly and leads to Berry Mountain Lake near the eastern edge of the area. Further east the same road owned by the Cascapedia Manufacturing and Trading Co., leads to the west branch of the Bonaventure river across the drainage basin of the Little Cascapedia river. This road is known locally as both the Bathurst road and the west branch road (West branch of the Little Cascapedia river). In 1951, it was also the road followed by sportsmen on their fishing tripsto Berry Mountain lake or Lake Ste. Anne. There is a relatively large number of motor roads, wagon roads and trails in the northeastern part of the area, all resulting from lumbering operations.

Nearly all township and county lines shown on the map are projected, and consequently are of no help in travelling through the woods. For practical purposes, canoes can be used only on the major streams and the poling of canoes up these rivers can be done only by strenuous effort, even by expert pole-men. Canoes can be poled up the Lake Branch to Loon lake; Miner brook to the "falls" - a small rapid located at the western boundary of the area; Go-A-Shore brook for a distance of approximately 5 miles and the Salmon Branch for a distance of approximately 18 miles above its mouth. All other rivers, except locally on their lower reaches, have their channels blocked by gravel bars, braided sections, or log dams.

TIMBER RESOURCES:

The area is densely covered by vegetation. The most common type of tree is the balsam fir. In the middle portion of the Square Forks river, and in the depression of the Square Forks lakes, black spruce is fairly common. Elsewhere in the area, the white and the black spruce, and the white and the yellow birch are occasionally met. Generally pines and poplars are extremely rare. Balm-of-Gilead (Jones 1930, p. 8) occurs in the Lake Branch depression, in the vicinity of the Cascapedia river. A small colony of cedar trees was seen at the base of the Big Berry Mountains escarpment, in the eastern part of the area.

Approximately 30 square miles in the southwestern part of the area were devastated by a forest fire some 40 years ago. At this locality, a mixture of white birch and poplar has replaced the usual cover of conifers. The vitality of the birch contrasts strongly with the unhealthy state of this type of tree growing elsewhere in Gaspé peninsula.

Approximately 25 per cent of the summit areas in the region is covered with a very dense and sometimes almost impenetrable growth of entangled dwarf fir and spruce. This growth combined with the abundance of "blow-downs", owing to the destructive action of the wind and the thinness of the soil, renders the travelling in Gaspé a difficult task at places. Travelling conditions have not improved much since 1844, when Logan, reaching Miner brook near Conical mountain, gave the following comment in his personal journal (Harrington

1883, p. 204-205):

"We travelled for most of the distance in a valley which contains a stream that had to be crossed half a dozen times: and we had to make our way through alders and other small shrubby trees which twist and interwine in such a manner as to make our efforts among them very much like those of animals entangled in a net. I had several tumbles and slides, and my feet and legs sank into deep holes when I did not expect it. Branches also scraped my face, and dead sticks were punched into my stomach. When I tried to save myself by catching hold of the trees near, I occasionally got hold of a dead one, which came tumbling on the top of me. I was like walking in a night-mare..."

In the southwestern part of the area, there is no indication of former large lumber operations. No extensive operations are now taking place in the northwestern quadrant of the area but "some twenty to forty years ago, lumber was cut by the Montgomery interests along the Lake Branch as far as Loon Lake, on Miner brook, as far as the western edge of the map-area, on Go-A-Shore as far up as Redwing brook (outside the present area), and on the Salmon Branch nearly up to Nine-mile brook (also north of the present area)" (McGerrigle 1950 MS).

Within the last ten years the Cascapedia Manufacturing and Trading Co., a subsidiary of the Bathurst Pulp and Paper Co., has been cutting a large portion of timber in the eastern half of the Lake Branch depression. The company still maintains a large depot near the junction of the North and East branches of Berry Mountain brook, to control their present workings north and east of the present area.

AGRICULTURAL POSSIBILITIES:

The agricultural possibilities of this part of the interior of Gaspé have been considered quite extensively by Jones (1930, p. 8-9) and McGerrigle (1950 MS).

In the present area, the factor of topography would certainly favor the development of agriculture. A large portion of the country consists of broad valleys and gentle interfluvial areas. Drainage conditions would have to be improved, however, in the Square Forks lakes depression, and the middle portion of the Square Forks valley. The average elevation of this part of the area stands between 700 and 900 feet; heavy frosts come only late in September. The soil developed on fluvial, and possibly glacial-lake deposits is of a fair quality, and could probably support good farming.

Other tracts of land could be cleared for cultivation on the southern flanks of the Big Berry Mountains, and on the gentle interfluvial spaces in the southwestern portion of the map.

CHAPTER 3

STRATIGRAPHY

GENERAL STATEMENT:

Gaspé peninsula is part of the Appalachian province which extends from the state of Alabama to Newfoundland and parallels the eastern coast of North America. Geologically, however, Gaspé peninsula is more closely akin to the New England Appalachians than to the Central and Southern Appalachians. Its rocks range in age from possibly Precambrian to Carboniferous. Its last orogeny (the Acadian) occured before the deposition of the flat-lying Carboniferous strata. The Taconic orogeny, a previous period of folding, took place at the end of Ordovician time.

Broadly speaking, Gaspé is divisible into three belts running east-west along the long axis of the peninsula (Fig. 1): a northern belt made of slates of predominantly Ordovician age, a central one made of rocks of Devonian age, and a southern belt made of rocks of predominantly Ordovician and Silurian age but including also some Devonian, Carboniferous and possibly Precambrian rocks. The greenstone series (Precambrian) of the Shickshock Mountains, the peridotite (Silurian) of Mount Albert, and the granite (Devonian) of the Tabletop Mountains are located between the Northern and Central belts, in the western half of the peninsula.

The Big Berry Mountains map-area belongs to the

Central belt of the peninsula. The rocks range in age from Upper Silurian (Lower Ludlow) to possibly Middle Devonian with a short stratigraphic gap representing Late Silurian time. The greatest part of the present study, however, is concerned with the Devonian succession which reaches an unusual thickness in the area. In the following pages Devonian formations are correlated, mainly on a lithological basis, with the type-sections of Eastern Gaspé. Only two new formation names are suggested.

TECTONIC FRAMEWORK:

The tectonic framework of the area is the Berry Mountain syncline (McGerrigle, 1946, p. 50). The Berry Mountain syncline is a somewhat basin-like fold, subcircular in surface plan, the axis of which runs slightly south of west in the central part of the area. The fold affects the whole sequence of rocks except in the southwestern part of the area where the Silurian beds are brought up to the surface by a series of thrust faults and a general anticlinal structure (Joshua brook anticline). The strata on the northern flank of the Berry Mountain syncline exhibit gentler dips than the strata on the southern flank which are commonly overturned to the north near the eastern boundary of the area. The fold plunges to the west, except in the southwestern part of the map where the axial line appears to be approximately horizontal.

The Berry Mountain syncline is part of the synclinorium which extends along the axis of the peninsula and corresponds in position to the Central belt described in a previous section. It is approximately in line with the York River syncline of Eastern Gaspé.

TABLE OF FORMATIONS

Period	Epoch	Stage	Formations	Characters
DEVONIAN	Middle?	Hamilton? Onondaga?	Mount Noble	Fine-grained silicified rhyolite. Porphyritic diabase. 2,000 feet.
			Battery Point	Greenish-grey, medium to coarse-grained, feldspathic (pink feldspars), pebbly sandstones. 8,000 - 10,000 feet.
			Lake Branch	Red and brown shales and sandstones. 4,000 - 5,000 feet.
		Onondaga? Oriskany?	York River	Greenish-grey, medium to fine-grained, feldspathic (grey feldspars) sandstones. Dark green shales and siltstones. 2,000 - 10,000 feet.
			Conical Mountain	Amygdaloidal diabase, andesite, olivine basalt, rhyolite. At places porphyritic.
		Oriskany	York Lake	Interbedded limestones, sandstones and shales. Some basic sills or interbedded volcanics. 2,000 feet.

Period	Epoch	Stage	Formations	Characters
DEVONIAN	Early	Oriskany	Fortin	Calcareous slates, limestones, sandstones and conglomerates.
			Grande Grève	Hard, well-bedded, calcareous siltstones or siliceous limestones. Basic sills or interbedded volcanics. 3,000 feet.
			Cape Bon Ami	Soft, argillaceous limestones and dark shales. 500 - 1,000 feet.
SILURIAN	Late	Cayugan	Volcanic rocks	Andesite, basalt, rhyolite, tuff, breccia. Amygdaloidal and porphyritic in places. 2,000 feet.
			Sedimentary rocks	Laminated, calcareous siltstones, sandstones and shales, limestones. Red and green shales.

SILURIAN

SEDIMENTARY ROCKS:

Silurian rocks are exposed in the southeastern part of the area. Folding and repeated normal and reverse faulting in these rocks do not allow the working of a satisfactory stratigraphic succession. Near the axis of the general anticlinal structure where the lowest beds are exposed, the strata are made up of greenish-grey, fine-grained, laminated, calcareous sandstone in beds up to a foot but generally less than four inches thick. The laminae in the sandstone consist of black shale and grey limestone. Fairly abundant minute grains of pyrite are disseminated through the fine-grained sandstone beds.

Above this zone in the stratigraphic succession, the predominant type of rock appears to be greenish to bluish-grey laminated siltstone carrying also a fairly large number of minute pyrite grains. The laminae, generally less than two millimeters thick, are made up of finely crystalline, grey shaly limestone. Towards the middle of the section, approximately one thousand feet above its base, some green and red mudstones, in beds two inches thick, are interbedded with the siltstones (Plate 6). Also at the same stratigraphic level, there are some light grey-weathering, bluish-grey, pure limestone beds generally less than three inches thick. The remaining part of the section is made of dark grey calcareous shale and arenaceous limestone in beds between two and four inches thick. Occasional yellowish-green tuff

Plate 6 : - Green Silurian shales along the west branch of Big Jonathan brook. One mile upstream from the Matapedia-Bonaventure County line.

beds are also found at various level in the sequence. The total thickness of the section is unknown but is probably less than 2,000 feet. The remarkable feature about the Silurian belt in the present area is the relative abundance of sandstones and siltstones in relation to limestones, as compared to the other Silurian belts of Gaspé. There are no limestone conglomerates and no "reef" crystalline limestones which are rock types fairly frequent in the Mount Alexander series (Jones, 1936, p. 12), the Chaleur series (Northrop, 1939) and the Silurian belts of Eastern Gaspé (McGerrigle, 1950, p. 35-49). Moreover no traces of invertebrate fossils except graptolites were seen in the present rocks. All this suggests a different environment of deposition for the present Silurian belt.

The best and most continuous exposures of these rocks are along the west branch of Big Jonathan brook, but good exposures also occur on the east bank of the Cascapedia river.

VOLCANIC ROCKS:

The sedimentary rocks described above are overlain by a sequence of volcanic flows best exposed in a cliff located in front of the mouth of Joshua brook, about half a mile east of the Cascapedia river. Good exposures of these rocks can also be seen along the Cascapedia river. The volcanic belt makes a prominent ridge which runs northeasterly in the southeastern corner of the area.

The rocks of this belt consist of andesite, rhyolite and basalt in approximate ratio 5: 2: 1, and of a small proportion of tuff. No attempt has been made to give a full petrographic description of these rocks but field identifications have been checked by examination under the microscope. The rocks exposed in the cliff mentioned above are made of andesitic lava flows generally more than 20 feet thick, interbedded with thin zones of hard, acidic tuffs. The andesite which is medium-to fine-grained is frequently amygdaloidal and occasionally porphyritic. It shows very commonly good ophitic texture. Under the microscope, the rock was seen to be made of laths of plagioclase (Ab65 An35) set in a matrix of augite, hornblende, biotite, and volcanic glass. Chlorite is present in some thin-sections, either as alteration products of the ferromagnesians or as a thin coating around the walls of the vesicles. The material filling the vesicles is predominantly calcite, but chalcedony is also present in smaller amounts. The tuff beds are made of very fine aggregate of quartz grains and microlites of feldspars. The remarkable features about this exposure is the fact that individual flows up to 30 feet thick are easily detectable. These flows are separable from one another by thin zones of chilled, fine-grained andesite or acidic tuffs. Contorted flow lines and ropy structures can be observed at several places. The bottom of one flow shows fairly distinct pillow-lavas (Plate 7).

The rocks exposed on the east bank of the Cascapedia river, slightly below the mouth of Charles Vallée brook, show similar characters. Pillows occur at the north end of the exposure. At the same locality, blocks of limestone up to 2 feet in diameter were seen engulfed in the andesite. A zone 30 feet wide of andesite breccia contains blocks of highly vesicular basalt up to 4 feet long (Pl. 8). Baked limestones in zones up to 10 feet thick were noted in the center of the exposure. Finally there are also beds of dark clastic tuffs up to one foot thick interbedded with the flows and the volcanic breccias (Pl. 9).

Fine-grained, pale to yellowish-grey rhyolite occurs in the same belt and several sections of this type of rock can be observed along the west branch of Big Jonathan brook. Under the microscope, the rock was seen to be made of about 80% "dirty looking", crypto-crystalline quartz grains between 0.02 and 0.05 millimeter in

Plate 7 : - Pillow lavas in the Silurian cliffs; half a mile east of Cascapedia river.

diameter. Approximately 15% of the fine aggregate consists of fresh looking, euhedral feldspar crystals. At places clusters of hematite and other iron oxides were observed. Iron oxides line the walls of minute veins of clear quartz which criss-cross the rock, a feature which can be also observed in the rock outcrops. Acidic flows appear to be predominant in the southern band of the volcanic belt near the eastern boundary of the area either as homogeneous flows or as thick beds of volcanic breccias (Pl. 10).

Basalt and olivine basalt are less abundant than the preceding types of rock but they are present in fair amounts at

Plate 8 : - Basaltic blocks in fragmental volcanics. East bank of Cascapedia river, near mouth of Charles Vallée brook.

certain localities, particularly in the lower portion of Charles Vallée west brook. They occur as black-weathering, crumpling exposures with a surface alteration nearly a foot deep in places. The olivine basalts contain commonly anastomosing minute veins of serpentine. Tongues of basaltic material were also observed in the exposures along the Cascapedia river (Pl. 11). These tongues might represent interbedded basaltic flows or basic dykes introduced later.

Besides the volcanic belt just described, there is an indeterminable amount of igneous bodies of intermediate to basic composition in the Silurian sedimentary belt. Some of these bodies

Plate 9 : - Tuff bands in volcanic breccia. East bank of Cascapedia river, near mouth of Charles Vallée brook.

probably represent narrow volcanic zones; others are probably sills; some are definitely dykes (Pl. 12). The enclosing sedimentary rocks are frequently baked and altered in their vicinity. In composition, these igneous bodies do not differ essentially from the ophitic andesite (or diabase) of the volcanic belt. They commonly contain amygdules of calcite and at places are porphyritic with feldspar phenocrysts up to 3 millemeters long. The igneous bodies are too poorly exposed

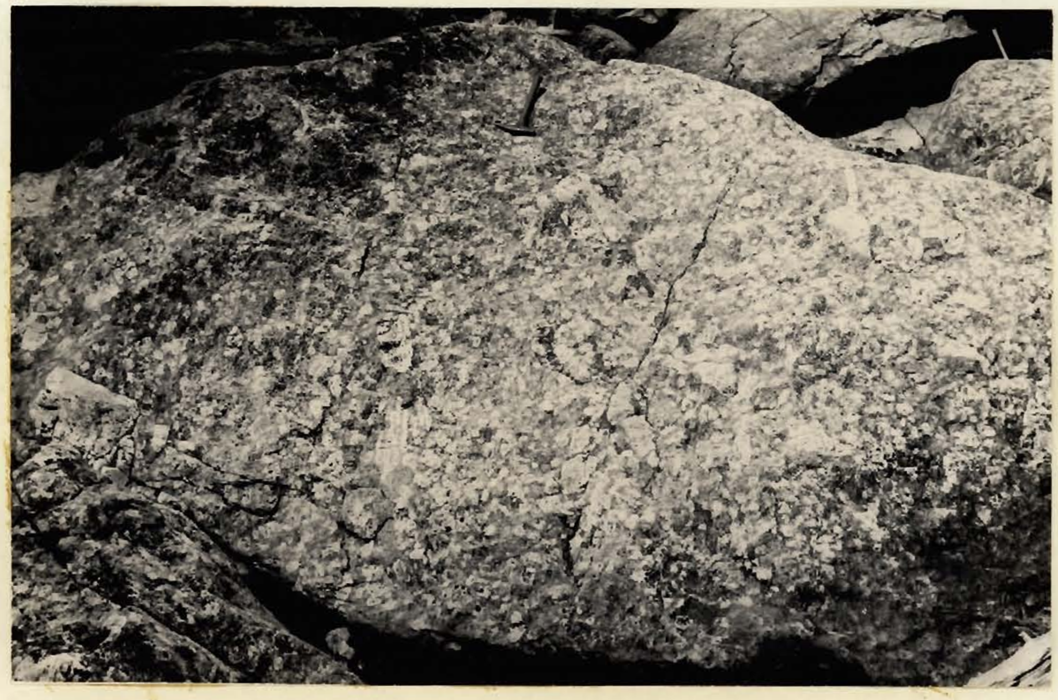


Plate 10 : - Boulder of volcanic breccia. East branch of Big Jonathan brook. Two miles north of southern boundary of the area.

and are generally too thin to be shown on the accompanying map. Several of them may represent feeders to the overlying volcanic belt.

The rocks of the sedimentary belt show a type of folding of medium intensity. Dips over 50° are infrequent and the beds generally are not severely fractured. No persistent overturning of the beds was observed. Near the volcanic bands, however, there might be local development of cleavage and drag folding (Pl. 13 and 14). Cleavage is also developed near fault zones which are fairly abundant in the sedimentary belt. Most of these zones show definite horizontal movement and the fault planes of several are vertical.

Plates 11 : - Partly fragmental, basaltic tongues in the Silurian volcanics. East bank of the Cascapedia river. Near mouth of Charles Vallée brook.

Low-angle thrust faults were observed along Beaver brook just outside the eastern boundary of the area (Fig. 4). The fault planes dip 20° to the south and strike east. The magnitude of the movement along these fault zones could not be determined but, from the nature of the rocks on both sides of the faults, it does not appear to be large.

Flow lines are commonly contorted and the rocks are jointed and fractured almost everywhere in the volcanic belt, but it is impossible to state the exact nature of the folding.

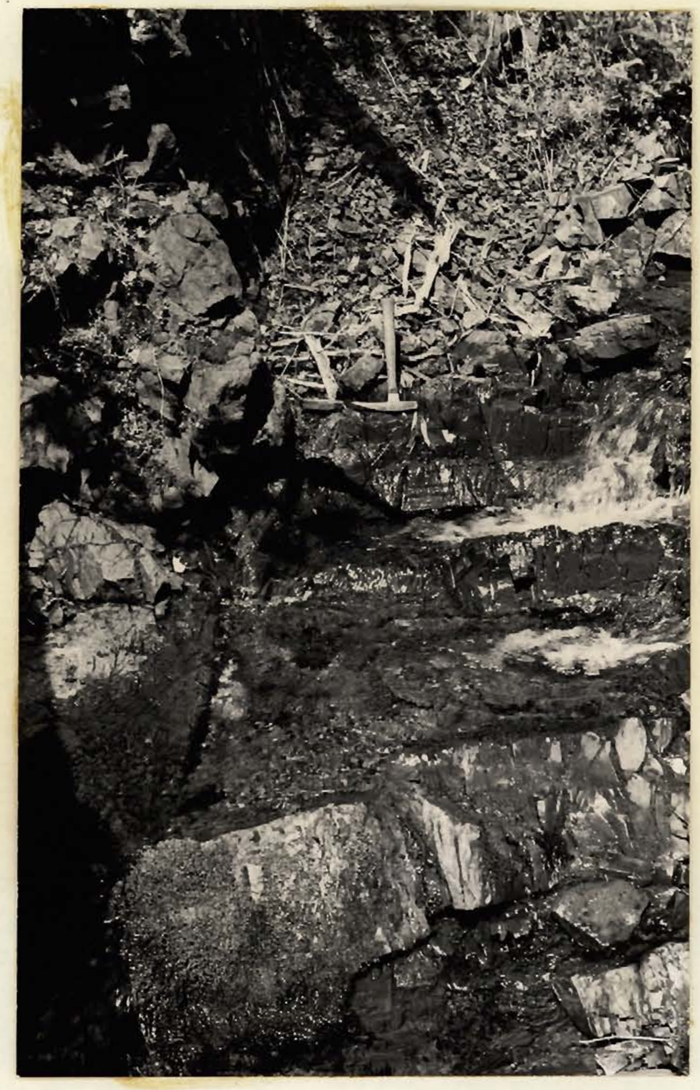


Plate 12 : - Silurian beds abuting against a diabase dyke. Along the Matapedia - Bonaventure county line, half a mile west of Big Jonathan brook (west branch).

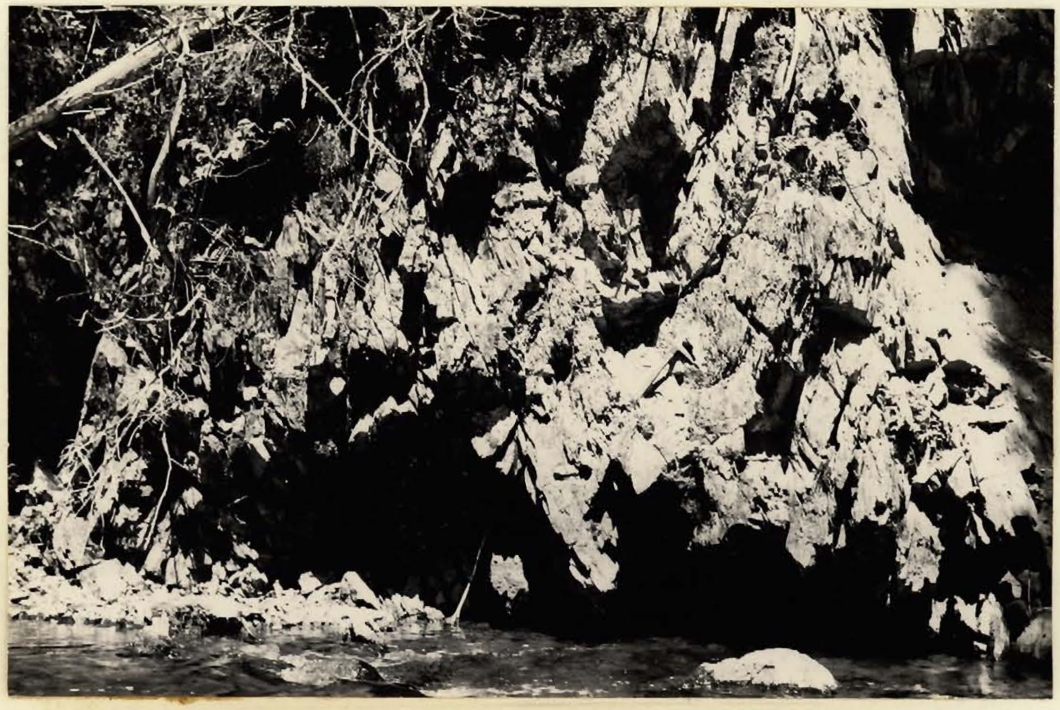


Plate 13 : - Contorted and cleaved Silurian beds close to a volcanic zone. Big Jonathan brook (west branch): two miles north of southern boundary of the area.

Plate 14 : -

Drag fold in the Silurian beds near a volcanic zone. Big Jonathan brook (west branch): one and a half mile north of the southern boundary of the area.

DEVONIAN

CAPE BON AMI FORMATION:

The Cape Bon Ami formation of the north cliffs of Forillon peninsula and the general region of Eastern Gaspé is defined by McGerrigle (1950, p. 48 and 60) as being made of dark, well-bedded, soft, shaly to finely sandy, often magnesian limestones, and dark shales. This definition is slightly different from the ones given by Logan (1863, p. 413) Clarke (1910, p. 36) and Russell (1946, p. 6) in the description of the type-section on the Forillon peninsula. But as in the inland areas, the succession of beds stratigraphically located between the underlying St. Alban formation and the overlying Grande Grève formation take the characters described by McGerrigle, McGerrigle's definition will be adopted. In the above sense, there are some beds, lithologically similar to the Cape Bon Ami formation, in the Big Berry Mountains map-area.

These rocks occupy a narrow band immediately to the north of the Silurian volcanics in the southeastern part of the map. They consist of 60% dark bluish-grey, soft limestone and 40% black-weathering, calcareous dark shale, regularly interbedded in thin beds generally less than one inch thick. The limestone is occasionally arenaceous. Towards the base of the section, it frequently contains minute carbonaceous specks and abundant flakes of muscovite on bedding planes. Using the width of the exposures in relation to the dips, the calculated thickness of the formation is approximately 1,000 feet.

The formation appears essentially conformable with the overlying York River formation. The transition zone between the two formations can be observed at three localities in the area. On the ridge between the Cascapedia river and Charles Vallée brook, typical Cape Bon Ami beds stand on edge within 280 stratigraphic feet from similarly inclined typical York River beds. The lower 10 feet of the transition zone between the two formations are made up of arenaceous, medium-grey limestones with shaly partings interbedded, at the upper end of the exposure, with rusty brown-weathering, medium-grained, calcareous sandstones in beds two inches thick. The upper 270 feet of the zone is occupied by large blocks of the same calcareous sandstones almost in place. There is no evidence of faulting.

The same structural relations were observed near the crest of the sharp ridge rising between Charles Vallée West brook and the Cascapedia river. At this locality, there is some 500 stratigraphic feet made up of calcareous siltstones and sandstones immediately above the Cape Bon Ami beds. Calcareous shales, siltstones and sandstones at the same stratigraphic level, were also observed on a brook which flows along the contact between the two formations, westward into the west branch of the Big Jonathan brook. The sequence of beds at this locality, however, is interrupted by a diabasic sill or flow which introduces some irregularities in the attitude of the adjacent formations. However variations in attitude within the York River beds along that brook, are more common and of a greater extent than variations in attitude between the Cape Bon Ami formation and the York River formation. In the present analysis, the calcareous siltstones and sandstones are included in the York River formation because several zones of the same beds can be found higher in the York River sequence.

Besides the diabasic sill or flow mentioned above, two other igneous bodies of indeterminable extent were found in the Cape Bon Ami formation. One is exposed a short distance north of the mouth of Charles Vallée brook along the hill side. The other occurs along the west branch of Big Jonathan brook, approximately in the middle of the stratigraphic sequence. Both are amygdaloidal diabase slightly porphyritic in places. The one exposed along the Big Jonathan brook shows ball-like structures which are considered to be pillows.

The sedimentary beds of the formation, owing to their fragile nature, are fractured and haphazardly jointed almost everywhere in the area. Dips are fairly steep along most of the belt, and east of Big Jonathan brook (west branch), the beds are overturned. No internal textures suggesting overturning were observed along that belt, but a few such textures are present in the overlying York River beds to the north. Moreover the apparent position of the Cape Bon Ami above the York River strongly suggests overturning.

The Cape Bon Ami beds are severely fractured and cleaved at the contact with the Silurian volcanics. It is reasonable to expect faulting along this horizon because of the great difference in competence of the rock types. However the stratigraphic succession suggests that such faulting, if it is present, is not of a large displacement. The Cape Bon Ami formation might have been deposited directly on the Silurian volcanics after a time gap representing part of Late Silurian time. Faulting, on a minor scale would develop later as an adjustment to orogenic forces.

GRANDE GREVE FORMATION:

Rocks showing the same lithology as the Grande Grève formation of Eastern Gaspé occupy two small portions of the area, in the northwestern and northeastern corners of the map. They are the southern extension of a belt one to two miles in width which is parallel to and north of the northern boundary of the map-area. The rocks are mainly dark to brownish grey, hard but brittle calcareous siltstones to siliceous limestones in beds generally two to eight inches thick. These beds are separated by thin layers of silty shale. The rock characteristically weathers light grey and on a weathered surface is more obviously silty than on a fresh one. There are occasional interbeds or zones of softer, shaly limestone, resembling the type of limestone found in the Cape Bon Ami formation.

The average thickness of the formation in the northwestern corner of the area is 3,000 feet. There is some difficulty, however, in locating the upper contact of the formation which is transitional into the York Lake formation. Part of the overlying York Lake beds possibly should be included in the Grande Grève. The average thickness of the formation in the inland areas of Eastern Gaspé was estimated by McGerrigle (1950, p. 64) to be 4,000 feet whereas the Forillon section, as redefined, is 1,387 feet thick. Thicknesses intermediate between these two values were also found but 4,000 feet appears to be the most frequent average. In the present analysis, the inclusion of the basal York Lake beds into the Grande Grève formation would bring the thickness of the formation into closer agreement with the average thickness found in Eastern Gaspé.

North of Berry Mountain lake, the data are not complete enough to give an estimate of the thickness of the formation. In the Lesseps map-area (Jones 1931), to the northeast, the formation was not separated as such from the Gaspé limestones but, owing to scarcity of exposures, it is doubtful if this could be done and if the thickness of the formation could be stated. No Grande Grève beds were seen on the south flank of the Berry Mountain syncline.

A wedge of volcanic rocks lies within the Grande Grève formation northeast of Berry Mountain lake. These rocks are almost continuously exposed in the north ditch of the Bathurst road leading from Berry Mountain lake to the west branch of the Little Cascapedia river. Very good exposures can also be seen along 6-Mile brook.* The rocks are made of medium- to fine-grained, dark greenish-grey, highly amygdaloidal andesite, frequently showing an ophitic

---

*N.B. - 6-Mile brook should not be confused with 6-Mile Bogan brook which flows into the Salmon Branch 6 miles above the "Fork".

texture, and crumply, fine-grained basalt and olivine basalt. At the point where the Bathurst road goes over 6-Mile brook, the rock is made of fine- to medium-grained, amygdaloidal and fragmental andesite carrying fragments of basalt, felsite and limestone up to 5 inches in diameter. The fairly abundant amygdules are made of calcite and chlorite.

Along 6-Mile brook, about half a mile upstream from the Bathurst road, turquoise-blue, tuffaceous and arenaceous, slightly crystalline limestones in beds 6 inches thick, and dark brown-weathering, soft, calcareous shale in beds one inch thick are interbedded with almost aphanitic, dark bluish-grey andesite layers 6 inches thick.

Approximately 1,000 feet farther upstream, the aphanitic andesite makes up only about 10 per cent of the rock. Approximately another 10 per cent consists of soft, bluish-grey, shaly limestone looking very much like the typical Cape Bon Ami limestone. The rest of the exposures is made of deeply-weathered, light green, coarse-grained to conglomeratic, highly calcareous, volcanic fragmental sandstone. Under the microscope, the rock was seen to consist of fragments of lava predominantly intermediate but also acid and basic in composition, cemented by approximately 50 per cent of calcite.

Still farther upstream, this tuffaceous sandstone becomes richer in cementing amorphous silica, quartz grains and volcanic fragments of acid composition. It makes a firm rock almost impossible to break. Near the upper contact of the volcanic wedge, in this type of rock, abundant solitary and colonial corals occur together with a few brachiopods and pelecypods. This sandstone and the soft limestones and shales were included in the volcanic wedge because they are interbedded with volcanic rocks and because they are distinctly different in lithology from the Grande Grève formation. The tuffaceous sandstones most likely were deposited in a marine environment with contemporaneous deposition of carbonate of calcium. Deposition, owing to coarseness of the volcanic fragments, must have occurred close to volcanic islands where corals and other invertebrates were striving to live, in rather adverse ecological conditions.

The Grande Grève formation dips gently towards the axis of the Berry Mountain syncline, southeasterly for the section in the northwest corner of the area, and westerly for the section north of Berry Mountain lake. Immediately west of Conical Mountain, at the western boundary of the area, the formation is gently folded over an anticlinal axis having a general north-south trend. Minor folding is suggested in the band north of Berry Mountain lake. Immediately east of the eastern boundary of the area, the exposures along the road leading to Lake St. Anne show that a gentle anticline runs northeasterly toward the Lesseps map-area. The curving trend of the contacts in the present area is a reflection of this minor structure. It is possible also that an adjacent minor syncline to the south runs through the volcanic wedge. The surface expression of this wedge suggests that. Lack of horizon markers, however, prevent the verification of such an hypothesis.

YORK LAKE FORMATION:

Concerning the distribution and stratigraphic relations of the York Lake formation, in Gaspé peninsula, McGerrigle (1946, p. 47) writes:

"The York Lake series, as a term, was introduced by I.W. Jones (1935) to identify a succession of rocks lying stratigraphically between the Gaspé Limestones and the Gaspé Sandstones. At the present time, we are inclined to include that series with the York River formation. Except for differences in detail, and the presence of more or less limestone in the York Lake, the two divisions are very similar lithologically. Also, from a stratigraphical viewpoint there is some suggestion that the York Lake series may correspond with the basal and generally fossiliferous half of the York River formation. However, the term itself serves as a useful label for the interbedded sandstone-shale-limestone zone which, in some areas, marks a transition between the Grande Grève and the York River formations. Furthermore, under more detailed mapping, the series may prove to have a greater significance than our present treatment assigns to it. The type area is in the general vicinity of York Lake. To the westward from this area limestone is present in increasing abundance while to the eastward the limestones decrease in importance until only shales and sandstones remain. In the eastern part of the region the series is not recognized in most sections and only possibly present in some. In the York Lake region it has a thickness of 4,000 feet and possibly of as much as 5,000 feet."

In the present area, rocks of this formation can be seen along Miner brook and Go-A-Shore brook. From the distribution of débris, it appears that a similar belt underlies Berry Mountain lake. Finally near the eastern boundary, at the headwaters of Beaver brook, there are limestones which are tentatively referred to the York Lake formation.

Except for the occurrence at the headwaters of Beaver brook, the rocks included in the formation are sandstones and shales similar to the clastics of the York River formation, interbedded with limestone of various types. Actual interbedding of the calcareous and clastics rocks was observed only in two sections. On Miner brook, the limestone beds are more similar to the Cape Bon Ami type than to the Grande Grève whereas the section on Go-A-Shore brook exhibits limestone interbeds of the Grande Grève type. Near Berry Mountain lake, the limestone is also of the Grande Grève type. The formation is approximately 2,000 feet thick.

Some basic lavas or sills are interbedded with or intruded in the upper part of the series. These igneous zones are of the same types as part of the Conical Mountain volcanics which will be described later. There is some suggestion of faulting between the York Lake and the Grande Grève formations in the section along Miner brook but elsewhere the two sequences appear essentially conformable.

The band at the headwaters of Beaver brook is made of poorly bedded, light brown-weathering, laminated, very arenaceous, brownish-grey limestone in layers up to 8 inches thick interbedded with soft, argillaceous, bluish-grey limestone close to the Cape Bon Ami type. Some beds look similar the Grande Grève limestone whereas others appear to be York River sandstone so calcareous as to be called a limestone. There are no typical sandstones or shale, but here also intermediate volcanics are interbedded with the limestones.

This band is faulted against a sequence of volcanic flows so that its exact stratigraphic position is difficult to state. It is probably in the center of the York River sequence of the present area. It is also probably high stratigraphically compared with the York Lake sections of Miner brook and Berry Mountain lake.

A short distance to the east of the present area (Fig. 4), a large expanse of the York River formation apparently grades laterally into the York Lake formation. No detailed geological mapping was done into that area. But three sections were obtained across the measures, at an interval of about two miles. Two were along large brooks and one along the road paralleling the east bank of the Little Cascapedia river. Interbedding of sandstone, shale or limestone can be observed commonly in the exposures of the Little Cascapedia road. The limestone is mostly of the Grande Grève type, but Cape Bon Ami type and types intermediate between these two also occur.

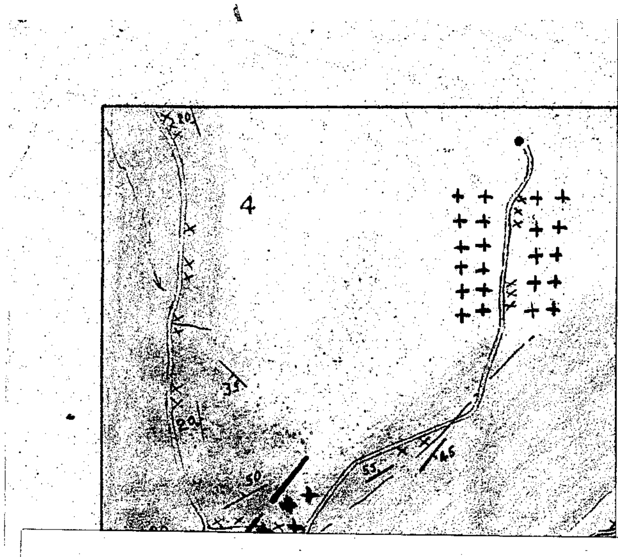


Figure 4 : - Portion of the area east of the Big Berry Mountains map-area.

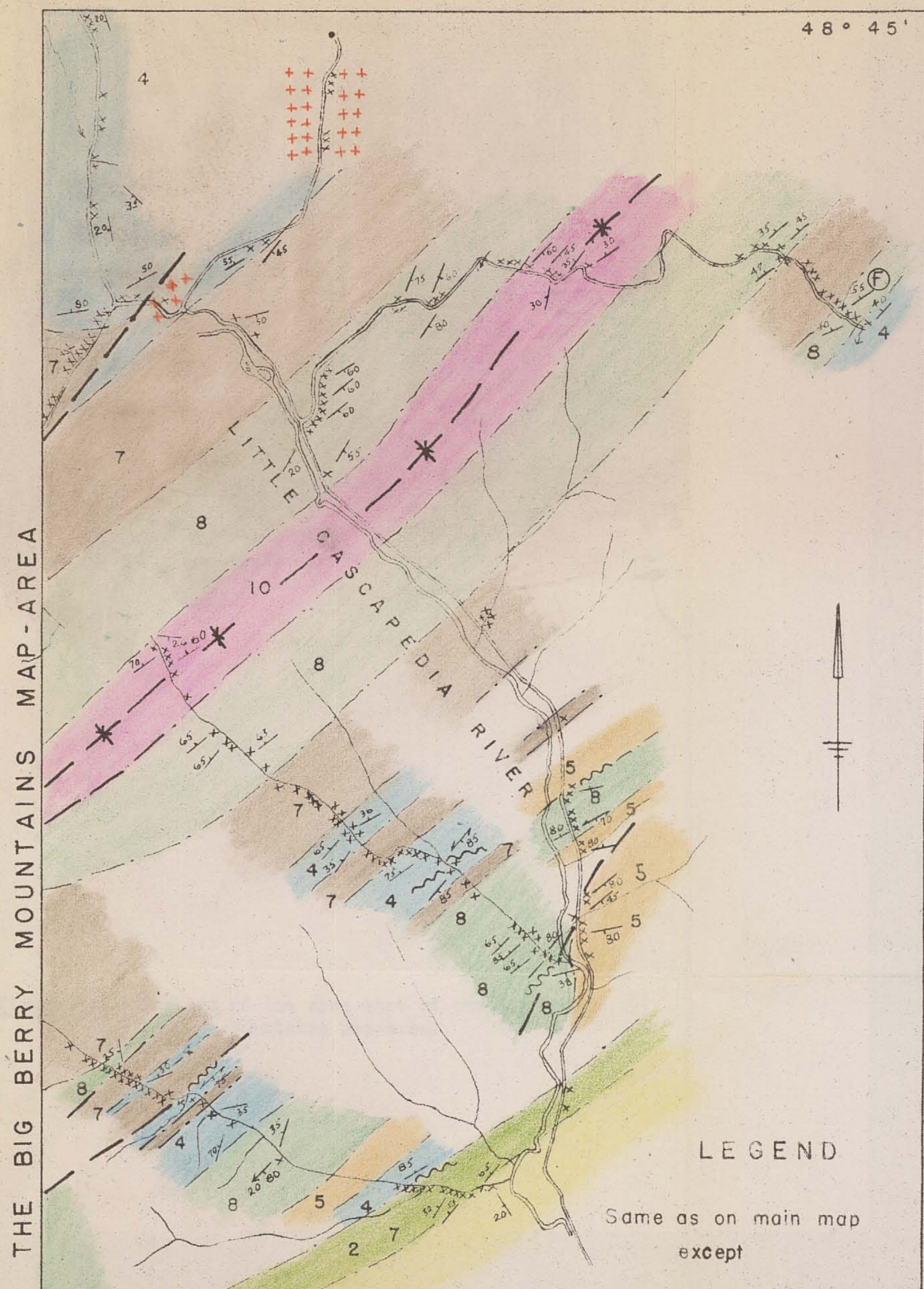

THE BIG BERRY MOUNTAINS MAP-AREA
48° 45'
LITTLE CASCAPEDIA RIVER
LEGEND
Same as on main map
except
syenite
SCALE
One mile to one inch
66° 00'
48° 35'

Fig. 4

The sections along the two unnamed brooks are not as well exposed but good sampling of the bedrock was done by digging along the valley flanks and by noting the character of the débris. The distribution of the débris shows that sandstones and limestones are interbedded in some parts of the section. From the rock exposures, however, it seems that homogeneous Grande Grève lenses up to 500 feet thick can occur within the York River formation. In figure 4, the rock types of this belt are shown without geological interpretation to state clearly the basis of the following discussion. Only the sequence of sandstones and limestones, actually interbedded, is shown as York Lake.

Although the geological information is not complete and although faulting brings confusion in the stratigraphic sequence, figure 4 provides fair evidence first that the York River sandstones grade laterally into the York Lake formation, and secondly that lenses of Grande Grève type of limestone can be expected in the otherwise typical York River sequence. The writer does not attempt to invalidate the stratigraphic and time divisions of the Eastern Gaspé Devonian. The Grande Grève formation of Eastern Gaspé, and of the Gaspé peninsula in general, certainly underlies the Gaspé sandstones and is predominantly older than the York Lake formation. Locally, however, as in the area under discussion, Grande Grève type of limestones might be found in the York River, as lenses. In other words, Grande Grève lithology can be found at a higher stratigraphic level than exhibited at the type section of the Forillon peninsula, or the type section is a typical one in not showing the clastic interbedded sedimentaries of the York River type. Lithology might not have followed the time boundaries set at the Forillon peninsula.

This discussion shows that the term York Lake is a very useful one to express this intermingling of lithologies. Inasmuch as practical mapping difficulties can be overcome, the writer feels that the York Lake facies should be shown on detailed geological maps of Gaspé because it seems to be of considerable thickness locally, and is of fairly common occurrence (Jones 1931, 1934, 1935, and the present mapping).

In this study, the term formation has been used persistently instead of series for the York Lake rocks. The "series" is at present fairly well known, and will most probably be never subdivided into rock-units of a formational standing. Furthermore the term series even uncapitalized may be confusing and may be given a time-stratigraphic sense. The "series" is transitional into the York River formation laterally as well as vertically. It may even involve the top of the Grande Grève time locally. Therefore the "series" is probably not isochronous throughout. Furthermore the Devonian of interior Gaspé has been and most likely will be mapped on a rock-unit basis (formation) for some time. It seems to the writer that the same policy could be adopted for the York Lake "series" which is not thicker than any other Devonian formation in Gaspé, and apparently does not involve a larger time interval. In view of the above considerations, the writer suggests that the term series be dropped and the term formation be used instead. The type section, or rather type area, for the formation is still in the general vicinity of York Lake. In that sense, the interbedded sandstones and limestones (in beds or lenses), in figure 4, would be considered as belonging to the York Lake formation and be equivalent in age mostly to the base of the York River formation but possibly also to the top of the Grande Grève formation.

FORTIN SERIES:

Prior to 1946, geological maps of Gaspé showed that, except for the areas near the Bay of Chaleurs, the southern half of the peninsula was underlain by rocks of Ordovician age. McGerrigle (1946, p. 48) is responsible for referring a considerable part of these rocks to the Devonian System. He introduced the term Fortin series for these rocks (Fortin township in Eastern Gaspé). In Eastern Gaspé, the rocks consist of dark slates and limestones interbedded with sandstones and conglomerates. The series occupies a belt up to 15 miles wide running east-west parallel to the long axis of the peninsula. The rocks generally show a strong cleavage and a structural confusion which easily explain why these rocks were first considered to be Ordovician in age. McGerrigle's interpretation "is supported by paleontological, stratigraphical, and structural evidence" (McGerrigle, ibid.).

In Eastern Gaspé, the series occupies a stratigraphic position roughly equivalent to the York Lake formation. As for the York Lake formation, the series may grade both laterally and vertically into the York River formation. The series is restricted to the south limb of the St. John River anticline. On the north limb, the strata are of York Lake, Grande Grève and Cape Bon Ami age. The absence of these formations on the south limb of the anticline has led McGerrigle (1950, p. 76) to suggest that the Fortin series may also include "both Cape Bon Ami and Grande Grève time without maintaining the characteristics of the formations".

Similar lithological, stratigraphical and structural conditions are met with in the southeastern corner of the present area. The rocks also consist of slates interbedded with limestones, sandstones and conglomerates, and in stratigraphic position the series also corresponds to the Cape Bon Ami, Grande Grève and York River formations. It is also on the south limb of a general anticlinal structure.

In detail, the predominant types of rocks are interbedded, brown-weathering, dark grey calcareous slates and dark-weathering, dark fissile siltstone. At the southern boundary of the area, a short distance east of the Cascapedia river, fresh-looking, light grey, pure limestone beds are interbedded with thin laminae of dark grey calcareous shale. Here the regional cleavage is represented by widely-spaced fracture cleavage (Pl. 15).

Towards the southern edge of the map-area, along Big Jonathan brook, there are occasional beds of light grey-weathering, medium-grained, greenish grey, arkosic sandstone up to 7 feet thick (Pl. 16). Even these massive sandstone beds are sheared. They

Plate 15 : - Pure limestone beds with widely-spaced fracture cleavage, leading to solution channels in Fortin series. Half a mile west of Cascapedia river at southern boundary of the area.

also contain elongated whorls and sheets of black shale probably representing former mud fragments. They are almost invariably accompanied by white, milky quartz stringers, possibly a result of metamorphic differentiation. At three localities, these sandstone beds are interbedded with, or grade into, conglomerate zones up to 3 feet thick. The pebbles of the conglomerate are generally less than half an inch in diameter. They are very well-sorted, and consist mainly of milky quartz with common black chert (Pl. 17).

Approximately one mile downstream from the Silurian

Plate 16 : - Thick sandstone beds in the Fortin series. Big Jonathan brook, 1,000 feet north of southern boundary of the area.

volcanics, along the East branch of Big Jonathan brook, there are shale-pebble conglomerate zones up to 40 feet thick. The pebbles, deformed, elongated, and smeared along cleavage planes, are set in a matrix of a similar composition but which is slightly more silty. These zones may represent intraformational conglomerates.

Sandstone layers as described above overlie the conglomerate zones. Under the microscope, the sandstone was seen to be made of 55 per cent quartz and chert fragments, 25 per cent potassic and plagioclase feldspars in about equal amounts, and 10 per cent altered biotite and ferromagnėsians. The matrix consists

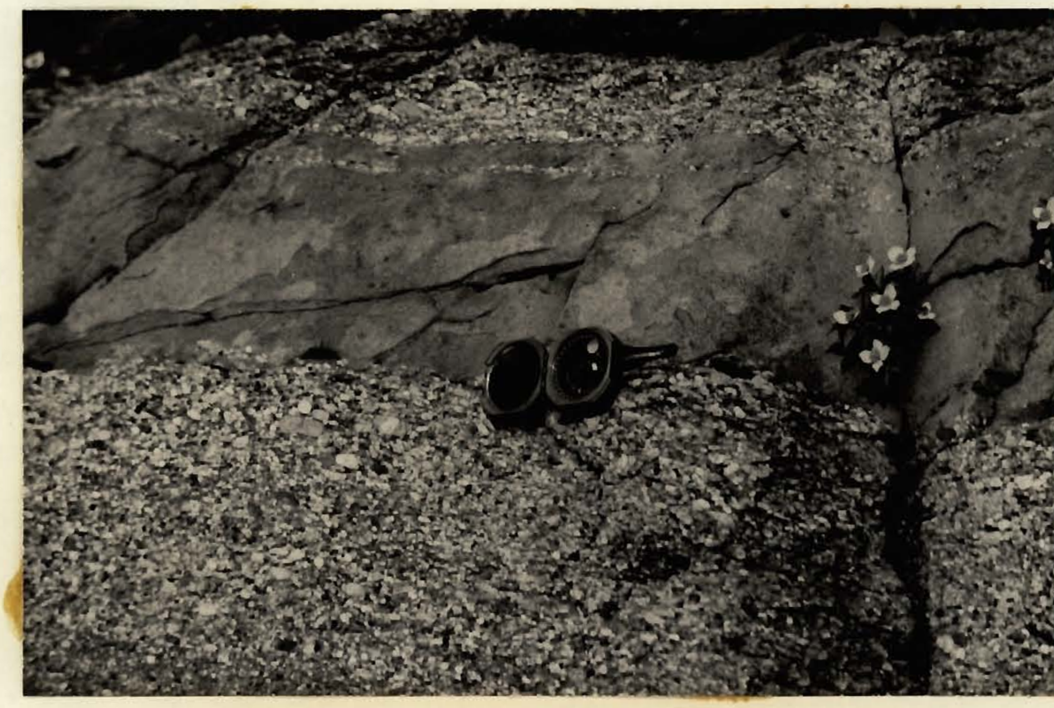


Plate 17 : - Interbedded sandstone and fine-pebble conglomerate in the Fortin series. Big Jonathan brook, at southern edge of the area.

of finely chopped mica flakes and iron oxides smeared between the grains.

Intermediate and basic dykes and/or sills occur here and there in the series but these are not abundant. Some are best described as lamprophyres with biotite phenocrysts up to 3 millimeters. Others consist of 60 per cent euhedral plagioclase (labradorite), 20 per cent epidote, 10 per cent magnetite and pyrite, and 5 per cent biotite with calcite, probably secondary, accompanying the epidote. Some amygdaloidal diabase bodies which were found towards the top of the series may belong to volcanic flows.

Fracture cleavage is strongly developed almost everywhere throughout the series. Within three quarters of a mile from the Silurian volcanics, the cleavage gradually disappears and the bedding becomes obvious. The rocks of this zone are not much different from the Silurian shales and siltstones to the north. Furthermore the Silurian rocks of the present area are very similar to the typical Fortin series, at the places where, on account of faulting, strong cleavage is developed. Consequently part of the Fortin series perhaps should be included in the Silurian. However, the rocks of the zone immediately south of the Silurian volcanics are generally more severely fractured and folded (Pl. 18) than the rocks underlying the volcanics, and if they are Silurian in age, they appear nowhere on the north limb of the Joshua brook anticline.

The Fortin series covers too small an area in the present study to give a full account of their structural features. The information at hand suggests that part of the folding developed at an incompetent stage. The series still presents many puzzling structural problems.

Plate 18 : - Large drag-fold and contorted zone in the Fortin series. Big Jonathan brook (east branch), one and a half mile north of southern edge of the area.

CONICAL MOUNTAIN VOLCANICS:

Almost everywhere in the area, the zone between the Grande Grève and the York River formation is occupied by a sequence of predominantly basic lavas. This igneous zone corresponds in stratigraphic position mainly to the York Lake series but lavas interbedded with associated sedimentaries can be found from Upper Grande Grève to Lower York River. Some have already been described with the Grande Grève formation. The rocks under consideration here are the volcanics found as a stratigraphic unit in the northern third of the map.

These rocks enter the area from the west near Miner brook. They find a topographic expression in a continuous rugged ridge which adopts the curving trend of the adjacent rock formations, to the northern boundary of the area. The belt then separates into two bands around the Federal Mine dome and the southern band reappears in the area near the North Branch of Berry Mountain brook. It then forms a wedge almost terminating at the Big Berry Mountains escarpment. Rocks tentatively correlated with the Conical Mountain volcanics makes the core of the eastern end of the Big Berry Mountains. This band continues eastward outside the area for several miles (McGerrigle, MS 1945). Several zones of lavas in figure 4 are believed to belong to the Conical Mountain volcanics.

The lavas are particularly well-exposed on the west flank of Conical Mountain (Fig. 3), a name given by Logan (1844) to a landmark located immediately north of Miner brook, near the western boundary of the area. For this reason, the writer suggests that the name Conical Mountain be applied to the whole belt. McGerrigle (1950 MS) gives the following description of the Conical mountain exposure: "In one cliff a 50-foot vertical section showed greenish, fine- to medium-grained diabase at the top followed below by 10 to 20 feet of darker and less green slightly amygdaloidal diabase with calcite-filled amygdules. This in turn was followed downwards by greenish-grey diabase, less amygdaloidal than the last, and with numerous reticulating lines of calcite suggesting a pseudo-breccia. In another cliff, agglomerate to breccia was seen in which small angular fragments of volcanics were included in a soft fragmental matrix along with fairly common rounded and angular lighter coloured volcanics up to two feet through".

Along Miner brook, immediately upstream from the mouth of the brook flowing west of Conical mountain, basic rocks are associated with thinly-bedded limestones. This igneous zone does not differ essentially from the basic volcanics described above. Diabase and olivine basalt are present. The diabase consists of augite penetrated by calcic plagioclase of labradorite composition with about 30 per cent of chlorite, biotite and magnetite. The limestones are baked near the contact with the diabase and recognizable blocks of limestones appear to be engulfed in the diabase. The olivine basalt is slightly amygdaloidal and carries pebbles of fine-grained intermediate volcanics containing a large amount of feldspars and calcite. The relationships of these rocks with the limestones are not clear, but they could represent feeders.

The types of rocks included in the Conical Mountain volcanics have been described quite extensively by Mailhiot (1919, p. 134), Alcock (1926, p. 45-47) and Jones (1930, p. 13-16), and description of these types need not be repeated here. Twenty-one thin-sections of these rocks were studied and attention was focused on types possibly not previously mentioned. The rocks are predominantly amygdaloidal andesites, basalts, olivine basalts, and andesite porphyry. Individual flows are seldom detectable and pillow-lavas are a rare feature.

The only feature which was not described before in the present area is the presence of occasional beds of tuffs. Tuff beds, from acidic to basic in composition, can be found commonly toward the base of the volcanic belt north, west, and south of Berry Mountain lake. Volcanic breccia is also present along the road leading to Berry Mountain lake. In the same general location, along Berry Mountain brook, there are breccias partly made of volcanic fragments apparently washed in a sedimentary basin and partly the result of faulting.

In general terms, the belt under discussion appears surprisingly homogeneous in composition and texture. This feature makes one suspect the presence of some intrusive phases. In the section along Miner brook, the volcanic belt is approximately 2,000 feet thick. It either reaches a far greater thickness east of Berry Mountain brook (North branch), or else it is considerably folded, for it occupies a surface width of nearly 5 miles across the strike.

The volcanic rocks making the core of the eastern end of the Big Berry Mountains escarpment differ from the Conical Mountain volcanics to the north in being acidic in character. Andesite and diabase are still present but no basalt or olivine basalt was found. The predominant types of rock are rhyolite porphyry and dacite. The dacite is made of 30 per cent of albite and potassic feldspar phenocrysts set in a groundmass consisting of quartz, feldspars, biotite, muscovite and magnetite. Trachytic texture can be observed in some of the thin-sections. The rocks are predominantly fine-grained to aphanitic. Volcanic breccias, agglomerates, and tuff beds are abundant throughout the belt but are especially so towards the base of it. Flow lines and vesicles at places filled by chalcedony are frequent features met in these rocks.

The structural interpretation of this part of the area would be considerably simpler if the rocks of this belt were intrusive. The information at hand, however, leaves little room for such an assumption. On the accompanying geological map, a thrust fault running northeastward is shown at the base of the present volcanic belt, and at the base of the belt immediately south and southeast of Berry Mountain lake. The fault is postulated on account of a contorted zone running parallel to it southeast of Berry Mountain lake, a strong discontinuity of structure in the same general vicinity and on the fact that different geological formations abut against the volcanic belt under discussion. A second fault running north-south is postulated to account for a displacement of the axis of the Berry Mountain syncline. Assuming that the volcanic belts of the blocks on each side of the north-trending fault are of the same age, one is forced to accept overthrusting to the northwest for the west block and overthrusting to the southeast (or underthrusting to the northwest) for the east block (See also figure 4). In the adjacent area to the east, the volcanics are York Lake in age, that is they are found between York River and Grande Grève beds. In the block on the west side of the north trending fault, their stratigraphic position is uncertain; there are no Grande Grève beds underneath and according to the present interpretation their lower contacts are fault-contacts. The volcanics of both blocks, however, consist of the same types of rocks in about the same ratio, with possibly a larger amount of andesite in the eastern block on the north limb of the Berry Mountain syncline. In the adjacent area to the east (McGerrigle's reconnaissance work and the writer's mapping), acidic types of volcanics become progressively more and more abundant along the belt.

If no faulting is assumed, the volcanics of the western block are very late York River on the north limb of the Berry Mountain syncline and middle York River on the south limb. Moreover, under such an assumption there would be an angular unconformity of a large order (nearly 90°) between the York River formation and the volcanics on the north limb of the syncline, i.e. between rocks which elsewhere in the area appear essentially conformable. Faulting therefore appears the most natural explanation for the present distribution and orientation of the rock units.

Granting the existence of the faults, however, there is still the possibility that the volcanics of the western block are slightly younger than the Conical Mountains volcanics near the northern and northwestern boundaries of the area.

YORK RIVER FORMATION:

The first mention of the York River formation as now understood (and the Battery Point formation as well) can be found in the second volume of the Geology of Quebec (Dresser and Denis, 1944, p. 299). Prior to Jones' and McGerrigle's work in Eastern Gaspé, the rocks of this age were referred to as the Gaspé sandstones although Logan gave lists of fossils from the "sandstones of the York River" and the "York River beds". Williams (1910, p. 688-698) defined the "York River beds" as the basal, calcareous, marine, and fossiliferous beds of the Gaspé sandstones, which would involve a thickness of some 2,500 feet. McGerrigle (1950, p. 78) included in the York River formation "all rocks in the section having the same lithology as the general series of "York River beds"". As now defined, the formation reaches a maximum thickness of 5,000 feet in the York River syncline of Eastern Gaspé, and it is made of greenish-grey, medium- to fine-grained, feldspathic sandstones, with numerous interbeds and lenses of greenish shale up to 100 feet thick. The sandstones of the York River formation can be distinguished from the sandstone of the overlying Battery Point formation by several lithological features among which the feldspar content is the most diagnostic. The feldspars of the York River sandstones are grey whereas the feldspars of the Battery Point sandstones are brown, pink or flesh-coloured.

A considerable part of the rocks exposed in the Big Berry Mountains map-area show the same lithological characters as the York River formation of Eastern Gaspé, but, as can be expected, variations occur. These rocks occupy two belts on each limb of the Berry Mountain syncline. The southern belt is very similar to the York River described above. Greenish-grey, medium- to fine-grained feldspathic sandstones are interbedded with brownish grey siltstones and greenish grey shales in approximate ratio 5: 3: 2. All these rocks are commonly slightly calcareous. Massive beds of medium-grained sandstone, generally less than 8 inches thick, become progressively more common and thicker towards the top of the belt where they grade imperceptibly into the Battery Point type of sandstone.

The rocks, near the nose of the Berry Mountain syncline, grade laterally into typical York River beds, but some phases of them show slightly different lithology. There are some thick beds of light brown, very fine-grained, quartz-rich sandstones and some bluish grey, calcareous and tuffaceous siltstones. Rare beds of crystalline limestone were also noted.

The belt of the northern limb of the Berry Mountain syncline is correlated with the York River formation on account of its stratigraphic position, though only part of it shows a York River lithology. In the section along Miner brook, the formation, here approximately 2,000 feet thick, overlies the Conical Mountain volcanics. In the section along the Salmon Branch and west of Berry Mountain lake, York River beds occur also below the igneous zone just referred to.

The part of the York River formation stratigraphically above the volcanics exhibits a great variety of rock types. The lower 500 feet of this section, from the Salmon Branch eastward, is made up of sandstones of the Battery Point type: medium to coarse-grained, with pink feldspars common. Some beds contain scattered pebbles of brownish shale and sandstone. Near the top of this zone, on the Salmon Branch, 1,500 feet downstream from the mouth of Nine-mile brook, there is a bed of small pebble conglomerate two to three feet thick. The well-rounded pebbles under one inch in diameter consist of fine-grained, dark-grey and green shale, greenish-grey sandstone, and dark grey, brownish-weathering, somewhat shaly to silty limestone. Small cubes of galena are scattered through the sandy matrix. The pebble conglomerate is succeeded upward by common interbeds of red to brown, fine- to medium-grained sandstones and grey to greenish-grey sandstones. The upper 500 feet of the formation consists of grey to brown, fine-grained, often calcareous sandstones with some interbeds of light grey, silty to sandy, crystalline limestone. As far as the lithology is concerned, the part of the York River formation above the pebble conglomerate is very similar to some of the beds found along the Inlet river, which will be discussed later.

Along the Salmon Branch, the part of the York River formation below the Conical Mountain volcanics was estimated by McGerrigle to be about 1,500 feet thick. West of Berry Mountain, at the same stratigraphic level, the formation may reach a thickness of 2,500 feet.

In the belt of the southern limb of Berry Mountain syncline, the formation reaches an unprecedented thickness for a single geological formation in Gaspé. The thickness is of the order of 10,000 feet. Reconstructed cross-sections made with careful analysis of the dips in relation to the width of the belt show a thickness of 12,000 feet. Of course, repetition of beds by faulting could partly account for the high value of the above estimates: no rock exposure is continuous enough to discard entirely this possibility. Probably less than 30 per cent of the formation is available for observation. West of the Cascapedia river, however, no indication or even suggestion of faulting was seen in any rock outcrop. Moreover strikes and dips are uniform throughout the belt. If faulting occurred, the contacts between the geological formations were not appreciably disturbed. Consequently to assign a thickness of 10,000 feet to the York River formation in this southern belt appears as a reasonable conclusion and the one which can most easily be deduced from the available information. Small scale faulting might have occurred but not so much as to modify greatly the above estimates.

Faulting occurred in the York River formation near the central eastern boundary of the area. The fault appears to be a normal one with a steep dip to the south, and a movement increasing in magnitude eastward. As a result of this faulting, the York River belt appears to be exposed over a larger width than it could be expected in that part of the area. On the accompanying map, several beds are shown as being overturned to the north, south of the fault under discussion. Overturning was inferred mainly on account of the stratigraphic succession (see Cape Bon Ami formation) but also from evidence shown by cross-bedding, in one case, and graded bedding in the other.

Cross-bedding (Pl. 19) on a large scale, and ripple-marks occur sporadically in the southern belt but these features are not common. Graded-bedding is rare. Cross-bedding on a minor scale and ripple-marks are common in the rocks of the northern belt, particularly in the eastern half of the area. In this same general location, plant remains and poorly preserved mollusks show occasionally a preferred orientation as if they were brought to place by currents. The direction of these currents as inferred from the orientation of organisms, cross-bedding or ripple-marks is shown on the accompanying geological map. The majority of the rocks of the northern belt appears to have been deposited in shallower waters than the rocks of the southern belt.

West of Joshua lakes, the York River beds are gently folded in a series of small adjacent anticlines and synclines running slightly north of east. Gentle dips are predominant in the York River formation on the north limb of the Berry Mountain syncline.

LAKE BRANCH FORMATION:

The Lake Branch formation is a new term introduced by McGerrigle (1950 MS) to name an extensive lens of red sandstones and shales, located in the northern third of the area. The formation derives its name from the Lake Branch of the Cascapedia river, the major stream which flows over it (Pl. 20). It roughly

Plate 19 : - Cross-bedding in the York River sandstone. East bank of the Cascapedia river: 1,000 feet upstream from Bonaventure - Matapedia County line.

Plate 20 : - Red beds of the Lake Branch formation. North bank of the Lake Branch, five miles upstream from the Fork.

coincides in position to the Lake Branch depression (fig. 3). There is no single type section for the formation as no reasonably continuous exposure can be found along a single section in the area. Good but scattered exposures of the formation can be seen along the Lake Branch, the Salmon Branch, Miner brook, Go-A-Shore brook, Brandy brook, and Berry Mountain brook.

The predominant color of the rocks is from brown to dull or bright red. Green streaks and spots occur commonly in some exposures, the green color being probably due to the reduction of the ferric oxides by organic matter. The formation is well-bedded but so poorly consolidated that it crumples very easily under the effects of weathering. Along the Salmon Branch, the rocks are mostly shales with interbeds of fine-grained argillaceous sandstones and siltstones. On Go-A-Shore brook, the rocks are medium- to fine-grained sandstones. Along Brandy brook, fine-grained types predominate with shales, mudstones and argillaceous, laminated siltstones as representatives. The three sections just cited are toward the bottom of the formation.

Toward the top of the formation, along the Lake Branch, shales and fine-grained sandstones are interbedded in about equal quantity. Occasional beds of medium-grained sandstones are present. Throughout the formation, the beds rarely exceed two feet in thickness. In some exposures, the fine-grained sandstones and occasionally the medium-grained variety are in layers one inch thick separated by thinner layers of red shale. Cross-bedding in the sandstone and siltstone beds, and mud-cracks in the shale beds are common features. Ripple-marks of both the current or wave types can be frequently observed. Plant fragments, features suggestive of rain imprints and rill marks, as well as worm borings occur here and there on some of the bedding planes of the formation.

The formation at places grades into the underlying York River formation along a transition zone of nearly 400 stratigraphic feet, where the red beds are interbedded with light green beds of approximately the same composition.

The contact of the Lake Branch formation with the overlying Battery Point formation was seen nowhere in the area and the type of contact could not be inferred from the débris. In the western half of the area, the zone between the two formations is locally occupied by the Mount Noble volcanics, which will be described later. Along the Inlet river, there seems to exist a difference of 20° between the regional trend of the two adjacent formations. In the general vicinity of the Cascapedia river, there is also a persistent difference of approximately 20° between the dips of the two formations. This divergence in attitude can be accounted for by faulting, by the character of the folding, by an angular unconformity, by sudden thinning of the Lake Branch formation southward and westward, or by steep primary dips in the Battery Point formation.

The idea of faulting along the Berry Mountains escarpment is attractive on account of the topographic break at this front. Irregularities in strikes and dips of the Battery Point beds in the vicinity of Mount Noble also suggest faulting. There is no faulting, however, in the Inlet river section, and the escarpment does not follow the trend of the rock formations west of Loon lake. The escarpment is most likely due to the friability and poor state of consolidation of the Lake Branch formation compared with the resistant Battery Point sandstones. West of Loon lake the escarpment apparently owes its existence to the interfingering of firm, calcareous, green sandstones in the typical, red Lake Branch beds. Consequently faulting is adequate to account for the difference in dips near the Cascapedia river but cannot explain the difference in trend of the two formations along the Inlet River.

For identical reasons, folding alone cannot account for the divergence in trend of the two formations along the Inlet river. As to the difference in dip, it appears to be of a too constant value to be accounted for by folding alone.

An angular unconformity between the Lake Branch and the Battery Point formations would be difficult to prove, since nowhere in the area or in Gaspé, in general, is there a suggestion of orogenic movement at this level. This hypothesis can be discarded without further comments.

The steepening of dips and change in attitude can be explained by thinning of the Lake Branch formation southward and westward, possibly by assuming the existence of a foreset slope at the contact of the two formations. This idea fits well with the composition, color, textural and structural features of the Lake Branch formation which seems to represent a delta-deposit.

Near the Cascapedia river where the exposures are relatively abundant, the two formations are not far from being conformable. The difference in dip increases as one records attitude of beds southward and climbs on top of the upland in the Battery Point nearly 1,200 feet above the level of the Lake Branch exposures. Supposing that a "deep" or steepening of slope existed in front of the Lake Branch delta at the beginning of Battery Point deposition, such a change of slope would be reflected by a change in attitude when the two formations are observed at a different level. The shape of the basin of deposition could also account for the divergence in strike along the Inlet River.

A foreset slope alone, however, seems inadequate to explain a difference of dip of 20°. Consequently it appears that more than one factor contributed to the present structural relationships. The writer favors the existence of a steepening of slope in the basin of deposition i.e. steep primary dips in the Battery Point formation with contemporaneous deformation and thinning of the Lake Branch southward. Subsequent faulting at the Big Berry Mountains escarpment would accentuate the original divergence in attitude. The fact that the Lake Branch formation does not appear on the south limb of the Berry Mountain syncline suggests an argument in favor of such structural relationships. At the contact, the beds of the two formations would be conformable. Only observations some distance from the contact (horizontally or vertically) would reveal a change in attitude.

Strict adherence to lithology would lead one to consider the Inlet River beds as belonging to a formation different from the Lake Branch formation. The 3,000 feet of sedimentary rocks in line stratigraphically with the Lake Branch formation are made of green, medium-grained, hard, calcareous sandstones in beds up to 2 feet thick, interbedded with laminated, dark grey siltstones and shales (Pl. 21). The red sandstones and shales of the Lake Branch type constitute less than 30 per cent of the rocks of the section. Toward the base of the formation, there are some beds of medium-grained, greenich-grey to dark green sandstone containing aboundant pink feldspars, therefore very similar to the Battery Point sandstone. Marine or brackish-water invertebrates were found at several localities in the Inlet River section, in the calcareous sandstones, suggesting that these rocks in this formation represent a near-shore facies where marine- and fresh-water conditions alternately occurred. These rocks were not grouped into a new rock unit, because the author wanted to present a simpler and clearer picture of the stratigraphy and because their distribution and characters are little known to the west of the area.

Part of the York River formation, where it crosses Berry Mountain brook (South branch), is made up of a succession of beds very similar to those just described. Interbedded green and red sandstones also occur. The red sandstones are generally more argillaceous and crumple more easily than the green, slightly calcareous sandstone beds which stand out in relief (Pl. 22).

Structurally, the Lake Branch formation shows the

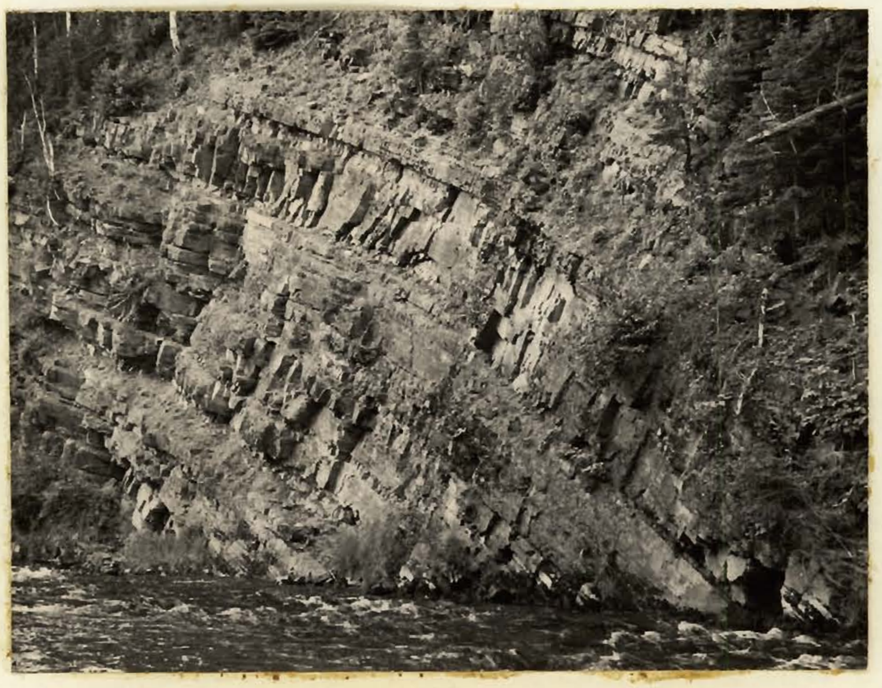


Plate 21 : - Thick, green beds in the Lake Branch formation. Inlet river - two miles east of western boundary of area.

gentle dips southward of the geological formations lying on the north limb of the Berry Mountain syncline. Minor faulting and drag folding occur in the section along Miner brook but such features are rare and are restricted to a short stratigraphic interval (Pl. 23). In the Berry Mountain map-area, Jones (1930, p. 23) assigned a thickness of 4,000 feet to the formation. McGerrigle (1950 MS) estimated the thickness to be about 5,000 feet but, owing to uncertainty in the location of the upper contact, accepted the thickness of 4,000 feet as possible. There is no doubt that the formation, as defined, varies in thickness at different localities.

Plate 22 : - Green sandstones interbedded with red sandstones (top and bottom). Berry Mountain brook (South branch). One and a half mile east of Matane - Gaspé county line.

BATTERY POINT FORMATION:

The section at Tar Point (Fig. 1), measured by Logan (1863, p. 416), and defined by him as the Gaspé sandstones, included practically only the Battery Point formation. Only the very top of the York River formation shows up on the nose of the Tar Point anticline and the rest of the section (7,036 feet) southward is made of Battery Point beds. The type section has been given a new locality, and is now at Battery Point "where Battery Park hotel stands, shortly outside of Gaspé village, and from the point westerly along

Plate 23 : - Drag in the Lake Branch formation. South bank of Miner brook, at mouth of Big brook.

the south shore of Gaspé basin for upwards of one mile" (McGerrigle, 1950, p. 84).

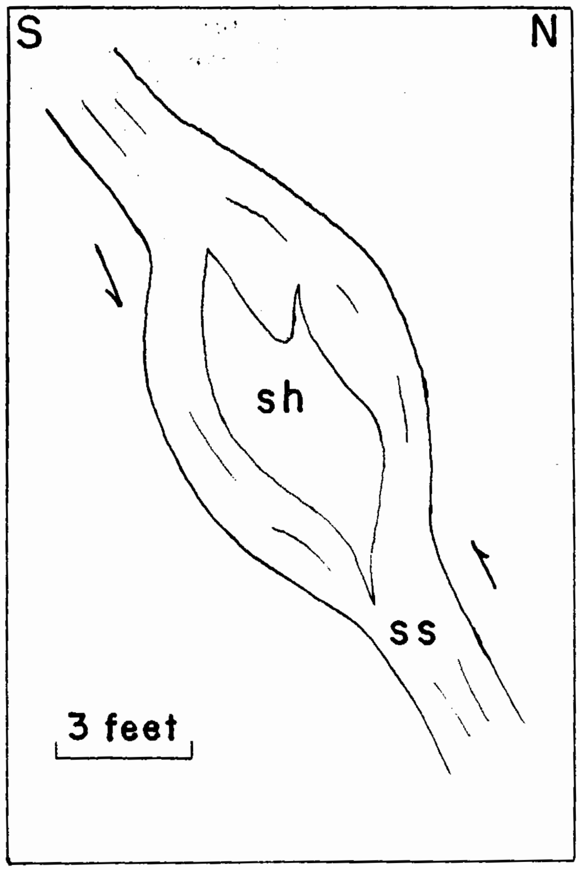
In Eastern Gaspé, the formation consists of medium to light greenish-grey sandstones varying in grain size from fine to very coarse. Some beds are fine-pebble conglomerates. Streaks of pebbles can also be found within the sandstone beds. The pebbles, generally well-rounded and under half an inch in diameter, are made of quartz, jasper, chert, quartzite, volcanic rocks, and occasional reddish granite and red syenite. Cobbles and boulders occur at places in the fine-pebble conglomerates (Pl. 24). Cross-bedding, on a minor or a large scale, is a common feature (Pl. 25). The formation differs from the York River formation by its generally coarser and more angular grains, and as pointed out before, by the color of its feldspars. The York River is also more shaly, less pebbly, and not so sharply cross-bedded. Red sandstones, shales and conglomerates occur towards the top of the Battery Point formation at Pointe St. Pierre. Ripple-marks, mud-cracks, cross-bedding, and occasional rain imprints were observed in these red beds (McGerrigle 1950, p. 85).

This description of the Battery Point in Eastern Gaspé applies integrally to 80 per cent of the rock shown as Battery Point in the Big Berry Mountains map-area. The rocks show the same lithology and physical features. Major cross-bedding is common and cut-and-fill structures were observed at two localities (Pl. 26). The sandstones at many places, over a long stratigraphic interval, appear very homogeneous, and bedding is difficult to decipher. Individual beds reach a thickness of 20 feet. Jones (1930, p. 22) noted the presence of "fine-grained, brown sandstones and chocolate brown shales" in the formation, "but only at a few places".

Approximately 2,000 feet downstream from the mouth of the Square Forks river, along the west bank of the Cascapedia river, green and chocolate brown shales in layers 8 inches thick are interbedded with massive 8 feet thick beds of medium-grained, distinctly green sandstone containing no pink feldspars. At the downstream end

Plate 24 : - Fine-pebble conglomerate interbedded with typical Battery Point sandstone in Logan's type-section. Half a mile south of L'Anse-à-Brillant.

Plate 25 : - Cross-bedding in the Battery Point sandstone. Logan's type-section. One mile south of L'Anse-à-Brillant.



Section on plane dipping
45° E.

Figure 5 : - Pseudo-drag fold in the Battery Point formation.

Plate 26 : - Cut-and-fill structure in the Battery Point sandstone. Indian Falls brook; two miles upstream from its mouth.

of the exposure, a green shale bed has flowed between two competent sandstone layers and exhibits a pseudo-drag fold fitting correctly in the general structural picture (Fig. 5). Although none of these beds carry pink feldspars, they are included in the Battery Point formation because good Battery Point beds occur stratigraphically lower along nearby brooks. No other chocolate brown or red beds were seen in the area at this general stratigraphic level. South and east of the mouth of Otter brook, however, the distribution of abundant débris suggests that red beds again are interbedded with the green sandstones.

Plate 27 : - Calcareous, greenish-grey, thinly bedded sandstones at the same stratigraphic level as the typical Battery Point sandstone. Inlet river: two miles west of point where river turns sharply north and flows toward Loon Lake.

In the southwestern corner of the area, the distribution of the débris and a few scattered exposures show that the underlying bedrock is mainly made of red sandstones, siltstones, conglomerates and shales in order of decreasing abundance. These red beds occur at the top of the Battery Point sequence, a position identical to the red beds of the Battery Point formation in Eastern Gaspé.

Along the Inlet river, the stratigraphic interval corresponding in position to typical Battery Point is occupied by medium- to fine-grained, light greenish-grey, calcareous sandstones interbedded with dark green, well-bedded sandstones and siltstones (Pl. 27). Some beds of argillaceous limestone are also present. Upstream or near the base of the section, interbedded red, purple and green sandstones and shales are commonly found. Some poorly preserved corals were found in the calcareous sandstones at the point where the Inlet river turns sharply north and flows toward Loon Lake (McGerrigle's collection). Parts of these beds, therefore, are marine.

The Battery Point formation is structurally located in the center of the Berry Mountain syncline. Minor folding and possibly faulting occur near the axis of the syncline in the eastern half of the area. A nearly east-west set of vertical joints is developed in the formation at the headwaters of the Square Forks river. Such joints grade into a narrow shear zone in the extreme southwestern corner of the area. How much movement took place along the shear zone cannot be determined but according to the succession of beds on both sides of the zone, the movement was slight.

Two parallel faults are shown on the accompanying map in the same general location. The tracing of these faults is based on very little information, and the irregularities in direction of dips could be explained as well by folding.

In the eastern half of the area, where faulting does not seem to have much disturbed the sequence of beds, the formation apparently reaches a thickness of 10,000 feet. This value added to the 10,000 feet of the York River, makes a considerable thickness for a single series of rocks in a restricted area. The geological implications set by these figures will be discussed more fully in the chapter under petrology. In the western half of the area, the Battery Point formation is too poorly exposed to allow an estimate of its thickness.

MOUNT NOBLE VOLCANICS (new term):

A small lens of acid and basic lavas makes part of the Big Berry Mountains escarpment in the western half of the area. The lens is 5 miles long, 2,000 feet thick, and located at the contact between the Lake Branch and Battery Point formations. The rocks in the eastern part of the lens are predominantly acid; in the western part, they are basic.

The acid rocks consist of creamy light brown to light green, hard, very fine-grained, rhyolite porphyry. The rocks at the eastern end of the lens range in color from light green to grey, to pink or red owing to the orthoclase phenocrysts sometimes visible to the naked eye. The red color is also partly due to limonitic staining. At places the rocks carry vesicles and amygdules containing quartz and chalcedony. Small lumps and stringers of quartz also occur. Very finely textured flow lines were observed at a few places. A crude quartz layering consisting of alternating layers (below half an inch thick) of quartz and rhyolite was also observed on the cliffs of a sharply pointed pinnacle which can be seen from the Lake Branch of the Cascapedia river. Finely bedded acid tuffs and volcanic breccias were found in the central part of the lens and in the débris.

The acid rocks of the Mount Noble volcanics were given a closer study than the other rocks in the area because disseminated, sub-microscopic flakes and grains of chalcopyrite were found in one of the rock outcrops. The main rock type is essentially a feldspar porphyry. The groundmass appears as a mesh or a very fine aggregate of cryptocrystalline quartz and microlites of feldspars. Two thin-sections showed rosettes of chalcedony. The major part of the groundmass is too fine-grained to be identifiable under the microscope and suggests an extrusive origin for these rocks. The phenocrysts consist mainly of albite, and orthoclase (or potassic feldspars) in lesser amount. Quartz may also occur as phenocrysts. The feldspar phenocrysts are fractured and crushed: some have been so much altered to sericite that they are hardly recognizable.

Apparently a large part of the quartz "phenocrysts" are the result of the recrystallization of the groundmass or the introduction of later quartz in the fracture of the rocks. Secondary growth rings and connection of the "phenocrysts" with openings filled by combed quartz point toward this conclusion.

In the six thin-sections studied, approximatively 20 per cent of the quartz appears to be secondary. This quartz is clear, well-crystallized, and can be identified easily whereas that of the matrix is obscure. Fractures in the matrix and the feldspar phenocrysts are filled by secondary quartz. Occasionally a thin band of muscovite and semi-opaque minerals lines the walls of the fractures, and this, with the addition of combed quartz, form a microscopic banding. Pseudomorphs of quartz after feldspar are present and usually contain a core of sericite leaflets. Some microscopic, rounded cavities contain projecting crystals of quartz.

Besides the quartz and feldspar phenocrysts, small crystals of apatite and zircon are scattered sparingly throughout the groundmass. The semi-opaque minerals, which probably contain the chalcopyrite, constitute a very small portion of the total mass. Genetically they appear to be related to the secondary quartz since they most commonly occur in druses and vesicles filled by clear quartz, or along thin channels leading to an aggregate of clear quartz crystals. They bear the same relationships to the muscovite. These semi-opaque minerals occur in slightly larger amount in the specimens coming from the eastern end of the igneous mass.

The basic part of the volcanic lens corresponds to a diabase in composition and texture. The rocks are fine-grained, commonly amygdaloidal and occasionally porphyritic. A porphyritic phase showed feldspar phenocrysts (Ab60 An40) up to a quarter of an inch long. No individual flow could be detected. Calcareous tuffs and shales, in beds 8 inches thick, were noted near the acidic part of the lens. At another locality, fine-grained clastic tuffs in layers 2 inches thick are interbedded with a sedimentary breccia in beds up to 8 inches thick. Microscopic examination revealed that the sedimentary breccia is made up of 60 per cent basic volcanic material (diabase fragments, basaltic glass, basaltic tuff) set in a matrix consisting of quartz (20 per cent of total), feldspar (10 per cent) and finely-chopped and decomposed igneous material. The granules of volcanic material are up to one centimeter but generally less than 3 millimeters in diameter.

An intrusive origin for the Mount Noble volcanics was partly subscribed to by the writer during the field season of 1950, but on finding in 1951 the several volcanic features mentioned above, he now believes that the major part if not all these rocks are extrusive. The term Mount Noble is suggested for these rocks although Mount Noble is located nearly two miles to the east of the volcanic lens. Mount Noble, however, is the best known, nearest and most prominent topographic feature in the general vicinity.

PLEISTOCENE AND RECENT:

The soil is thin, but the regolith as a whole is comparatively thick over most of the area, particularly on the upland. Débris which can be found near the roots of overturned trees is usually representative of the underlying bedrock. There is no sign of residual soil but the vegetation is thick enough to prevent examination of the soil in most places. Residual soil occurs in the Federal Mine area (Gill, J.E., personal communication).

In the Lake Branch and the Square Forks lakes depressions, and in the lower reaches of the tributaries to the Cascapedia river, the streams commonly cut through unconsolidated material. Along the Inlet river and the Square Forks river, the deposits, generally less than 30 feet thick as exposed, are made up of stratified, sometimes imbricated, generally well-sorted gravels interbedded with lenses of medium-grained sands or pebbly sands. Red silt and fine-grained sands are commonly found toward the base of the sections (Pl. 28). These are river deposits belonging to the former floodplains of the Inlet river and the Square Forks river. No typical till was observed.

In the Lake Branch depression and along the tributaries to the Cascapedia river, the fairly commonly exposed sections which are sometimes up to 60 feet thick, generally consist of three zones. An upper layer is made of interbedded, roughly to well-stratified gravels and medium- to fine-grained sand beds up to 2 feet thick (Pl. 29 and 30). The fragments in the gravels are generally well-rounded and range in size from pebbles to cobbles. Below this upper zone, is a layer up to 10 feet thick made of unsorted material with angular to rounded fragments ranging in size from 2 inches to 3 feet across. Striated boulders and soled pebbles are occasionally found in this layer which is considered to be a till. The zone below the till is generally hidden by slumping from above. Where it was exposed, it was seen to consist of well-sorted and stratified gravels interbedded with fine-grained sands and silts (Pl. 31). At several places along Berry Mountain brook (South branch), reddish brown,

Plates 29 and 30 : - Typical unconsolidated deposits in the lower part of the tributaries to the Cascapedia river and in the Lake Branch depression. Indian Falls brook, 1,200 feet above its mouth.

Plate 31 : - Detail of one of the fine sand layers in plates 30 and 31.

CHAPTER IV

PALEONTOLOGY AND CORRELATION

SILURIAN

Fossils are rare in the sedimentary belt of the southeastern corner of the area but the single genus found is diagnostic of the Silurian System. Along the west branch of Big Jonathan brook, on the north limb of the Joshua brook anticline, the following fossils were found:

Monograptus tumescens Wood
M. Nilssoni (Barrande)
M. sp., cf. *M. vulgaris* Wood
M. sp., cf. *M. dubius* (Suess)

On the south limb of the anticline, at the same horizon, the fossils collected were:

Monograptus dubius (Suess)
M. sp., cf. *M. colonus* var. *compactus* Wood
M. sp., cf. *M. varians* Wood
Kionoceras sp.

Another fossil locality on the east branch of Big Jonathan brook revealed the presence of

Monograptus sp., cf. *M. dubius* (Suess)
M. sp.

The three specifically identified specimens are illustrated in plates 32, 33, 34. One specimen of Monograptus cf. vărians Wood is shown in plate 35.

This assemblage of monograptids represents a Lower Ludlow horizon within the Silurian, i.e. it correlates with the lowermost Upper Silurian beds of Great Britain. As pointed out by L.W. Cumming who kindly checked the identification of the fossils, "the assemblage represents one of the few well defined post-Wenlockian age determinations from Gaspé. Its proximity to (and definite separation from) the Gaspé limestone provides an important locality with regard to the Silurian-Devonian boundary" (Personal letter).

The age determination also shows that a small time interval elapsed between the outpouring of the overlying lavas and the deposition of the Cape Bon Ami formation in the present area.

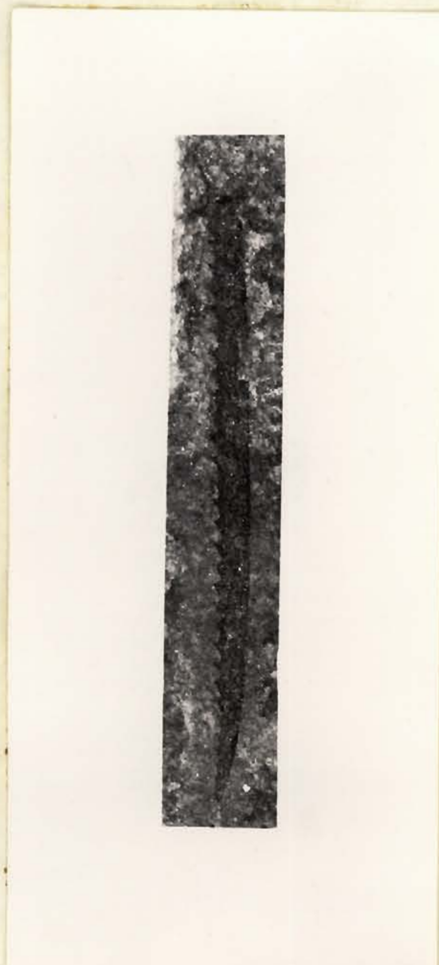


Plate 32 : - Monograptus
tumescens Wood,
x 2.5

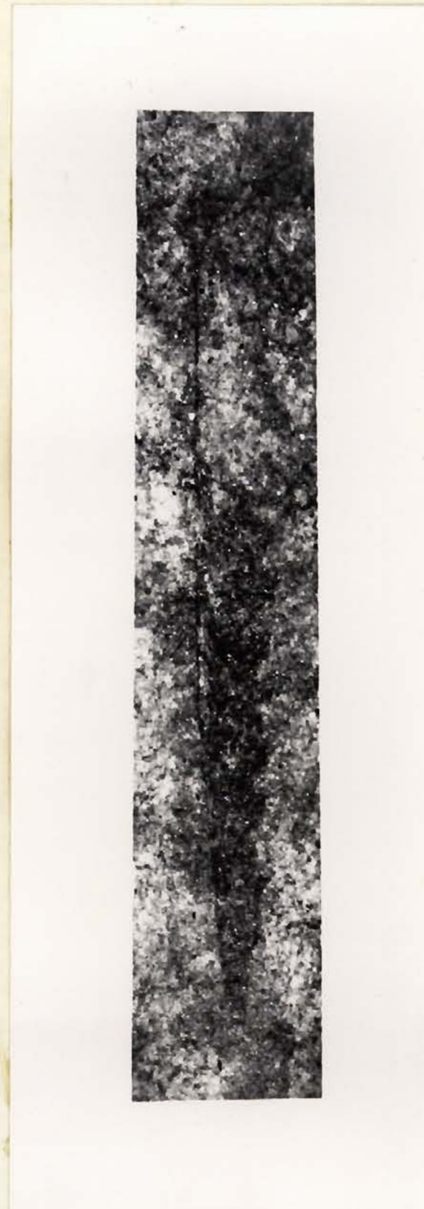


Plate 33 : - Monograptus
dubius (Suess),
x 9.7

Plate 34 : - Monograptus Nilssoni (Barrande), x 2.5 Hooked theca apparently due to preservation only.

Plate 35 : - Monograptus cf. varians Wood, x 10

DEVONIAN

Fossils of Devonian age can be found at several localities in the present area. The fossil content of the formations has not been used as a tool to classify the rocks, but rather the fossils have been assigned to the formations in which they were found. The formations have been correlated, on a lithological basis, with the Eastern Gaspé Devonian. Fossils generally are few and they commonly are so poorly preserved as to be of little use in correlation. The differences in the known fauna of the various Devonian formations in Gaspé are slight. In the present area, no locality has yielded a fossil assemblage diagnostic enough to indicate definitely to which formation it belongs. However a general Lower and/or Middle Devonian age is clearly indicated.

In Eastern Gaspé, the Cape Bon Ami and Grande Grève formations are considered as Oriskany in age; the Fortin series and York Lake formation as Oriskany or Onondaga; the York River and Battery Point formations as Hamilton (McGerrigle, 1950, p. 23). Certain paleontologists (e.g. Cooper, 1942, p. 1760), however, favor a Lower Devonian age (Onondaga and older) for the whole Gaspé limestones and sandstones sequence. McGerrigle (ibid. p. 87-91) gives a complete historical treatment and a review of the various opinions on this problem. In the following pages, the modern practise of considering the Onondaga as part of the Lower Devonian Series (Cooper, 1942) is adopted.

CAPE BON AMI FORMATION:

The Cape Bon Ami formation of the present area is unfossiliferous, as far as stratigraphical paleontology is concerned. Comminuted plant fragments can be occasionally found on bedding planes, but besides these occurences, not a single other trace of fossils was seen in rock outcrops or in the débris.

It must be clearly pointed out that the rocks under discussion are correlated with the Cape Bon Ami formation exclusively because of their lithological characters. Stratigraphically they occupy the place of the Grande Grève formation.

GRANDE GRÈVE:

Three lots of fossils were collected from the Grande Grève formation on two tributaries of Miner brook near the western edge of the map-area. The composite list of two of the lots collected from closely spaced outcrops near the upper limit of exposures on Moose brook includes Chonostrophia complanata Hall, Chonetes sp. nov., and Spirifer modestus nitidulus Clarke.

The third lot obtained from outcrops near the contact with the overlying formation, and located to the east of Moose brook, contains Leptaena rhomboidalis (Wilckens), Orthotetes woolworthanus gaspensis Clarke, Chonostrophia dawsoni (Billings), Spirifer gaspensis? Billings, Spirifer cyclopterus? Hall, and Meristella champlaini Clarke.

On the fauna yielded by the three lots, McGerrigle

(1950 MS) writes: "This fauna suggests a close relationship with the Grande Grève at the type locality although some of the forms are present also in the York River formation."

Approximately one mile north of Berry Mountain Lake, fossils occur in a tuffaceous sandstone, stratigraphically located at the same horizon as the top of the Grande Grève formation. The list of species collected is given in table 1 with the other localities where they have been recorded. The Spirifers and Rhytistrophia indicate a Grande Grève age. The corals are new for the Grande Grève formation. Heterophrentis prolifica (Billings) is found in the Onondaga of Erie County, Ohio (Olentangy shale). It occurs also in the Centerfield coral reef of the Mahantage formation in Pennsylvania (Hamilton), and is present at several other localities in Middle Devonian rocks. Emmonsia tuberosa (Rominger) is present in the Onondaga limestone of New York, the Falls of the Ohio, and of Ontario but it is also found in the Moscow shale and the Centerfield limestone. It is more common in the Onondaga than in younger rocks. These species apparently have not been recorded in Oriskany rocks. If so, the rocks correlated with the Grande Grève formation, because of their lateral gradation into typical Grande Grève beds, possibly should be considered as York Lake in age. At the best, they appear to belong to the Onesquethaw stage (Onondaga) whereas the Grande Grève formation, at the Forillon peninsula, belongs to the Deerpark stage (Oriskany). However, there is still the possibility that these species developed at an earlier time in the Gaspé basin than elsewhere.

TABLE 1 - V = identities

SPECIES	Eastern Gaspé		New York			Maryland			New Jersey			Maine	
	Grande Grève	York River	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Chapman ss	Moose river ss
Spirifer arenosus (Conrad)	V		V			V			V				V
S. murchisoni Castelnau	V		V			V			V				
S. sp., cf. S. modestus (Hall)													
S. sp., cf. S. gaspensis Billings													
Protoleptostrophia blainvillii (Billings)	V	V											
Leptostrophia sp., cf. L. magnifica (Hall)													
Rhytistrophia beckii (Hall)	V		V	V									V
Chonetes billingsi Clarke	V	V											
? Chonetes hudsonicus gaspensis (Clarke)													
Actinopteria sp.													
? Dalmanites sp.													
Heterophrentis prolifica (Billings)													
Emmonsia tuberosa (Rominger)				V									

YORK LAKE FORMATION:

In the section along Miner brook, the York Lake formation has yielded five collections of fossils made at different horizons, mainly from sandstone beds, but in one case from a limestone bed. The composite faunal list includes: Algae?, Plant fragments, *Zaphrentis* sp., *Favosites* sp., *Lingula* sp., *Chonetes hudsonicus gaspensis* Clarke, *Dalmanella lucia* (Billings), *Leptaena rhomboidalis* (Wilckens), *Leptocoelia flabellites* (Conrad), *Rensselaeria* sp., *Orthotetes woolworthanus gaspensis* Clarke, *Spirifer gaspensis* Billings, *Spirifer arenosus* Conrad, *Stropheodonta* sp., *Eotomaria* cf. *rotula* Clarke, *Strophostylus* cf. *expansus* Hall, *Platyceras tortuosum* Hall, *Platyceras* cf. *leboutillieri* Clarke, *Actinopteria* sp., *Cypricardinia* sp., *Grammysia* sp., *Pterinea* sp., *Dalmanites whiteavesi* Clarke.

Under this list, McGerrigle (1950 MS) gives the following comments: "The above list of fossils indicates a closer age relationship with the Grande Grève formation than with the York River and suggests, further, that the enclosing rocks belong to the Lower Devonian Oriskany division. However, the differences between the known total faunas of the Grande Grève and the York River in the peninsula as a whole are not great, and such differences as seemed to exist have become progressively less as the collections of fossils have increased. Small collections such as we have from the various Devonian formations in the present area do not permit conclusive comparisons".

Approximately one mile northwest of Berry Mountain lake, along the road leading to Taylor's lumber camp, a small collection of fossils has been made from typical Grande Grève beds. This belt is shown as belonging to the York Lake formation on the accompanying map because very abundant sandstone débris, almost in place, was found in the road ditch, eastward. Table 2 shows the fauna collected at this locality. The specifically identified forms indicate affinities with the Grande Grève fauna although they occur some 1,200 stratigraphic feet above the Onondaga corals found in the tuffaceous sandstone (Table 1). The internal structures of the genus Prionothyris or Beachia could not be observed, but the two genera range in age from the Deerpark stage (Oriskany) to the end of the Onesquethaw stage (Onondaga). The anomaly between the stratigraphic location of the present fauna and the fauna in the tuffaceous sandstone suggests faulting. In the area, however, there is no other clue for the existence, location and mechanism of the possible faulting.

TABLE 2 - V - identities - X - helderberg

SPECIES	Eastern Gaspé		New York			Maryland			New Jersey			Maine	
	Grande Grève	York River	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Chapman ss	Moose River ss
Spirifer arenosus (Conrad)	V		V			V			V				V
S. gaspensis Billings		V											
Strophonella sp.													
Prionothyris sp. or Beachia sp.			V	V									
Etymothyris gaspensis (Clarke) (Rensselaeria ovoides gaspensis)	V	V											
Leptostrophia sp.													
Chonetes sp.													
Schuchertella woolworthana (Hall)			X			X			X				
S. sp.													
Orbiculoidea sp.													
Strophonella continens Clarke	V												
Paleoneilo sp. nov.													
Proetus sp.													
Crinoid stems													

FORTIN SERIES:

No identifiable fossils have been found in the Fortin series. All organic remains appear to have been destroyed or obscured by the metamorphism affecting these rocks in the present area. Comminuted plant fragments and carbonaceous markings were noted half a mile south of the Silurian volcanics on the east branch of Big Jonathan brook.

YORK RIVER FORMATION:

In the portion of the area mapped by H.W. McGerrigle, "fossils have been found in beds assigned to the York River formation at four localities. Two of these localities are on Indian brook, one near the top of the formation and the other about 1,000 feet from the top. The former (F 13/47) included some poorly preserved corals, ?Favosites sp., Cystiphyllum sp., Zaphrentis sp., as well as Leptocoelia flabellites (Conrad); while the latter (F 23/43) included a poorly preserved Rensselaeria sp. On Go-A-Shore brook a horizon towards the middle of the formation yielded (F 11/47) Rensselaeria atlantica Clarke, Leptodomus cf. communis Clarke, Paleoneilo sp., and some unidentifiable pelecypods representative of two or three species. This horizon was notable for the number of pelecypods present. A fourth collection (F 2/47), made from a horizon also towards the middle of the formation, on Miner brook, included Coelidium sp., Kionoceras rhysum Clarke, and Cypricardinia distincta Billings". And McGerrigle (1950 MS) adds: "Judging from these fossils alone, or without knowledge of their stratigraphic position, the formation could as well be correlated with the Grande Grève as with the York River, and they suggest a Lower Devonian (Oriskany) age".

Jones (1930, p. 19) found the following fossils from the "finer-phase of the lower division", i.e. the York River formation, in the Berry Mountain map-area:

" 1. From an outcrop of buff, calcareous sandstone on the east bank of Berry Mountain brook (North branch) about 3,640 feet downstream from where the line between Lemieux and Baldwin townships crosses the brook:

Edmondia?

Edmondia sp.

Goniophora tethys Billings?

Modiomorpha sp.

2. From an outcrop of buff, calcareous sandstone on Berry Mountain brook (North branch) 4,240 feet downstream from the Lemieux-Baldwin township line:

Lingula rectilatera Hall

Also, species similar to those of group 1, not collected.

3. From an outcrop of grey sandstone on top of the east bank of Brandy brook (Main branch) on the Gaspé-Matane county line:

Annelid trails

4. From loose block of grey sandstone, believed to be nearly in place; some location as 3:

Stropheodonta, cf. *Schuchertana* Clarke

Spirifer gaspensis Billings

Aviculopecten? sp.

5. From loose block of grey sandstone, some doubt as to being in place; same location as 3 and 4:

Favosites heldergergiae Hall

Spirifer gaspensis Billings

Cyrtina sp.

6. From loose slabs on old road leading from the mouth of Brandy brook to Federal mine. Rocks represent underlying sediments:

Rensselaeria cf. *Atlantica* Clarke

7. (Field number 10). From outcrop of arenaceous limestone on west bank of Brandy brook (Main branch) about 3,500 feet upstream from the junction of the Main and North branches:

Spirifer gaspensis Billings

Spirifer cf. *concinnus* Hall

Spirifer sp. "

E.M. Kindle who identified the fossils made the following observations on the significance of the fauna: "The lots included in this list of fossils represent Devonian horizons. Two types of sandy sediments are present. Rensselaeria and one or two of the pelecypods appear to be associated with the cleaner and less silty type of sand with which the fossils are associated; while the corals and Spirifers occur in a finer textured sediment sometimes with calcareous bands. All of these faunules are considered to belong to zones lying within the Gaspé Sandstone. This is a formation which, wherever studied, shows evidence of having been formed under conditions which alternately admitted and excluded marine faunas. The period of its deposition apparently overlapped the transition from Lower to Middle Devonian".

In the same area, where the road to Brandy brook, sharply turns northeast and afterwards follows the east bank of the brook, the writer found a few forms not previously mentioned. The fossils occur in a coarsely crystalline, light grey, arenaceous limestone, in beds up to 3 feet thick and divisible into smaller units 2 inches thick. Fossils also are found in the overlying calcareous, green, fine-grained sandstones. The fossil lot included Spirifer arenosus (Conrad), Spirifer murchisoni Castelnau, Schuchertella sp., Heliophyllum halli (Edwards and Haime), Syringopora sp., Trachytoechus moniliformis Fritz, Cladopora sp.

The Spirifers of the present lot are also found in the Grande Grève formation of Eastern Gaspé, and in the Oriskany of New York, Maryland and New Jersey. Heliophyllum halli (E. and H.) with its very abundant varieties occurs in the Onondaga of Ontario, Ohio, Michigan, Virginia and Kentucky. It is also of widespread occurrence in Middle Devonian rocks of the same, and other localities.

Trachytoechus moniliformis Fritz is a new species particular to this area (Fritz, 1944, p. 35-37). It is even possible that the holotype comes from the same locality as the present one. Fritz (ibid. p. 35) locates the holotype as follows: "The outcrop is in the side of a new road on the east bank of Brandy Creek, two and a half miles south of the camp of the Federal Zinc and Lead Company, Limited. It is on the edge of the flat plateau surface. Though the characteristic rocks of the area are sandstone, the fossil was found in a limy zone approximately 5 feet thick". The present occurrence is in a limy zone 11 feet thick; it is located three and a half miles in a straight line exactly southwest (bearing 225°) of the Federal Mine Camp. These data would seem sufficient to set apart the present locality from the holotype locality. However no other limy zones were seen along the Brandy brook road. Furthermore nowhere is the road following the east bank of Brandy brook located south of the Federal Mine Camp. Therefore it can very well be that the two localities are identical.

When Trachytoechus moniliformis was described, the genus had never been reported from rocks other than Middle Devonian, and this fact was taken as an argument in favor of "an Onondaga-Traverse age, i.e. Middle Devonian" for the Gaspé sandstones. The argument has more recently been somewhat invalidated for Fritz (1951, p. 27) has since described the same genus from the Helderberg of New York. To summarize then, the Spirifers of the present locality are found in rocks of Oriskany age and Heliophyllum halli (E. and H.) indicates an Onondaga-Traverse age.

Three other lots of fossils were collected from beds assigned to the York River formation in the section along Berry Mountain brook (South branch) and along one tributary to Berry Mountain brook. The first lot, toward the top of the formation, yielded Leptodomus communis Clarke, Palaeoneilo sp., cf. P. marylandica Prosser, Panenka sp. nov., Lingula sp., Orbiculoidea sp., Orbiculoidea sp. nov.?, Orthonota sp., Kionoceras? sp. The collection from a tributary to Berry Mountain brook (see map for location) contains Globithyris callida (Clarke), several unidentifiable pelecypods and gastropods, Psilophyton princeps Dawson and other poorly preserved plant fragments.

The above faunules have very little correlative value. However Lingula and Globithyris callida (Clarke) are useful in indicating the line of movement of contemporaneous currents. They show a persistent orientation northeast-southwest, without indicating, however, the direction of the currents.

The York River formation on the south limb of the Berry Mountain syncline has yielded only one fossil locality, although fossiliferous fragments can be seen rather commonly in the débris. The locality is toward the middle of the formation, at the head of Charles Vallée brook. Table 3 shows its fossil content. The faunule is not diagnostic enough to allow one to draw any conclusions as to the exact age of the enclosing strata. Actinopteria communis (Hall) indicates a Lower Devonian age but Palaeoneilo maxima (Conrad)

TABLE 3 - V = identities - X = helderberg

SPECIES	Eastern Gaspé		New York			Maryland			New Jersey			Maine	
	Grande Grève	York River	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Chapman ss	Moose River ss
Spirifer gaspensis Billings		V											
Mendathyris mainensis (Williams)												V	
(Rensselaeria atlantica Clarke)													
? Sphenotus truncatus (Conrad)		V			V								
Goniophora sp.													
Actinopteria communis (Hall)	V		XV			XV			X				
Palaeoneilo maxima (Conrad)		V			V			V					
P. sp.													
Pterinea edmundi Clarke												V	
Leptodomus communis Clarke												V	
"Cyrtoceras" sp.													

occurs in the Hamilton of New York and Maryland. The remarkable feature about this faunule is the large number of individuals of Spirifer gaspensis Billings. Among a large population of normal shape, some individuals are narrow, strongly alate but show no apparent distortion. The specimens of Mendathyris mainensis (Williams) are persistently smaller (12 millimeters long, 9 millimeters wide) than normal adults of this species.

In the area to the east, toward the end of the Bathurst road, as shown in Fig. 4, fossils were found in a brown, calcareous, medium-grained sandstone assigned to the York River formation. The locality appears to be toward the base of the formation but its exact stratigraphic location is unknown. Again the specifically identified forms are too few to provide the faunule with a definite diagnostic value. Except for Sphenotus truncatus (Conrad), a Lower Devonian age is indicated. The list of fossils is shown in table 4.

LAKE BRANCH FORMATION:

The Lake Branch formation contains only plants fragments which are generally much comminuted. Along the Inlet river, the green calcareous sandstones which are interbedded with the typical Lake Branch red beds, have yielded Globithyris callida (Clarke), Sphenotus truncatus (Conrad) and several other poorly preserved pelecypods. Globithyris callida (Clarke) is very abundant in some beds, and is persistently smaller (20 millimeters long, 17 millimeters wide) than

TABLE 4 - V = identities - X = helderberg

SPECIES	Eastern Gaspé		New York			Maryland			New Jersey			Maine	
	Grande Grève	York River	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Oriskany	Onondaga	Hamilton	Chapman ss	Moose River ss
Etymothyris gaspensis (Clarke) (Rensselaeria ovoides gaspensis)	V	V											
? Globithyris callida (Clarke)													
Beachia sp. or Prionorthis sp.													
? Rhynchospira formosa Hall	V		X										
Spirifer arenosus (Conrad)	V		V			V			V				V
Sphenotus truncatus (Conrad)		V			V								
Pterinea sp.													
Macrodus sp.													
Aviculopecten sp.													
Mytilarca sp.													
Anodontopsis sp.													

typical adults of this species. The pelecypods also, in some beds, are all half the size of the typical adults so that the Inlet river beds seem to contain a dwarf fauna. Globithyris callida (Clarke) is a lower Devonian species whereas Sphenotus truncatus (Conrad) is found in the Hamilton of New York and the York River of Eastern Gaspé.

BATTERY POINT FORMATION:

The typical Battery Point beds are poor in organic remains. Poorly preserved plant fragments and coal laminae occur here and there. The coal laminae, however, are much less abundant than in Eastern Gaspé. A fish spine was found in the débris near the eastern boundary of the area, two miles south of Berry Mountain Lake.

Along the Inlet river, Globithyris callida (Clarke), Leptodomus communis (Clarke), Sphenotus truncatus (Conrad), and Platyceras sp. were collected from greenish grey calcareous sandstones, in line stratigraphically with typical Battery Point beds. Poorly preserved corals also occur at the point where the Inlet river turns sharply north and flows toward Loon Lake (McGerrigle's collection). This faunule is very similar to the one given above, in the Lake Branch formation; it has the same poor correlative value. However, it shows that the enclosing beds were deposited in a marine environment.

TABLE 5

Composite list of Devonian fossils collected in the Big Berry Mountains map-area. Fossils assigned to the formations in which they were found.

X = identities

- = affinities

J = Jones

M = McGerrigle

C = Carbonneau

	Grande Grève	Oriskany	Onondaga	Hamilton
GRANDE GREVE FORMATION				
Emmonsia tuberosa (Rominger)			XC	XC
Heterophrentis prolifica (Billings)			XC	XC
Chonetes billingsi Clarke	XC			
C. hudsonicus gaspensis? Clarke		XC		
C. sp. nov. M				
Chonostrophia complanata Hall	XM	XM		
C. dawsoni Billings		XM		
Leptaena rhomboidalis (Wilckens)	XM			

		Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Meristella champlaini Clarke		XM			
Leptostrophia sp., cf. L. magnifica (Hall)	C				
Orthotetes woolworthanus gaspensis Clarke		XM			
Protoleptostrophia blainvillii (Billings)		XC			
Spirifer arenosus (Conrad)		XC	X		
S. cyclopterus? Hall	M				
S. gaspensis? Billings			XMC		-MC
S. modestus nitidulus Clarke		XM			
S. murchisoni Castelnau		XC	XC		
Rhytistrophia beckii (Hall)		XC	XC		
Actinopteria sp.	C				
Dalmanites sp.	C				
<u>YORK LAKE FORMATION:</u>					
Algae?	M				
Plant fragments	M				
Favosites sp.	M				
Zaphrentis sp.	M				
Chonetes hudsonicus gaspensis Clarke			XM		

		Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Chonetes sp.	C				
Dalmanella lucia (Billings)		XM			
Eotomaria sp., cf. E. rotula Clarke	M				
Etymothyris gaspensis (Clarke) (Rensselaeria ovoides gaspensis)		XC	-C		
Leptaena rhomboidalis (Wilckens)		XM			
Leptocoelia flabellites (Conrad)		XM	XM		
Leptostrophia sp.	C				
Orthotetes woolworthanus gaspensis Clarke		XM			
Prionorthis sp. or Beachia sp.			XC	XC	
Rensselaeria sp.	M				
Schuchertella woolworthana (Hall)	C				
Schuchertella sp.	C				
Spirifer arenosus Conrad		XMC	XMC		
S. gaspensis Billings			XMC		
Stropheodonta sp.	M				
Strophonella continens Clarke		XC			
S. sp.	C				
Strophostylus sp., cf. S. expansus Hall	M				
Lingula sp.	M				

		Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Orbiculoidea sp.	C				
Platyceras tortuosum Hall		XM	XM		
P. sp., cf. P. leboutillieri Clarke		XM			
Actinopteria sp.	M				
Cypricardinia sp.	M				
Grammysia sp.	M				
Palaeoneilo sp. nov.	C				
Pterinea sp.	M				
Dalmanites whiteavesi Clarke	M				
Proetus sp.	C				
Crinoid stems	C				
<u>YORK RIVER FORMATION:</u>					
Heliophyllum halli (Edwards and Haime)				XC	XC
Cystiphyllum sp.	M				
Favosites helderbergiae Hall		XJ	XJ		
Favosites sp.	M				
Syringopora sp.	C				
Zaphrentis sp.	M				
Trachytoechus moniliformis Fritz				-C	-C

		Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Cladopora sp.	C				
Cyrtina sp.	J				
Globithyris callida (Clarke)			XC		
Etymothyris gaspensis (Clarke) (Rensselaeria ovoides gaspensis)		XC	-C		
Edmondia?	J				
Edmondia sp.	J				
Leptocoelia flabellites (Conrad)		XM	XM		
Mendathyris mainensis (Williams) (Rensselaeria atlantica Clarke)			XJC		
Prionorthis sp. or Beachia sp.			XC	XC	
Rensselaeria sp.	M				
Rhynchospira formosa? Hall		XC			
Schuchertella sp.	C				
Spirifer arenosus (Conrad)		XC	XC		
S. cf. concinnus Hall	J				
S. gaspensis Billings			XJC		
S. murchisoni Castelnau		XC	XC		
Stropheodonta sp., cf. S. schuchertana Clarke	J				
Lingula rectilatera Hall		XJ			
Lingula sp.	C				
Orbiculoidea sp.	C				

	Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Orbiculoidea sp. nov. C				
Actinopteria communis (Hall)		XC		
Anodontopsis sp. C				
Aviculopecten sp. JC				
Cypricardinia distincta Billings	XM			
Goniophora tethys? Billings	XJC			
Leptodomus communis Clarke		XMC		
Macrodus sp. C				
Modiomorpha sp. J				
Mytilarca sp. C				
Orthonota sp. C				
Panenka sp. nov. C				
Palaeoneilo maxima (Conrad)				XC
P. sp., cf. P. marylandica Prosser C				
P. sp. M				
Pterinea edmundi Clarke		XC		
Sphenotus truncatus (Conrad)				XC
Coelidium sp. M				
"Cyrtoceras" sp. C				
Kionoceras rhysum Clarke	XM			
Kionoceras? sp. C				

		Grande Grève	Oris-kany	Onon-daga	Hamil-ton
Annelid trails	J				
Coprolites	CX				
LAKE BRANCH FORMATION:					
Globithyris callida (Clarke)			XC		
Sphenotus truncatus (Conrad)					XC
Plant fragments	C				
BATTERY POINT FORMATION:					
Globithyris callida (Clarke)			XC		
Leptodomus communis (Clarke)			XC		
Sphenotus truncatus (Conrad)					XC
Platyceras sp.	C				
Corals	M				
Plant fragments	C				
Fish spine	C				

CONCLUSIONS:

To summarize the information, a complete composite list of Devonian fossils collected in the Big Berry Mountains map-area is presented in table 5. The table includes Jones', McGerrigle's and the writer's findings. The table shows that the Grande Grève formation of the present area contains 11 species reported from the Grande Grève of Eastern Gaspé or from the Oriskany of other regions. Two fairly well-preserved species are Onondaga or Hamilton in age. However, the stratigraphic location of these two species is too uncertain to invalidate the information provided by the 11 other species. It appears, therefore, that the lithologically defined Grande Grève formation of the present area is correctly correlated with the Grande Grève formation of Eastern Gaspé and is Oriskany in age.

The York Lake formation of the present area has yielded 10 species reported from the Grande Grève of Eastern Gaspé and/or the Oriskany of other regions, and one genus common to the Oriskany and Onondaga of other regions. Thus the formation appears to be Oriskany in age. In the type area, near York Lake, only the long ranging species Leptaena rhomboidalis has been identified specifically (Jones 1936, p. 18).

The York River formation contains 14 species of Grande Grève or Oriskany age, one genus common to the Oriskany and Onondaga, one species of coral common to the Onondaga and Hamilton, and two species of pelecypods of Hamilton age. Eight brachiopods, 4 pelecypods, 1 cephalopod, and 1 coral make the 14 Grande Grève or

Oriskany species. In Eastern Gaspé the brachiopods of the York River formation indicate an early Devonian age (Oriskany) whereas the pelecypods or mollusks are Hamilton species. To overcome the difficulty of this faunal mingling, it has been suggested by various writers that the brachiopods are part of a relict fauna inherited from Oriskany time; the pelecypods, being newly introduced elements, would thus have greater weight in assigning a definite age to the rocks. On this basis, the York River formation would be Hamilton in age. On adopting this explanation, one would have to assume: 1) the presence of favourable environmental conditions for the integral preservation of the Oriskany brachiopods on the evolving path through the Onondaga up to the Hamilton; 2) the presence of land barriers to prevent the Onondaga fauna from migrating into the Gaspé basin; 3) the introduction of the Hamilton species without migration of the Oriskany brachiopods elsewhere; 4) the introduction of the Hamilton pelecypods but not the Hamilton brachiopods. Clark (1937, p. 52) has shown conclusively the existence of a seaway connecting Gaspé, New York and New Jersey, during Gaspé limestone time.

In the present area, 4 pelecypods are Oriskany and 2 are Hamilton species. One coral is Oriskany and another Onondaga or Hamilton in age. The brachiopods are all Oriskany in age. On account of this confusion, the writer is inclined to rely more on thickness comparisons and stratigraphic position than on conflicting paleontological data. The Grande Grève formation seems definitely Oriskany in age. The York Lake formation appears Oriskany in age. The York River formation partly grades laterally into and overlies the York Lake formation. Since there is no evidence of a break in the sedimentation record above the York Lake, it is reasonable to assume that the lower part, at least, of the York River formation is either Oriskany or Onondaga in age but not Hamilton. On the south limb of the Berry Mountain syncline, it is possible that York River beds take the place of the Grande Grève formation immediately above the Cape Bon Ami. A Hamilton age for the base of the York River in the present area would imply a considerable slackening or change in the conditions of sedimentation (representing Onondaga time). If such a change or slackening happened, it failed to impress itself upon the rocks or to affect the shape of the stratigraphic units. In view of the above considerations, it appears that the stratigraphic relationships have more weight than the incomplete and conflicting paleontological evidence in deciding the age of the York River formation. Thus an Oriskany or Onondaga age for the lower part of the York River formation is subscribed to in this thesis.

As far as their fossil content is concerned, the Lake Branch and Battery Point formations could have been included in the above discussion. They could be considered as Oriskany or Onondaga in age. Thickness comparisons would suggest that the Battery Point, and possibly the Lake Branch and top of the York River, are Hamilton in age. The rate of deposition of sediments can vary between large intervals but the great thickness involved points toward this conclusion.

As a final conclusion and summary, it may be added that, in relation to the standard section of North America (Cooper, 1942), the Devonian formations of the present area appear to range in age from middle Early Devonian to early Middle Devonian. The Grande Grève formation belongs to the Deerpark stage, the York Lake partly to the Deerpark and partly to the Onesquethaw, the York River to the Onesquethaw, and the Lake Branch and Battery Point formations possibly to the Cazenovia stage (Hamilton). This attempt of correlation is based on fossil evidence for the Grande Grève and York Lake formations, partly on evidence from fossils, and partly on the principle of superposition for the York River, and on thickness comparisons for the Lake Branch and Battery Point formations. Except for the Grande Grève formation, no stage determination can be considered as certain and final.

CHAPTER 5

PETROGRAPHY OF THE GASPE SANDSTONES

By its original definition, the term "Gaspé Sandstones" included only the Battery Point formation. In this thesis, the term is extended to include the York River and Lake Branch formations as well. A total of 60 thin-sections were examined. Of these 27 belong to the Battery Point formation, 29 to the York River and 4 to the Lake Branch. Thirteen thin-sections come from specimens collected in Eastern Gaspé (5 from the Battery Point and 8 from the York River). Twenty heavy mineral analyses and 7 mechanical analyses were made.

BATTERY POINT FORMATION

The Battery Point formation consists of approximately 80 per cent sandstones of various grain sizes, and about 20 per cent interbedded shales. In such a thick stratigraphic unit, a choice had to be made between the various lithologies. Attention has been focussed on the medium-grained sandstones which best fit the definition of the typical Battery Point sandstone, i.e. a medium-grained, greenish grey, gritty sandstone containing a high proportion of pink to red particles.

MASS COMPOSITION:

For descriptive purposes, the detrital particles of the sandstone may be grouped into 8 compositional classes. Five mineral species or mineral associations make the matrix. The detrital particles of the rock were seen to be made of the following elements:

Group 1: Quartz particles.

1a) - Large, clear quartz particles. These quartz grains commonly contain gas bubbles, liquid inclusions, and occasionally inclusions of apatite, rutile, zircon and tourmaline (Pl. 37). They show no anomalous extinction and can be referred to as "igneous quartz". Rare particles consist mostly of clear quartz, with plagioclase and potassic feldspars attached to it (Pl. 38 and Fig. 6). The original shape of a few of the clear quartz particles has been modified by secondary enlargment. Good crystal forms were not observed in thin-section but they occur in the light portion of the heavy mineral separations.

1b) - Aggregates of two or three crystals, welded together and undergoing extinction at different position, but acting apparently as a single sedimentary unit. Some of these aggregates are fragments of quartzite; others appear as vein-type quartz aggregates. A small proportion represents small detrital particles welded together with or without addition

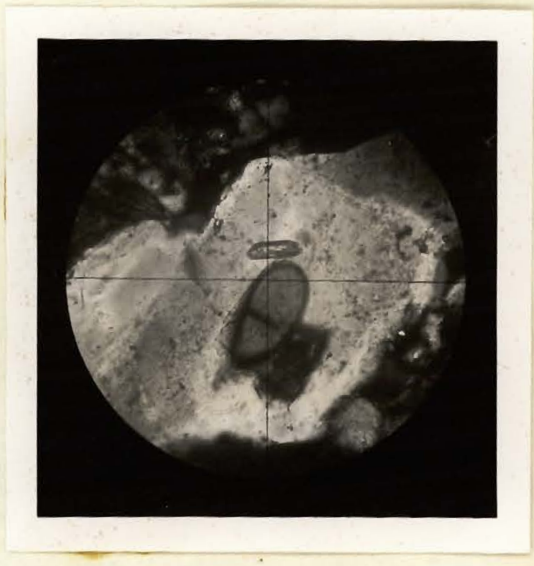


Plate 37 : - Rutile (prismatic) apatite (hexagonal) and zircon (squarish) inclusions in a quartz particle.

Crossed nicols, x 225.

of secondary silica. 1a) and 1b) types of quartz make approximately 90 per cent of the large quartz particles.

1c) - Quartz particles showing flamboyant, feathered or lamellar extinction and usually considered as "vein-quartz" (Pl. 39). Several of these quartz particles exhibit anomalous optic properties (strain shadows, biaxial character) and very likely represent metamorphic quartz.

1d) - Pseudomorph of quartz after feldspar. Rare occurrence. This quartz partly replaces plagioclase feldspars. On account of the well defined grain boundaries, it seems that the replacement occurred before deposition, i.e. it was not the result of authigenic processes.

Plate 38 : - Typical acid igneous rock fragment with quartz, plagioclase and potassic feldspars on same particle (center of field).

Crossed nicols, x 30.

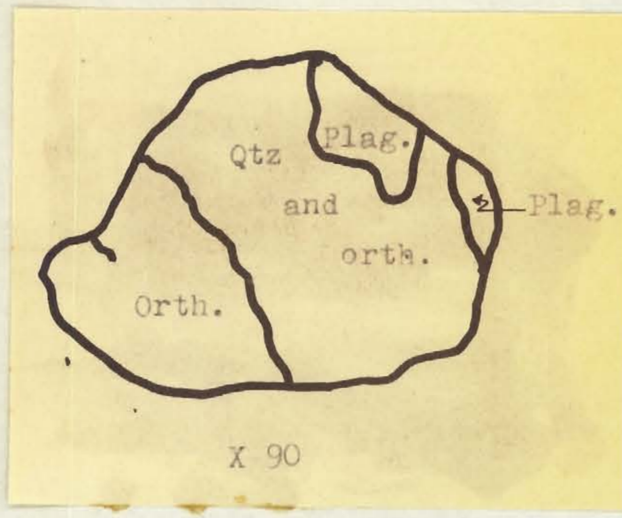


Figure 6 : - Camera lucida drawing of same particle as plate 38.

Group 2: Sedimentary particles made of an aggregate of numerous small crystals of various minerals.

2a) - Mosaic of abundant small quartz crystals, closely welded together, and extinguishing individually (Pl. 40). The quartz of these aggregates is no different in texture and mode of occurrence from type 1b) described above. Only the size and number of the individual crystals vary. Small quartz veinlets, for instance, in acid lavas, show exactly the same characters. On the other hand, preferred orientation of the individual crystals in some of the aggregates suggests a metamorphic derivation for some of the particles (Pl. 41 and Fig. 7). Other particles of the same composition but different texture are siltstone fragments (Pl. 42 and 43).

2b) - Obscure mixtures or aggregates of quartz, biotite, sericite and chlorite and finely chopped minerals. Part of this group definitely belongs to the matrix and will be described later. Some well defined sedimentary particles, however, show this composition (Pl. 44). Other particles of this group are made up of quartz with approximately 30 per cent of small microlites of white mica all oriented in one direction: these particles would naturally be identified as mica-schist fragments. However a series of intermediate stages can be observed between fairly fresh feldspars, cloudy sericitized feldspars, and aggregates in all respects similar to the one just described. At the end of this transition it appears

Plate 39 : - Quartz particles showing flamboyant extinction and feathered structure.

Crossed nicols, x 34.

Plate 40 : - Sedimentary particle made of mosaic of small quartz crystals (center of field).

Crossed nicols, x 34.

Plate 41 : - Mosaic of small quartz crystals showing preferred orientation.

Crossed nicols, x 34.

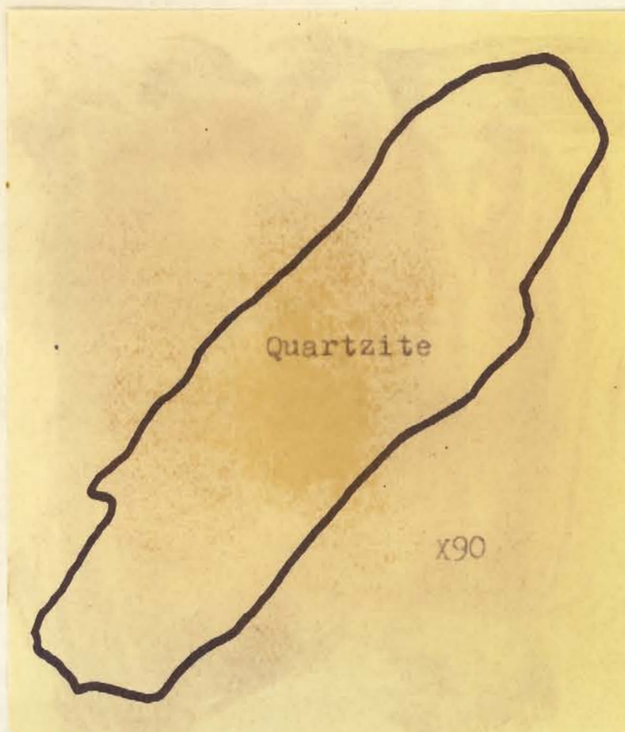


Figure 7 : - Camera lucida drawing of particle of Pl. 41.

Plate 42 : - Siltstone particle in center of field. Ordinary light, x 34.

Plate 43 : - Same as Pl. 42.

Crossed nicols, x 34.

impossible to differentiate between altered feldspars and mica-schists. Consequently this group might represent mostly mica-schists, phyllites and impure siltstones but it contains certainly an unknown amount of altered feldspars.

2c) - Very fine aggregate of quartz, generally considered as chert (Pl. 45). This aggregate makes nearly 50 per cent of group 2. Several of these chert granules look like the material of the cherty layers in the Grande Grève formation but a large portion should be referred to acid lavas. Occasional glass specks occur in some of these particles. Incipient plagioclase phenocrysts and quartz veinlets were found in particles of this group, an occurrence which one could expect in fragments of acid lavas (Pl. 46,47,48). In fact, fragments derived from rhyolite porphyries in the Mount Noble volcanics would appear exactly the same as nearly 60 per cent of the present group. However, it is difficult to know for sure the exact origin of these particles.

Group 3 : Sedimentary particles made of intermediate to basic lavas (Pl. 49 and 50). These particles are green to reddish brown in ordinary light. Most of them show euhedral feldspar laths or needles set in an obscure matrix made of green or dark brown material.

Plate 44 : - Aggregate of quartz, micas and chlorite (center of field).
Crossed nicols, x 34.

Plate 45 : - Well rounded granule of chert.

Crossed nicols, x 14.

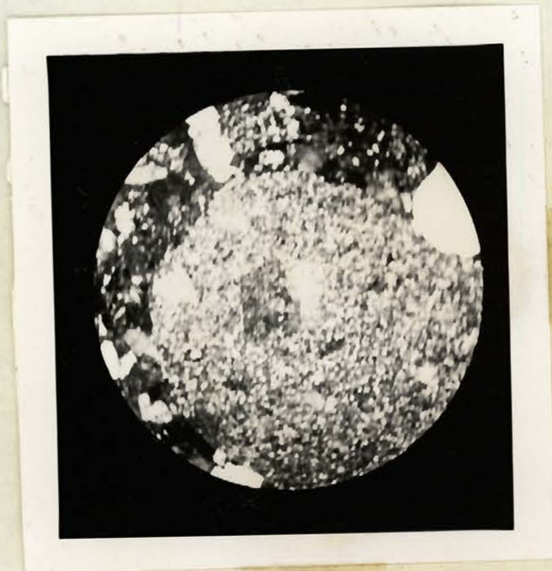


Plate 46 : - Acid lava (?) fragment with incipient plagioclase phenocryst in center of field.

Crossed nicols, x 10.

Plate 47 : - Same as Pl. 46 but x 15.

Plate 48 : - Quartz veinlet through an acid lava (?) fragment.

Crossed nicols, x 30.

Plate 49 : - Green lava fragment showing feldspar laths. Ordinary light, x 34.

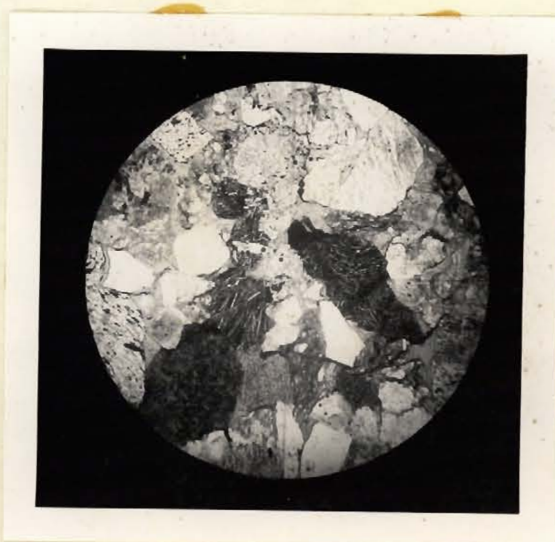


Plate 50 : - Two dark lava fragments showing feldspar needles. Ordinary light, x 34.

Plate 51 : - Perthite particle in center of field. Below the perthite, rounded grain of shale or tuff.

Crossed nicols, x 34.

Group 4: Occasional particles of perthite showing very irregular exsolution bands (Pl. 51). This perthite is very similar to the perthite found in the Laurentian granites and gneisses.

Group 5: Potassic feldspars. Mainly orthoclase but microline occasionally occurs (Pl. 52). Some potassic feldspars look very fresh; others are clouded and contain flakes of sericite. They grade imperceptibly into particles of group 2b). Very fresh potassic feldspars may lie close to or against clouded feldspars. This shows that the alteration took place before deposition of the grains.

Group 6: Plagioclase particles generally lying close to the boundary between andesine and oligoclase (Pl. 52). Several particles are albite. The central emergence of α and the indices of refraction were used to determine the composition. Again these feldspars grade into particles of group 2b).

Group 7: Micas. Muscovite occurs either as individual flakes or as alteration products of the feldspars. It is rare as individual flakes and then is possibly authigenic. Allogenic biotite can be seen commonly. It occurs as long wavy shreds. It is almost always altered into a complex mixture of chlorite and iron oxyde but, even altered, still shows pleochroism.

Group 8: Iron-bearing minerals (Pettijohn, 1949, p. 333). Magnetite, hematite, limonite, pyrite and ilmenite, in order of their abundance, may make up to 8 per cent of the minerals of the sandstone. Oriented thin-sections show that these minerals lie commonly along bedding planes. A large amount of limonitic stains in the rocks may be due to the alteration of the ferromagnesians of which none was observed besides the biotite.

MATRIX:

Very little material was added to bind together the detrital particles described above. Calcite was found in one occurrence to make up to 20 per cent of the binding material but usually calcite is found only as traces and several thin-sections do not contain any. Commonly quartz crystals are welded together with apparently no addition of binding material. Generally secondary quartz contributes up to 30 per cent of the matrix (Pl. 53). This secondary quartz might have been deposited contemporaneously with the other components or it might have been derived from small quartz detritals.

The remaining portion of the matrix is made of an obscure mixture of chlorite, biotite, muscovite, quartz, chopped minerals ("clay") and iron oxides. Part of this mixture results from the disintegration of particles of group 2b) (Pl. 44). In several instances, chlorite appears to be the only binding material. It is occasionally ingrown with secondary quartz (Pl. 54). Opal is of very rare occurrence.

Plate 52 : - Microline particles in center of field. Plagioclases in southwest and northeast quadrants.

Crossed nicols, x 34.

Plate 53: - Secondary quartz cementing various sedimentary particles and partly replacing a small perthite grain in the center of the field.

Crossed nicols, x 80.

Plate 54 : - Cross-fibers of chlorite cementing quartz grains and partly ingrown with secondary quartz (center of field).

Ordinary light, x 34.

The above description applies to all the thin-sections studied. Only the relative proportions of the individual components vary from one section to another. Specimens from the red beds of the Battery Point showed the same essential characters; limonite or the iron oxides was not found to be more abundant than in the typical sandstones.

The relative proportions of the various componenents of the sandstones have been computed by two methods. The results given in table 6 were obtained by the Delesse method. An entire field was drawn on a piece of paper with a camera lucida (magnification 90) and the areas covered by the various grains were cut and weighted on a precision balance. A more complete set of data was provided by this method. In table 7, the percentages were computed by the Rosiwal method with an integrating stage.

TABLE 6 : - Relative percentages of the components of the Battery Point sandstone. Delesse method.

Samples	Components Groups (Percentages)													
No.	1a	1b	1c	2a	2b	2c	3	4	5	6	7	8	Matrix	Total
1	15	4.1	2.1	1.7	6.8	3.9	2.9	1.5	9.3	4.0	3.5	3.1	43.2	101.1
2	29	6.2	2.0	6.8	4.7	7.6	5.7	4.9	3.1	1.5	2.0	2.2	25.0	100.7
3	12.6	1.5	3.7	2.0	8.3	7.7	2.1	1.2	8.2	2.3	3.1	4.0	42.2	98.9
4	13.9	12.3	0.7	3.3	11.6	8.9	1.5	3.0	10.5	1.0	2.5	2.8	28.4	100.4
Average	17.6	6.0	2.1	3.5	7.8	7.0	3.0	2.7	7.8	2.2	2.8	3.0	34.7	100.2

Sample No. 1 - From type-section in Eastern Gaspé, at Battery Park Hotel.

Sample No. 2 - From present area, at headwaters of Indian Falls brook.

Sample No. 3 - From a point one mile southeast of Mount Noble.

Sample No. 4 - From Battery Point outcrops along Otter brook.

Large variations occur between the relative proportions of the various components and the relative proportions of the same components in the 6 samples. The quartz of group 1 is generally below 30%, the potassic feldspars below 15%, the plagioclase below 5% but two samples contain respectively 12 and 9% of this mineral. The matrix shows great variations in percentage. These variations, however, are only partly apparent. In some thin-sections, the individual sedimentary particles are difficult to make out except for the quartz of group 1. In these specimens, the grains have no sharp boundaries and in particular the group 2 particles have to be included in the matrix. It will be noted that when the percentage of group 2 is small, that of the matrix is high and vice-versa.

In order to compare the present results with published diagrams, the percentages of tables 6 and 7 were reworked along different lines. Quartz and chert, micas and chlorite, and feldspars and kaolin were grouped together. Particles of group 2b) were considered as made of 40% quartz, 30% mica, and 30% feldspar and kaolin. Particles of group 3 were considered to be made of 40% feldspars and 30% chlorite and mica. The other 30% was not taken into account. The matrix was divided into 40% quartz 40% chlorite and 20% feldspar and kaolin. The results of these computations are summarized by table 8, after recalculation to a base of 100. The results grouped according to the end-members concept were plotted into the fundamental sandstone triangle devised by Krynine (1948, p. 137 (Fig. 8). Pettijohn (1949, p. 227) conceived another triangle not much different from Krynine's diagram which would not affect the following conclusions. Pettijohn applies the term greywacke to Krynine's high rank greywacke, and subgreywacke to the low rank greywacke. Figure 8 shows that the composition of the Battery Point sandstone falls at or near the boundary between arkoses and high-rank greywackes. The estimated percentages of the components of several other specimens show also that the

TABLE 7 : - Relative percentages of the components of the Battery Point sandstone. Rosiwal method.

Samples	Components (Percentages)						
No.	Quartz	Potassic feldspars	Plagio-clase	Rhyolite and chert	Others	Matrix	To-tal
5	25	12	12	5.7	20	26	100.7
6	26	22	9	13	14	16	100

Sample No. 5 - From Logan's type-section at L'Anse-à-Brillant.

Sample No. 6 - At Clarke-Gravier township line, near the Square Forks river.

composition falls close to the same boundary but on the greywacke side generally. The micas and chlorite never exceed 30 per cent whereas the feldspars show a tendency to increase at the expense of quartz and chert.

By its color, texture and average composition, however, the Battery Point sandstone is not a rock type which would readily be called an arkose. The Committee on Sedimentation defines an arkose as a "sandstone containing 25 or more per cent of feldspars derived from the disintegration of acid igneous rock of granitoid texture". Krynine (1940, p. 50) considers an arkose as a "highly feldspathic (30 per cent of feldspar or more) sediment derived from a granite and having the appearance of a granite". Pettijohn (1949, p. 248)

TABLE 8 : - Reworked percentage of the Battery Point sandstone.

Delesse and Rosiwal methods combined.

Samples	Components			
No.	Quartz and chert	Micas and chlorite	Feldspar and kaolin	Total
1	46.5	24.3	29.2	100
2	62.3	15.8	21.9	100
3	48.0	26.0	26.0	100
4	55.2	19.0	25.8	100
5	48.0	19.3	32.7	100
6	49.0	19.0	32.0	100
Total	309.0	123.4	167.6	600
Average	51.5	20.6	27.9	100
Average greywacke	0 to 75	20 to 75	50 to 80	
Average subgrey-wacke	0 to 80	20 to 75	0 to 10	
Average arkose	0 to 80	0 to 20	25 to 100	

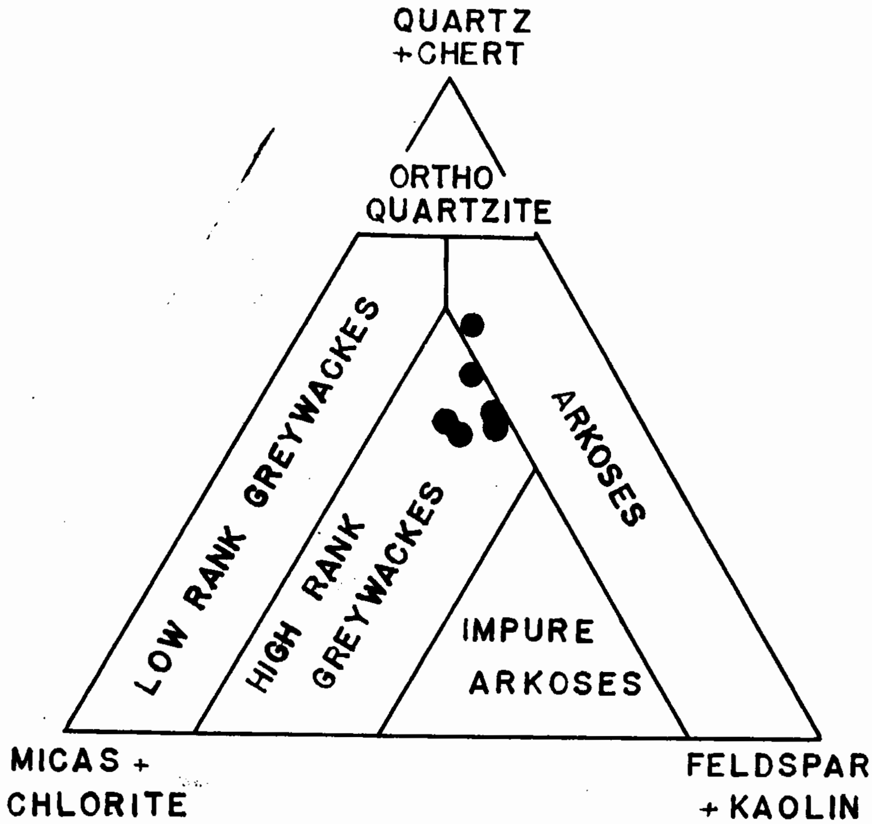


Figure 8 : - Location of the Battery Point sandstones in sandstone triangle of Krynine (1948 p. 137)

writes: "Typically, the arkose is light pink or light grey, unlike the dark greenish black of the greywackes"(Underlining by present writer). The fact, however, that most definitely sets the Battery Point sandstone apart from the arkose field is the high percentage of chloritic clayey paste in the matrix. Therefore it can be concluded that the Battery Point sandstone comes closest to greywacke in rock type, although at places it may look like an arkose.

Figure 9 shows how the Battery Point sandstone compares with the average high rank greywacke. It can be seen thereby that the Battery Point sandstone is not a typical greywacke but greywacke is the closest rock type to which it comes. In order to apply the diagram to the sandstone, it has been necessary to obtain new end-members by reworking the percentages of the various components in the samples. Five per cent of the quartz of group 1 was considered as secondary SiO_2. Particles of group 2b) were divided into 40% quartz, 25% feldspars and 10% clayey paste. Particles of

TABLE 9 : - Reworked percentages in the Battery Point sandstones for comparison with the average greywacke.

Specimens	Components			
	Quartz, chert & feldspars	Chloritic clayey paste	Secondary SiO_2	Total
1	61.3	23.1	15.6	100
2	75.0	15.1	9.9	100
3	63.5	22.3	14.2	100
4	73.2	16.0	10.8	100
Total	273.0	76.5	50.5	400
Average	68.2	19.1	12.7	100

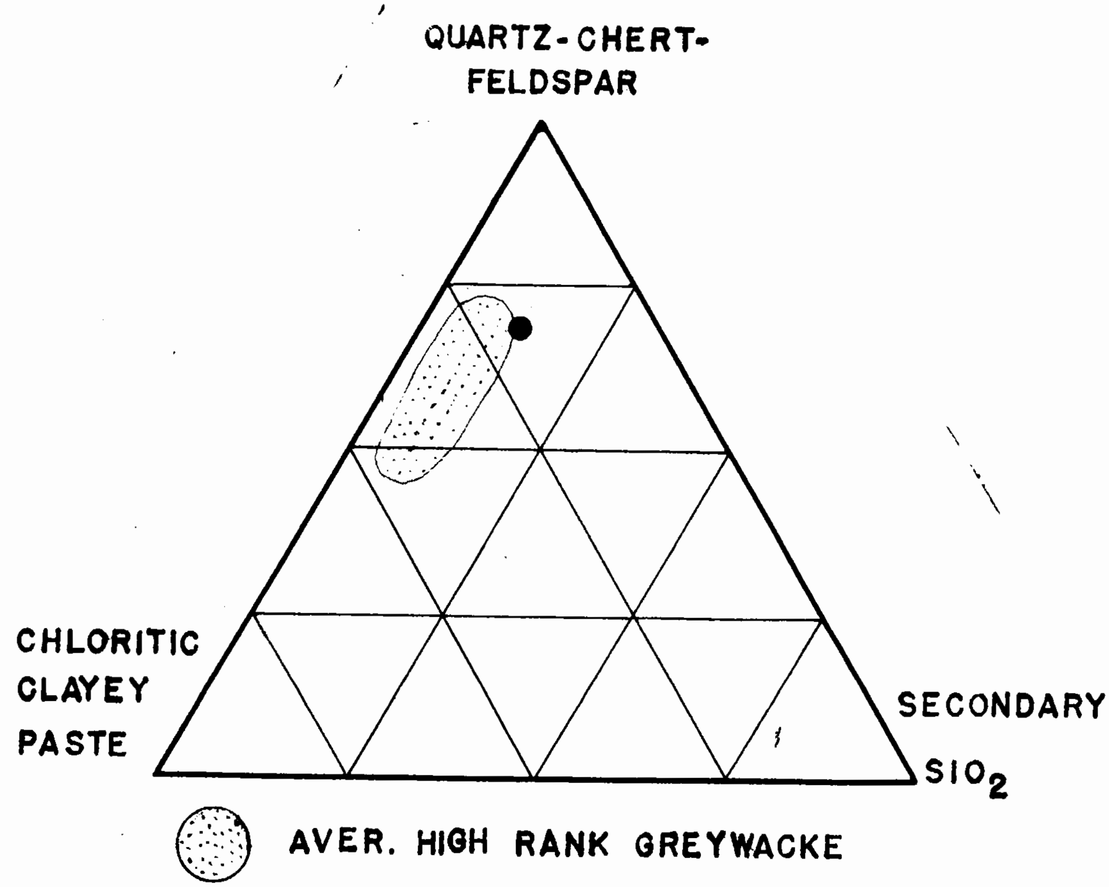


Figure 9 : - Comparison of the average composition of the Battery Point sandstone with the composition of the average high rank greywacke (data from Kynine 1948, p. 150).

group 3 were considered as made of 40% feldspars and 10% chloritic clayey paste: the other 50% was discarded. The matrix was divided into 30% secondary SiO_2, 25% quartz and 45% chloritic clayey paste. Thirty per cent of group 7 was included into the chloritic clayey paste. The other components were not taken into consideration and the results (table 9) were recalculated to a base of 100.

SIZE DISTRIBUTION:

Greenman (1951) devised a method to obtain the total size distribution of the grains of a rock from thin-section data. Krumbein (1935) had presented a method by which the moments of a thin-section size distribution could be corrected to obtain those of the loose-grain size distribution. In his paper, Greenman extended Krumbein's theory. By a sound analysis of the problem, he presented means to correct the thin-section data and to reconstruct the total arithmetic or logarithmic distribution. The method was applied to the St. Peter sandstone and to a reworked glacial sand. The cumulative curve obtained from the corrected thin-section measurements was compared to the curve of the loose-grains distribution (sieve analysis). In the two cases, the two curves were almost identical and fitted remarkably well. From this identity, Greenman concluded that his correction factors enable one to compare directly the results of corrected thin-section measurements with that of "the large body of published mechanical analysis data". However, the identity of the two curves in Greenman's examples seems almost accidental.

From elaborate experimental data, Rosenfeld, Jacobsen and Ferm (1952) have shown conclusively that the conversion factors "vary within samples, among samples and among rock types", and that they must be empirically derived to bring the two sets of data into agreement (thin-section and sieve data). This conclusion limits appreciably the usefulness of Greenman's method. However, when, as in the present case, the sieve technique cannot be applied and empirical conversion factors cannot be established, the only recourse is to use Greenman's correction factors. It should be kept in mind, however, that these results do not correspond to the results of the sieve analyses.

The mathematical concepts and deductions of Greenman's paper will not be repeated here but one complete example of the calculations involved will be presented. For the reconstruction of the original total arithmetic distribution, Greenman's basic and general formula is:

$$F\ (r_n) = \frac{Qn}{A_1}$$

$$F\ (r_{n-1}) = \frac{Qn + Qn-1 - A_2\, F\ (r_n)}{B_1}$$

$$\vdots$$

$$F\ (r_{n-p+1}) = \frac{\sum_{i=n}^{i=n-p+1} Qi - \left[A_p F(r_n) + B_{p-1} F(r_{n-1}) + \ldots + Y_2 F(r_{n-p+2})\right]}{Z_1}$$

Where n and p depend of the number of class intervals,

r_n is the largest size observed,

$F\ (r_n)$ is the number-frequency of grains of uniform diameter r_n,

$F\ (r_{n-1})$ is the number-frequency of grains of uniform diameter r_{n-1} and so on for the $F(r)$s,

$Q_n, Q_{n-1}, \ldots Q_2, Q_1$ are the thin-sections number frequency of grains in the classes $r_n - r_{n-1}$, $r_{n-1} - r_{n-2}$, ... $r_2 - r_1, r_1 - 0$,

$A_p, B_{p-1} \ldots Z_1$ are constants found by an anterior operation to be equal to $\frac{\sqrt{s\ (2n-s)}}{n}$ and the values of which are given in table 10.

s takes the value 1 when the F(r) first appears in an equation of the series and increase by 1 in each subsequent equation.

For example, if n=10, using the values in table 10, the formula becomes:

$$F\ (r_{10}) = \frac{Q_{10}}{0.436}$$

$$F\ (r_9) = \frac{Q_{10} + Q_9 - 0.600\ F\ (r_{10})}{0.458}$$

$$F\ (r_8) = \frac{Q_{10} + Q_9 + Q_8 - 0.714F(r_{10}) + 0.628F(r_9)}{0.484}$$

.
.
.
.
.
.

As pointed out by Greenman, "... Because of the original assumption of groups of grains of uniform size, $F(r_1)$, $F(r_2), \ldots, F(r_n)$ are to be regarded as number frequencies in the size classes $r_{1-\frac{1}{2}} - r_{1+\frac{1}{2}}$, $r_{2-\frac{1}{2}} - r_{2+\frac{1}{2}}$,...., $r_{n-\frac{1}{2}} - r_{n+\frac{1}{2}}$, where r_1, r_2,...., r_n are the respective mid-points".

In applying the method to the Gaspé sandstones, the long diameter of 300 grains was measured in each thin-section of the samples analysed. A micrometer eyepiece was used to make the measurements. The sample selected as an example was the one showing best the typical texture of the Battery Point sandstones out of 50 hand specimens. Table 11 and figure 10 show the results obtained. Table 12 shows in detail the steps involved in the calculation. Reference should be made to table 10 for values of $\frac{\sqrt{s(2n-s)}}{n}$.

In a discussion on the value of Greenman's treatment of mechanical analysis of sediments from thin-section data, Pelto (1952) recommends the investigator to group into one large class all reconstructed classes near the fine end of the size range. Pelto writes: "as a practical and safe rule for determining how many classes are to be thus incorporated, it is suggested that the relative frequency of the compound class be at least 3.25 times, and preferably 3.50 times its estimated standard deviation". Pelto's remarks apply generally to samples of a finer grain size that the ones analysed in this study. The above requirements are fully satisfied in our analysis.

TABLE 10 - Values of $\frac{\sqrt{s(2n-s)}}{n}$

s	n									
	10	9	8	7	6	5	4	3	2	1
1	0.436	0.458	0.484	0.515	0.553	0.600	0.661	0.745	0.866	1.000
2	0.600	0.628	0.661	0.700	0.745	0.800	0.866	0.943	1.000	
3	0.714	0.745	0.781	0.821	0.866	0.917	0.968	1.000		
4	0.800	0.831	0.866	0.904	0.943	0.980	1.000			
5	0.866	0.896	0.927	0.958	0.986	1.000				
6	0.917	0.943	0.968	0.990	1.000					
7	0.954	0.975	0.992	1.000						
8	0.980	0.994	1.000							
9	0.995	1.000								
10	1.000									

TABLE 11 - Total arithmetic distribution of sample No. 7.

Thin-section frequency number	Thin-section frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
			0 -0.05	
		0. -0.1		
			0.005-0.15	
17	5.6	0.1-0.2		
			0.15-0.25	
70	23.0	0.2-0.3		
			0.25-0.35	11.2
113	36.7	0.3-0.4		
			0.35-0.45	39.0
72	24.4	0.4-0.5		
			0.45-0.55	33.0
27	8.7	0.5-0.6		
			0.55-0.65	13.9
4	1.3	0.6-0.7		
			0.65-0.75	2.14
1	0.33	0.7-0.8		
			0.75-0.85	0.638
304	100.0			99.8

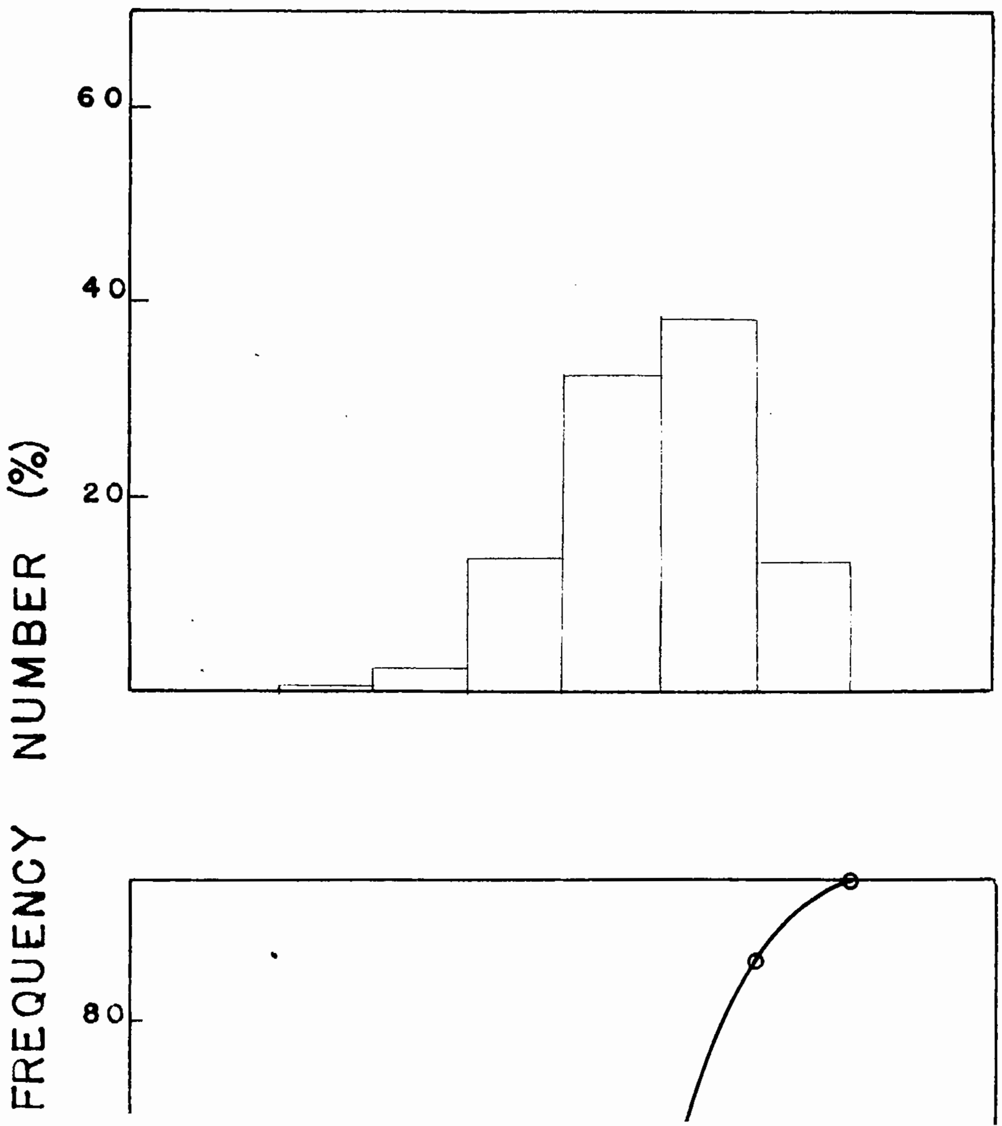


Figure 10 : - Histogram and cumulative curve of sample No. 7, based on arithmetic distribution.

TABLE 12 : - Method of calculation of total arithmetic distribution of sample No. 7

$n = \frac{0.8}{0.1} = 8$	$n = 7$	$n = 6$	$n = 5$
$Q_8 = 0.33$ $F(r_8) = \frac{0.33}{0.484} = 0.683$	$Q_8 + Q_7 = 1.64$ $0.661F(r_8) = 0.452$ $F(r_7) = \frac{1.64-0.452}{0.515} = 2.29$	$Q_8+Q_7+Q_6 = 10.34$ $0.781F(r_8) = 0.534$ $0.700F(r_7) = 1.6$ 2.134 $F(r_6) = \frac{10.34-2.134}{0.553} = 14.9$	$Q_8+\dots Q_5 = 34.74$ $0.866F(r_8) = 0.592$ $0.821F(r_7) = 1.88$ $0.745F(r_6) = 11.06$ 13.532 $F(r_5) = \frac{34.74-13.532}{0.600} = 35.4$
$n = 4$	$n = 3$	$n = 2$	$n = 1$
$Q_8+\dots Q_4 = 71.44$ $0.927F(r_8) = 0.634$ $0.904F(r_7) = 2.05$ $0.866F(r_6) = 12.85$ $0.800F(r_5) = 28.3$ 48.834 $F(r_4) = \frac{71.44-48.83}{0.661} = 41.7$	$Q_8+\dots Q_3 = 94.44$ $0.968F(r_8) = 0.661$ $0.958F(r_7) = 2.2$ $0.943F(r_6) = 14.0$ $0.917F(r_5) = 32.4$ $0.866F(r_4) = 36.2$ 85.461 $F(r_7) = \frac{94.44-85.46}{0.745} = 12.0$	$Q_8+\dots Q_2 = 100.04$ $0.992F(r_8) = 0.678$ $0.990F(r_7) = 2.27$ $0.986F(r_6) = 14.65$ $0.980F(r_5) = 34.6$ $0.968F(r_4) = 40.4$ $0.943F(r_3) = 11.3$ 103.898	$Q_8+\dots Q_1 = 100.4$ $F(r_8) = 0.683$ $F(r_7) = 2.29$ $F(r_6) = 14.9$ $F(r_5) = 35.4$ $F(r_4) = 41.7$ $F(r_3) = 12.0$ 106.973 Recalculated to a base of 100 in table 11

Fewer steps are necessary for the calculation of the total logarithmic distribution from thin section data. The general formula established by Greenman is as follows:

$$F\ (r_{n-p+1}) = \frac{\sum_{i=n}^{i=n-p+1} Qi - M_p F(r_n) + M_{p-1} F(r_{n-1}) + \ldots\ldots}{M_1}$$

where M is equal to $\sqrt{1-\frac{1}{q^{2p}}}$ q is a constant which depends upon the class interval. The values of M for half a class interval (phi units) are given in table 13. The other symbols are the same as in the arithmetic case.

TABLE 13 - Values of $\sqrt{1-\frac{1}{q^{2p}}}$

p	Class interval (phi units) = $\frac{1}{2}$ Q = $2^{\frac{1}{2}}$
1	0.707
2	0.866
3	0.935
4	0.968
5	0.984
6	0.992
7	0.996
8	0.998
9	0.999
10	0.9995

TABLE 14 : - Total logarithmic distribution of sample No. 7 Phi units.

Thin-section frequency number	Thin-section frequency number (per cent)	Class limits (Mm.)	Reconstructed frequency number (per cent)
		0-0.105	
2	0.658	0-0.125	
		0.105-0.149	
7	2.3	0.125-0.177	
		0.149-0.210	
50	16.4	0.177-0.25	
		0.210-0.297	9.24
98	32.5	0.25 -0.354	
		0.297-0.420	31.0
114	37.4	0.354-0.500	
		0.420-0.59	45.6
32	10.5	0.500-0.707	
		0.59 -0.84	13.7
1	0.33	0.707-1.00	
		0.84 -1.18	0.44
304	100.0		99.98

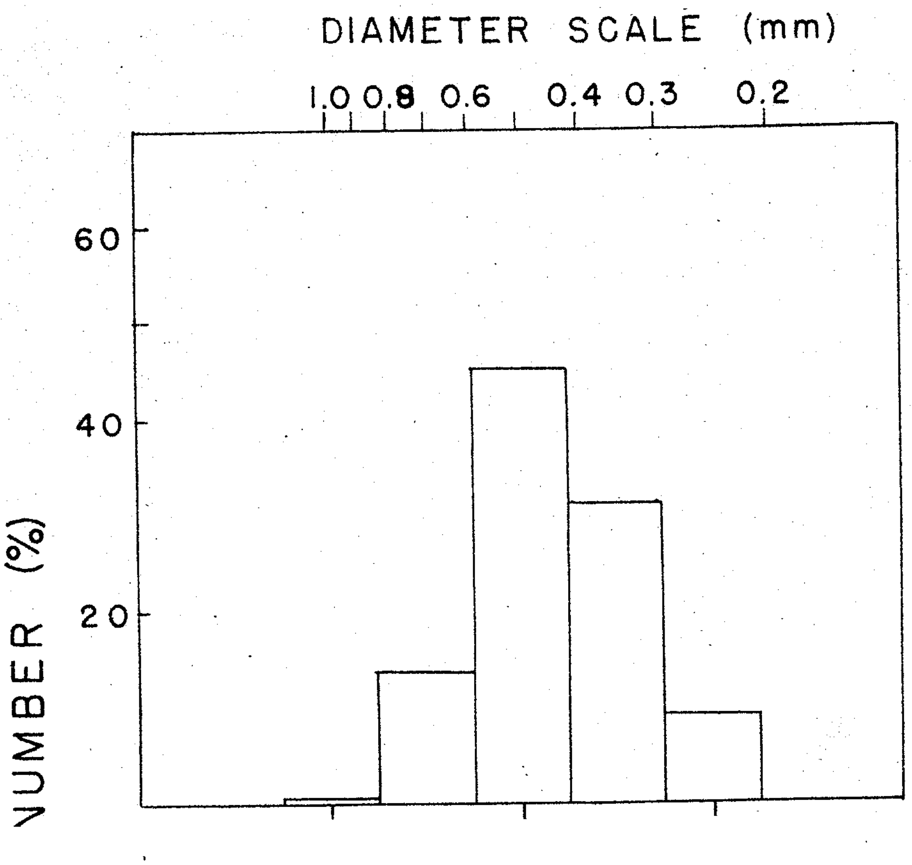


Figure 11 : - Histogram and cumulative curve of sample No. 7, in phi units.

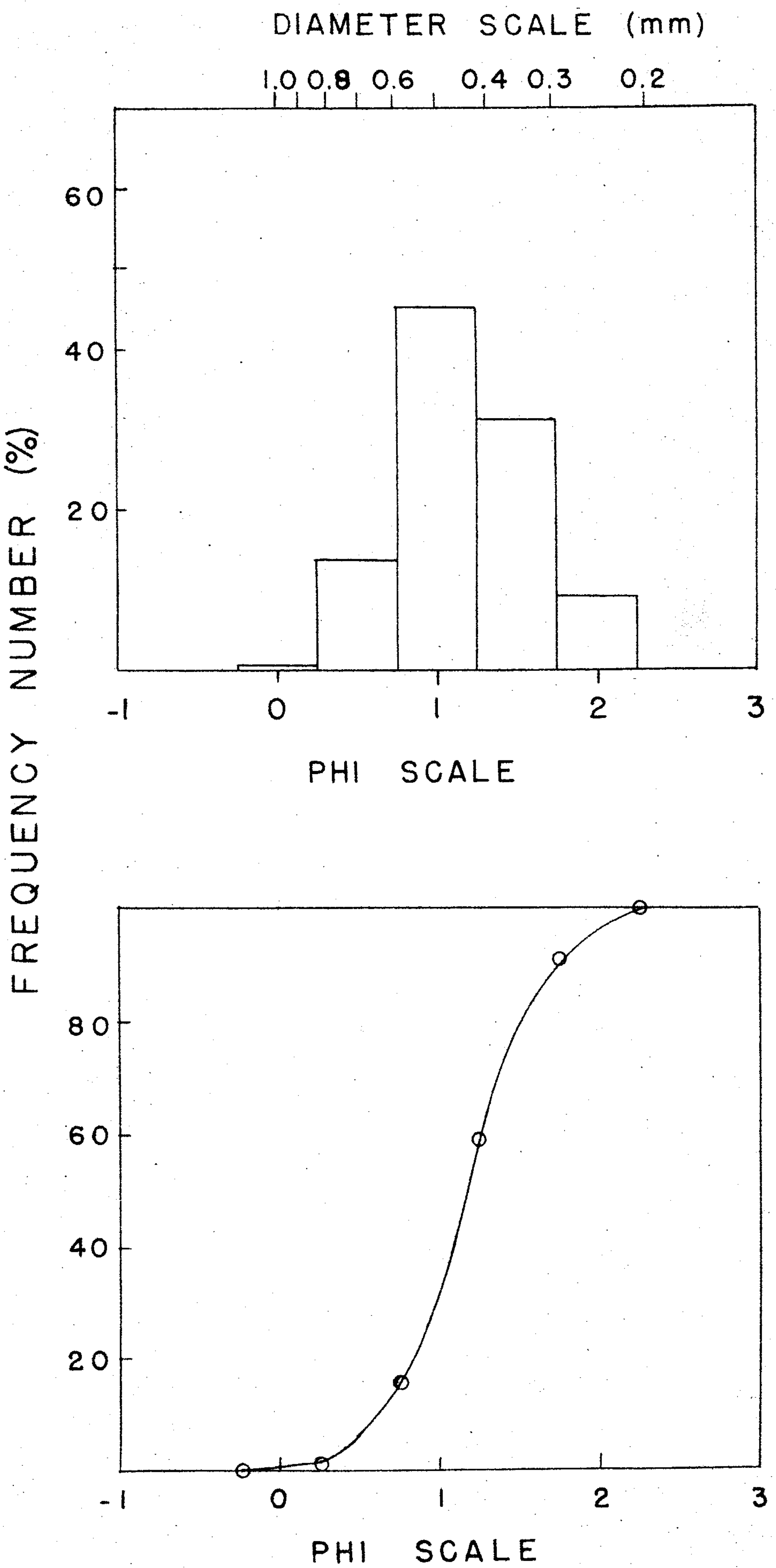

DIAMETER SCALE (mm)
1.0 0.8 0.6 0.4 0.3 0.2
60
40
20
-1 0 1 2 3
PHI SCALE
FREQUENCY NUMBER (%)
80
60
40
20
-1 0 1 2 3
PHI SCALE

TABLE 15 : - Method of calculation of total logarithmic distribution of sample No. 7.

p = 1	p = 2	p = 3	p = 4
Q_{10} = 0.33 $F(r_{10}) = \frac{0.33}{0.707} = 0.466$	$Q_{10} + Q_9$ = 10.83 $0.866F(r_{10})$ = 0.405 $F(r_9) = \frac{10.83-0.405}{0.707} = 14.8$	$Q_{10} + \ldots Q_8$ = 48.23 $0.935(Fr_{10})$ = 0.436 $0.866(Fr_9)$ = 12.8 13.236 $F(r_8) = \frac{48.23-13.24}{0.707} = 49.5$	$Q_{10} + \ldots Q_7$ = 80.73 $0.968F(r_{10})$ = 0.452 $0.935F(r_9)$ = 13.8 $0.866F(r_8)$ = 42.8 57.052 $F(r_7) = \frac{80.73-57.05}{0.707} = 33.5$
p = 5	**p = 6**	**p = 7**	**p = 10**
$Q_{10} + \ldots Q_6$ = 97.13 $0.984F(r_{10})$ = 0.459 $0.968F(r_9)$ = 14.3 $0.935F(r_8)$ = 46.2 $0.866F(r_7)$ = 29.1 90.059 $F(r_6) = \frac{97.13-90.06}{0.707} = 10.0$	$Q_{10} + \ldots Q_5$ = 99.43 $0.992F(r_{10})$ = 0.463 $0.984F(r_9)$ = 14.52 $0.968F(r_8)$ = 47.8 $0.935F(r_7)$ = 31.3 $0.866F(r_6)$ = 8.63 103.963	$Q_8 + \ldots Q_4$ = 100.88	$Q_{10} + \ldots Q_1$ = 100.88 $F(r_{10})$ = 0.466 $F(r_9)$ = 14.80 $F(r_8)$ = 49.5 $F(r_7)$ = 33.5 $F(r_6)$ = 10.0 108.266 Recalculated to a base of 100 in table 14.

It can be seen that, in the logarithmic case, the same set of multipliers applies to all the F(r). In the arithmetic case, the value of $\frac{\sqrt{s(2n-s)}}{n}$ depends upon the subscript of r, thereby changes with each F(r). The histogram and cumulative curve based on reconstructed thin-section data for sample No. 7 are shown in figure 11. Table 14 summarizes the information. An example of the steps involved in the calculation of the total logarithmic distribution is shown in table 15. For instance, if p = 1,

$$F(r_n) = \frac{Q_n}{M_1} = \frac{0.33}{0.707} = 0.466.$$

If p = 2, $F(r_{n-1}) = \frac{Q_n + Q_{n-1} - M_2 F(r_n)}{M_1} = \frac{0.33 + 10.5 - 0.866 \times 0.466}{0.707} = 14.8$

and so forth.

The generally accepted grade scale in North America is that of Wentworth. This scale is a slight modification of Udden's grade scale. It is a geometric grade scale in which each class interval differs from its predecessor by the constant ratio $\frac{1}{2}$. In order to simplify the calculations in statistical analysis of grains distribution, Krumbein (1934) proposed a logarithmic transformation equation for the Wentworth grade scale. For class limits, he suggested using the logarithm (to the base 2) of the diameter instead of the diameter. To avoid negative numbers, he used the transformation equation; phi = - $\log_2$ diameter (mm.). The resulting phi scale has been adopted by numerous sedimentologists. The tendency is to use this logarithmic scale more and more to express the size distribution

TABLE 16 : - Total logarithmic distribution of sample No. 1.

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
3	0.9	0 -0.44		
5	1.5	0.044-0.0625		
			0.052-0.074	
10	3.0	0.0625-0.088		
			0.074-0.105	1.82
16	4.7	0.088-0.125		
			0.105-0.149	2.00
29	8.7	0.125-0.177		
			0.149-0.210	4.35
56	16.8	0.177-0.250		
			0.210-0.297	11.75
103	31.1	0.250-0.354		
			0.297-0.420	35.45
86	25.8	0.354-0.500		
			0.420-0.590	34.30
23	6.9	0.500-0.707		
			0.59 -0.840	9.55
2	0.6	0.707-1.00		
			0.84 -1.18	0.85
333	100.0			100.07

Sample No. 1 - From type-section in Eastern Gaspé at Battery Park hotel.

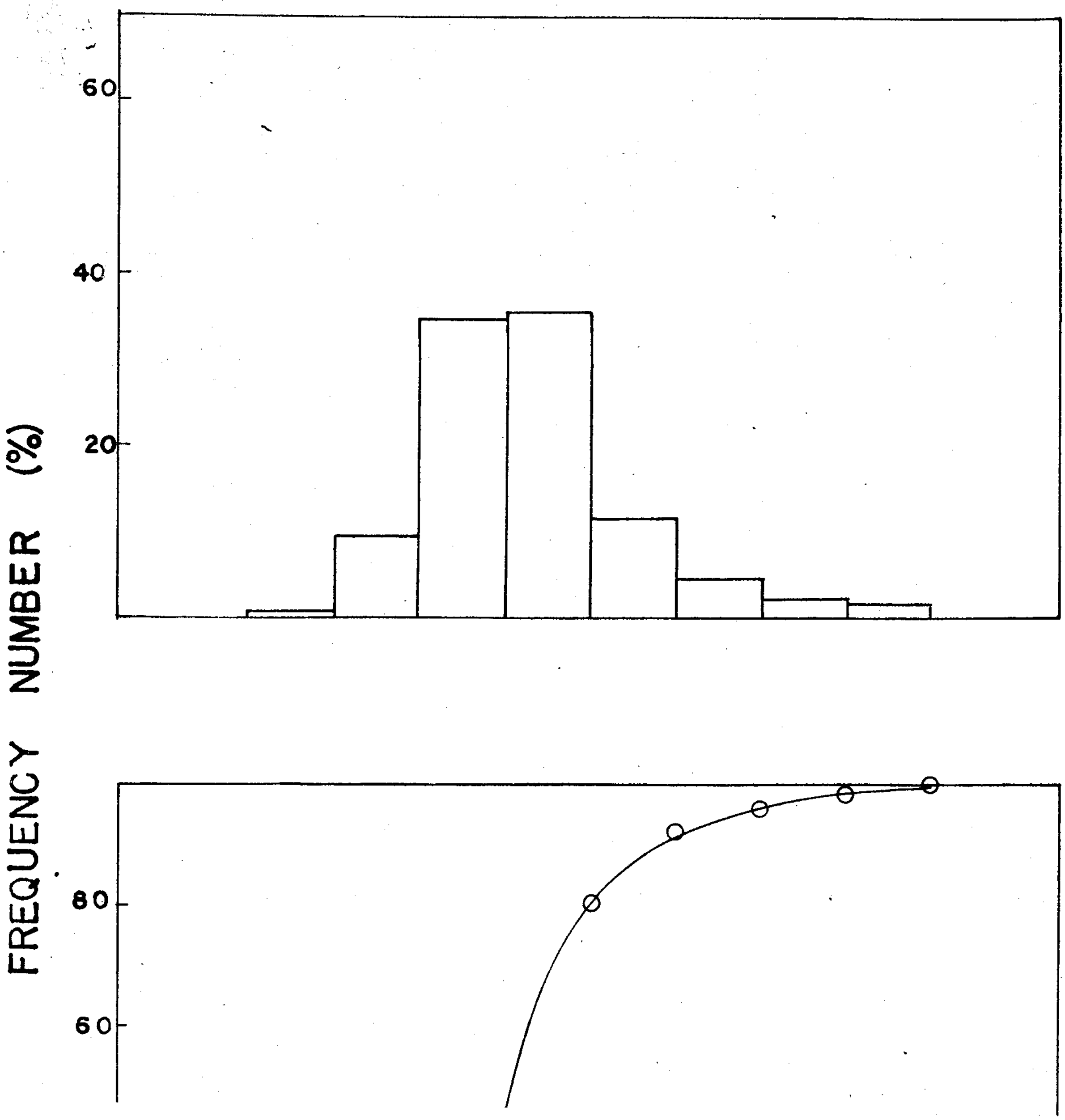


Figure 12 : - Histogram and cumulative curve of sample No. 1.

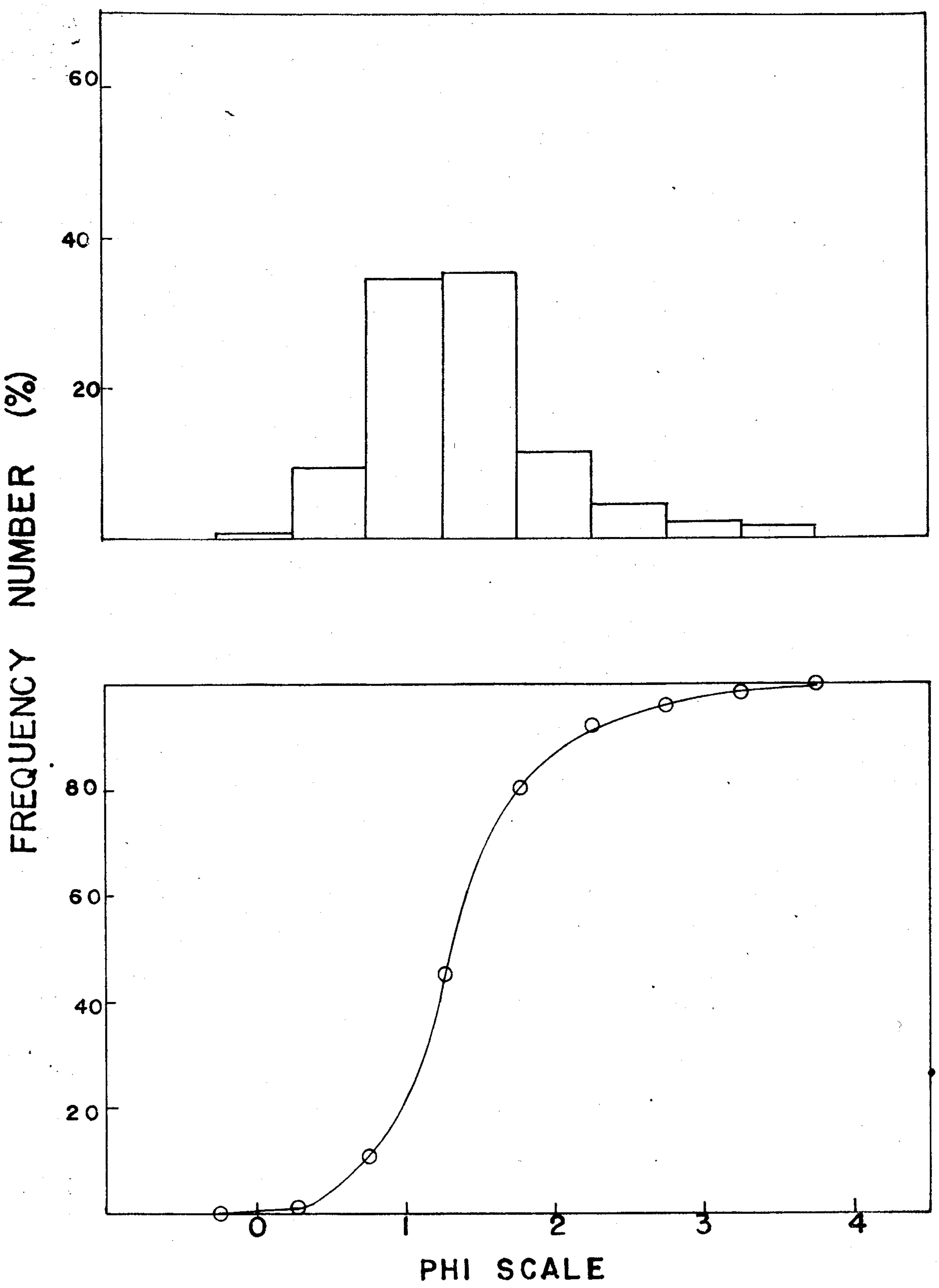

60
40
20
FREQUENCY NUMBER (%)
80
60
40
20
0
1
2
3
4
PHI SCALE

TABLE 16a : - Total logarithmic distribution of sample No. 5.

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
2	0.66	0 -0.044		
3	0.99	0.044-0.0625		
4	1.32	0.0625-0.088		
6	1.98	0.088-0.125		
28	9.15	0.125-0.177		
97	31.7	0.177-0.250		
			0.210-0.297	28.8
135	45.0	0.250-0.354		
			0.297-0.42	59.2
24	7.8	0.354-0.500		
			0.42 -0.59	10.25
4	1.32	0.500-0.707		
			0.59 -0.840	1.80
303	99.82			100.05

Sample No. 5 - From Logan's type section at L'Anse-à-Brillant.

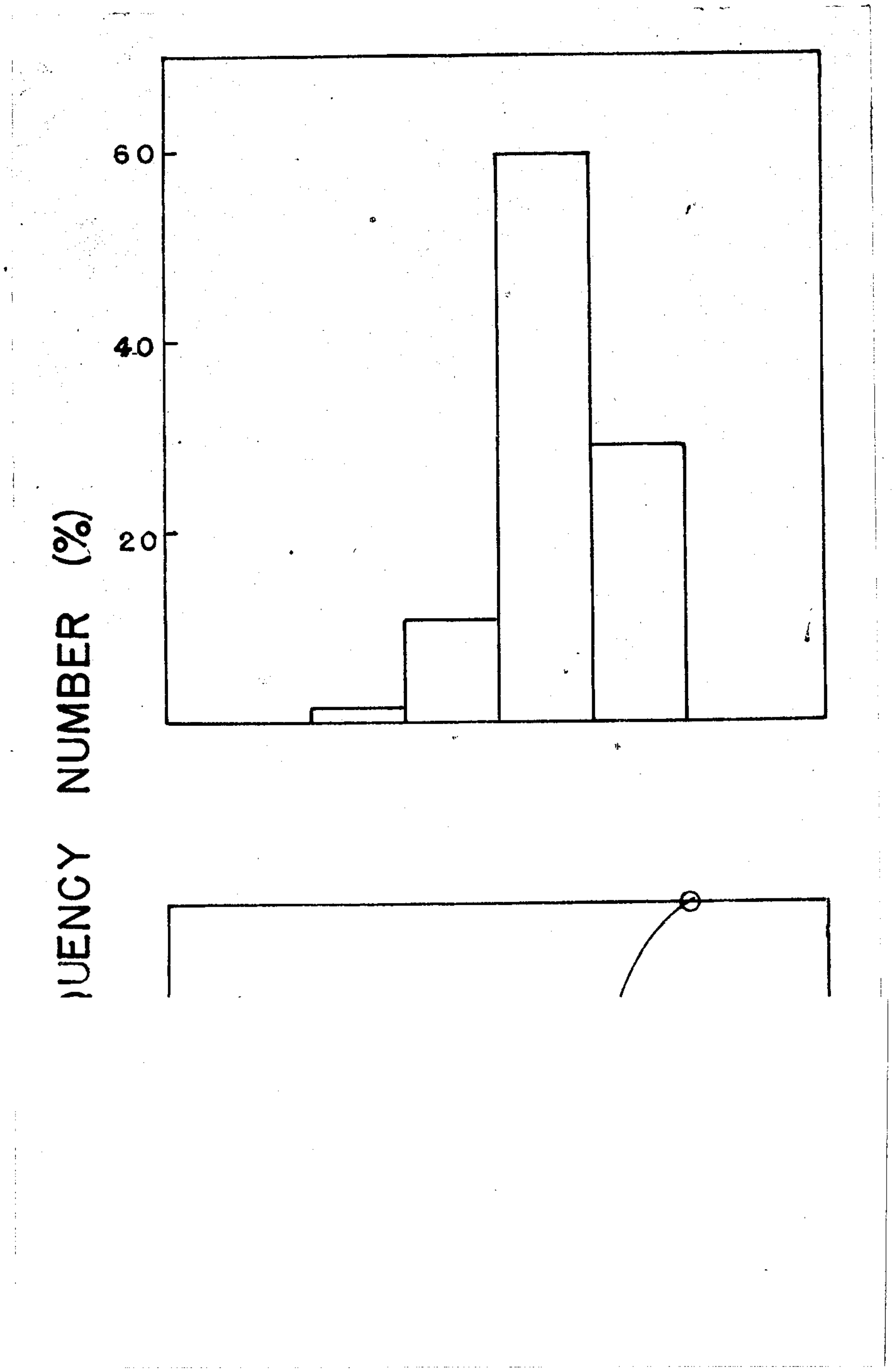
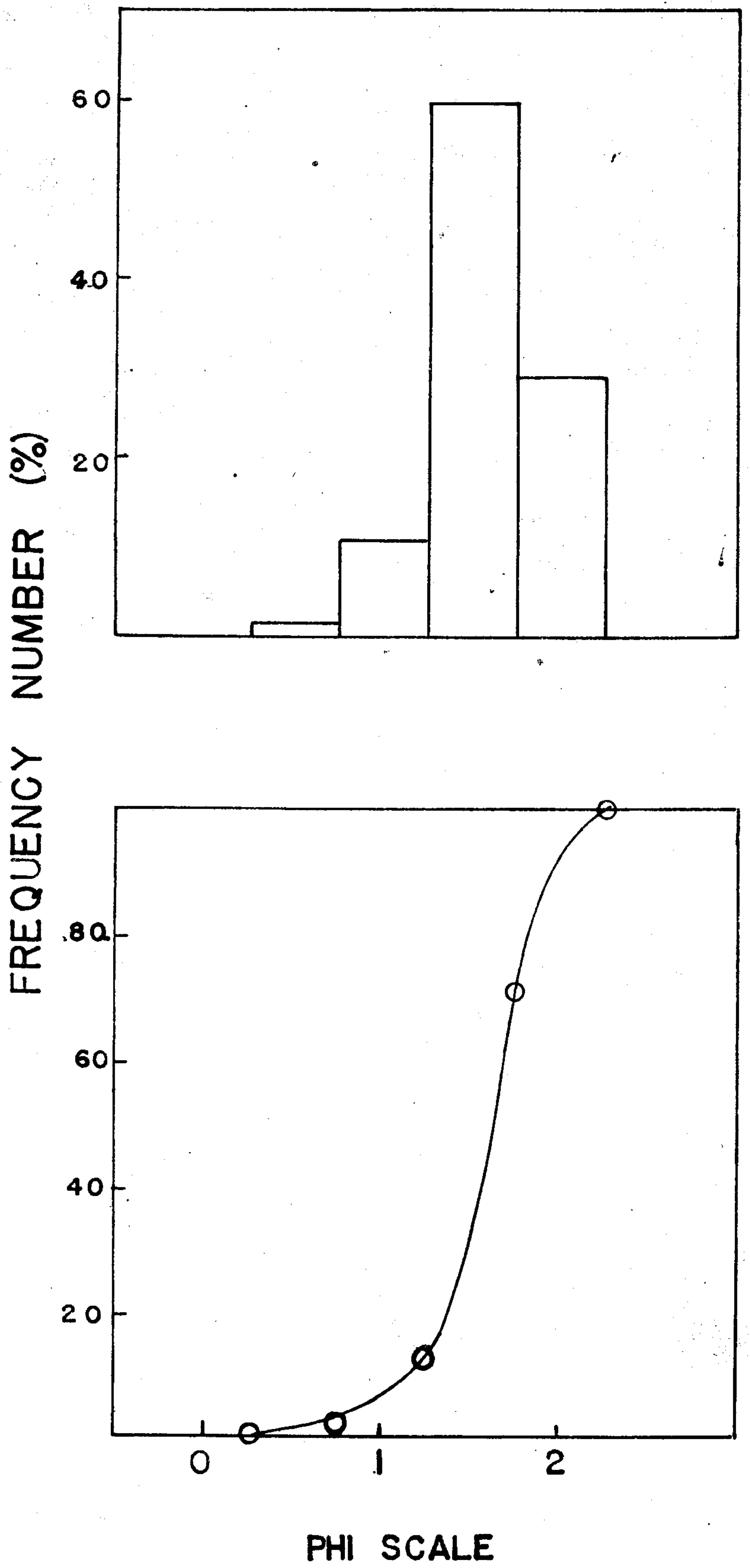


Figure 13 : - Histogram and cumulative curve of sample No. 5.



Figure

TABLE 17 : - Total logarithmic distribution of sample No. 3

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
1	0.318	0 -0.0625		
3	0.95	0.0625-0.088		
7	2.22	0.088 -0.125		
18	5.72	0.125 -0.177		
86	27.3	0.177 -0.250		
			0.210-0.297	24.1
116	36.8	0.250 -0.354		
			0.297-0.420	44.0
47	14.9	0.354 -0.500		
			0.420-0.59	16.8
33	10.5	0.500 -0.707		
			0.59 -0.84	13.7
3	0.95	0.707 -1.00		
			0.84 -1.18	1.18
1	0.318	1.00 -1.414		
			1.18 -1.66	0.425
315	100.9			100.2

Sample No. 3 - From a point one mile southeast of Mount Noble.

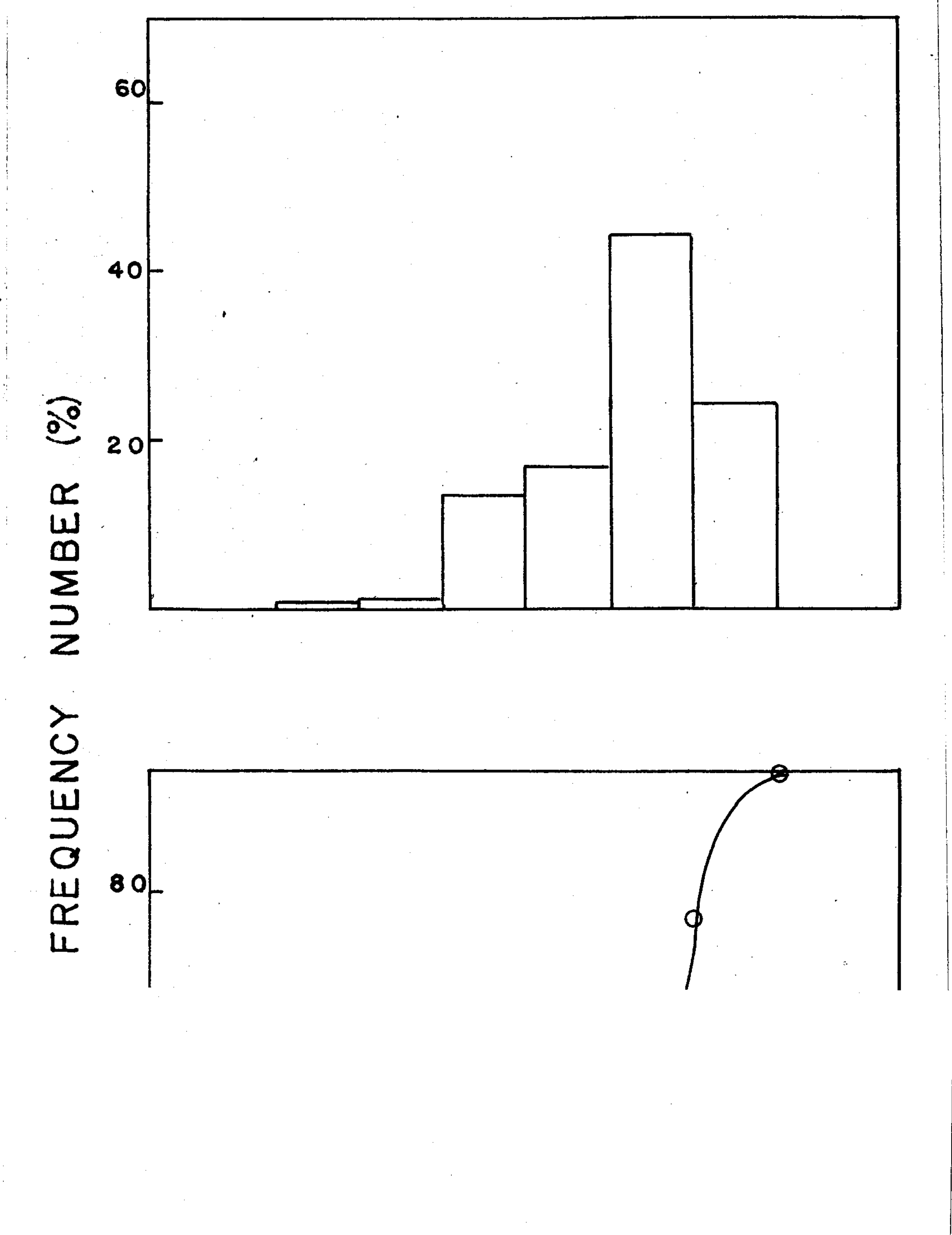
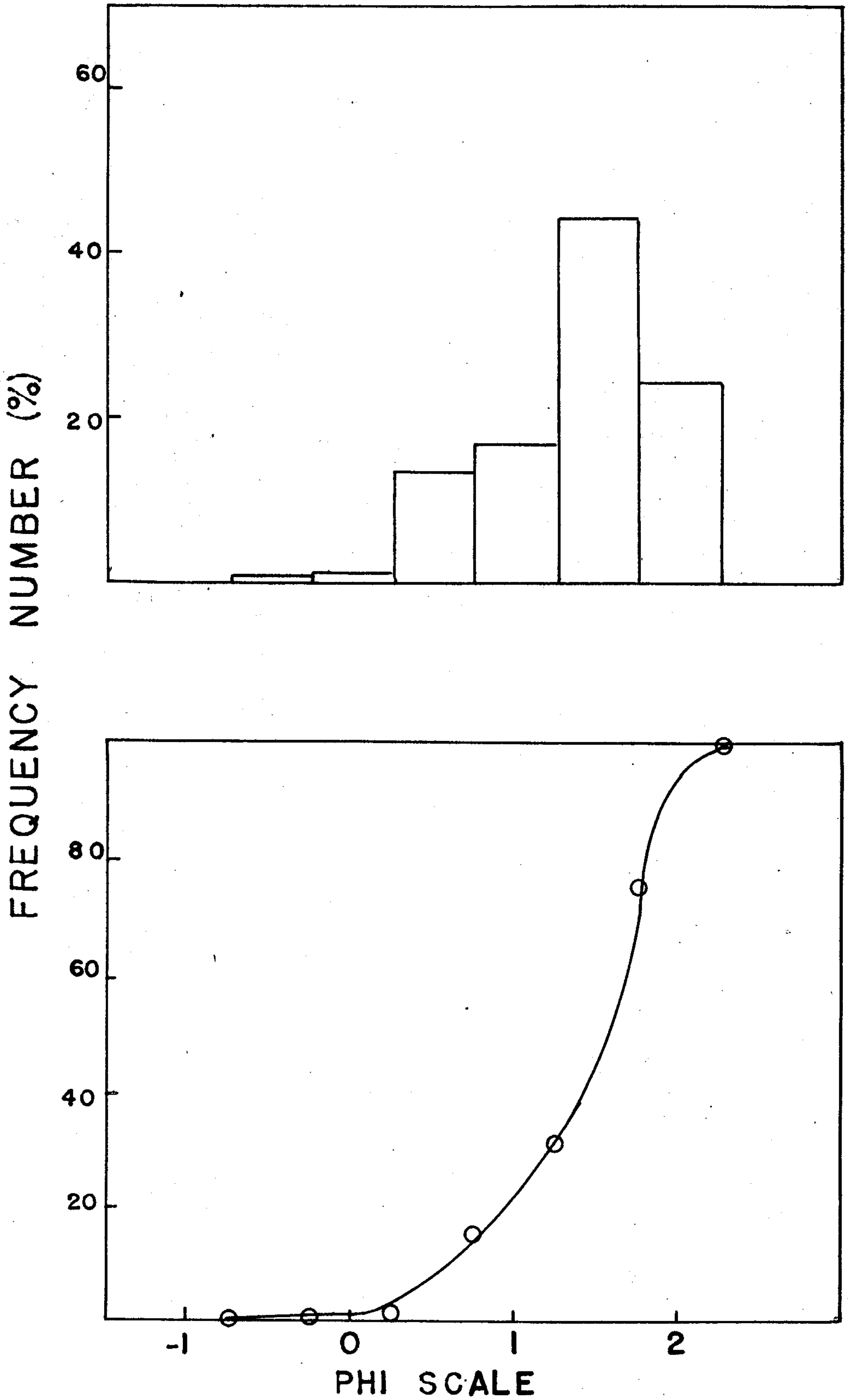


Figure 14 : - Histogram and cumulative curve of sample No. 3.


60
40
20
FREQUENCY NUMBER (%)
80
60
40
20
-1
0
1
2
PHI SCALE

of sedimentary data. In this thesis, both the histogram and the cumulative curve have been used to plot the data for each sample. The histograms provide a diagram in a readily visualized form but only the cumulative curves are suited for numerical summaries of the data. Half a phi unit has been used as class limits to show the size distribution better.

The mechanical analyses of the Gaspé sandstones, in general, are accurate only to a certain extent. When the thin-section is moved one grid interval by the mechanical stage, the center of the field is sometimes occupied by particles of altered feldspars, mica-schists, or by the matrix. In such a case, it is always a problem to select an individual grain. Is the small particle in the center of the field an individual grain or part of a mica-schist fragment? When this question could not be answered satisfactorily, the grain closest to the center of the field was selected. The secondary silica may also weaken the accuracy of the analysis. Secondary quartz growths on quartz particles might not always be detectable and thereby may tend to falsify the measurements. Such growths, however, do not appear common. The other particles seem to represent the original grains as they were deposited in the Devonian seas.

The cumulative curves allow the statistical analysis of the size distribution data. Only the quartile measures will be given in this thesis since these measures are the most widely used for describing and comparing sediments. The quartile measures include the median diameter, the quartile deviation (sorting coefficient), quartile skewness and quartile kurtosis. The median diameter is defined as the size of the middlemost member of the distribution and represents an average of the group. The quartiles are the diameters which correspond to frequencies of 25 and 75 per cent. The quartile deviation is the measure of the average spread of the distribution; it can be arithmetic, geometric or logarithmic. The geometric quartile deviation is also called sorting coefficient. The skewness may be measured by the extent of departure of the median from the arithmetic mean of the quartiles. The geometric skewness is the square root of the ratio of the product of the quartiles to the square of the median. The quartile kurtosis can be measured by the ratio of the quartile deviation to that part of the size range which lies between the 10-per cent and 90-per cent lines. The mathematical expression of the quartiles measures is given in table 18. Krumbein and Pettijohn (1938, p. 228 to 239) discuss the geological significance of these values. In this study, advantage was taken of the phi scale, and the data were computed in phi units. Table 18 shows the values of the quartile measures in the four Battery Point samples analysed.

The computation of the quartiles measures permits the following conclusions:

1) The median or the "average" grain diameter of the typical Battery Point sandstone ranges between 1.2 and 1.63 phi units or between 0.43 and 0.32 mm.

2) The coefficient of sorting ranges between 1.12 and 1.27. The Battery Point sandstones, therefore, are very well sorted, for values below 2.5 are generally considered to be well sorted.

3) The logarithm of the skewness or the phi quartile skewness Skq indicates how much the arithmetic mean of the quartiles deviates from the median. The sign refers to the direction of deviation of the mean of the quartiles. In other words, for sample 7, the mean of the quartiles lies 0.02 of a Wentworth grade to the left of the median i.e. toward the coarse admixtures: the cumulative curve is skewed toward the left or toward the direction of negative phi axis.

The kurtosis is not easy to visualize and has not been very successfully applied to sedimentary statistics. It is included here only for the sake of completeness.

HEAVY MINERAL ANALYSIS:

A representative sampling of the heavy mineral content of the Gaspé sandstones would require a very large number of analyses because of the thickness and the large areal distribution of the sandstones. Since there were no correlation problems involved, only a restricted number of samples were selected. The analyses were made to obtain a general knowledge of the characters of the source-area. Altogether 20 heavy mineral residues were studied.

Two analysed Battery Point samples come from the type-section of Eastern Gaspé, at Battery Park Hotel, along the shore. One sample was collected in Logan's type-section, one mile south of L'Anse-à-Brillant. The seven other samples come from the Big Berry Mountains map-area.

TABLE 18 - Quartile measures for the Battery Point sandstones

Name	Median	$Quartile_3$	$Quartile_1$	Log_2 Coef. Sorting	Coef. Sorting	Log_2 Skewness	Skewness			Kurtosis
Abbreviation	Md	Q_3	Q_1	Qd	QDg = So	Skq	Sk	P_{90}	P_{10}	Kq
Formula	50 percentile	75 percentile	25 percentile	$\frac{Q_3 - Q_1}{2}$	$\sqrt{Q_3/Q_1}$	$\frac{Q_1 + Q_3 - 2Md}{2}$	Q_1Q_3/Md^2	90 Percentile	10 Percentile	$\frac{Q_3 - Q_1}{2(P_{90}-P_{10})}$
Parameter	"Average"				"Sorting"		"Symmetry"			"Peakedness"
Samples										
7	1.20	1.45	0.9	0.275	1.18	- 0.02	1.03	1.75	0.65	0.25
1	1.3	1.62	1.05	0.285	1.2	0.05	0.930	2.17	0.75	0.20
5	1.63	1.78	1.42	0.18	1.12	- 0.05	1.07	1.95	1.15	0.225
3	1.55	1.79	1.05	0.37	1.27	0.14	1.21	1.9	0.6	0.284

In order to perform the analyses, each sample was crushed first in a small gyratory crusher, then in a roll crusher. After sieving through a series of screens, the portion larger than 0.2 mm (65 meshes) was treated again in the roll crusher. After this second operation, the sample was generally distributed in approximately 50 per cent fragments below 0.2 mm. in diameter and 50 per cent fragments larger than 0.2 mm. The dust was then removed by decantation from the finer portion. After removal of the dust, the fine portion weighed between 35 per cent and 40 per cent of the original sample, and was ready for the separation. The above process resulted not only in liberating the individual particles reasonably well but probably also in increasing the relative heavy mineral content of the rock. This had no harmful effect for the analysis was not intended to solve any correlation problem. On the other hand, the abundant heavy mineral crop provided more particles for optical tests.

A first separation was made by using bromoform (specific gravity 2.8). For 4 samples, a second separation was obtained with methylene iodide (specific gravity 3.3).

The heavy mineral residues contain 17 mineral species and 5 varieties which are in order of abundance: garnet (2 varieties), magnetite, muscovite, biotite, chlorite, pyrite, ilmenite, zircon, tourmaline (3 varieties), rutile, sillimanite, titanite, kyanite, leucoxene, diopside, monazite and fluorite. To this can be added several types of rock fragments. In order to record the relative frequencies of the individual minerals, Milner's scale (1929,

p. 386), given below, was adopted.

Term	Number
"Flood"	9
Very abundant	8
Abundant	7
Very common	6
Common	5
Scarce	4
Very scarce	3
Rare	2
Very rare	1

Garnet: (Frequency 8)

Garnet (grossularite) is present in all separations. In six of them, it is very abundant. In the other four residues, it can still be considered as a common mineral of frequency 5. It occurs mostly as euhedral dark brown to red crystals, commonly as nearly perfect dodecahedrons.(Plate 55). Octahedrons can also occasionally be observed (Plate 56). Garnet is the most abundant and the most widely distributed of all the heavy minerals of the Battery Point sandstone. It is mostly a first-cycle mineral as the edges of the crystals are very little worn. Possibly 5 per cent of the garnet found in the separation is very well rounded and was probably derived from a sedimentary terrane. In this case, it is nearly black (pyrope).

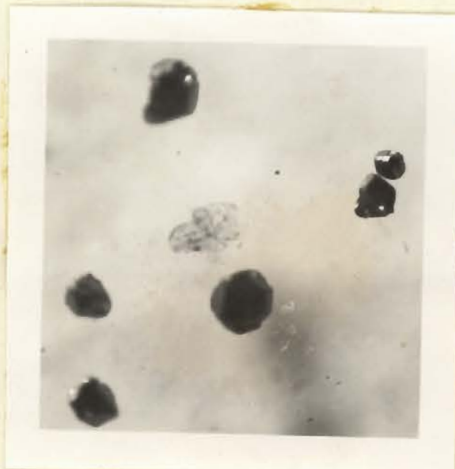


Plate 55 : - Octahedrons and dodecahedrons in garnets of the Battery Point sandstone, x 25.

Plate 56 : - Rounded garnet (lower part of picture) and octahedron garnet (center) in the Battery Point sandstone. Muscovite magnetite and light minerals with magnetite attached to them can also be seen in the field, x 25.

Magnetite: (Frequency 7)

Magnetite comes next to garnet in abundance. In 3 separations, it makes nearly 75 per cent of the residue. It is possible that part of the magnetite was dissolved during the mild acid (HCl) treatment introductory to the separations. If such is the case, magnetite possibly should be considered as more abundant than garnet. It is sub-angular in roundness and rarely exhibits good crystal faces. It commonly occurs as a coating over particles of light minerals.

Muscovite: (Frequency 5)

Muscovite occurs as clear flakes irregular in outline. A considerable part of it was lost as dust during the crushing process.

Zircon: (Frequency 5)

Zircon usually occurs as colorless to slightly pink, nearly prismatic grains. It is generally devoid of inclusions. Approximately 10 per cent of the grains are almost spherical.

Biotite: (Frequency 4)

Biotite occurs as irregular shreds coated with chlorite and hematite. The biotite of the matrix does not appear to reach the heavy mineral residues.

Chlorite: (Frequency 2)

Chlorite occurs mostly as an alteration product of biotite but it was also detected as very small, individual, greenish to bluish shreds.

Pyrite: (Frequency 2)

Pyrite is usually rare, but was found up to 10 per cent in one separation. Part of the original content may have been destroyed by the acid treatment.

Ilmenite: (Frequency 2)

Ilmenite accompanies the magnetite and was abundant only in the 3 separations where magnetite made nearly 75 per cent of the residue. Concentration and separation of the ilmenite from the magnetite was done with a bar magnet.

Tourmaline: (Frequency 6)

Tourmaline occurs as three varieties:

1) As dark, smoky, translucid, well-rounded grains.
2) As yellowish, dark brown prisms commonly showing striated faces and usually well rounded terminations.
3) As sub-angular grains brown in color but exhibiting a distinct pinkish tint.

The first two varieties are about equally common and equally distributed. The third variety is rare and present only in two separations (Plate 57).

Rutile: (Frequency 2)

Vitreous to amber, red and reddish brown, usually sub-rounded grains. Distributed evenly in all separations. In two cases, prismatic grains exhibited geniculate twins.

Sillimanite: (Frequency 2)

Vitreous, basal flakes (parallel to 001) exhibiting good biaxial figure. Also long fibers and prism showing a slight greenish tint. It commonly contains dark inclusions distributed along cleavage lines. It is present in nearly all separations and reaches a frequency of 5 in three separations (Plate 58).

Titanite: (Frequency 2)

Brownish-yellow, translucent grains, usually sub-rounded but also irregularly shaped. Evenly distributed in all except 2 separations.

Leucoxene: (Frequency 1)

Yellowish-white, irregularly shaped grains present in 4 separations.

Kyanite: (Frequency 1)

Greyish-green, sub-angular, prismatic grains containing irregularly spaced inclusions. Detected in one separation only.

Diopside, monazite and fluorite: (Frequency 1)

The diopside is pale green, and was distinguished from kyanite by its cleavage. It was found in two separations.

Red, egg-shaped monazite and colourless irregularly shaped fluorite grains were detected only once and in the same separation. Fluorite was positively identified by its isotropic character and its low refractive index. Monazite was distinguished from rutile by its optical characters.

Rock fragments: (Frequency 5)

Lavas and siltstone fragments are commonly found in the heavy residues of all separations. Frequently jasper also was

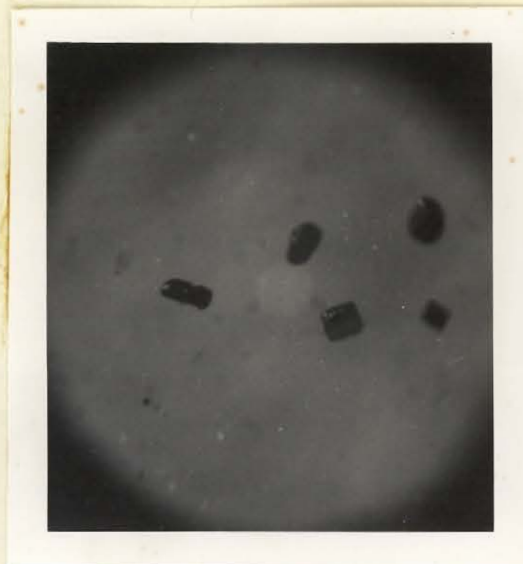


Plate 57 : - Prismatic and rounded tourmaline grains in Battery Point sandstone, x 25.

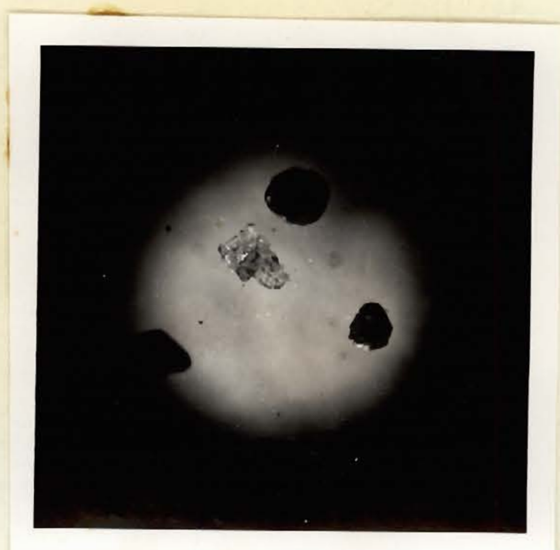


Plate 58 : - Sillimanite flake with inclusions. Battery Point sandstone, x 25.

observed. Due to the difficulty of liberating the individual grains entirely, fragments of magnetite and garnet may stay attached to light minerals. This results in diluting the heavy residues with the light portion. In some separations, this effect was very annoying and made difficult the detection of the rare heavies.

PARTICLE SHAPE, ROUNDNESS AND SURFACE:

Examination of the light portions of the heavy mineral separations supplemented by thin-section studies reveals that few particles could be considered as spherical. The grains were compared with published charts of sphericity (e.g. Krumbein and Sloss 1951, p. 81) and the percentage of grains in each class was estimated by eye. For the 10 heavy-mineral separations and the corresponding thin-sections, the grains had sphericity values distributed as follows:

Sphericity value	Number frequency (Percentage)
0.1 to 0.4	9
0.4 to 0.6	35
0.6 to 0.8	46
0.8 to 1.0	10

The present values of sphericity show that the shape of probably only a few grains has been modified by transportation.

By comparison also with published charts, the particle roundness of the Battery Point sandstone was found to be distributed as follows:

Roundness value	Number frequency (Percentage)	Grade term
0 to 0.15	7	Angular
0.15 to 0.25	35	Subangular
0.25 to 0.4	50	Subrounded
0.4 to 0.6	6	Rounded
0.6 to 1.0	2	Well rounded

Most of the particles therefore show a high angularity of edges and indicate a rather immature sedimentary rock.

The surface of the particles offers little interest. The particles are neither dull nor polished but intermediate in character. The surface itself is rather rough but shows no significant texture. Only a few well-rounded grains are frosted.

In estimating the characters of the particle shape, roundness and surface, an attempt was made to correct the error introduced by crushing the rock and liberating the grains.

YORK RIVER FORMATION

The York River formation may contain up to 35 per cent of interbedded shales and siltstones in several parts of Eastern Gaspé and the Big Berry Mountains map-area. In this thesis, mainly the medium- to fine-grained sandstones have been studied. Three thin-sections of siltstone showed that this rock scarcely differs in composition from the coarser arenites. However, the relative proportion of the detrital components of the siltstones may vary through larger intervals than for the Battery Point sandstones and the medium- to fine-grained York River sandstones.

Depending upon the percentage of calcite in the matrix and the degree of alteration of the ferromagnesian minerals, the York River sandstones may vary considerably in texture and color so that it is difficult to define a typical York River sandstone. Efforts have been made to restrict the study of thin-sections to samples made of greenish-grey, medium- to fine-grained sandstone much less gritty than the Battery Point sandstone. Variations from this general type can be expected.

MASS COMPOSITION:

Under the microscope, the York River sandstone exhibits nearly the same characters as the Battery Point sandstone. The two formations contain the same suite of detrital components in nearly the same proportions. The matrix is generally less preponderant in the York River sandstone but variations occur and invalidate the use of this criterion as a means of separating the two formations. The pink feldspars of the Battery Point formation appear cloudy under the microscope as do the feldspars of the York River.

Rock fragments made of rhyolite or chert are commonly twice as abundant in the York River sandstone as in the Battery Point. In some thin-sections, fresh or altered biotite may make up to 20 per cent of the composition (Pl. 59). Generally, the York River sandstone appears richer in biotite and decomposed ferromagnesians than the Battery Point. Six thin-sections contained up to 10 per cent of fresh and altered lava fragments.

Calcite is present in the matrix of nearly 50 per cent of the samples. It frequently replaces the feldspars and in some cases is up to 20 per cent of the total composition. Secondary quartz is also a more common cementing material. Generally, the individual grains are more corroded than in the Battery Point sandstone, that is grain boundaries are not sharp (Pl. 60, 61, 62). Samples from the York River of the north limb of Berry Mountain syncline contain up to 20 per cent of hematite and magnetite which are mainly interstitial between the grains.

The percentages of the various components have been determined in four thin-sections by the Rosiwal method. The results are shown in table 19 and they are regrouped under different headings in table 20 for comparison with Krynine's sandstone triangle in figure 15.

Plate 59 : - Picture showing proportion of biotite in relation to other minerals. About 70 per cent of the dark shreds and flakes are biotite.

Ordinary light, x 15.

Plates 60 and 61 : - Poorly defined grain boundaries in the York River sandstone. Crossed nicols, x 34.

Plate 62 : - Perfectly fresh plagioclase feldspars surrounded by highly altered potassic feldspars (particularly southwest quadrant). Crossed nicols, x 34.

As shown in figure 15, the York River sandstone falls near the boundary between arkose and greywacke, but more on the arkose side than in the case of the Battery Point. On account of its color and composition, however, the York River sandstone cannot be readily classified as an arkose. It is intermediate in character between an arkose and a greywacke.

In view of such similarity between the Battery Point and York River sandstones, the question which may arise is: what is the origin and nature of the pink granules in the Battery Point sandstone? It does not seem that the type itself of the feldspars enters into consideration. Potassic and plagioclase feldspars

TABLE 19 : - Relative percentages of the components of the York River sandstones. Rosiwal method.

Sample		Components					
No.	Quartz	Potassic feldspars	Plagioclase	Rhyolite and chert	Others	Matrix	Total
8	25	26	9	9	11	20	100
9	27	15	10	7	28	13	100
10	25	22	8	17	11	17	100
11	28	21	9	6	24	12	100

Sample No. 8 - From south bank of St. John river, one and a half mile east of Little Fork brook.

Sample No. 9 - From d'Argent brook, half a mile upstream from the junction of the brook with the York River.

Sample No.10 - From outcrops along Federal Mine road, 2,000 feet above base of formation.

Sample No.11 - From Berry Mountain brook (South branch).

are present in both sandstones (Pl. 62). The potassic feldspars (orthoclase, microcline, perthite) are nearly twice as abundant in the York River as in the Battery Point. The fact is that the potassic feldspars in the Battery Point are pink whereas they are grey in the York River. The plagioclase feldspars in either case are nearly always grey except for some rare albite fragments. In the Battery Point sandstone, there is also about 20 per cent of the pink and red

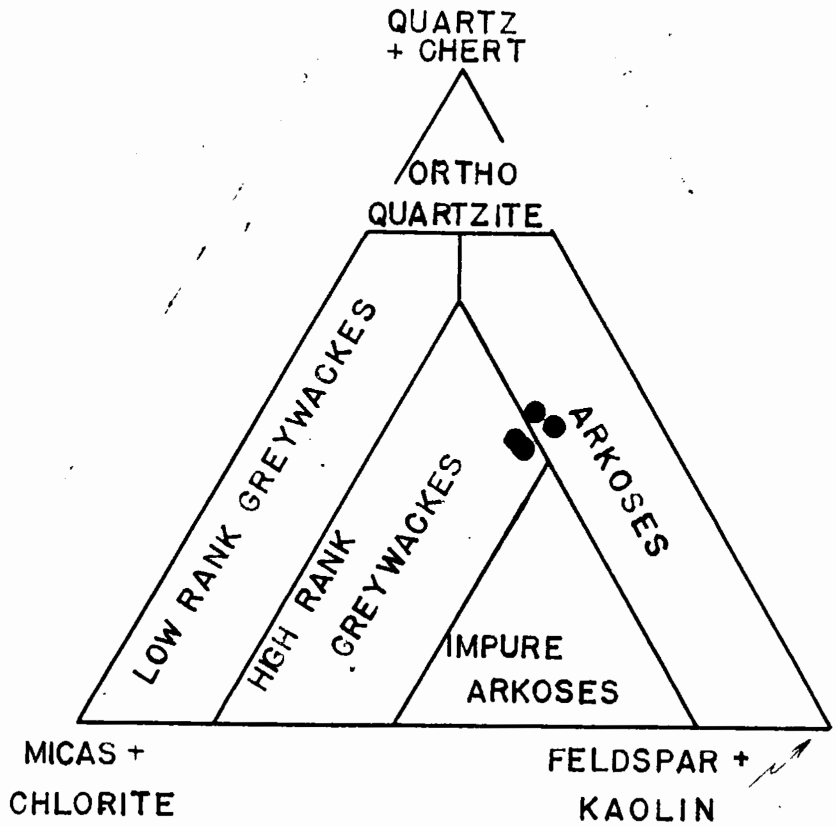


Figure 15 : - Location of York River sandstones in sandstone triangle of Krynine.

granules which are made of jasper. Generally the potassic feldspars in the York River sandstone are more altered and cloudy than in the Battery Point. The degree of alteration, however, is not the only reason for the difference in pigmentation because perfectly fresh potassic feldspars and altered plagioclase may occur beside one another and vice versa, in both formations.

TABLE 20 : - Reworked percentages of the York River sandstones. Rosiwal method.

Sample	Components			
No.	Quartz & chert	Micas & chlorite	Feldspar & kaolin	Total
8	46	14	40	100
9	44	20.5	35.5	100
10	48	16	36	100
11	43	20	37	100

The York River formation is generally considered as a "more marine" formation than the Battery Point which has been assigned a continental origin by several authors. The general characters of the Battery Point further point toward a more rapid deposition than for the York River formation. Being accepted that the York River sediments were washed during a longer period of time in the contemporaneous seas, the pigmentation of the feldspars may have been reduced and at present do not show a pink color. On the other hand, the Battery Point sediments (poured-in type) were not washed as long and the pigmentation stayed on or in the feldspars. Under this suggestion, the source area would not be responsible alone for the change in the color of the feldspars. The suggestion would explain why a zone of Battery Point type beds can be found in the York River formation on the north limb of the Berry Mountain syncline; a slightly faster rate of sedimentation could produce Battery Point lithology within the York River. It would also offer an explanation for the fact that York River beds, very similar to the Battery Point in other respects, do not have the pink feldspars. Furthermore, the finer arenites interbedded with the Battery Point sandstone seldom contain pink granules.

The pink color of the Battery Point feldspars may also very well reflect a change in the character of the source area. Under such an assumption, however, it seems that larger variations in total mineralogical composition could be expected between the York River and the Battery Point formations.

SIZE DISTRIBUTION:

The mechanical analyses for the York River formation have been performed by the same methods as the analyses for the Battery Point. The typical York River sandstone does not show a size distribution differing much from that of the Battery Point. Sample 7, analysed before (page 162), is at the transitional contact between the two formations. It could be considered a typical York River as well as a typical Battery Point sample as far as size distribution is concerned. The three samples selected for the present analyses, and shown in the following pages, belong to sandstones of the York River formation. However, they could not be considered as typical York River.

TABLE 21 : - Total logarithmic distribution of sample No. 12.

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
1	0.318	0 -0.0625		
2	0.635	0.0625-0.088		
13	4.12	0.088 -0.125		
			0.105-0.149	0.4
22	7.0	0.125 -0.177		
			0.149-0.210	1.65
67	21.2	0.177 -0.250		
			0.210-0.297	17.4
102	32.3	0.250 -0.354		
			0.297-0.420	36.9
76	24.2	0.354 -0.500		
			0.420-0.59	30.9
28	8.9	0.500 -0.707		
			0.59 -0.84	11.0
3	0.95	0.707 -1.00		
			0.84 -1.18	1.21
1	0.318	1.00 -1.414		
			1.18 -1.67	0.44
315	99.9			99.9

Sample No. 12 - From near mouth of Charles Vallée brook, about 100 stratigraphic feet above Cape Bon Ami formation.

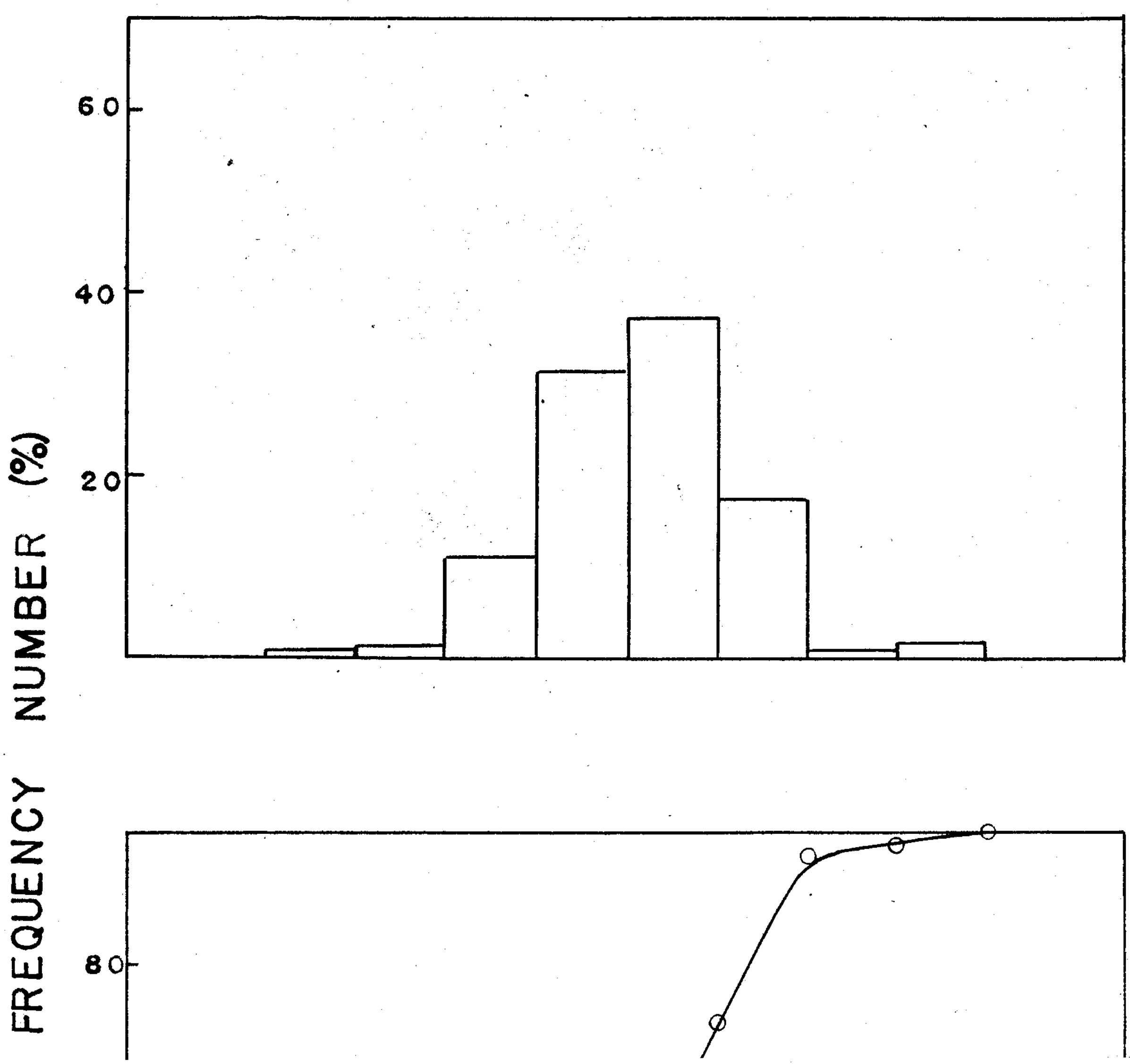


Figure 16 : - Histogram and cumulative curve of sample No. 12.

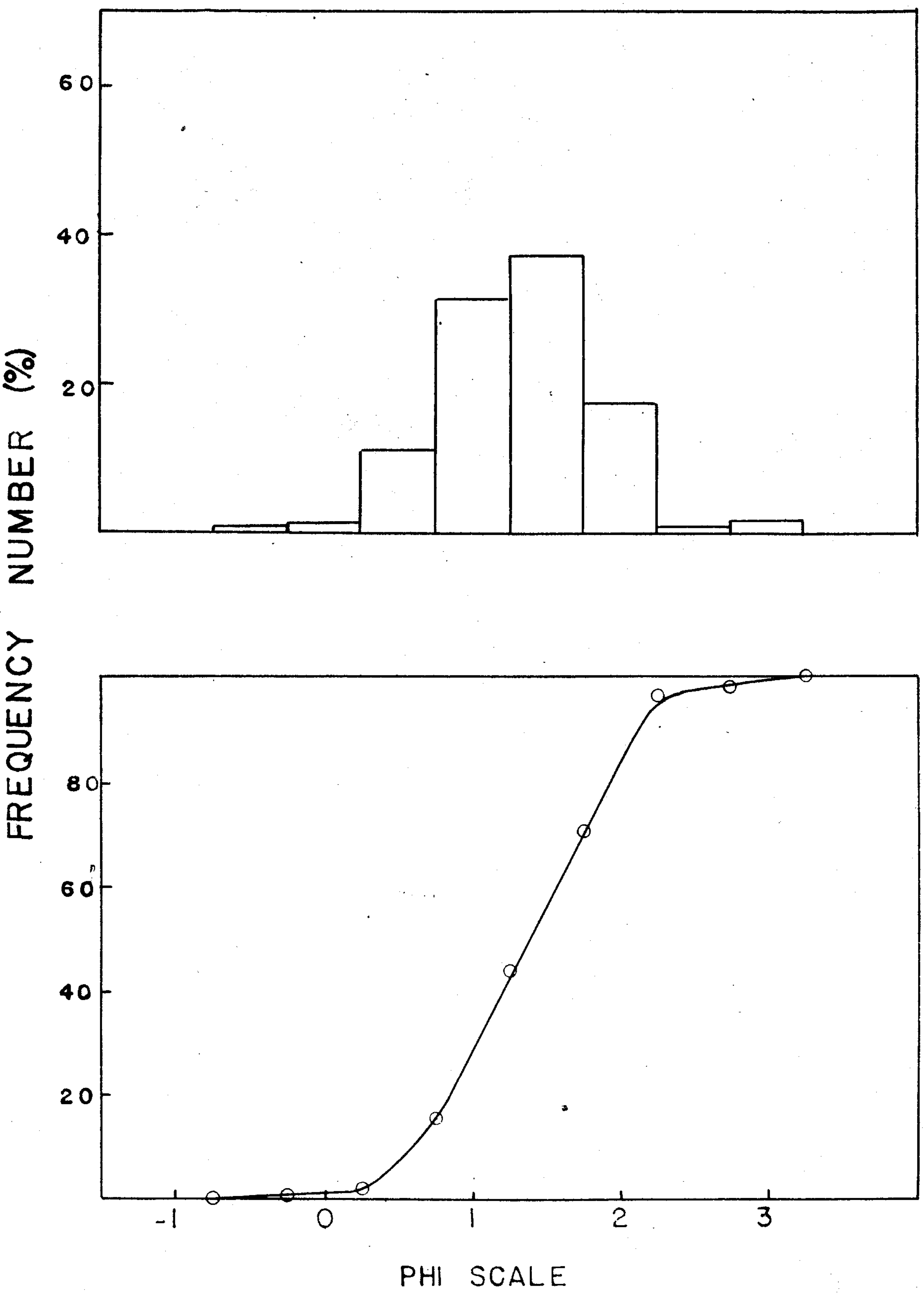

60
40
20
80
60
40
20
FREQUENCY NUMBER (%)
-1
0
1
2
3
PHI SCALE

TABLE 22 : - Total logarithmic distribution of sample No. 13

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
9	2.93	0 -0.0625		
76	24.8	0.0625-0.088		
			0.074-0.105	23.6
74	24.1	0.088 -0.125		
			0.105-0.149	24.7
53	17.2	0.125 -0.177		
			0.149-0.210	17.2
45	14.7	0.177 -0.250		
			0.210-0.297	15.9
27	8.8	0.250 -0.354		
			0.297-0.420	9.5
18	5.85	0.354 -0.500		
			0.420-0.59	7.1
4	1.3	0.500 -0.707		
			0.59 -0.84	1.61
1	0.33	0.707 -1.00		
			0.84 -1.18	0.422
307	100.0			100.0

Sample No. 13 - From outcrops containing oriented brachiopods, one mile north of Berry Mountain brook (South branch).

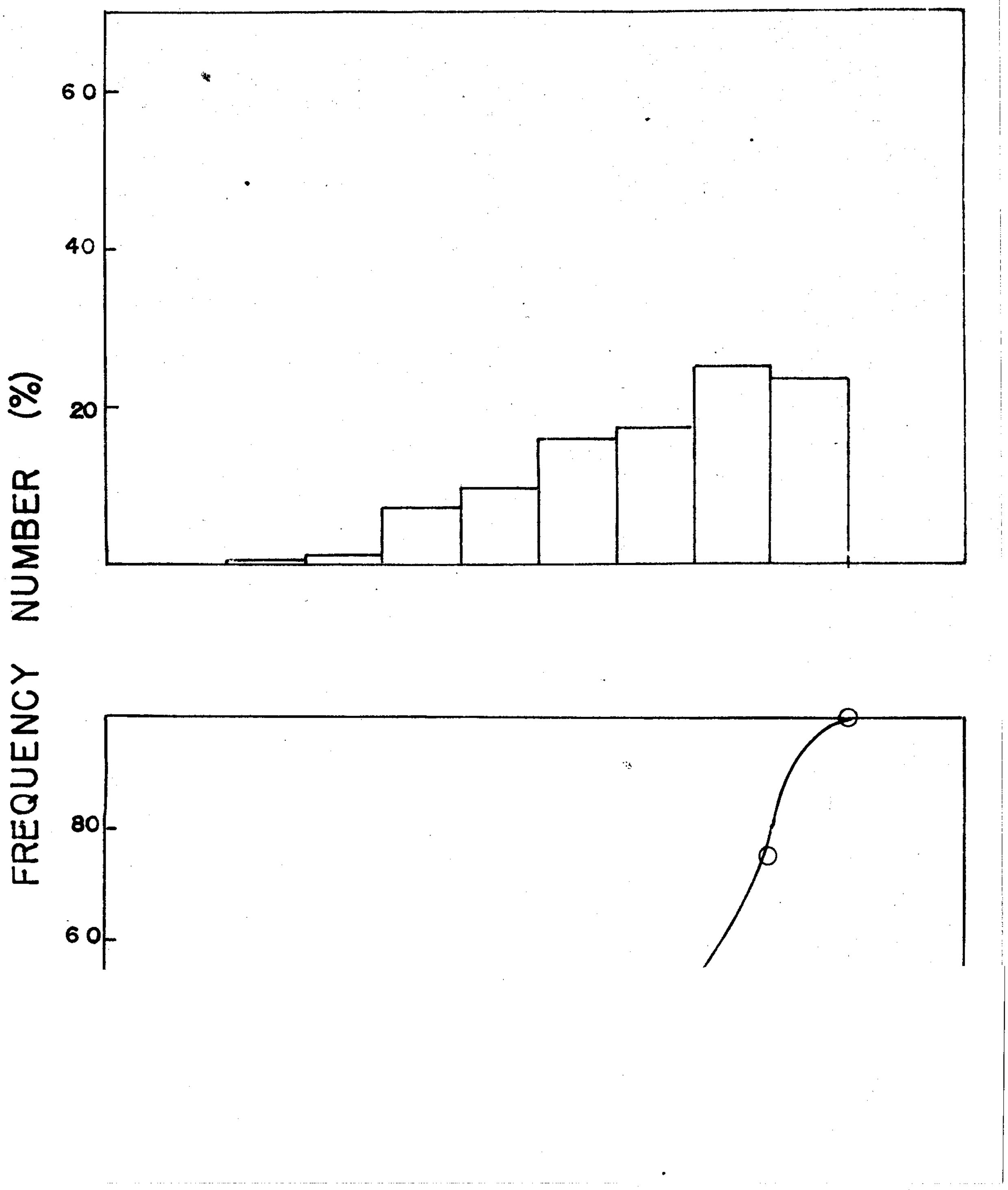


Figure 17 : - Histogram and cumulative curve of sample No. 13.

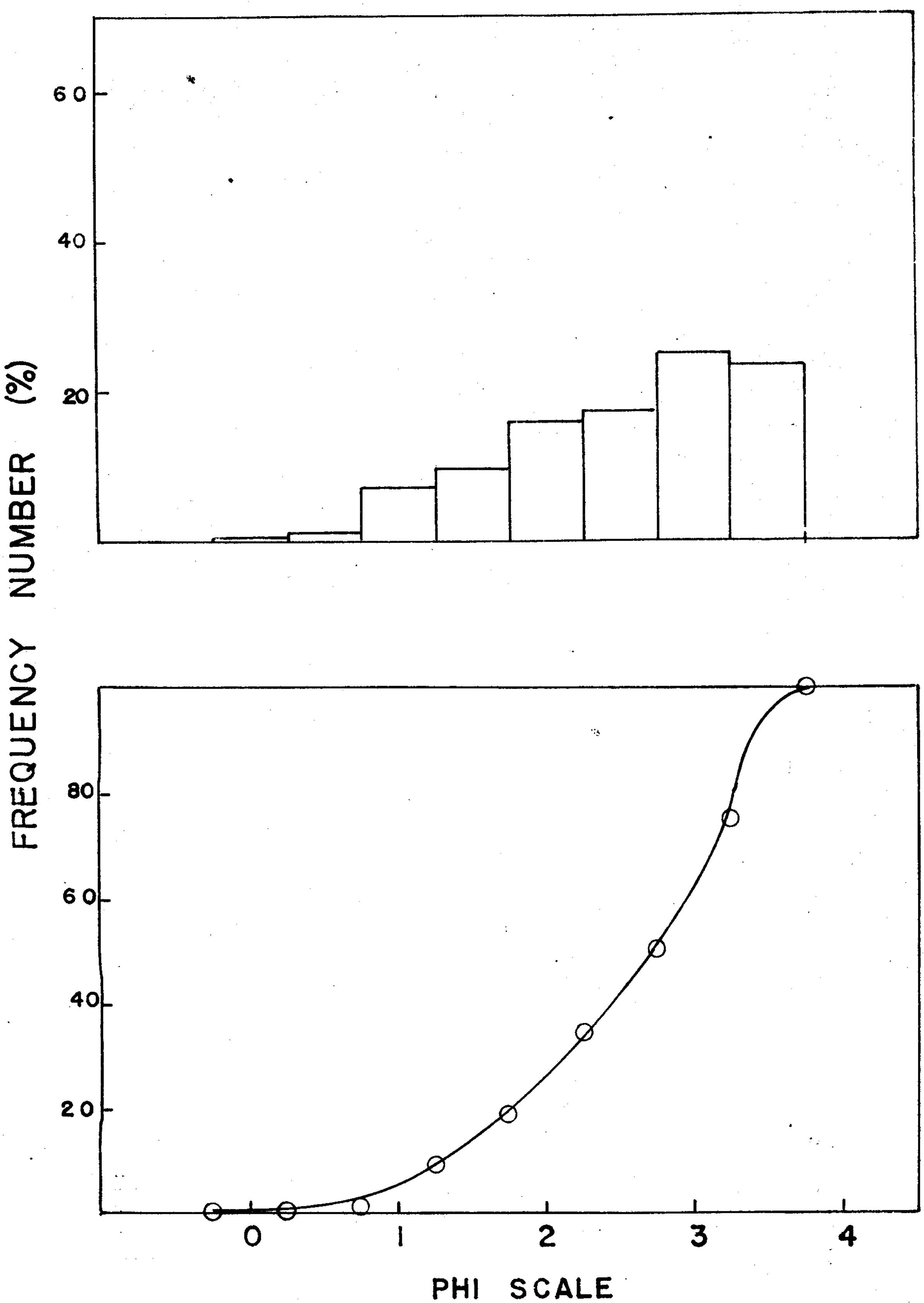

60
40
20
FREQUENCY NUMBER (%)
80
60
40
20
0
1
2
3
4
PHI SCALE

TABLE 23 : - Total logarithmic distribution of sample No. 14

Frequency number	Frequency number (per cent)	Class limits (Mm.)		Reconstructed frequency number (per cent)
2	0.64	0 -0.0625		
8	2.54	0.0625-0.088		
32	10.2	0.088 -0.125		
			0.105-0.149	5.9
50	16.0	0.125 -0.177		
			0.149-0.210	6.6
138	44.0	0.177 -0.250		
			0.210-0.297	52.4
72	23.0	0.250 -0.354		
			0.297-0.42	30.2
9	2.86	0.354 -0.500		
			0.42 -0.59	3.58
3	0.95	0.500 -0.707		
			0.59 -0.84	1.28
314	100.2			99.9

Sample No. 14 - From a quartz-rich bed, near the base of the formation at Little Gaspé bay.

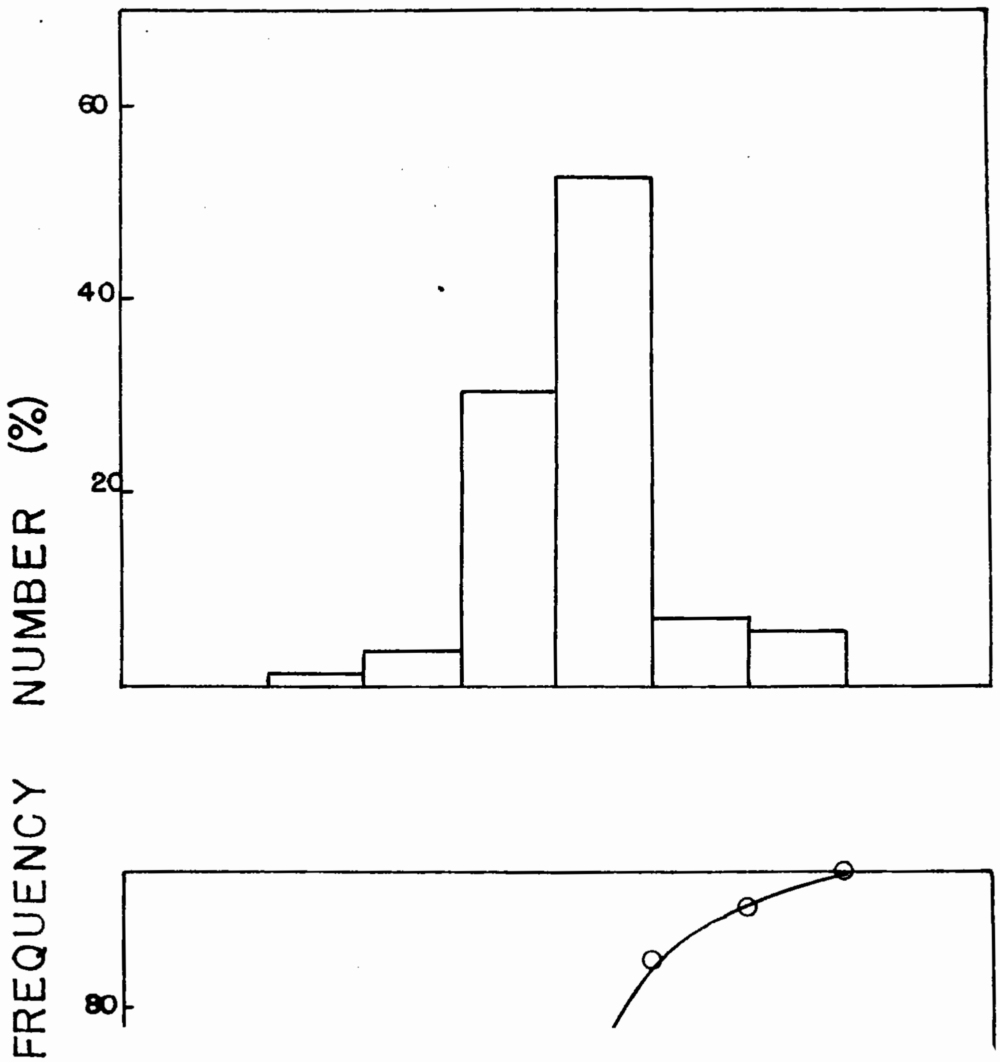
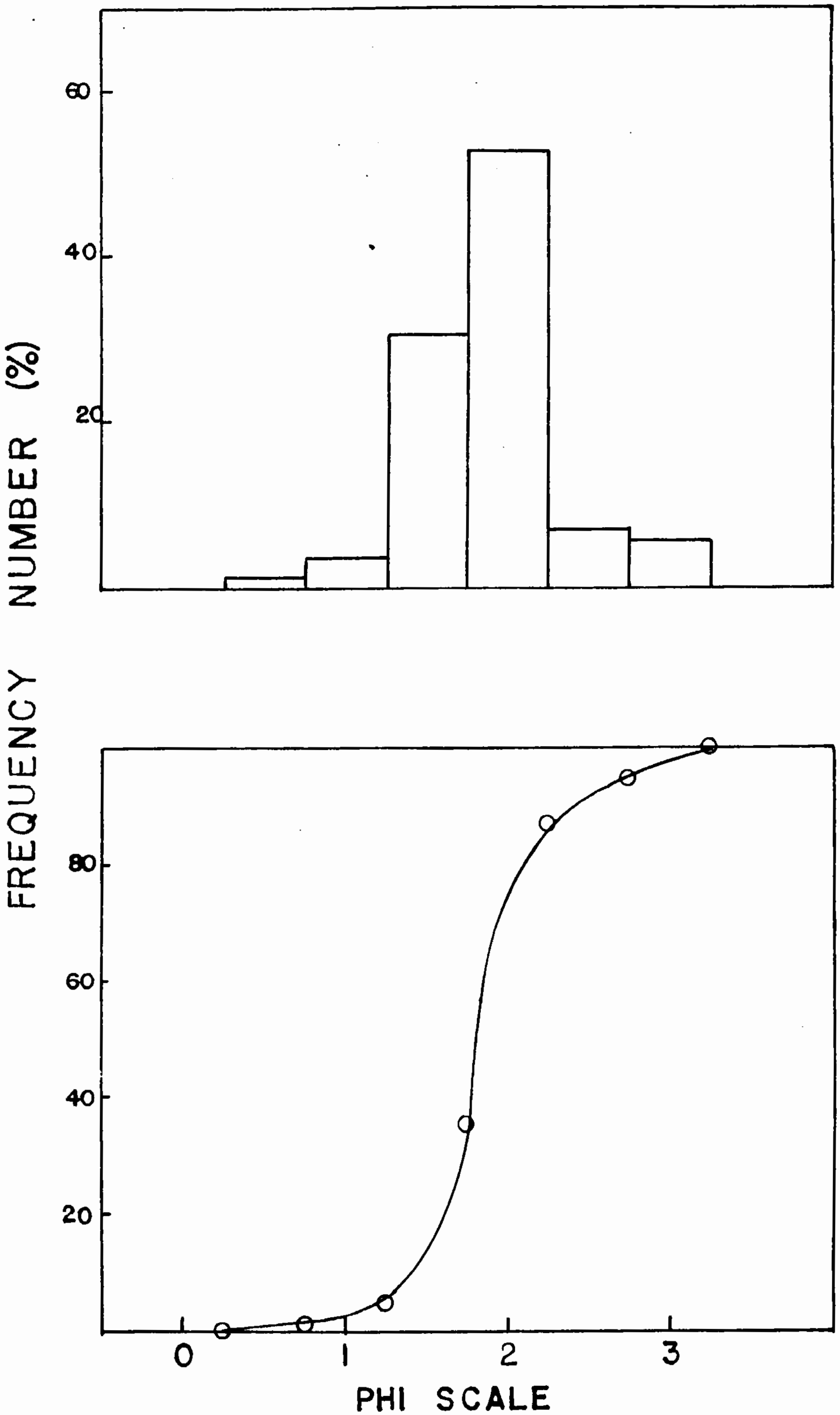


Figure 18 : - Histogram and cumulative curve of sample No. 14.


60
40
20
80
60
40
20
FREQUENCY NUMBER (%)
0
1
2
3
PHI SCALE

The quartile measures of the three analysed samples are presented in Table 24 and allow the following comments.

Sample 12 comes from the transitional beds immediately above the Cape Bon Ami formation on the south limb of the Berry Mountain syncline. The conditions of sedimentation for this sample came after quiet conditions during which argillaceous limestones were deposited. This may explain why the cumulative curve for the sample is perfectly symmetrical (skewness = 1.0): there are equal amount of coarse and fine admixtures on each side of the median. On the other hand, the coefficient of sorting is low and indicates good sorting.

Sample 13 is associated with oriented brachiopods. Its cumulative curve is different from that of all other samples of the Gaspé sandstones. The curve is strongly skewed toward the coarser admixtures. The sample is also the least well sorted. Therefore it represents a phase different from the typical Gaspé sandstones deposition. The sample also shows well the effects of deposition in agitated waters upon the characters of the cumulative curve.

Sample 14 does not seem different from other typical Gaspé sandstones beds.

TABLE 24 : - Quartile measures for sandstones of the York River formation

Name	Median	Quartile$_3$	Quartile$_1$	Log$_2$Coef. Sorting	Coef. Sorting	Log$_2$ Skewness	Skewness			Kurtosis
Abbreviation	Md	Q_3	Q_1	Qd	Dg = So	Skq	Sk	P_{90}	P_{10}	
Formula	50 percentile	75 percentile	25 percentile	$\frac{Q_3 - Q_1}{2}$	$\sqrt{Q_3/Q_1}$	$\frac{Q_1 + Q_3 - 2Md}{2}$	$\frac{Q_1 Q_3}{Md^2}$	90 Percentile	10 Percentile	$\frac{Q_3 - Q_1}{2(P_{90}-P_{10})}$
Parameter	"Average"				"Sorting"		"Symmetry"			"Peakedness"
Samples										
12	1.4	1.85	0.95	0.45	1.35	0	1.0	2.1	0.6	0.3
13	2.7	3.25	1.9	0.625	1.52	- 0.13	1.2	3.4	1.3	0.29
14	1.8	2.0	1.65	0.175	1.1	0.025	0.96	2.38	1.42	0.182

HEAVY MINERAL ANALYSIS:

The heavy mineral analysis for the York River formation were made by the methods adopted for the Battery Point formation. Ten samples were analysed. Three samples were collected in Eastern Gaspé; one from the quartz-rich beds on the north shore of Gaspé Bay: another from a point located along Ruisseau d'Argent, one mile above its mouth, and the third one along the St. John river from a point 1.2 mile east of Little Fork brook. The 7 other samples were collected in the Big Berry Mountains map-area.

In relation to the Battery Point formation, the York River shows a greater frequency of garnet. Magnetite however is predominant in the sample coming from Ruisseau d'Argent. Colourless zircon of the second or third cycle appears more abundant in the York River than in the Battery Point. Only two varieties of tourmaline were found: first, a dark yellowish-brown type, in sub-rounded prisms like that of the Battery Point, and second, a nearly colourless (slight smoky tint) variety occurring as prisms or rounded grains. This colourless tourmaline appears to be confined to the York River and was detected in 6 samples. Apatite was found in two separations. No leucoxene, titanite, kyanite, monazite nor fluorite were detected. All other minerals or rock fragments found in the Battery Point sandstone are represented in the York River with approximately the same frequencies. The sample coming from the quartz-rich beds of the north shore of Gaspé Bay differed from other specimens only in having a lesser amount of magnetite.

PARTICLE SHAPE, ROUNDNESS AND SURFACE:

The sphericity and roundness values for the York River formation are slightly higher than for the Battery Point formation as shown in the following tables:

TABLE 25 : - Distribution of the sphericity values in the York River sandstone.

Sphericity value	Number Frequency (percentage)
0.1 to 0.4	7
0.4 to 0.6	30
0.6 to 0.8	50
0.8 to 1.0	13

TABLE 26 : - Distribution of the roundness values in the York River sandstone.

Roundness value	Number Frequency (percentage)	Grade term
0.0 to 0.15	2	Angular
0.15 to 0.25	13	Subangular
0.25 to 0.4	75	Subrounded
0.4 to 0.6	8	Rounded
0.6 to 1.0	2	Well rounded

These values indicate a first-cycle and a rather immature sandstone.

The surface of the York River particles shows no characters appreciably different from those of the Battery Point particles.

LAKE BRANCH FORMATION

The rocks of the Lake Branch formation show only minor points of difference from the rest of the Gaspé sandstones. Lithologically and stratigraphically, the formation can be considered as a red facies of the York River formation. Only two thin-sections of the typical Lake Branch were examined. They show the same suite of minerals in various proportions with a slightly larger percentage of limonite. The iron-rich minerals in the Lake Branch are more strongly decomposed than in the rest of the Gaspé sandstones so that they might have made an important contribution of limonite to the binding material.

The greenish-grey sandstones along the Inlet river, mapped as Lake Branch on account of their stratigraphic position, contain a higher percentage (20 per cent) of calcite than the average Gaspé sandstones. Diagenetic changes, particularly the recrystallization of silica as secondary quartz, have taken place on a large scale. One Rosiwal analysis showed the average bed to be made of 34 per cent quartz, 15 per cent potassic feldspars, 15 per cent plagioclase, 3 per cent rhyolite and chert, 24 per cent matrix and 9 per cent of biotite, muscovite, lava fragments and decomposed ferromagnesians. The matrix is made of an obscure mixture of detrital quartz, altered feldspars, chloritic clayey paste and calcite.

The other properties of the Lake Branch formation are the same as those of the Battery Point and York River formations.

CHAPTER VI

PETROLOGY OF THE GASPE SANDSTONES

In the preceding chapters, the present study has been mainly concerned with the factual matter on the stratigraphy, paleontology and petrography of the Gaspé sandstones. It remains to interpret these facts and consider their paleogeographic implications in relation to the characters of the source-area, the location of the source-area, the environment of deposition and the prevailing climate during deposition.

CHARACTERS OF THE SOURCE-AREA:

The reconstruction of the characters of the source-area can be made by referring to the chapter on the petrography of the Gaspé sandstones. The mass composition of the Battery Point sandstone shows that the particles are distributed approximately as 50 per cent of igneous derivation, 30 per cent of metamorphic derivation, 10 per cent of volcanic derivation and 10 per cent of sedimentary derivation. Several particles classified as igneous may belong to a metamorphic terrane. For instance, much of the clear quartz could belong to granitic gneisses. The metamorphic particles include mica-schists, phyllites and quartzite fragments. The potassic and plagioclase feldspars, the perthite, the clear quartz and the "vein quartz" are considered as igneous in origin and indicate an acidic source. The pebbles in the conglomerates of the Battery Point formation are made of quartz, chert, jasper, volcanics, reddish granite and syenite.

In the heavy mineral residues, the association garnet - sillimanite - magnetite - kyanite - diopside suggests a high-rank metamorphic terrane. The association zircon - monazite - microcline - tourmaline - biotite may indicate an acidic igneous parent rock. On the other hand, fluorite, garnet, tourmaline, monazite, muscovite, microcline occur also in pegmatites. Grouped together, ilmenite, magnetite, leucoxene and rutile suggest a basic igneous terrane. The siltstone and, in part, the chert fragments come from sedimentary rocks. This rapid survey of the lithological properties of the Battery Point sandstone shows that the parent rocks represent a complex terrane including several rock types.

The York River sandstone comes from a source which provided the rock with an average of 37 per cent potassic and sodic feldspars and up to 20 per cent biotite. The other mineral components indicate a parent rock very similar to that predicated for the Battery Point sandstone, with possibly a larger areal distribution of basic to intermediate volcanic rocks. In the heavy mineral residues, apatite can be included in the mineral association suggestive of an acid igneous terrane.

The available information, therefore, indicates that the parent rocks for the Gaspé sandstones were mainly of acidic composition. They were either granite or granitic gneisses. A source-area containing granitic gneisses, paragneisses and pegmatite veins can best account for a considerable part of the mineral suite of the Gaspé sandstones. To satisfy fully the requirements of the mineral composition, this acidic terrane must have contained scattered areas of intermediate volcanics and basins of sedimentary rocks, or volcanic and sedimentary fragments were picked up by streams toward the end of transportation, at the edge of the main terrane.

Considering the thickness, texture and areal distribution of the Gaspé sandstones, it can be easily inferred that the source-area was of large extent and had considerable relief.

LOCATION OF THE SOURCE-AREA:

Evidences and suggestions as to the location of the source-area come from the composition, texture, bedding structures, fossil content, distribution of the sandstones, and also from the shape of the stratigraphic units.

No pre-Devonian terrane fitting the requirements of the composition of the Gaspé sandstones can now be located to the south, southeast or southwest of the Gaspé peninsula. If such a terrane had once been brought to the surface, it has since been hidden by overthrusting, or covered by post-Devonian sediments, or down-faulted into the Atlantic basin. On the other hand, the present Canadian Shield, north of the peninsula, together with the northern Ordovician belt (the Quebec group), constitute a terrane which would almost perfectly fit the reconstructed parent rocks of the Gaspé sandstones. The igneous and metamorphic components of the sandstones can be found now in the Canadian Shield and the Ordovician belt can provide the volcanic and sedimentary fragments of the sandstones. A strong argument in favor of such a location of the source-area is the large percentage of feldspars (37 per cent in the York River), garnet and magnetite in the Gaspé sandstones.

The mechanical analyses of the sandstones show that the sediments are generally well sorted, but this does not take into account the several conglomerate beds of the Battery Point formation. The pebbles of these beds have probably not travelled very far (Pl. 24). The low roundness values of the sedimentary particles also points toward a near-by source, although rapidity of burying may have been an important contributor to these low values.

It has been mentioned in the chapter on Stratigraphy that cross-bedding and ripple-mark are more common in the York River rocks of the northern limb of the Berry Mountain syncline than on the southern limb. Further the mollusks and brachiopods found in the rocks of the northern limb are smaller than usual and belong to types generally indicating brackish-water conditions. This suggests that the rocks of the northern limb were deposited in agitated, shallow waters, and that the shore-line and the source of fresh water was located to the north.

The Gaspé sandstones extend from the Matapedia valley to the eastern end of the peninsula, as a band generally more than 10 miles wide. They are 10,000 feet thick (McGerrigle, 1946,

p. 53) in the Matapedia valley, reach at least 20,000 feet in the present area, and are up to 10,000 feet thick in Eastern Gaspé (McGerrigle, 1950, p. 22). Except for 20 miles, the band is continuous from the Matapedia valley to Eastern Gaspé. It is reasonable to assume that a certain part of it has been eroded since deposition and that the band was continuous from Eastern Gaspé to Western Gaspé in Devonian time. A prism 150 miles long, more than 10 miles wide and at least 2 miles thick contains 3,000 cubic miles of sediments. Before erosion, this figure may have been twice as big. The source-area, therefore, must have been of a fairly large extent. If it were located to the south, at a short distance, it seems unlikely that no trace of it could be found.

In the Big Berry Mountains map-area, the shape of the stratigraphic units suggests strongly that the source-area was located to the north. The Lake Branch formation, on the northern limb of the Berry Mountain syncline, can reasonably be considered as a delta deposit. The formation thins out to the south, as tentatively shown in figure 19. Faulting at the Big Berry Mountains escarpment cannot alone explain the absence of the formation on the southern limb of the syncline. The Mount Noble and the Conical Mountain volcanics also thin out to the south. There is thus indicated a source of volcanism located to the north. Due to the great thickness of lava involved, it seems very likely that land volcanoes were in existence to the north, close to the present area, at the beginning of the Gaspé sandstones deposition. In this respect, it is interesting

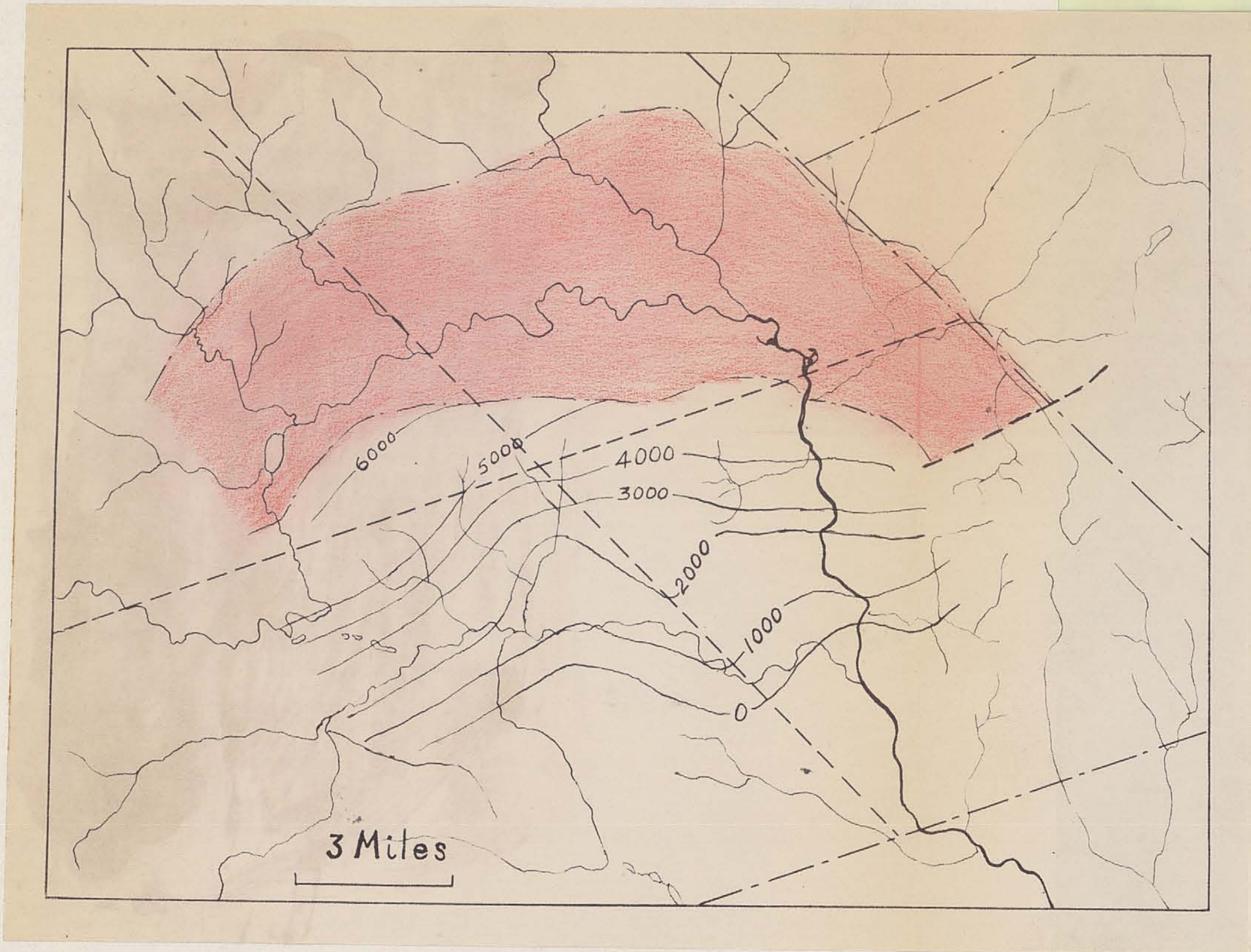


Figure 19 : - Isopach map of the Lake Branch formation, assuming no faulting at the Big Berry Mountains escarpment. Contour interval = 1,000 feet. In red, area of exposure of the formation.

to note that Gill and Auger (1943, p. 470), from a study of intrusive bodies, found some evidence of an erosional break between the Gaspé limestones and the Conical Mountain volcanics in the Federal Mine area. McGerrigle (MS, 1945), in the same area, found a conglomerate zone, immediately overlying the Gaspé limestones, and containing fragments of cherty layers and limestones of Grande Grève type. Consequently, locally at least, there is evidence of uplands, north of the present area, at the beginning of the Gaspé sandstones deposition. These sources could even partly explain the presence of fragments of intermediate lavas and chert in the sandstones since lavas can be found at several horizons toward the top of the Grande Grève formation which is siliceous throughout.

The York River formation, as such, seems to be thicker on the southern limb of the Berry Mountain syncline than on the northern limb. Thickening to the south would indicate a source to the south. However, it is not certain that the York River formation actually does thicken to the south. Since deposition, shortening of the earth's crust occurred during the Acadian revolution and a considerable amount of material has been eroded. The present southern limb of the Berry Mountain syncline may coincide in position with the area of maximum York River accumulation. The part of the formation which, during Devonian, was thinning to the south would have been eroded.

Possibly of more significance is the fact that the shale-limestone Fortin series in the present area appears to occupy a stratigraphic position equivalent to the lower part of the York River formation. If so, the Fortin series may represent an off-shore facies of part of the York River formation. Since the Fortin series is located to the south of the York River formation and is of a much finer grain, the sediments presumably came from the north.

Oriented fossils, ripple-marks and cross-bedding indicate currents predominantly from the northeast and, in some cases, from the east. The writer is inclined to put little faith in these features as indicators of provenance of sediments when they are not treated statistically. The present ones are not numerous and they may have been controlled by local factors as shore currents, tidal currents, wave currents and shore geography.

ENVIRONMENT OF DEPOSITION:

The Gaspé sandstones have generally been considered as deposited under continental conditions for the following reasons:

1) Plant remains are present practically through the entire sequence, and marine invertebrates are confined to the lower beds.

2) The plant remains belong to forms known to be land plants.

3) Dawson (1871, p. 8) described places where the roots of these plants are embedded in the soil in which they grew.

4) The sediments are dominantly clastic, in places conglomeratic.

5) The "series" is rather thick and of a wide areal extent.

6) The rocks show structures and textures such as cross-bedding, ripple-marks, mud-cracks and rarely rain imprints.

7) Part of the "series" is reddish in colour.

On the basis of these arguments, Alcock (1926, p. 45) summarized the prevailing opinion, and concluded that the rocks apparently were deposited "largely under terrestrial rather than marine conditions... as deltas and along floodplains".

Before reviewing the arguments in favor of a continental origin for the Gaspé sandstones, it is necessary to search what is meant by a marine or a continental environment. According to modern textbooks (Pettijohn, 1949, p. 441, Twenhofel, 1950, p. 51, Krumbein and Sloss, 1951, p. 196) and older ones (Grabau, 1913, p. 582), the continental environments can be divided into a terrestrial environment (desert, glacial) and an aqueous environment (alluvial, lacustrine, paludal, spelean). The marine environments include the neritic, bathyal and abyssal environments. Between the marine and the continental environments, there is a group of transitional environments (deltaic, lagoonal and littoral), sometimes called mixed continental and marine environments.

There is little doubt that most authors meant transitional environment (deltaic and lagoonal) when they referred to the conditions of deposition of the Gaspé sandstones. Terrestrial conditions, in the sense of glacial or aeolian conditions, do certainly not apply to the sandstone body as a whole. For most authors also, the prevailing conditions do not appear to have been fluvial, lacustrine or paludal conditions. If so, keeping the definitions of the various environments in mind, the Gaspé sandstones were not laid down under continental conditions. Under the present definition of terms, therefore according to most authors, the conditions of deposition of the sandstones belong to the deltaic environment with possibly locally some lacustrine, paludal and marine beds. In the Big Berry Mountains map-area, the Gaspé sandstones appear to have been laid down commonly under alluvial and deltaic conditions, but predominantly under littoral and neritic conditions. The position adopted by the present writer therefore leans somewhat more toward a marine environment than a continental one.

It is true that plant remains are found at numerous places in the Gaspé sandstones and that these plant remains belong to forms known to be land plants. The majority of these plants, however, are comminuted fragments which were evidently floated into the basin of deposition. The same plants with the same preservation are found with marine fossils in the York River.

Dawson (1871, p. 8) describes "groups of beds" including "fossil soils of the nature of under-clay" in the sandstones of Eastern Gaspé. He also cites the occurence of shale fragments in the sandstones "interlaced with roots or stems of Psilophyton which sometimes project beyond their limits into the sandstone, as if the vegetable fibres had preserved the clay from removal". According to him, "these lines of patches of shale seem to be remnants of soils on which Psilophyton has flourished abundantly, and which have been partially swept away by the currents which deposited the sand".

Dawson (ibid.) found several of these fragments in the sandstones, together with "large drifted trunks and stumps of Prototaxites". Whatever the significance of the shale fragments, there is room for occasional paludal beds within the Gaspé sandstones sequence. A lag of subsidence in the basin of deposition would expose some beds to subaerial conditions to be buried later by a transgressing sea or by rapid deposition. Dawson's observations were mostly made in the Battery Point formation and along Logan's type section. Modern work along the Gaspé coast (McGerrigle, personal communication) has failed to reveal the presence of rooted plants.

The fact that the Gaspé sandstones are dominantly clastic, and conglomeratic, and that there is no limestone is the fourth argument in favor of a "continental origin". A limy zone (Trachytoechus beds) with marine fossils, within the York River occurs on the north limb of the Berry Mountain syncline. Moreover, several limestone beds can be found toward the base of the sequence (York Lake facies). The conglomeratic zones may belong easily to a deltaic environment and the finer clastics (sandstones, siltstones and shales) could have been deposited under littoral and neritic conditions as well as under other conditions.

The fact that the "series" is quite thick and of a wide lateral extent does not necessarily militate in favor of a continental origin. Thick sequences of beds can also occur in a transitional environment.

Cross-bedding is common in the Battery Point formation; ripple-mark and cross-bedding, mud-cracks and rare rain-imprints occur in the Lake Branch formation. The cross-bedding, the coarseness of the grains, and the thickness of the individual beds point toward an alluvial origin for the Battery Point formation, possibly under conditions of coalescing deltas at some places, and of alluvial fans at others.

The cross-bedding and the ripple-marks of the York River formation do not necessarily demand continental conditions; ripple-mark can also occur under littoral and even neritic conditions. The regular and gentle cross-bedding of the York River could equally have originated under the action of littoral currents or tide currents in a shallow sea.

The cross-bedding, rain-imprints and mud-cracks of the Lake Branch formation, combined with the stratigraphic relationships, indicate a deltaic environment. The features suggesting subaerial conditions, however, are not abundant and several beds might have been deposited along the littoral of contemporaneous seas.

The seventh and final argument in favour of a "continental origin" for the Gaspé sandstones is the red colour of the Lake Branch formation and of the top of the Battery Point formation. If the red colour is considered alone, it does not help to solve the problem, for red colour is not necessarily indicative of subaerial conditions. However, the other subaerial features (rain-imprints, mud-cracks) show that parts of the Gaspé sandstones were really exposed, most probably as flood-plains, to the atmosphere during deposition. It is therefore highly probable that the red colour is due to the oxidizing conditions prevailing in this environment.

The above discussion shows that no features of the Gaspé sandstones necessarily demand a continental environment of deposition. On the other hand, some features suggest and others indicate a transitional or a marine environment. Locally paludal conditions prevailed.

The invertebrate content of the Gaspé sandstones does not contradict the above statement. On the contrary, the marine invertebrates found at the base of the York River formation (in the middle of the formation for the south limb of the Berry Mountain syncline) indicate a littoral or neritic environment.

It has been frequently suggested (e.g. Clarke, 1908, p. 86) that the fossiliferous zones of the York River represent times when marine waters invaded the Gaspé basin over some bars or land barriers. The rest of the formation would have been deposited under lagoonal conditions. The absence of marine fossils elsewhere in the formation is considered as an argument in favor of the hypothesis. However it is difficult to explain how lagoonal beds could persist in representing exactly the same lithology over a considerable thickness, in large areas, as well in Eastern Gaspé as in Central Gaspé. Furthermore the fossiliferous strata of the York River are overlain and underlain by a thick succession of strata showing no lithological characters appreciably different from the "marine beds". The fossiliferous strata are generally calcareous, but calcareous beds also occur at numerous stratigraphic levels in the York River. Consequently the present writer sees no reason why the unfossiliferous York River could not also be considered to be marine in origin having accumulated under littoral and neritic environments.

Marine formations are not necessarily fossiliferous throughout. Many of the sandstone beds show evidences of having accumulated rapidly. The composition of the sandstones suggests that the contemporaneous seas must have been rich in iron compounds. The environment therefore might not have been favorable for the continuous flourishing of marine faunas. Only at certain times, under quiet conditions and possibly when continental waters did not dilute the marine waters to too great an extent, could marine faunas develop on the sea-floor. These conditions could have been created during a slight transgression of the sea.

Four fresh-water vertebrates (Clarke, 1908, p. 84) have been found in the Battery Point formation of Eastern Gaspé together with the plant fragments mentioned before. In the present area, one fish spine was collected. Along the Inlet river, brachiopods, pelecypods and corals occur in beds stratigraphically in line with the typical Battery Point sandstones. In Eastern Gaspé, several marine invertebrates were found on the Little Fork of Malbaie river (McGerrigle, 1950, p. 87). The biological aspect of the Battery Point formation therefore points toward mixed continental and marine conditions, i.e. to a transitional environment. Alluvial fan deposition near sea-level coupled with alternating slight regression and transgression of the sea seems to fit best the biological and lithological characters of the Battery Point formation.

The Gaspé sandstones deposition appears as a sedimentation unit starting with neritic conditions (York Lake, base and middle of York River). Then as time went on, the basin of deposition became more and more filled to its brim with sediments as alluvial conditions became prevalent. Lagoonal conditions developed locally but the bulk of the Battery Point sediments appears to have been poured into a brackish-water basin under alluvial and deltaic conditions. Locally only were beds exposed during a certain time to subaerial conditions (Lake Branch facies).

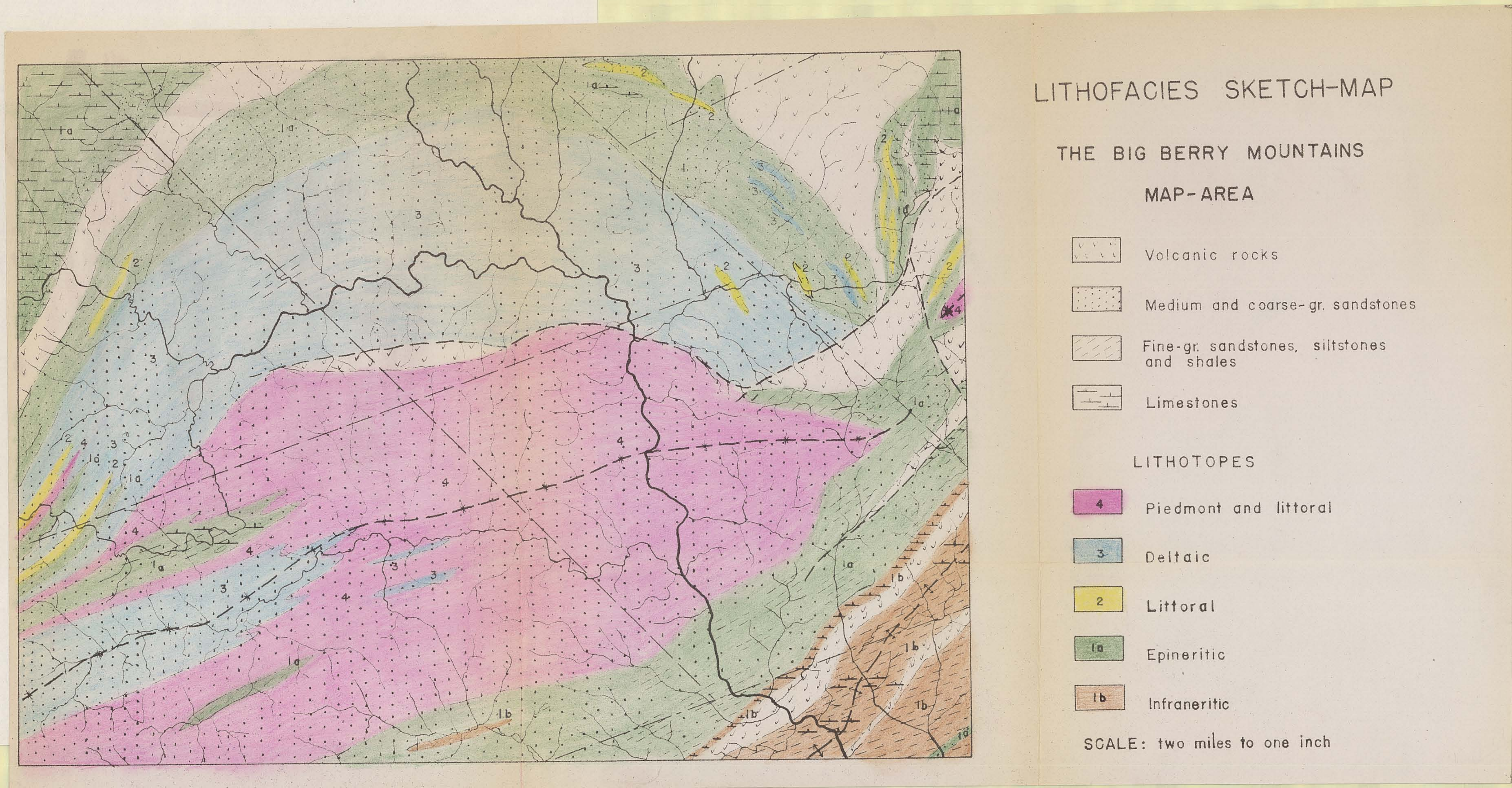
The cycle ended by deposition of the red beds of the Battery Point, possibly under predominantly lagoonal conditions. Up to the last phase of the cycle, the seas where the sandstones were laid down appear to have been shallow with a littoral shelf of large extent, undergoing the particularly strong winnowing action of tides on account of the gentle seaward slope.

The tendency to interpret the Gaspé sandstones in terms of continental sedimentation has been certainly influenced by the easily made comparison with the Old Red Sandstone of Great Britain. And this was particularly true when only the coastal sections of Eastern Gaspé were known. When the inland areas are taken into consideration, the proportion of red beds to grey and green beds becomes less important, and analogies with the Old Red Sandstone become less striking.

If analogies are to be drawn, the Gaspé sedimentation appears possibly closer to the Devonian of Continental Europe than that of Great Britain. In Belgium for example, vari-colored sandstones and shales of roughly equivalent age are interbedded with abundant red beds and occasional limestone layers. More than 400 marine invertebrate species have been collected in these rocks together with 10 species of fishes in the Siegenian and Emsian (Coblenzian). The brachiopods and pelecypods are particularly abundant, both in species and individuals. No fewer than 17 plant species, all considered as having floated in, have been identified; a few forms are closely allied to the Gaspé plants, and two are identical. As in Gaspé, the formations are now exposed in individual basins. In the Neufchâteau basin, they reach a thickness of 30,000 feet for the Lower Devonian alone.

Many other characters common to the Devonian of Gaspé and Belgium could be cited. Asselbergh (1946, p. 346 and 560), who devoted a lifetime to the Lower Devonian of Les Ardennes, concluded that: "Les formations éodévoniennes de l'Ardenne et des régions voisines...sont essentiellement marines. Ni la couleur rouge

Figure 20 : - Lithofacies sketch-map of the Big Berry Mountains map-area.


LITHOFACIES SKETCH-MAP
THE BIG BERRY MOUNTAINS
MAP-AREA
Volcanic rocks
Medium and coarse-gr. sandstones
Fine-gr. sandstones, siltstones and shales
Limestones
LITHOTOPES
4 Piedmont and littoral
3 Deltaic
2 Littoral
1a Epineritic
1b Infraneritic
SCALE: two miles to one inch

de certaines couches, ni la présence de Pteraspis dans d'autres ne permettent de conclure à leur origine lagunaire... /Elles/ se sont déposées dans les zones néritiques et littorales d'une mer plate peu profonde".

The above discussion and the conclusions arrived at are summarized in figure 21: the York River formation is assigned to an epineritic environment, i.e. to the part of the neritic environment where the waters are agitated by normal waves and littoral currents. The Lake Branch is considered as a deltaic deposit. The Battery Point is shown as a piedmont and alluvial deposit, built at sea-level where tidal and littoral currents would spread the sediments. The Battery Point formation shows characters similar to those met in the Rencontre formation of Newfoundland (Twenhofel, 1947, p. 102), the Siwalik Series of the Northern Punjab (Anderson, 1927) and the Flysch of the Alps.

CLIMATE:

The corals found in the York Lake, York River and Battery Point formations and the terrestrial plant fragments distributed throughout the entire group of rocks suggest deposition under mild climatic conditions. The Gaspé sandstones represent a large volume of clastic sediments, deposited in a relatively short time. This requires rapid weathering in the source-area. The rapid weathering can be best accounted for by humid conditions, with high relief and scarcity of vegetation as contributing factors. At certain times, semi-arid conditions or seasonal rain-fall might have prevailed as shown by the mud-cracks, rain-imprints and red color of the Lake Branch formation.

CHAPTER VII

GEOLOGICAL HISTORY AND CONCLUSIONS

1 - The geological history of the Big Berry Mountains map-area begins with the deposition of calcareous muds, siltstones and sandstones during Late Silurian time, accompanied by slight volcanic activity.

2 - This was followed by a period of volcanic activity, partly submarine, during which more than 2,000 feet of predominantly intermediate lavas accumulated over the Silurian sediments.

3 - At the beginning of Early Devonian time, the area was covered by a warm sea in which were deposited the calcareous mud of the Cape Bon Ami formation and the siliceous limestones of the Grande Grève formation. The present area gives no definite clue as to the direction of transgression by the sea or as to the provenance of the material of the Gaspé limestones. North of the area, the end of Grande Grève deposition was marked by volcanic activity and local uplift followed by erosion.

4 - As time went on, clastic sediments coming from the north, began to reach the Grande Grève sea (York Lake facies), in the northern part of the area. At the same time in the south, calcareous muds and silts (Fortin series) were beginning to be deposited. At this stage, the Fortin seas were possibly receiving

sedimentary material from the south.

5 - Partly contemporaneous with the York Lake deposition, there was more and more volcanic activity to the north of the present area. This culminated in the outpouring of the Conical Mountain volcanics at more than one interval of time.

6 - This was succeeded by the deposition of the Gaspé sandstones toward the end of Early Devonian time. First, uplift occurred in the Precambrian areas and in the Ordovician Taconic mountains to the north. The York River clastics were shed on neritic shelves of large extent which were contemporaneously subsiding.

7 - A lag in the subsidence of the basin of sedimentation, or rapid, renewed uplift in the source-area, created deltaic conditions under which the Lake Branch formation was deposited.

8 - Uplift increased in magnitude in the source-area and mountains came to lie fairly close to the basin of sedimentation which was continuously subsiding. First, more volcanism occurred to the north (Mount Noble volcanics). Then, piedmont alluvial fans and deltas were formed, to be spread, sometimes in part only, by littoral and tidal currents (Battery Point sandstones and conglomerates).

9 - The last phase of the Gaspé sandstone sedimentation was the prelude to the Acadian revolution which may have occupied the rest of Devonian time in Central Gaspé. During this orogeny, the rocks of the present area were folded (Berry Mountain

syncline), jointed and faulted. The Silurian belt was brought up toward the surface by anticlinal folding. The Battery Point formation was partly thrust over the Lake Branch formation. The Fortin series was brought closer to the Gaspé sandstones by shortening of the earth's crust.

There are no data concerning the extent to which the rocks of the present area were affected by the Appalachian revolution or the Palisade disturbance.

BIBLIOGRAPHY

ALCOCK, F.J. - (1922) Geology of Lemieux Township, Gaspé County, Quebec: Geol. Surv. Canada, Sum. Rept. 1921, Pt D, p. 71-96.

- (1926) Mount Albert Map-area, Quebec: Geol. Surv. Canada, Mem. 144.

- (1928) Zinc-lead Field of Central Gaspé, Que.: Geol. Surv. Canada, Sum. Rept. 1927, Pt C, p. 27-46.

ANDERSON, R. van V. - (1927) Tertiary Stratigraphy and Orogeny of the Northern Punjab: Geol. Soc. Am. Bull., vol. 38, p. 665-720.

ASSELBERGHS, E. - (1946) L'Eodévonien de l'Ardenne et des Régions voisines: Mémoires de l'Institut géologique de l'Univ. de Louvain, Tome XIV.

AUGER, P.E. - (1946) Structure de la mine Federal Zinc and Lead, Gaspésie (abstract) Assoc. Can.-franç. Av. Sci., Annales, vol. 12, p. 72.

BROWN, R.A. - (1938) North Shore of Gaspé Bay: Que. Bur. of Mines, P.R. No. 125, p. 4.

- (1939) The Geology of the North Shore of Gaspé Bay, Quebec: Ph. D. thesis, McGill Univ.

CLARK, T.H. - (1937) in Cooke, H.C. - Thetford, Disraeli and Eastern half of Warwick map-areas, Quebec: Geol. Surv. Canada, Mem. 211, p. 43 - 50.

CLARKE, J.M. - (1908) Early Devonic History of New York and Eastern North America. New York State Museum, Mem. 9.

COLEMAN, A.P. - (1922) Physiography and glacial geology of Gaspé peninsula: Geol. Surv. Canada, Bull. 34.

COOPER, G.A. - (1942) Correlation of the Devonian Sedimentary formations of North America: Geol. Soc. Am. Bull., vol. 53, p. 1729 - 1794.

DAWSON, W.J. - (1871) Fossil plants of the Devonian and Upper Silurian formations of Canada: Geol. Surv. Canada, Sum. Rept. 1871, p. 1 - 92.

DRESSER, J.A. and DENIS, T.C. - (1944) Geology of Quebec, vol. II. Descriptive Geology: Que. Dept. of Mines, Geol. Rept. No. 20, p. 299 - 300.

ELLS, R.W. - (1883) Report on Explorations and Surveys in the Interior of Gaspé Peninsula: Geol. Surv. Canada, Rept. of Prog. for 1882 - 1883 - 1884, Pt E, p. 7 - 11.

FRITZ, M.A. - (1944) Bryozoa indicate Middle Devonian Age for Gaspé Sandstone: Trans. Roy. Soc. Canada, vol. 38, Sec. IV, p. 35 - 37.

- (1951) Genus Trachytoechus from Helderberg of Scoharie, New York: Wagener Free Institute of Science, Bull. 26, p. 27 - 29.

GILL, J.E. and AUGER, P.E. - (1943) Zinc Deposits of the Federal Area. Gaspé, Que.: Can. Inst. Min. and Met. Trans., vol. 46, p. 456 - 473.

GRABAU, A.W. - (1913) Principles of Stratigraphy: A.G. Seiler and Co., New York.

GREENMAN, N.N. - (1951) The mechanical analysis of sediments from thin-section data: Jour. Geol., vol. 59, p. 447 - 462.

HARRINGTON, B.J. - (1883) Life of Sir William Logan: Dawson Brothers, Montreal.

JONES, I.W. - (1930) The Berry Mountain Map-Area, Gaspé: Que. Bur. Mines., Ann. Rept., Pt D., p. 1 - 42.

- (1931) The Lesseps Area, Gaspé Peninsula: Que. Bur. Mines, Ann. Rept., Pt D., p. 195 - 226.

- (1932) The Bonnecamp map-area, Gaspé Peninsula: Que. Bur. Mines, Ann. Rept., Pt D., p. 41 - 75.

- (1935) Dartmouth River Map-area, Gaspé Peninsula: Que. Bur. Mines, Ann. Rept., Pt D., p. 3 - 44.

- (1935) Upper York River Map-area, Gaspé Peninsula: Que. Bur. Mines, Ann. Rept., Pt D., p. 3 - 28.

- (1936) Mount Alexander Map-area, Gaspé Peninsula: Que. Bur. Mines, Ann. Rept., Pt D., p. 5 - 26.

- (1938) The Gaspé Bay Area: Que. Bur. Mines, P.R. No. 125.

JONES, I.W. and McGERRIGLE, H.W. - (1937) Geology of Parts of Eastern Gaspé: Que. Bur. Mines, P.R. No. 130.

KRUMBEIN, W.C. - (1935) Thin-section mechanical analysis of indurated sediments: Jour. Geol., vol. 43, p. 482 - 496.

KRUMBEIN, W.C. and SLOSS, L.L. - (1951) Stratigraphy and Sedimentation: W.H. Freeman and Co., San Francisco, Cal.

KRUMBEIN, W.C. and PETTIJOHN, F.J. - (1938) Manual of Sedimentary Petrography: D. Appleton - Century Co., New York.

KRYNINE, P.D. - (1940) Petrology and genesis of the Third Bradford Sand: Penn. State College Bull., no. 29, p. 50.

- (1948) The megascopic study and field classification of sedimentary rocks: Jour. Geol., vol. 56, p. 130 - 165.

LOGAN, W.E. - (1843) (General geologic features of eastern and western Canada): Geol. Surv. Canada, Rept. of Prog. for 1843, p. 48.

- (1844) Geological Section on Chaleur Bay and Coast of Gaspé: Geol. Surv. Canada, Rept. of Prog. for 1844, p. 80 - 100.

- (1844) On the Geology of the Chat and Cascapedia Rivers, Gaspé and the Chaleur Bay: Geol. Surv. Canada, Rept. of Prog. for 1844, p. 5 - 66.

- (1863) Geology of Canada: Geol. Surv. Canada, Rept. of Prog. for 1863.

LOW, A.P. - (1883) Reports on Explorations and Surveys in the Interior of Gaspé Peninsula: Rept. of Prog. for 1882 - 83 - 84, Pt F.

MAILHIOT, A. - (1919) Geology of a portion of the projected township of Lemieux, county of Gaspé, Que: Que. Dept. Col. Min. Fish., Rept. Min. Oper., 1918, p. 134 - 145.

McGERRIGLE, H.W. - (1938) Joncas-Fortin area, Gaspé County: Que. Bur. Mines, P.R. No. 125.

McGERRIGLE, H.W. - (1940) The Power-Joncas Area, Gaspé County: Que. Bur. Mines, P.R. No. 153.

- (1945) Reconnaissance Geological Survey of South-Central and Western Gaspé Peninsula, Quebec: Unpublished manuscript in the files of the Que. Dept. of Mines.

- (1946) A revision of the Gaspé Devonian: Trans. Roy. Soc. Canada, Sec. IV, vol. 40, p. 41 - 54.

- (1950) The Geology of Eastern Gaspé: Que. Dept. of Mines, Geol. Rept. 35.

- (1950) The Tourelle-Lake Cascapedia Map-area, Gaspé Peninsula: Unpublished manuscript in the files of the Que. Dept. of Mines.

- (1952) Pleistocene Glaciation in Gaspé Peninsula: Trans. Roy. Soc. Canada, Sec. IV, vol. 46, p. 37 - 52.

MILNER, H.B. - (1929) Sedimentary Petrography: Thomas Murby & Co., London.

NORTHROP, S.A. - (1939) Paleontology and Stratigraphy of the Silurian rocks of the Port-Daniel-Black Cape Region, Gaspé: Geol. Soc. Am., Special Paper No. 21.

PELTO, C.R. - (1952) The mechanical analysis of sediments from thin-section data. A discussion: Jour. Geol. vol. 60, p. 402 - 407.

PETTIJOHN, F.J. - (1949) Sedimentary Rocks: Harper and Brothers, New York.

ROSENFELD, M.A., JACOBSEN, L., FERM, J.C. - (1952) Comparison of sieve and thin-section technique for size analysis: (Abstract) Geol. Soc. Am. Bull., vol. 63, p. 1293.

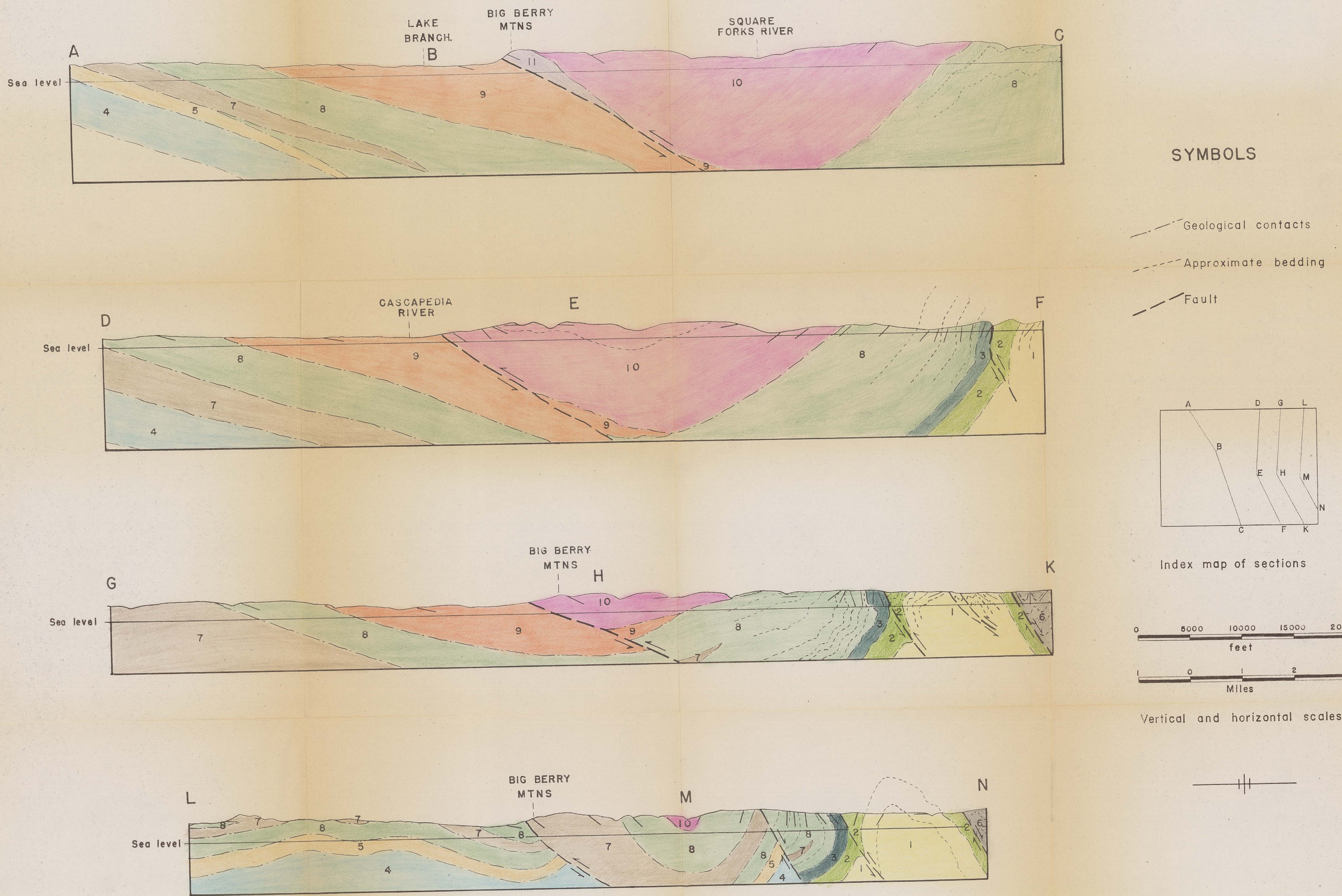
RUSSELL, L.S. - (1946) The Stratigraphy of the Gaspé limestones series, Forillon Peninsula: Que. Dept. of Mines, P.R. No. 195.

TWENHOFEL, W.H. - (1947) The Silurian of Eastern Newfoundland, with some data relating to physiography and Wisconsin glaciation of Newfoundland: Am. Jour. Sci., vol. 245, p. 65 - 122.

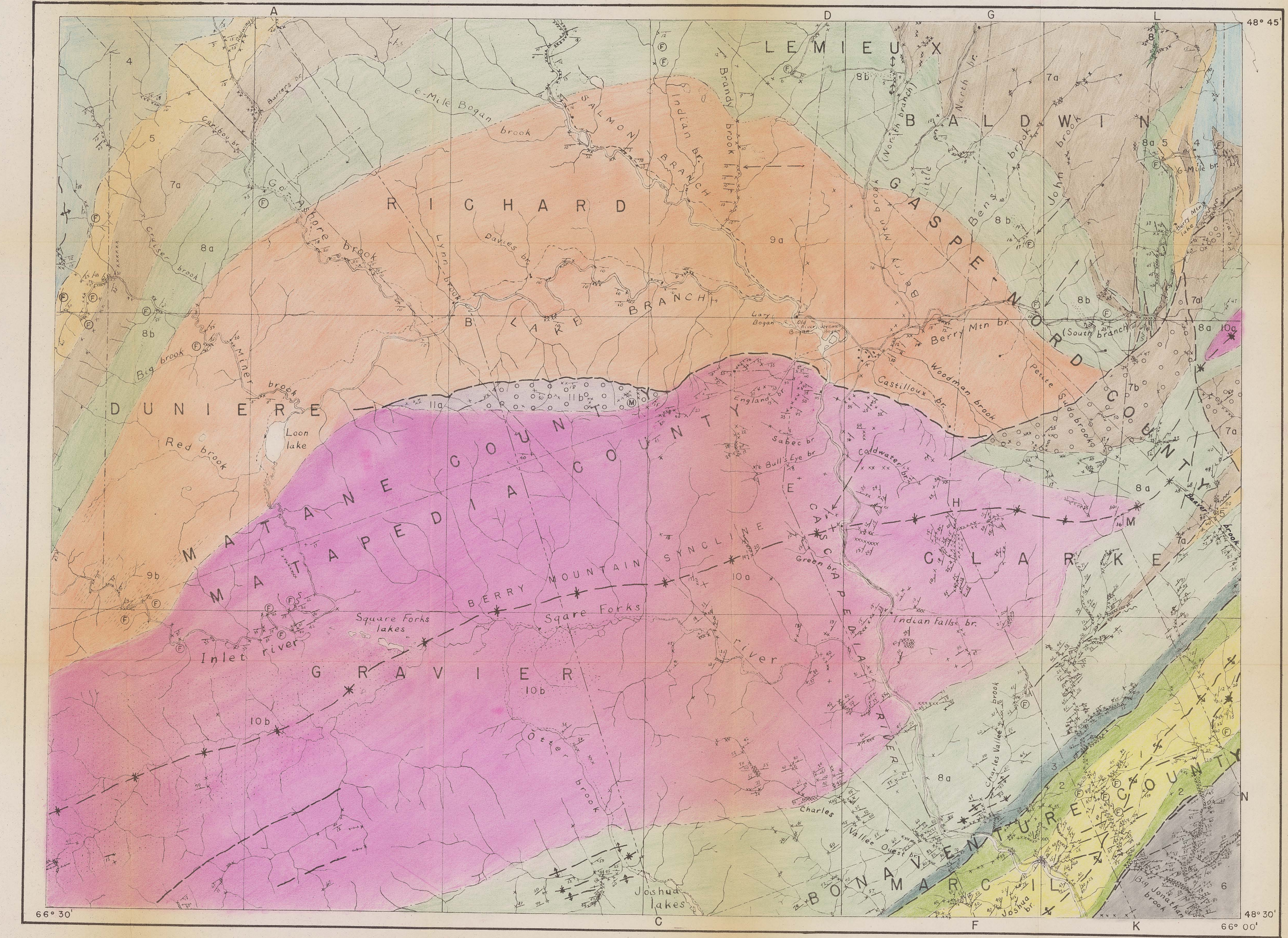
- (1950) Principles of Sedimentation: McGraw-Hill Book Co. Inc., Toronto.

WILLIAMS, H.S. - (1910) Age of the Gaspé Sandstone: Geol. Soc. Am. Bull., vol. 24, p. 688 - 698.

VERTICAL SECTIONS



THE BIG BERRY MOUNTAINS MAP-AREA



THE BIG BERRY MOUNTAINS MAP-AREA

LEGEND

MIDDLE OR LOWER DEVONIAN

MOUNT NOBLE	11b	Rhyolite porphyry
	11a	Andesites, basalts
BATTERY POINT	10b	Red sandstones and shales
	10a	Greenish grey, feldspathic sandstones. Pink feldspars
LAKE BRANCH	9b	Greenish grey beds
	9a	Interbedded red and brown sandstones and shales
YORK RIVER	8b	Red sandstones and shales
	8a	Greenish grey, feldspathic sandstones and shales. Grey feldspars

LOWER DEVONIAN

CONICAL MOUNTAIN	7b	Mainly rhyolite
	7a	Mainly andesites and basalts
FORTIN	6	Slates, sandstones and conglomerates
YORK LAKE	5	Interbedded sandstones and limestones
GRANDE GREVE	4	Siliceous limestones
CAPE BON AMI	3	Argillaceous limestones and dark shales

UPPER SILURIAN

2	Andesite, basalt, rhyolite
1	Shales, limestones, sandstones

Symbols

- a b c d — Strike and dip of bedding a) inclined b) vertical c) contorted d) overturned
- Strike and dip of shearing
- Strike and dip of axial plane and plunge of minor folds
- Glacial striae. Direction of movement unknown
- Major fault
- Axis of a) syncline b) anticline
- Current direction inferred from oriented fossils, ripple-marks, cross-bedding
- Geological contacts
- Vertical section
- a b c — a) outcrop b) mineralized outcrop c) fossil locality
- a b — County and township lines a) surveyed b) not surveyed
- Surveyed line
- a b c — a) motor road b) wagon road c) trail
- Camps

SCALE

One mile to one inch or 1 : 63360

1 0 1 2 3